TREE MANAGEMENT PLAN

Town of Warwick, New York

November 2018

Prepared for:

Town of Warwick
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ACKNOWLEDGMENTS

The Town of Warwick'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.

Warwick is thankful for the grant funding it received from the New York State Department of Environmental Conservation, Division of Lands and Forests, Urban Forestry Program (Round 13, 2017). The Grant Program is designed to encourage communities to create and support long-term and sustained urban and community forestry programs throughout New York.

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EXECUTIVE SUMMARY

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

State of the Existing Urban Forest

The July 2018 inventory included trees, stumps, and planting sites along public cul-de-sacs rights-of-way (ROW), and in specified parks. The Town of Warwick selected areas and parks for the inventory, which included all six public parks: Airport Road, Cascade Lake, Greenwood Lake Waterfront, Wickham, Union Corners Road, and Pine Island Parks, as well as 12 cul-de-sac roads. A total of 1,581 sites were recorded during the inventory: 1,440 individual trees, 42 stumps, and 99 vacant sites. Analysis of the tree inventory data found the following:

- *Acer* (red maple) comprise the largest percentage of the parks (18%) and street ROW (33%) and threaten biodiversity.
- On the street ROW, *Acer* (maple) were found in abundance (50%), which is a biodiversity concern for the city's streetscape.
- Overall, the diameter size class distribution of the inventoried tree population trended towards less than ideal, with a fewer number of Young trees than Established, Mature, or Maturing trees.
- The overall condition of the inventoried tree population is rated fair.
- Approximately 13% of the inventoried trees have dead or dying parts.
- Approximately 13% of the inventoried trees have weakly attached branches and codominant stems.
- Overhead utilities occur among 2% of the sites collected.
- Granulate ambrosia beetle (*Xylosandrus crassiusculus)* and Asian long-horned beetle (*Anoplophora glabripennis)* pose the biggest threats to the health of the inventoried population.
- Trees provide approximately $28,357 in the following annual benefits:
    - *Aesthetic and other benefits*: valued at $13,619 per year.
    - *Air quality*: 242.1 pounds of pollutants removed valued at $1,483 per year.
    - *Net total carbon sequestered and avoided*: 22,227.28 lbs. CO_2 sequestered and 35,987.08 lbs. CO_2 avoided, valued at $169 per year.
    - *Energy*: 16,463.29 kilowatt-hours (kWh) saved and 6,288.80 therms saved, valued at $11,083 per year.
    - *Stormwater peak flow reductions*: 250,141.52 gallons valued at $2,001 per year.

Tree Maintenance and Planting Needs

Trees provide many environmental and economic benefits that justify the time and money invested for planting and maintenance. Recommended maintenance needs include pruning (13%), large tree crown cleaning (38%), small tree crown cleaning (5%), tree removal (13%), stump removal (3%), training prune (5%), and tree planting (6%). Maintenance should be prioritized by addressing trees with the highest risk first. The inventory noted 10 Extreme and High Risk trees (.06% and .6% of trees assessed, respectively); these trees should be pruned or removed 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.

REMOVAL	Total = 203 trees Extreme Risk = 1 tree High Risk = 9 trees Moderate Risk = 64 trees
PRIORITY PRUNING	Total = 206 trees Moderate Risk = 9 trees Low Risk = 197 trees
ROUTINE PRUNING CYCLE	Total = 686 trees Number of Trees in Cycle Each Year = Approximately 96
YOUNG TREE TRAINING CYCLE	Total = 84 Trees Number of Trees in Cycle Each Year = At least 28
TREE PLANTING	Number of Trees Each Year = At least 14 Ideal number of trees = 41 (1% of canopy)

Warwick’s urban forest will benefit greatly from a three-year young tree training cycle and a seven-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 15 young trees should be structurally pruned each year during the young tree training cycle, and approximately 98 trees should be cleaned each year during the routine pruning cycle. This cycle begins in Year 3, after all high and moderate risk/prunes have been taken care of.

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). Currently, the vacant sites around Warwick allow for about 15 trees to be planted per year. DRG recommends planting at least 15 trees of a variety of species each year to offset losses, increase canopy, maximize benefits, and account for ash tree loss.

The township-wide 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, 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) should be limited until the species distribution normalizes. 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.

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

Urban Forest Program Needs

Adequate funding will be needed for the town to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this seven-year program is $92,137. This total will decrease to approximately $63,515 per year by Year 4 of the program. High-priority removal and pruning is costly; since most of this work is scheduled during the first year of the program, the budget is higher for that year. After high-priority work has been completed, the urban forestry program will mostly involve proactive maintenance, which is generally less costly. Budgets for later years are thus projected to be lower.

Over the long term, supporting proactive management of trees through funding will reduce municipal tree care management costs and potentially minimize the costs to build, manage, and support certain town 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.

Warwick 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 publicly owned trees.

FY 2019 $92,137

21 Extreme, High, and Moderate Risk Removals
9 Extreme, High, and Moderate Risk Prunes
74 Low Risk Prunes
14 Trees Recommended for Planting and Follow-Up Care
YTT Cycle: ⅓ of Young Tree Trained = 28 trees
Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2020 $86,808

32 High and Moderate Risk Removals
28 Trees Recommended for Planting and Follow-up Care
122 Low Risk Prunes
YTT Cycle: ⅓ of Young Tree Trained = 28 trees
Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2021 $78,317

21 High and Moderate Risk Removals
11 Low Risk Removals
RP Cycle 1/7 of Public Trees Cleaned = 98 Trees
YTT Cycle: 28 Trees
15 Trees Recommended for Planting and Follow-up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2022 $63,515

RP Cycle: 1/7 of Public Trees Cleaned = 98 Trees
18 Low Risk Removals
YTT Cycle: 28 Trees
15 Trees Recommended for Planting and Follow-up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs To Be Determined

FY 2023 $60,216

RP Cycle: 1/7 of Public Trees Cleaned - 96 Trees
39 Low Risk Removals
YTT Cycle: 28 Trees
15 Trees Recommended for Planting and Follow-up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs To Be Determined

FY2024 $55,257

RP Cycle: 1/5 of Public Trees Cleaned = 96 Trees
31 Low Risk Removals
YTT Cycle: 28 Trees
15 Trees Recommended for Planting and Follow-up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs To Be Determined

FY2025 $55,466

RP Cycle: 1/5 of Public Trees Cleaned = 95 Trees
30 Low Risk Removals
YTT Cycle: 28 Trees
15 Trees Recommended for Planting and Follow-up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs To Be Determined

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INTRODUCTION

The Town of Warwick is home to more than 30,000 full-time residents who enjoy the beauty and benefits of their urban forest. Since it was founded in 1788, the community grew to include three incorporated villages (Warwick, Greenwood Lake, and Florida) within its boundaries. Warwick is also unique in that it is comprised of fields and cultivated farmland around these civic centers. Today, the town 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).

The Town of Warwick conducted an inventory of public trees in 2018. The town has a shade tree commission, celebrates Arbor Day, and has been a Tree City USA community for over three years.

Approach to Tree Management

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

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

- Inventory of trees, stumps, and planting sites along the cul-de-sacs' ROW and within all six public parks.
- Analysis of tree inventory data.
- Development of a plan that prioritizes the recommended tree maintenance.

This plan is divided into three sections:

- Section 1 (*Tree Inventory Analysis*) summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: Benefits of the Urban Forest* summarizes the economic, environmental, and social benefits that trees provide to the community. This section presents statistics of a TreeKeeper® benefits analysis conducted for Warwick.
- *Section 3: Tree Management Program* utilizes the inventory data to develop a prioritized maintenance schedule and projected budget for the recommended tree maintenance over a seven-year period.

SECTION 1: TREE INVENTORY ANALYSIS

In July 2018, DRG arborists, certified by the International Society of Arboriculture, assessed and inventoried trees, stumps, and planting sites along the cul-de-sacs' ROW and specified parks. A total of 1,581 sites were collected during the inventory: 1,440 trees, 42 stumps, and 99 planting sites. Figure 1 provides a detailed breakdown of the number and type of sites inventoried.

Warwick's public street rights-of-way areas were selected by the Town and Shade Tree Commission for the inventory.

Inventoried public areas include: Airport Road Park, Cascade Lake Park, Greenwood Lake Waterfront, Wickham Park, Union Corners Park, and Pine Island Park.

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

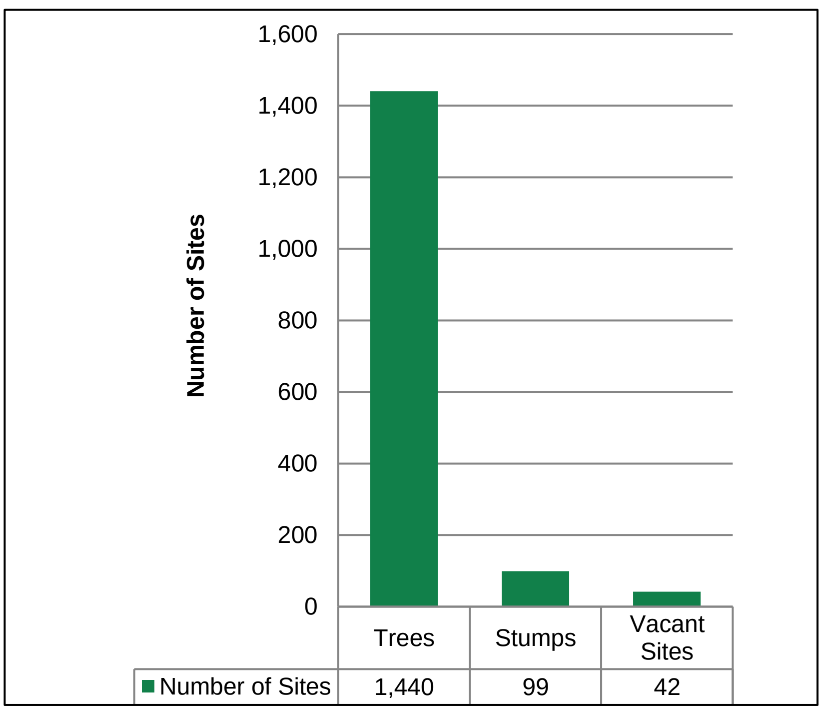


Figure 1. Sites collected during the 2018 inventory.

Assessment of Tree Inventory Data

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

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

Species Diversity

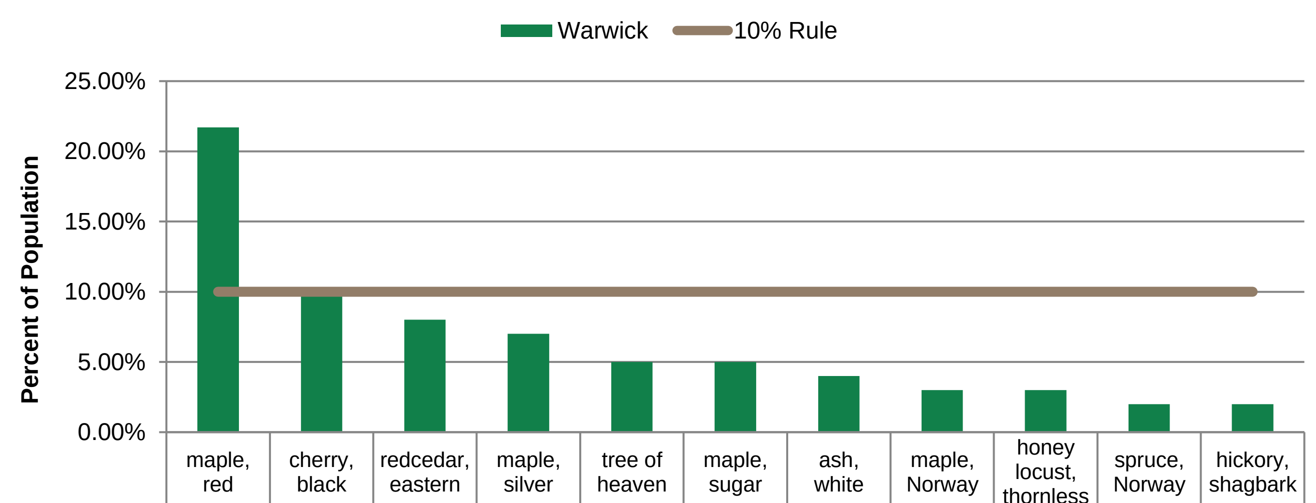
Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics such as the devastating results of Dutch elm disease (*Ophiostoma novo-ulmi*) throughout New England and the Midwest. Due to the spread of Dutch elm disease in the 1930s, combined with the disease 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. Emerald ash borer (EAB, *Agrilus planipennis)* and Asian longhorned beetle (ALB, *Anoplophora glabripennis*) are non-native insect pests that attack some of the most prevalent urban shade trees and certain agricultural trees throughout the country.

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

Findings

Analysis of Warwick's tree inventory data indicated relatively good diversity, with 37 genera and 76 species represented.

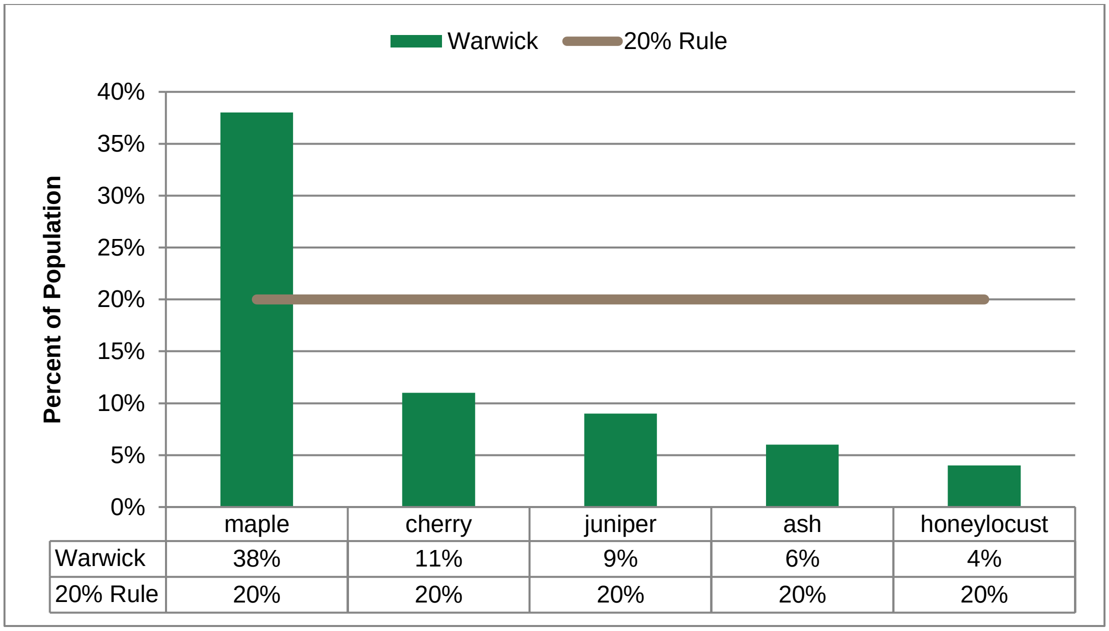
Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory. *Acer rubrum* (maple, red) exceeds the recommended 10% maximum for a single species in a population, comprising 22% of the inventoried tree population. *Prunus serotina* (cherry, black) is at the 10% threshold.



	maple, red	cherry, black	redcedar, eastern	maple, silver	tree of heaven	maple, sugar	ash, white	maple, Norway	honey locust, thornless	spruce, Norway	hickory, shagbark
Warwick	21.70%	10%	8%	7%	5%	5%	4%	3%	3%	2%	2%
10% Rule	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

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

Figure 3 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory. *Acer* (maple) far exceeds the recommended 20% maximum for a single genus in a population, comprising 38% of the inventoried tree population.



	maple	cherry	juniper	ash	honeylocust
Warwick	38%	11%	9%	6%	4%
20% Rule	20%	20%	20%	20%	20%

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

Discussion/Recommendations

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

Considering the large quantity of *Acer* (maple) in the town's population, along with its susceptibility to pests, the planting of *Acer* (maple) should be limited to minimize the potential for loss in the event that Asian longhorned beetle (ALB) or granulate ambrosia beetle (*Xylosandrus crassiusculus*) threaten Warwick's urban tree population. See Appendix C for a recommended tree species list for planting.

Diameter Size Class Distribution

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

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

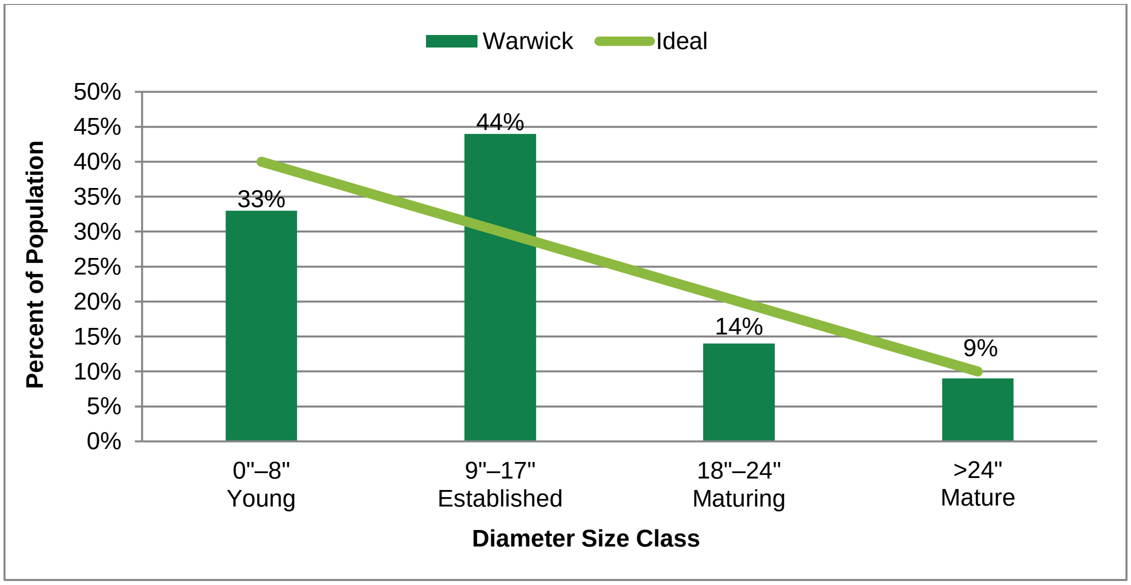


Figure 4. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Findings

Figure 4 compares Warwick's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). Warwick's distribution trends towards the less ideal; established trees exceed the ideal by over 10%, while young tree diameter size class falls short of the ideal.

Discussion/Recommendations

Warwick has too few young, maturing, and mature trees, which indicates that the distribution is skewed. One of Warwick's objectives is to have an uneven-aged distribution of trees at the street, park, and townwide levels. DRG recommends that Warwick 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 town must promote tree preservation and proactive tree care to ensure the long-term survival of older trees. See Appendix B for more information on risk assessment and priority maintenance. Additionally, tree planting and tree care will allow the distribution to normalize over time. See Appendix C for a recommended tree species list for planting. See Appendix D for planting suggestions and information on species selection.

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

Condition

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

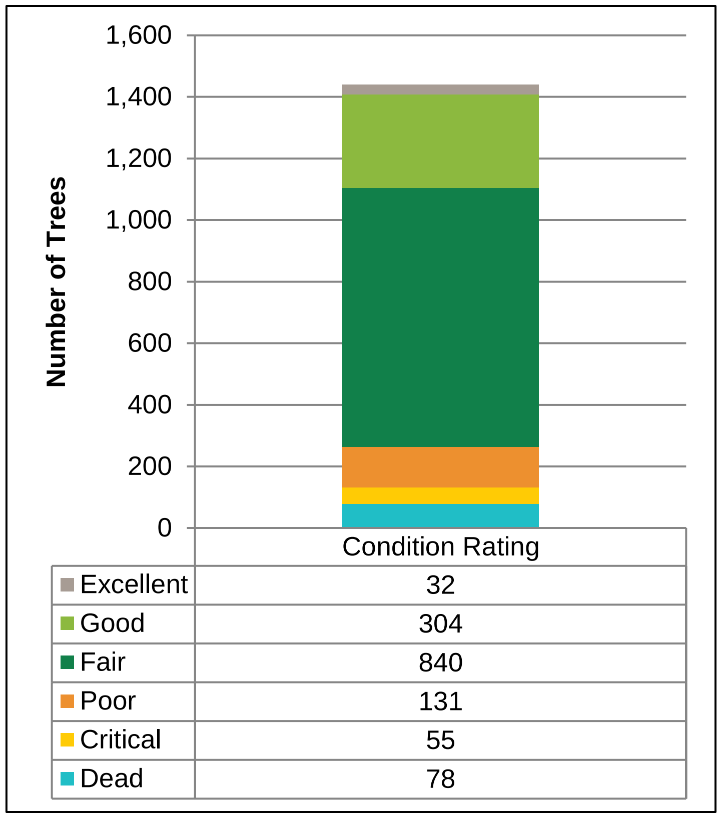


Figure 5. Condition of inventoried trees.

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

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

Findings

Most of the inventoried trees were recorded to be in Fair or Good condition, 58% and 23%, respectively (Figure 5). Based on these data, the general health of the overall inventoried tree population is rated Fair. Figure 6 illustrates that most of the young, established, maturing, and mature trees were rated to be in Fair condition.

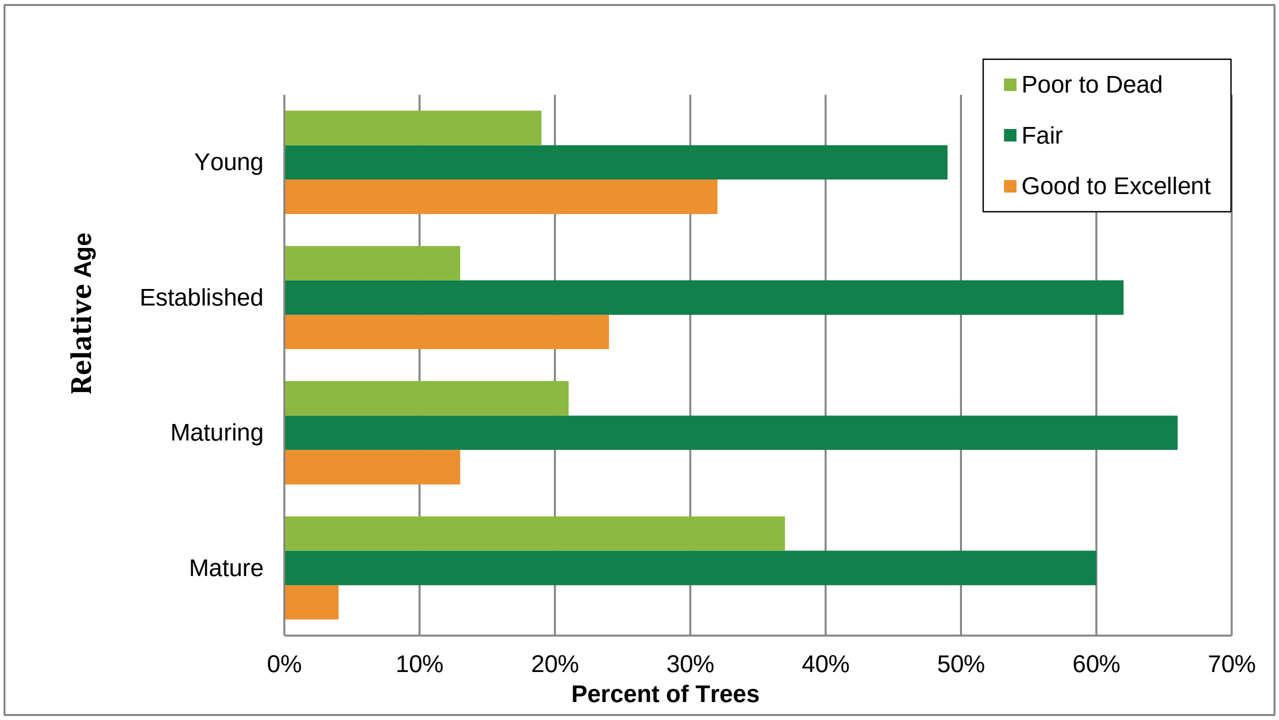


Figure 6. Tree condition by relative age during the 2018 inventory.

Discussion/Recommendations

Even though the condition of Warwick'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 the tree population reveals that growing conditions and/or past management of trees were consistent.
- Younger trees rated in Fair or Poor condition may benefit from improvements in structure that may improve their health over time. Pruning should follow *ANSI A300 (Part 1)* (ANSI 2008).
- Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Proper tree care practices are needed for the long-term general health of the urban forest. 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 Warwick's, stocking level is used to estimate the total number of sites along the street ROW that could contain trees. Park trees and public property trees are excluded from this measurement.

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

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

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

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

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

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

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

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

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

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

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

Findings

The inventory found 99 planting sites. Of the inventoried sites, 70 were potential planting sites for large-size trees (8-foot-wide and greater growing space size); 29 were potential sites for medium-size trees (6- to 7-foot-wide growing space sizes); and there were no potential sites for small-size trees (3- to 5-foot-wide growing space sizes or had overhead utilities). Based on the data collected during this inventory (with an estimated 845 trees collected in parks), Warwick's current cul-de-sacs' ROW tree stocking level is 30%.

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. Generally, this entails a planned program of planting, care, and maintenance for the town's street trees.

The town of Warwick has a current total of 99 planting sites along the street ROW; it would take approximately 7 years for the town to plant in these locations. If budgets allow, DRG recommends that Warwick increase the number of trees planted per year to 44 to account for tree loss as well. 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 the town's urban forest. The more residents and greater housing density the town possesses, the greater the need for trees to provide benefits.

Defects

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

Findings

Dead and dying parts and weakly attached branches and codominant stems were most frequently observed and recorded (13% and 13% of inventoried trees, respectively). Of these 367 trees, 43 were recommended for removal, and 42 were rated to be Extreme, High, or Moderate Risk trees.

Table 1. Defects Recorded During the Tree Inventory

Observation	Number of Trees	Percent
Dead and Dying Parts	183	12.71%
Broken and/or Hanging Branches	102	7.08%
Cracks	6	0.42%
Weakly Attached Branches and Codominant Stems	184	12.78%
Missing or Decayed Wood	111	7.71%
Tree Architecture	40	2.78%
Root Problems	96	6.67%
Other	74	5.14%
N/A	644	44.72%
Total	**1,440**	**100%**

Discussion/Recommendations

Unless slated for removal, trees noted as having defects such as tree architecture and weakly attached branches (224 trees) or missing or decayed wood (111 trees) should be regularly inspected. Corrective actions should be taken when warranted. If their condition worsens, removal may be required. Of the 111 trees noted for missing or decayed wood, 42 were recommended for removal. Of the 184 trees noted for weakly attached branches or tree architecture, only 10 were recommended for removal.

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

Overhead Utilities

In an urban setting, space is limited both above and below ground. Trees in this environment may conflict with utility wires which may pose risks to public health and safety. Existing or possible conflicts between trees and powerlines were recorded during the inventory. The presence of overhead utility lines (powerline only, telecommunication, and drop wires were not a concern) above a tree or planting site was noted; it is important to consider this data when planning pruning activities and selecting tree species for planting.

Findings

There were only 4 trees recorded that were conflicting with overhead utilities. Another 22 sites had overhead utilities present. Of these 22 sites, 11 are trees and 11 sites are stumps.

Table 2. Overhead Utilities

Conflict	Presence	Number of Trees	Percent
Overhead Utilities	Present and Conflicting	4	0.25%
	Present and Not Conflicting	22	1.39%
	Not Present	1,555	98.36%
Hardscape Damage	Present	0	0.00%
	Not Present	1,581	1

Discussion/Recommendations

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

Further Inspection

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

Photographs 3 and 4. *Ashes throughout New York state have been found to have emerald ash borer. This ash tree in New Paltz, New York has emerald ash borer and has been marked for insect/ disease monitoring. The tree will eventually have to be removed if not treated for the pest. An ISA Certified Arborist should continue to monitor for pests.*

Findings

DRG recommended 32 trees for further inspection. Of these 32 trees, 30 are marked for insect/disease monitoring, and 70% are ash trees.

Discussion/Recommendations

An ISA Certified Arborist should perform additional inspections of the Level III (2 trees) assessment. If it is determined that these trees exceed the threshold for acceptable risk, the defective part(s) of the trees should be corrected or removed, or the entire tree may need to be removed.

The inventoried ash trees that showed symptoms of EAB should be monitored and eventually removed. Once the ash tree is removed, the site should be inspected for a 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 Warwick'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 and the rest of the country (see Figure 7). It is important to note that the figure only presents data collected from the inventory. Many more trees throughout Warwick, 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 trees (22% and 14%, respectively). These pests were not detected in Warwick, but if they were detected the town could see severe losses in its tree population.

There were 81 ash trees inventoried in Warwick, and the majority of the population showed symptoms of EAB. Private trees that were not part of this inventory also showed symptoms of infestation. Of the 81 ash trees inventoried, 45 were marked for removal. The unknown number of private trees that were not part of this inventory may be a future concern.

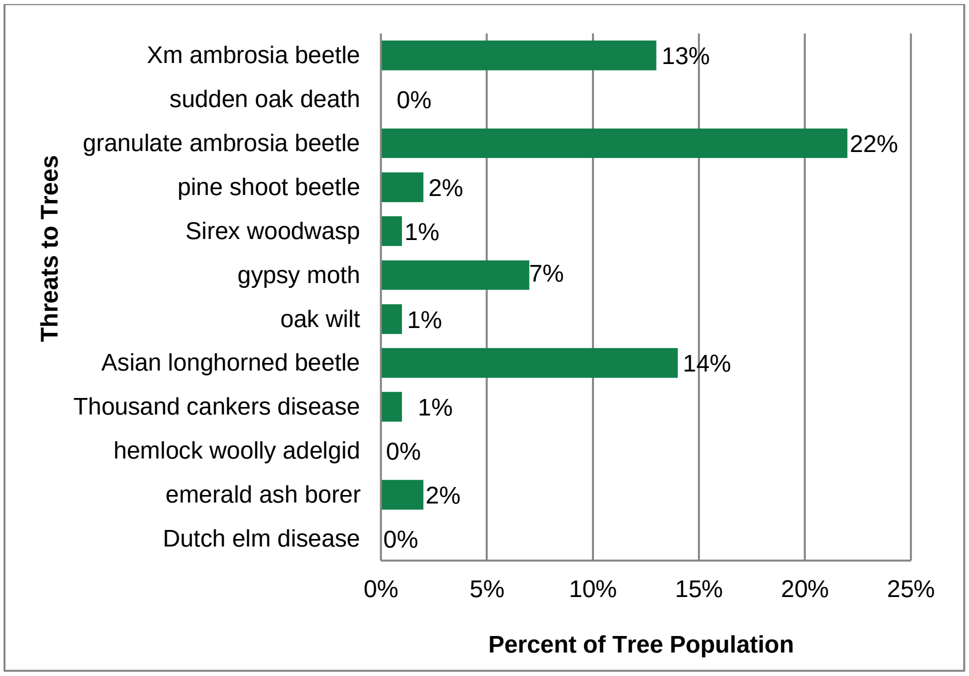


Figure 7. Potential impact of insect and disease threats noted during the 2018 inventory.

Discussion/Recommendations

Warwick 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, record keeping, and evaluating results.

SECTION 2: BENEFITS OF THE URBAN FOREST

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

Environmental Benefits

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

Economic Benefits

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

Social Benefits

- Tree-lined streets are safer; traffic speeds and the amount of stress drivers feel are reduced, which likely reduces road rage/aggressive driving (Wolf 1998a, Kuo and Sullivan 2001a).
- Chicago apartment buildings with medium amounts of greenery had 42% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Chicago apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Employees who see trees from their desks experience 23% less sick time and report greater job satisfaction than those who do not (Wolf 1998a). Hospital patients recovering from surgery who had a view of a grove of trees through their windows required fewer pain relievers, experienced fewer complications, and left the hospital sooner than similar patients who had a view of a brick wall (Ulrich 1984, 1986).
- When surrounded by trees, physical signs of personal stress, such as muscle tension and pulse rate, were measurably reduced within 3 to 4

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

Photograph 5. *Trees provide significant aesthetic value to the community. Additionally, the tangible services of trees provide quantifiable benefits that justify the time and money invested in planting and maintenance.*

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

Tree Benefit Analysis

i-Tree Streets

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

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

These quantified benefits and the reports generated are described below.

- **Aesthetic/Other Benefits:** Shows the tangible and intangible benefits of trees reflected by increases in property values (in dollars).
- **Stormwater:** Presents reductions in annual stormwater runoff due to rainfall interception by trees measured in gallons.
- **Carbon Stored:** Tallies all of the carbon dioxide (CO_2) stored in the urban forest over the life of its trees as a result of sequestration. Carbon stored is measured in pounds and has been translated to tons for this report.
- **Energy:** Presents the contribution of the urban forest towards conserving energy in terms of reduced natural gas use in the winter (measured in therms [thm]) and reduced electricity use for air conditioning in the summer (measured in Megawatt-hours ([MWh]).
- **Carbon Sequestered:** Presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reductions in energy use. This is measured pounds and has been translated to tons for this report. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.
- **Air Quality:** Quantifies the air pollutants (ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], particulate matter less than 10 micrometers in diameter [PM_{10}]) deposited on tree surfaces, and reduced emissions from power plants (NO_2, PM_{10}, volatile organic compounds [VOCs], SO_2) due to reduced electricity use in pounds. The potential negative effects of trees on air quality due to biogenic volatile organic compounds (BVOC) emissions is also reported.
- **Importance Value (IV):** IVs are calculated for species that comprise more than 1% of the population. The Streets IV is the mean of three relative values (percentage of total trees, percentage of total leaf area, and percentage of canopy cover) and can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. IVs offer valuable information about a community's reliance on certain species to provide functional benefits. For example, a species might represent 10% of a population but have an IV of 25% due to its substantial benefits, indicating that the loss of those trees would be more significant than just their population percentage would suggest.

i-Tree Tools

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

THE BENEFITS OF WARWICK'S URBAN FOREST

i-Tree Streets Inputs

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

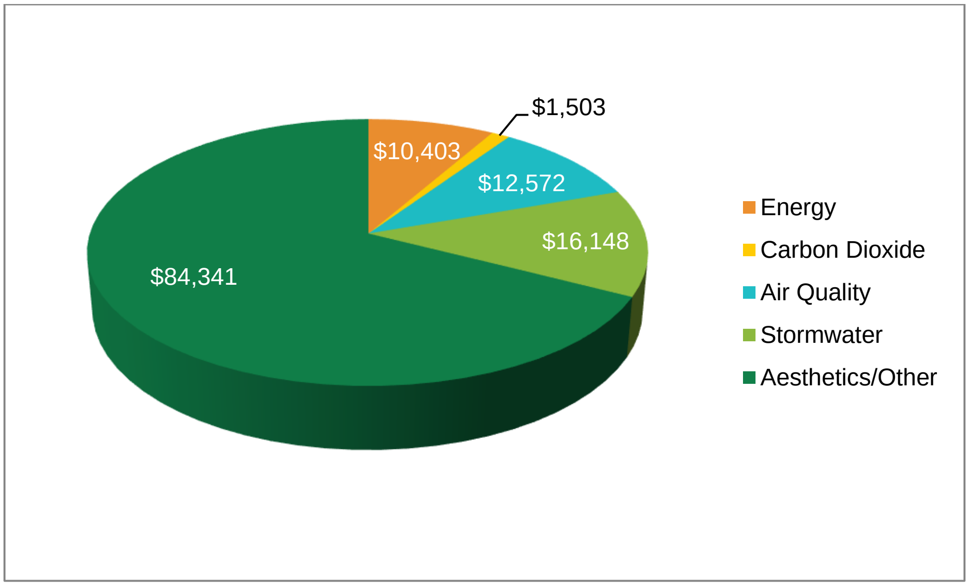


Figure 8. Breakdown of total annual benefits provided to Warwick.

Table 3. Benefit Data for Common Trees by Species

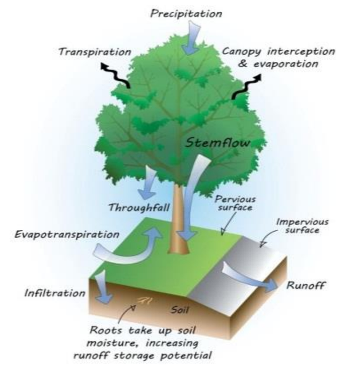
Most Common Trees Collected During Inventory		Number Trees on the ROW	Percent of Total Trees	Canopy Cover	Benefits Provided by Street Trees						Importance Value (IV)
					Aesthetic/ Other	Stormwater	Carbon Dioxide Stored	Energy	Carbon Sequestered	Air Quality	
Common Name	Botanical Name		(%)	(ft2)	Average/$/Tree						0–100 (higher IV = more important species)
maple, red	*Acer rubrum*	313	21.7	162, 647	59.71	8.93	4.77	5.68	0.74	6.4	18.77
cherry, black	*Prunus serotina*	138	9.6	72,525	13.74	6.98	22.64	5.76	0.89	6.78	7.3
cedar, eastern red	*Juniperus virginiana*	122	8.5	58,802	30.28	6.67	2.19	5.08	0.91	7.69	5.6
maple, silver	*Acer saccharinum*	100	6.9	86,908	56.77	14.17	13.97	9.04	1.28	10.56	8.14
tree-of-heaven	*Ailanthus altissima*	78	5.4	123,446	119.52	25.25	19.24	14.52	1.87	18.17	10.35
maple, sugar	*Acer saccharum*	70	4.9	58,286	68.13	15	20.42	8.59	1.34	9.8	6.01
ash, white	*Fraxinus americana*	64	4.4	82,497	71.19	18.79	16.41	12.1	1.75	14.97	6.7
maple, Norway	*Acer platanoides*	47	3.3	28,149	51.8	7.94	10.18	6.25	1.16	7.42	2.65
honeylocust, thornless	*Gleditsia triacanthos inermis*	37	2.6	32,886	86.67	10.75	5.21	9.15	1.22	10.06	2.73
spruce, Norway	*Picea abies*	33	2.3	5,098	29.08	3.18	0.99	1.56	0.18	1.83	1.09
hickory, shagbark	*Carya ovata*	31	2.2	50,200	128.27	25.95	20.1	14.63	1.93	18.45	4.21
pear, callery	*Pyrus calleryana*	28	1.9	18,523	128.92	9.98	5.58	6.81	1.41	8.57	1.75
oak, pin	*Quercus palustris*	25	1.7	3,873	45.43	2.25	1.38	1.6	0.23	1.75	0.82
walnut, black	*Juglans nigra*	23	1.6	26,753	125.2	17.38	9.42	12.21	1.67	14.29	2.27
larch, American	*Larix laricinia*	22	1.5	18,348	26.56	15.54	6.88	8.51	0.98	10.47	1.58
cherry/plum spp.	*Prunus* spp.	22	1.5	6,891	29.8	4.47	2.97	3.59	0.66	5.16	0.84
pine, Austrian	*Pinus nigra*	21	1.5	10,885	31.32	9.99	0.65	5.4	0.65	6.46	1.14
other street trees	~37 genera of varying species	266	18.5	174,185	2,020	362.49	475.88	216.93	13.13	260.39	18.05
ROW Total	~37 genera and ~78 species on the ROW	1,440	100	858,255	3,122	565.71	638.88	347.41	32	419.22	100

Aesthetic/Other Benefits

The total annual benefit associated with property value increases and other tangible and intangible benefits of publicly owned street trees was $84,340. The average benefit per tree equaled $58.57 per year.

Stormwater Benefits

Trees intercept rainfall, which helps lower costs to manage stormwater runoff. The inventoried trees in Warwick intercept 2,018,495 gallons of rainfall annually (Table 4). On average, the estimated annual savings for the town in stormwater runoff management is $11.21 per tree.



Trees reduce stormwater runoff by capturing and storing rainfall in their canopy and releasing water into the atmosphere.
Tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil.
Trees help slow down and temporarily store runoff and reduce pollutants by absorbing nutrients and other pollutants from soils and water through their roots.
Trees transform pollutants into less harmful substances.

Of all species inventoried, red maple contributed most of the annual stormwater benefits. The population of red maple (22% of trees) intercepted approximately 349,214 gallons of rainfall. The next most dominant species, black cherry (10% of ROW), only intercepted approximately 120,420 gallons of rainfall. On a per-tree basis, large trees with leafy canopies provided the most value. Tree-of-heaven comprised 5% of the population and absorbed 2% times more gallons of rainfall than black cherry. These large-statured trees with big canopies offered the greatest benefits. Tree-of-heaven is an invasive species, however, and is the preferred host species for the spotted lanternfly, an invasive insect native to China (Appendix E).

Air Quality Improvements

The inventoried tree population annually removes 1,140 pounds of air pollutants (including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter) through deposition. The population also avoids 1,451 pounds annually.

The i-Tree Streets calculation takes into account the biogenic volatile organic compounds (BVOC's) that are released from trees. The net total value of these benefits is estimated to be $12,571. The inventoried trees removed or avoided more pollutants than they emitted, resulting in a positive economic value. The trees that provided the most benefits based on an annual per-tree average value were *Acer rubrum* (red maple) and *Ailanthus altissima* (tree-of-heaven) ($ 6.40 and $18.17, respectively).

While trees do a great deal to absorb air pollutants, they also contribute negatively to air pollution. Trees emit various BVOCs such as isoprenes and monoterpenes, which can also contribute to formation of ozone, a harmful gas that pollutes the air and damages vegetation. These BVOC emissions are accounted for in the air quality net benefit.

Table 4. Stormwater Benefits Provided by Town Trees

Most Common Trees Collected During Inventory		Number of Trees	Percent of Total Trees	Total Rainfall Interception
Common Name	Botanical Name		(%)	(gal.)
red, maple	*Acer rubrum*	313	22%	349,214
cherry, black	*Prunus serotina*	138	10%	120,420
cedar, eastern red	*Juniperus virginia*	122	8%	101,710
maple, silver	*Acer saccharinum*	100	7%	177,114
tree-of-heaven	*Ailanthus altisima*	78	5%	246,145
maple, sugar	*Acer saccharum*	70	5%	131,252
ash, white	*Fraxinus americana*	64	4%	150,313
maple, Norway	*Acer platanoides*	47	3%	46,655
honeylocust, thornless	*Gleditsia triacanthos inermis*	37	3%	49,730
spruce, Norway	*Picea abies*	33	2%	13,103
hickory, shagbark	*Carya ovata*	31	2%	100,562
pear, callery	*Pyrus calleryana*	28	2%	34,933
oak, pin	*Quercus palustris*	25	2%	7,038
walnut, black	*Juglans nigra*	23	2%	49,953
larch, American	*Larix larcinia*	22	2%	42,724
cherry/plum spp.	*Prunus* spp.	22	2%	12,281
pine, Austrian	*Pinus nigra*	21	1%	26,234
ash, green	*Fraxinus pennsylvanica*	17	1%	43,176
birch, river	*Betula nigra*	15	1%	24,806
honeylocust	*Gleditsia triacanthos*	15	1%	35,524
unknown tree	unknown tree	14	1%	18,034
pine, eastern white	*Pinus strobus*	14	1%	16,189
planetree, London	*Platanus × acerifolia*	13	1%	720
fir, balsam	*Abies balsamea*	11	1%	7,959
other trees	*~37 genera of varying species*	167	12%	5,114,148
Total	~37 genera and ~78 species	1,440	100%	6,919,937

Carbon Storage and Carbon Sequestration

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

Photograph 6. *Trees improve quality of life and help enhance the character of a community. Trees filter air, water, and sunlight, moderate local climate, slow wind and stormwater, shade homes, and provide shelter to animals and recreational areas for people.*

The i-Tree Streets calculation takes into account the carbon emissions that are *not* released from power stations due to the heating and cooling effect of trees (i.e., conserved energy in buildings and homes). It also calculates emissions released during tree care and maintenance, such as driving to the site and operating equipment. The net carbon benefit is approximately $1,503 per year.

The town's street trees store 2,327 tons of carbon (measured in CO_2 equivalents). This amount reflects the amount of carbon they have amassed during their lifetimes. Through sequestration and avoidance, 227.7 tons of CO_2 are removed each year. Black cherry provided the most carbon benefits, with each tree storing an annual average of $22.64 and sequestering $0.56 worth of carbon.

Energy Benefits

***Acer rubrum* (red maple)**	***Prunus serotina* (black cherry)**	***Juniperus virginiana* (eastern redcedar)**	***Acer saccharinum* (silver maple)**
22% of ROW	**10% of ROW**	**8% of ROW**	**7% of ROW**
18 MWh Electricity	**8 MWh Electricity**	**6 MWh Electricity**	**9 MWh Electricity**
6,905 thm Natural Gas	**3,300 thm Natural Gas**	**2,132 thm Natural Gas**	**3,389 thm Natural Gas**
$38.91 Average $/tree	**$41.38 Average $/tree**	**$32.00 Average $/tree**	**$60.40 Average $/tree**

Public trees conserve energy by shading structures and surfaces, which reduces electricity use for air conditioning in the summer. Trees divert wind in the winter to reduce natural gas use. Based on the inventoried trees, the annual electric and natural gas savings are equivalent to 104.51 MWh of electricity and 7,305 therms of natural gas, which accounts for an annual savings of $69,226 in energy consumption.

Red maple contributed $5.68 per tree to the annual energy benefits of the urban forest, but its contribution was mostly due to its dominance in the cul-de-sacs and parks. Other tree species, specifically eastern cottonwood and scarlet oak contributed more to reduce energy usage on a per-tree basis. The annual value these trees provide exceeds $15 per tree, although they comprise only 0.3% of the population, respectively. These large leafy canopies are valuable because they provide shade, which reduces energy usage. Smaller trees inventoried, such as dogwood, ginkgo, and *Ulmus* spp. (elm), were found to have smaller reductions in energy usage on a per-tree basis. Ginkgo is valued at only $0.10 per tree.

Importance Value (IV)

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

The i-Tree Streets assessment found that red maple has the greatest IV in the ROW population at 18.77; it comprises only 22% of the ROW. This indicates that the loss of the red maple population would be economically detrimental. The second highest IV was for tree-of-heaven (10.35), followed by silver maple (8.14) and black cherry (7.3). The abundances of tree-of-heaven (5%) and silver maple (7%) on the ROW are not as great as black cherry (10%), but their IVs are greater. Because they are large growing, the size and canopy of broadleaf species by nature provide more environmental benefits to the community, which all factor into assigning IV. The IV for black cherry is less than its percentage of the population, indicating that if black cherry was lost, its economic impact would not be as significant.

Discussion/Recommendations

The i-Tree Streets analysis found that ROW trees provide environmental and economic benefits to the community by virtue of their mere presence on the streets. Currently, the aesthetic/other benefits provided by ROW trees were rated as having the greatest value to the community. The property value increase provided by trees is important to stimulate economic growth. In addition to increasing aesthetics and property values, trees manage stormwater through rainfall interception, provide shade and windbreaks to reduce energy usage, and store and sequester CO_2. Even though these environmental benefits were not found to be as great as the aesthetic/other benefits, they are noteworthy. Trees work to intercept rainfall and reduce runoff—in Warwick, as little as 1,440 ROW trees absorb over 2 million gallons of rainfall.

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

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

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

SECTION 3: TREE MANAGEMENT PROGRAM

This tree management program was developed to uphold Warwick'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, it is also essential to routinely monitor the tree population to identify other Extreme or High Risk trees so that they may be systematically addressed. While regular pruning cycles and tree planting is important, priority work (especially for Extreme or High Risk trees) must sometimes take precedence to ensure that risk is expediently managed.

Priority and Proactive Maintenance

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

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

Tree and Stump Removal

Although tree removal is usually considered a last resort and may sometimes create a reaction from the community, there are circumstances in which removal is necessary. Trees fail from natural causes, such as diseases, insects, and weather conditions, and from physical injury due to vehicles, vandalism, and root disturbances. DRG recommends that trees be removed when corrective pruning will not adequately eliminate the hazard or when correcting problems would be cost-prohibitive. Trees that cause obstructions or interfere with power lines or other infrastructure should be removed when their defects cannot be corrected through pruning or other maintenance practices. Diseased and nuisance trees also warrant removal.

Even though large short-term expenditures may be required, it is important to secure the funding needed to complete priority tree removals. Expedient removal reduces risk and promotes public safety.

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

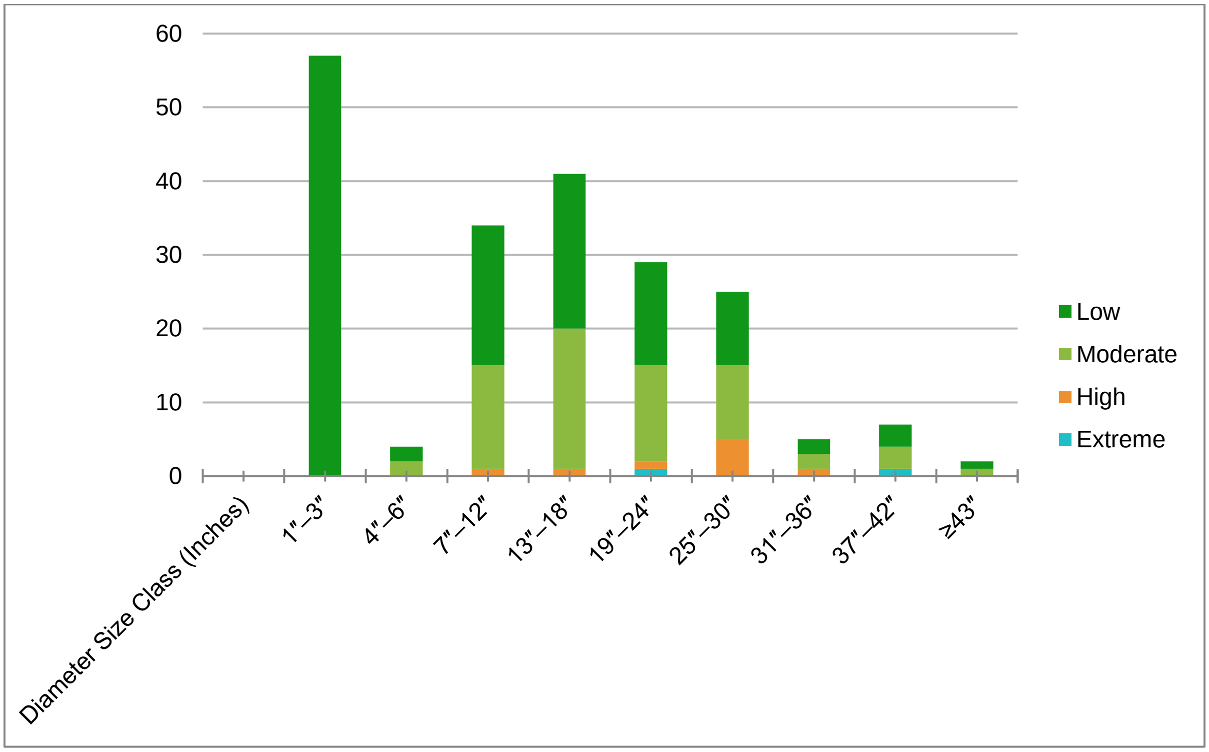


Figure 9. Tree removals by risk rating and diameter size class.

Findings

The inventory identified 11 Extreme or High Risk trees, 64 Moderate Risk trees, and 129 Low Risk trees that are recommended for removal.

The diameter size classes for High Risk trees ranged between 7–12 inches diameter at breast height (DBH) and 37–42 inches DBH. These trees should be removed immediately based on their assigned risk. High Risk removals and pruning can be performed concurrently.

Most Moderate Risk trees were smaller than 30 inches DBH. These trees should be removed as soon as possible after all High Risk removals and pruning have been completed.

Low Risk removals pose little threat; these trees are generally small or do not often have targets, are 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.

Discussion/Recommendations

Unless already slated for removal, trees noted as having poor tree architecture or weakly attached branches and codominant stems (184 trees) or missing or decayed wood (111 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 workload 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

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

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

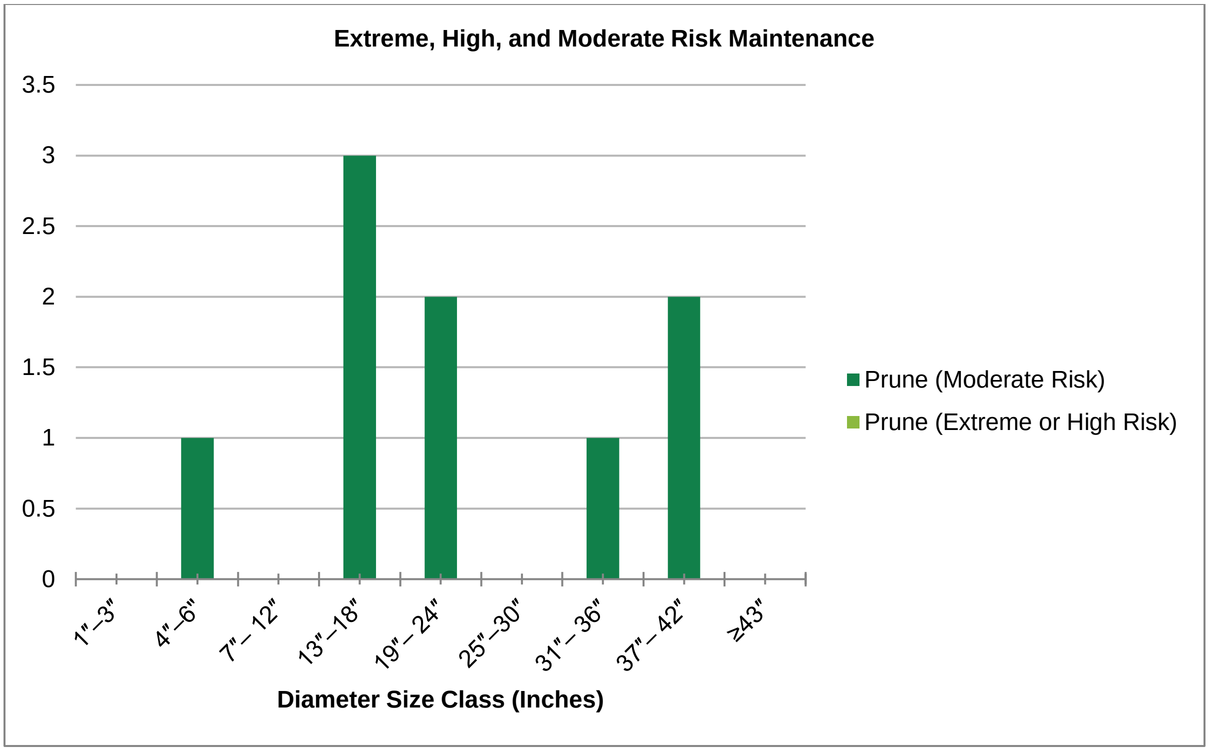


Figure 10. High and Moderate Risk pruning by diameter size class.

Findings

The inventory identified no High Risk trees and 27 Moderate Risk trees recommended for pruning.

Moderate Risk trees ranged in diameter size classes from 4–6 inches DBH to 37–42 inches DBH. Low Risk trees recommended for pruning should be included in a proactive, routine pruning cycle after all the higher risk trees are addressed.

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 High and Moderate 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.

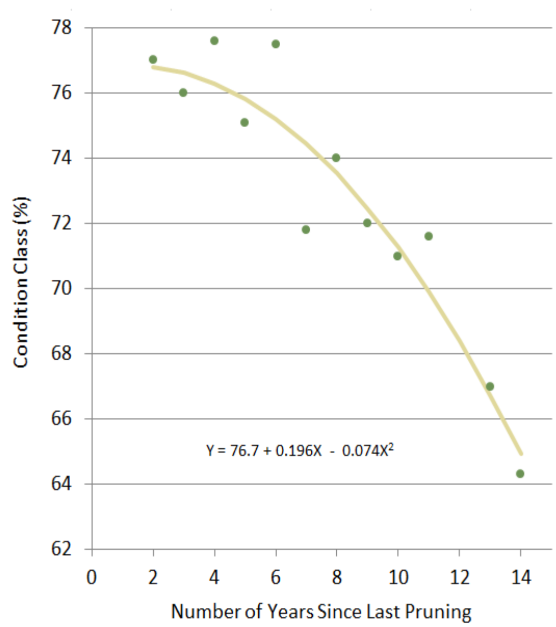


Figure 11. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

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.

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

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.

Young Tree Training Cycle

Trees included in the YTT Cycle are generally less than 8 inches DBH. These younger trees sometimes have branch structures that can lead to potential problems as the tree ages. Potential structural problems include codominant leaders, multiple limbs attaching at the same point on the trunk, or crossing/interfering limbs. If these problems are not corrected, they may worsen as the tree grows, increasing risk and creating potential liability.

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

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

Recommendations

DRG recommends that Warwick implement a three-year YTT Cycle to begin after all High and Moderate Risk trees are removed or pruned. The YTT Cycle will include existing young trees. During the inventory, 84 trees that were 10 inches or smaller 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 28 trees be structurally pruned each year over 3 years, beginning in Year Three 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 town should strive to prune approximately one-third of its young trees each year.

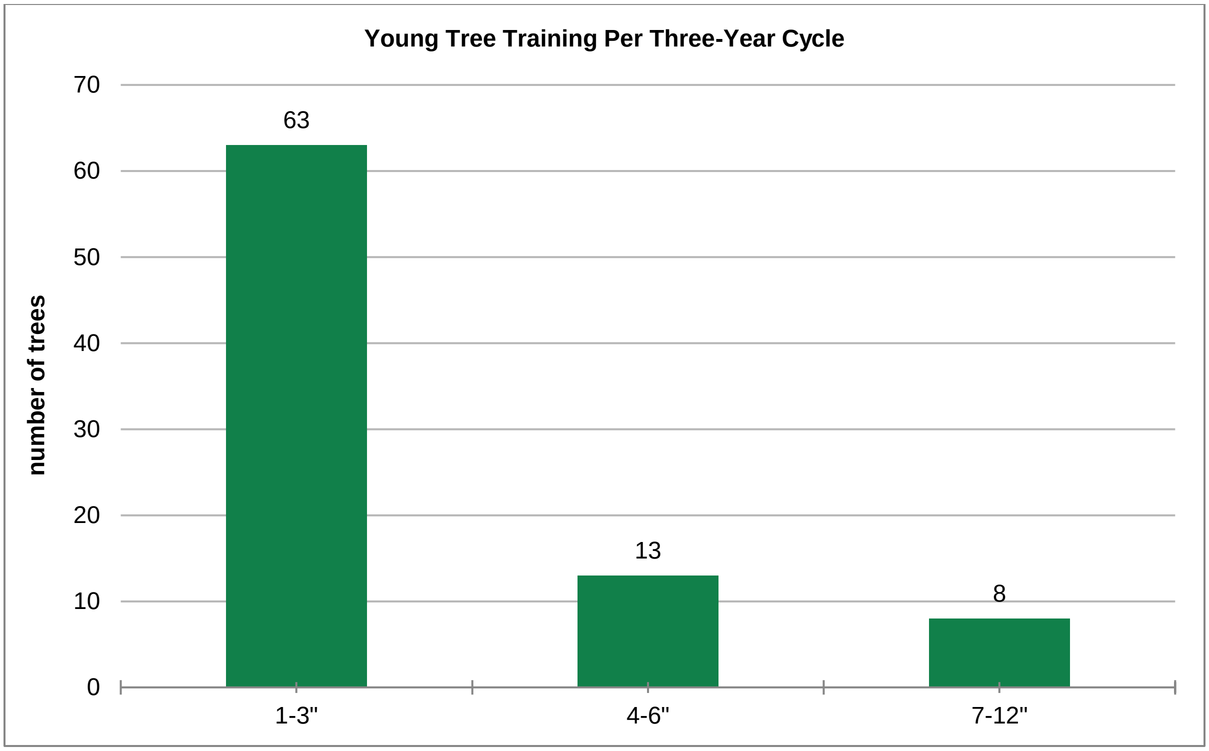


Figure 12. Trees recommended for the YTT Cycle by diameter size class.

Routine Pruning Cycle

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

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

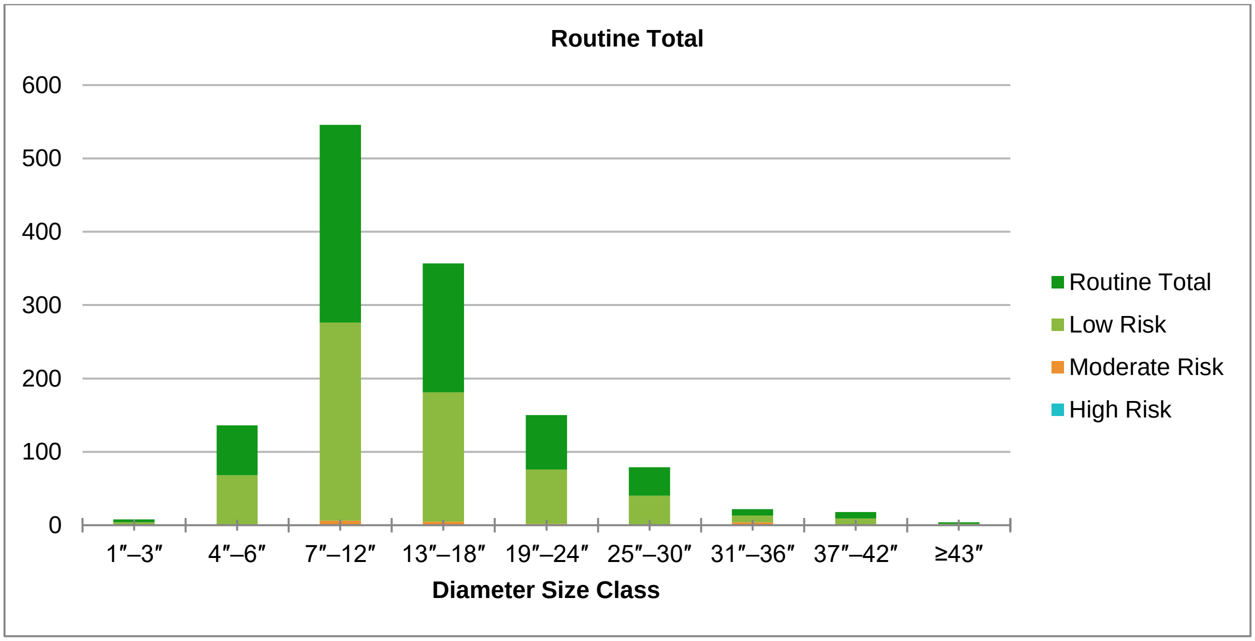


Figure 13. Trees recommended for the RP Cycle by diameter size class.

Recommendations

DRG recommends that the town establish a seven-year RP Cycle in which approximately one-seventh of the tree population is to be pruned each year. The 2018 tree inventory identified approximately 669 trees that should be pruned over a five-year RP Cycle. An average of 93 trees should be pruned each year over the course of the cycle. DRG recommends that the RP Cycle begin in Year Three of this seven-year plan, after all High and Moderate Risk trees are pruned.

The inventory found that most trees (46%) needed routine pruning. Figure 13 shows that a variety of tree sizes will require pruning; however, most of the trees that require routine pruning were smaller than 24 inches DBH.

Maintenance Schedule

Utilizing data from the 2018 Town of Warwick 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 Warwick. A summary of the maintenance schedule is presented; a complete table of estimated costs for Warwick's seven-year tree management program follows.

The schedule provides a framework for completing the inventory maintenance recommendations over the next seven 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 town's tree maintenance budget should be no less than $92,137 for the first year of implementation, no less than $86,808 for the second and third years, and no less than $55,466 for the final two years of the maintenance schedule. Annual budget funds are needed to ensure that high risk trees are remediated and that crucial YTT and RP Cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

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

Table 5. Estimated Costs for Seven-Year Urban Forestry Management Program

Estimated Costs for Each Activity			2019		2020		2021		2022		2023		2024		2022		Seven-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	# of Trees	Total Cost	# of Trees	Total Cost	
Extreme, High, Moderate Risk Removal	1-3"	$100	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$175	0	$0	0	$0	2	$350	0	$0	0	$0	0	$0	0	$0	$350
	7-12"	$300	1	$300	4	$1,200	10	$3,000	0	$0	0	$0	0	$0	0	$0	$4,500
	13-18"	$850	1	$850	10	$8,500	9	$7,650	0	$0	0	$0	0	$0	0	$0	$17,000
	19-24"	$1,275	2	$2,550	13	$16,575	0	$0	0	$0	0	$0	0	$0	0	$0	$19,125
	25-30"	$1,550	10	$15,500	5	$7,750	0	$0	0	$0	0	$0	0	$0	0	$0	$23,250
	31-36"	$1,895	3	$5,685	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$5,685
	37-42"	$2,000	3	$6,000	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$6,000
	43"+	$2,400	1	$2,400	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$2,400
Activity Total(s)			**21**	**$33,285**	**32**	**$34,025**	**21**	**$11,000**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$78,310**
Low Risk Removal	1-3"	$25	0	$0	0	$0	0	$0	0	$0	19	$475	19	$475	19	$475	$1,425
	4-6"	$105	0	$0	0	$0	0	$0	0	$0	1	$105	1	$105	0	$0	$210
	7-12"	$220	0	$0	0	$0	0	$0	0	$0	7	$1,540	6	$1,320	6	$1,320	$4,180
	13-18"	$355	0	$0	0	$0	0	$0	6	$2,130	5	$1,775	5	$1,775	5	$1,775	$7,455
	19-24"	$525	0	$0	0	$0	0	$0	7	$3,675	7	$3,675	0	$0	0	$0	$7,350
	25-30"	$845	0	$0	0	$0	5	$4,225	5	$4,225	0	$0	0	$0	0	$0	$8,450
	31-36"	$1,140	0	$0	0	$0	2	$2,280	0	$0	0	$0	0	$0	0	$0	$2,280
	37-42"	$1,470	0	$0	0	$0	3	$4,410	0	$0	0	$0	0	$0	0	$0	$4,410
	43"+	$1,850	0	$0	0	$0	1	$1,850	0	$0	0	$0	0	$0	0	$0	$1,850
Activity Total(s)			**0**	**$0**	**0**	**$0**	**11**	**$12,765**	**18**	**$10,030**	**39**	**$7,570**	**31**	**$3,675**	**30**	**$3,570**	**$30,365**
Stump Removal	1-3"	$18	0	$0	0	$0	0	$0	0	$0	19	$342	19	$0	19	$342	$684
	4-6"	$28	0	$0	0	$0	2	$56	0	$0	1	$28	1	$28	0	$0	$112
	7-12"	$44	1	$44	4	$176	10	$440	0	$0	7	$308	6	$264	6	$264	$1,496
	13-18"	$72	1	$72	10	$720	9	$648	6	$432	5	$360	5	$360	5	$360	$2,952
	19-24"	$94	2	$188	13	$1,222	0	$0	7	$658	7	$658	0	$0	0	$0	$2,726
	25-30"	$110	10	$1,100	5	$550	5	$550	5	$550	0	$0	0	$0	0	$0	$2,750
	31-36"	$138	3	$414	0	$0	2	$276	0	$0	0	$0	0	$0	0	$0	$690
	37-42"	$160	3	$480	0	$0	3	$480	0	$0	0	$0	0	$0	0	$0	$960
	43"+	$182	1	$182	0	$0	1	$182	0	$0	0	$0	0	$0	0	$0	$364
Activity Total(s)			**21**	**$2,480**	**32**	**$2,668**	**32**	**$2,632**	**18**	**$1,640**	**39**	**$1,696**	**31**	**$652**	**30**	**$966**	**$11,116**
Further Inspection	All Trees	$6	32	$192	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$192
Activity Total(s)			**32**	**$192**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$192**
Extreme, High, Moderate Risk Pruning	1-3"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$35	1	$35	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$35
	7-12"	$80	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$120	3	$360	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$360
	19-24"	$200	2	$400	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$400
	25-30"	$250	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31-36"	$320	1	$320	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$320
	37-42"	$410	2	$820	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$820
	43"+	$615	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**9**	**$1,935**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$1,935**
Low Risk Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	10	$300	0	$0	0	$0	0	$0	0	$0	0	$0	$300
	7-12"	$75	0	$0	94	$7,050	0	$0	0	$0	0	$0	0	$0	0	$0	$7,050
	13-18"	$120	35	$4,200	18	$2,160	0	$0	0	$0	0	$0	0	$0	0	$0	$6,360
	19-24"	$170	22	$3,740	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$3,740
	25-30"	$225	8	$1,800	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$1,800
	31-36"	$305	2	$610	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$610
	37-42"	$380	4	$1,520	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$1,520
	43"+	$590	3	$1,770	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$1,770
Activity Total(s)			**74**	**$13,640**	**122**	**$9,510**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$23,150**
Routine Tree Cleaning (5-year cycle)	1-3"	$20	0	$0	0	$0	1	$20	1	$20	1	$20	1	$0	0	$0	$60
	4-6"	$30	0	$0	0	$0	10	$300	10	$300	10	$300	10	$300	10	$300	$900
	7-12"	$75	0	$0	0	$0	40	$3,000	40	$3,000	40	$3,000	40	$3,000	40	$3,000	$9,000
	13-18"	$120	0	$0	0	$0	26	$3,120	26	$3,120	26	$3,120	26	$3,120	26	$3,120	$9,360
	19-24"	$170	0	$0	0	$0	11	$1,870	11	$1,870	11	$1,870	11	$1,870	11	$1,870	$5,610
	25-30"	$225	0	$0	0	$0	6	$1,350	6	$1,350	6	$1,350	6	$1,350	6	$1,350	$4,050
	31-36"	$305	0	$0	0	$0	1	$305	2	$610	1	$305	1	$305	1	$305	$1,220
	37-42"	$380	0	$0	0	$0	2	$760	1	$380	1	$380	1	$380	1	$380	$1,520
	43"+	$590	0	$0	0	$0	1	$590	1	$590	0	$0	0	$0	0	$0	$1,180
Activity Total(s)			**0**	**$0**	**0**	**$0**	**98**	**$11,315**	**98**	**$11,240**	**96**	**$10,345**	**96**	**$10,325**	**95**	**$10,325**	**$32,900**
Training Prune (3-year cycle)	1-3"	$20	21	$420	21	$420	21	$420	21	$420	21	$420	21	$420	21	$420	$2,100
	4-6"	$30	4	$120	4	$120	4	$120	4	$120	4	$120	4	$120	4	$120	$600
	7-12"	$75	3	$225	3	$225	3	$225	3	$225	3	$225	3	$225	3	$225	$1,125
Activity Total(s)			**28**	**$765**	**28**	**$765**	**28**	**$765**	**28**	**$765**	**28**	**$765**	**28**	**$765**	**28**	**$765**	**$3,825**

Estimated Costs for Each Activity			2019		2020		2021		2022		2023		2024		2022		Seven-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	# of Trees	Total Cost	# of Trees	Total Cost	
Replacement Tree and Vacant Site Planting	Purchasing	$170	29	$8,500	29	$8,500	29	$8,500	29	$8,500	29	$8,500	29	$8,500	29	$8,500	$42,500
	Planting	$110	29	$5,500	29	$5,500	29	$5,500	29	$5,500	29	$5,500	29	$5,500	29	$5,500	$27,500
Activity Total(s)			**58**	**$14,000**	**58**	**$14,000**	**58**	**$14,000**	**58**	**$14,000**	**58**	**$14,000**	**58**	**$14,000**	**58**	**$14,000**	**$70,000**
Replacement and Vacant Site Young Tree Maintenance	Mulching	$100	29	$5,000	29	$5,000	29	$5,000	29	$5,000	29	$5,000	29	$5,000	29	$5,000	$25,000
	Watering	$100	29	$5,000	29	$5,000	29	$5,000	29	$5,000	29	$5,000	29	$5,000	29	$5,000	$25,000
Activity Total(s)			**58**	**$10,000**	**58**	**$10,000**	**58**	**$10,000**	**58**	**$10,000**	**58**	**10,000**	**58**	**$10,000**	**58**	**10,000**	**$50,000**
Annual Mortality (1%) Removals	Average Tree	$220	10	$2,200	10	$2,200	10	$4,554	10	$4,554	10	$4,554	10	$4,554	10	$4,554	$22,770
Annual Mortality (1%) Stump Removals	Average Tree	$44	10	$440	10	$440	10	$3,102	10	$3,102	10	$3,102	10	$3,102	10	$3,102	$15,510
Annual Mortality (1%) Planting	Average Tree	$480	10	$4,800	10	$4,800	10	$15,840	10	$15,840	10	$15,840	10	$15,840	10	$15,840	$79,200
Activity Total(s)			**30**	**$15,840**	**30**	**$15,840**	**30**	**$15,840**	**30**	**$15,840**	**30**	**$15,840**	**30**	**$15,840**	**30**	**$15,840**	**$79,200**
Activity Grand Total			**331**		**360**		**336**		**308**		**348**		**332**		**329**		**380,993**
Cost Grand Total				**$92,137**		**$86,808**		**$78,317**		**$63,515**		**$60,216**		**$55,257**		**$55,466**	**$380,993**

Community Outreach

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

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

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

Warwick's data are instrumental in helping to provide tangible and meaningful 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. Arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care.

Trees along the street ROW should be regularly inspected and attended to as needed based on the inspection findings. When trees need additional or new work, they should be added to the maintenance schedule and budgeted as appropriate. Use appropriate computer management software such as TreeKeeper® 8 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. Warwick 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 town can sustain its program and accurately project future program and budget needs:

- Conduct inspections of trees after all severe weather events. Record changes in tree condition, maintenance needs, and risk rating in the inventory database. Update the tree maintenance schedule and acquire the funds needed to promote public safety. Schedule and prioritize work based on risk.
- Perform routine inspections of public trees as needed. Windshield surveys (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* (ANSI 2011) will help town 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 update all data fields in seven years, or a portion of the population (1/7) every year over the course of seven years.
- Revise the Tree Management Plan after seven years when the re-inventory has been completed.

VOLUNTEERISM

Goal: Encourage public and private participation in urban forest management through volunteerism

It is said that volunteers have time to give, not time to waste, and that they are unpaid not because they are worthless, but because they are priceless.

Understanding what volunteers' value about their role and what motivates them to give their time, skills, and energy is crucial to recruiting, retaining, and motivating them.

Motivation—keeping employment skills up-to-date; building a resume, making a difference in the environment, widening a social network, feeling like a part of something bigger, learning new things and having new experiences, requirements for school, and reacting to an issue.

Recruiting Methods—web, mailing, word of mouth, targeted, and public relation efforts.

Retention—rewards, recognition, and enjoyable events.

Results—stronger programs, cost savings, and community buy-in.

There is clearly an important role for volunteers in urban forestry; this is evidenced by the proliferation of similar volunteer organizations that provide citizen-based municipal tree care across North America. These organizations may have different names for their volunteers: Citizen Foresters (Washington, DC, and Newport, RI); Tree Stewards (Portland, OR; Fall River, MA; and Richmond, VA); Citizen Pruners (Binghamton, NY; New York, NY; and Thunder Bay, ON); and Tree Tenders (Philadelphia and Pittsburgh, PA). In Ithaca, the Cornell Cooperative Extension-organized Citizen Pruners works with public works employees represented by the Civil Service Employees Association.

Volunteers are usually involved with tree planting, pruning, mulching, watering, and other activities related to tree establishment. Most often they are organized either through their respective state university cooperative extension or a local nonprofit. They are often the strongest advocates for urban forestry in their municipality. Some volunteer groups take a creative approach; in Philadelphia an "Arbrew Day" combines beer drinking with tree planting.

They frequently work in harmony with municipal employees and public sector unions. Warwick might want to consider instituting a Citizen Pruners/Tree Stewards group. The Tree Commission has already created a Memorial Tree Program. It is actively involved in the DEC 5th grade poster contest, and residents are invited to presentations on pruning, planting, and maintenance once or twice a year. In addition, the town organizes an annual Arbor Day celebration. These initiatives are in line with other tree-friendly communities and could be expanded. Warwick might even want to initiate a sort of Arbrew Day of its own, which would combine arboreal volunteerism with tastings from the local vineyards and distilleries. Rather than taking jobs away from professional arborists and city employees, the people who help nurture a community's urban forest strengthen municipal programs through advocacy. They fill niches and accomplish tasks that might otherwise go undone.

Issues

- Volunteer and public employee interaction can lead to successful partnerships through a fair and open negotiation process between management and labor.
- Liability and risk exposure are issues that can be addressed through means such as contracts, agreements, insurance, and background checks.
- The scope of work allowed through volunteerism must be clearly defined to reduce the unintended and inappropriate actions by "rogue volunteers".
- Volunteer burnout can be avoided, and reliability improved by proper reward and recognition.
- Coordination of volunteers with objectives of the professional program is a function that is essential for town managers and officials to review and modify as necessary in order to achieve positive results.
- Safety issues and safe work habits like the proper use of personal protective equipment should be routinely communicated to volunteers as a program requirement.
- Projecting an appropriate and identifiable public image must be understood and practiced by volunteers.

Recommendations

- Concentrate volunteer efforts in disadvantaged neighborhoods where tree canopy is lowest.
- Examine similar programs in the U.S. and Canada and adopt innovative practices for use in Warwick.
- Create an advanced Citizen Pruners course aimed at arborist certification for veteran Citizen Pruners.
- Create synergy by increasing collaboration with other organizations involved in environmental efforts, such as the NYS DEC, NY ReLeaf, and the Cornell Cooperative Extension.
- Foster corporate and university volunteer programs by engaging the principles of civic stewardship.

Case Study: Volunteerism

CommuniTree Stewards, Syracuse, New York

Project Description

Necessity is the mother of invention: such was the case with the CommuniTree Steward program in Syracuse, NY, run by Cornell Cooperative Extension (CCE) of Onondaga County. Syracuse's urban tree canopy had been on the decline since the spread of Dutch elm disease of the 1950s and was further reduced by the 1998 Labor Day Storm. These events drove home two salient lessons: diversify tree species and prune weak branch unions while trees are still young.

Funded by the City of Syracuse and Onondaga County, the CommuniTree Steward Program started in 2002 as a way to cost-effectively plant and maintain trees by exchanging tree maintenance classes for volunteer work on public trees.

Students enroll in the winter and begin the required CCE courses in April. Course work includes tree biology, soils, basic pruning, structural pruning, proper mulching, watering, tree identification, matching tree species to the site, and tree planting (bare-root and container). Students are closely monitored and instructed during urban forestry projects; by the end of the summer, most are doing excellent work and need little supervision. When fall comes along, CommuniTree Stewards participate in large-scale, bare-root planting events. Veteran Tree Stewards, who return yearly to work on tree projects and plantings, will often pair up with new Tree Stewards and will serve as instructors.

Accomplishments

This program developed a highly skilled, motivated volunteer workforce who planted and maintained thousands of trees in the City of Syracuse and Onondaga County villages. Volunteers are also able to serve on specialty projects such as tree inventories and invasive species mapping.

Veteran CommuniTree Stewards have gone on to organize their own neighborhood and park tree projects, so the program has had an impact beyond its own projects.

Tree Stewards make very good ambassadors for the cause of increasing the urban tree canopy. They are knowledgeable and can effectively respond to objections and dispel misconceptions regarding tree-related issues.

Lessons Learned

Program success largely hinges on effective recruitment, management, and retention of volunteers:

- Make it fun and sociable: they are volunteers, not employees. Make time for visiting after training and project work.
- Be organized: start on time, end on time, and do not overwork them. Celebrate what was accomplished, do not complain about what was not completed.
- Keep them safe: emphasize tool safety and utility wire safety, provide high-visibility safety vests.
- Keep it interesting: provide more advanced workshops for veteran stewards.
- Tact and diplomacy: keep a level head if a difficult situation arises.

FUNDING

Goal: Match funding to desired level of service for urban forestry management

Urban forestry and public education services often must compete for funding with established community services such as law enforcement, fire protection, and infrastructure construction and repair. Decreased and insufficient funding is one of the greatest challenges facing our nation’s urban forests today.

No doubt the level of funding will determine the viability and sustainability of Warwick’s urban forestry program within the broader context of all of the town’s responsibilities. Only with sufficient financial resources will the town’s urban forestry program best fulfill its mission, respond to change and challenges, and serve the public.

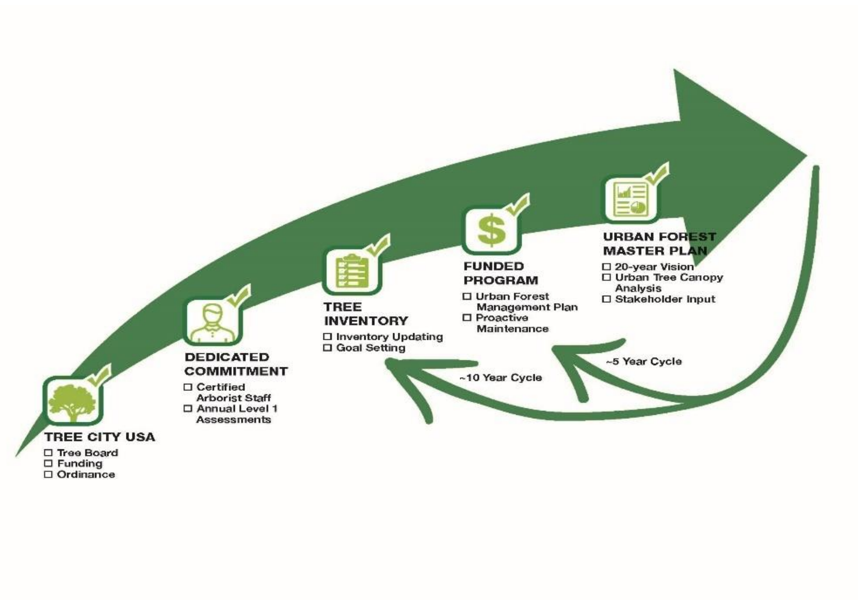


Figure 14. The Urban Forest Program Continuum

Warwick should be proud of accomplishing the milestones of becoming a Tree City USA, having a Certified Arborist on staff, and most recently completing a comprehensive tree inventory. The next milestone on the Urban Forest Program Continuum is to ensure that the urban forestry program is adequately funded to include risk reduction, proactive pruning, and planting.

No precise formula exists to determine how much funding is needed for a proactive, sustainable forestry program. There should be sufficient funding for performing preventative tree maintenance, emergency response, and adequate planting, as well as for staff, equipment, and contractual services. Based on reports that 3,130 communities submitted to the National Arbor Day Foundation for Tree City, USA certification in 2006, the average municipal urban forestry budget for a town the size of Warwick was $336,465, an average expenditure of $8.73 per capita.

Urban forestry budgets in U.S. cities are typically allocated for maintenance (58% includes pruning and removal), planting (14%), and administration (8%). There is no national standard for effective urban forest budget allocation. Planting should be a significant portion of the total budget, second only to maintenance, and generally should not exceed 50% of the operating budget.

Warwick’s urban forestry program funding allocation from all sources is generalized; the allocation should be continually adjusted depending on the condition of the trees, planting needs, incidences of severe weather, insect and disease threats, and the desires of the citizens and community leaders at the time budgets are developed.

Fiscal resources exist to maintain a robust forestry approach. For example, the Urban Forestry program of the New York State Department of Environmental Conservation provides grants for tree maintenance as well as planting. The grants require a 25% match from the recipient, an amount that may well fall within the town’s operating budget. DRG recommends that Warwick apply for these state grants when they are next offered. The funds could represent an important part of the overall management plan. In addition, tree maintenance work can also appropriately come out of the community’s capital budget.

Case Study: Funding

Funding Mechanisms in Various U.S. Cities

Special Assessments

One of the most stable sources of funding for urban forestry programs is a special assessment. Some states authorize cities to assess all property owners for specific public benefits and services such as stormwater and sewer systems, and public trees. The assessment can be levied as a fee per foot of right-of-way frontage or as a percentage of the property value. The cities of Cincinnati and Toledo, Ohio have a frontage street tree assessment authorized by state and city codes that has been in effect for over 30 years. The same enabling state law restricts the use of this revenue for anything other than maintenance and planting of trees. The City of Pittsburgh should investigate the legality and potential for a citywide special assessment to fund the urban program pursuant to PA. STAT. ANN. tit. 53, §§ 1721,1081 (construct, reconstruct, pave, grade, alter, or renew streets, alleys, footpaths, parking, landscaping, bridges, sewers, drains, and piers). Special assessments are approved annually by Council with the support of the community. In Cincinnati, the average cost to property owners is $7 year, and the assessment generates over $1 million annually for the program. A special assessment in Pittsburgh could supplement and/or reduce general fund support.

Neighborhood Improvement Districts (NIDS)

In Pittsburgh, NIDs already exist (the Pittsburgh Downtown Partnership and the Oakland Business Improvement District) and offer a legal and equitable way to generate funds to provide a variety of enhanced and new services that would be less likely to come from the city. Often described as offering the services of "safe, clean, and green", NIDs can help plant and maintain trees as well as fund other infrastructure upgrades and neighborhood needs. There is interest to move the city's best prepared Main Street programs into NIDs which follow a model that has been one of the most successful nationwide. Tree Pittsburgh should campaign the idea of creating NIDs and ensure that higher level urban forest management services are included in the NID budgets.

Taxes

Many cities throughout the U.S. attain funding for urban forestry through special taxes. St. Louis, Missouri implements a property transfer tax and a sales tax (1/2 cent) to pay for the city's urban forestry program. In Burlingame, California, a portion of a gas tax has provided $100,000 to the urban forestry's departmental budget in previous years. While new taxes are currently politically unpopular, earmarking a small percentage of existing taxes may be a source of revenue to consider.

Capital Improvement Project Budgets

Capital projects have large, comprehensive budgets that have been carefully determined. All aspects and impacts of the project can be accounted for with these kinds of funds. Although restricted to the specific project, often tree maintenance, tree preservation, and planting can be included as a valid expenditure. If trees are viewed and defined as capital assets, then during road and bridge construction and utility projects, funds can be allocated for protection of existing trees, remediation treatment for any trees impacted by construction activities, and planting new trees after the project is complete. The City of Milwaukee has had success making trees part of its street and road improvement projects for decades.

Tree Work Permit, Development, and Inspection Fees

These common funding mechanisms can be used for urban forest management, to the extent permitted under state and local codes. Examples include:

- *Permit and Plan Review and Inspection Fees:* Cities often require private developers and businesses to provide funding for plan review and site inspection. Charging for the time and expertise needed to approve permit applications, review plans, and make site inspections might be a viable option to finance additional urban forestry positions.
- *Development Fees:* Landowners in a "benefit area" may be required to pay for a proportionate share of the public facilities required to serve a development. Trees can be considered public facilities, and the costs to plant and care for them can be supported by these fees. Developers could also be required to pay a set amount to support a community's overall urban forestry program, as a cost of doing business within the city limits. The fee could be a percentage of the total project cost, based on the number of housing units built, or based on the area of land being developed.

Compensatory Payments and Environmental Fines

Trees on public land are public property, and the city should be compensated for the loss or damage to public property. If tree damage or loss occurs due to a development project, vehicular accident, vandalism, private utility work, etc., then the responsible party should be required to pay for the appraised or replacement value or repair costs. This source may not generate a great deal of money, but it is a legitimate and often under-pursued source of funds. Generally, the compensation is collected from the insurance company of the person/agency responsible for the damage or directly from the business that caused the damage to public trees. Compensation funds can be used to remediate the specific damage or for other legitimate urban forestry functions. Environmental fines can be another source of legitimate funding. Since the enactment of federal and state clean water and air legislation, companies in violation of those laws are often required to pay significant sums through environmental court fines. By coordinating with the enforcement agency, all or a portion of those fines can be directed to the urban forestry program.

Sale of Municipal Wood Products

If city policies allow public property to be sold, the wood waste from tree maintenance can be a source of funds. Rather than pay for removal and disposal, many cities sell excess wood products (firewood, hardwood timber, rough wood chip mulch, and compost) to the general public and commercial businesses. A new trend is to use the removal of a significant or historic public tree as a source of creative fund raising. The logs and useable wood are given to local craftsmen who create furniture, sculpture, and other collectibles from it. These are sold, and proceeds are returned to the urban forestry program. Another new trend is to use tree removals due to invasive insects and disease as a source of quality lumber products. The cities of Winnipeg, Manitoba, and Cincinnati sell logs from trees that have succumbed to Dutch elm disease and EAB to local companies that mill dimensional lumber as environmentally sustainable products used in buildings and projects that qualify for LEED certification.

Biogenic Utility Payments

A biogenic utility is a utility based on the net benefit of freed energy and other benefits from trees, which can be calculated in dollars, pounds of pollution filtered, gallons of rainwater intercepted, and kWh of energy not used. Trees provide Pittsburgh measurable benefits as documented by the i-Tree Streets and Eco reports—the annual value of avoided energy and air pollution control costs exceeds $3 million each, $330,000 in storm water mitigation, and nearly $9.5 million in carbon storage and sequestration. The City of Kent, Ohio performed a feasibility study to explore the possibility of calculating the economic value of the beneficial functions trees perform and devising a funding mechanism to pay for these functions. The income generated would be used to manage and enhance the urban forest to meet goals of increased canopy cover within the city. The rationale is that urban forests, like urban infrastructure, require planning, management, and oversight; they are not self-sustaining like natural forests. In Colorado, Denver Water, the utility that supplies drinking water to 1.3 million people, and the Forest Service signed a $33 million cost-sharing agreement for forest management and watershed restoration. The average residential water user will pay an extra $27 over the course of five years to match the Forest Service's $16.5 million allocation. Denver's agreement is an example of an emerging financial tool, "ecosystem services", in which a market value is applied to environmental functions that users usually exploit without payment. Healthy forests provide safe drinking water as well as other environmental and public health and safety benefits at far lower cost than it would take to build infrastructure to replace those services. Other cities are realizing this, and Pittsburgh may want to begin exploring this developing trend in municipal financing.

CONCLUSIONS

Every hour of every day, public trees in Warwick are supporting and improving the quality of life. The inventoried town trees provide an annual benefit of $124,966. When properly maintained, trees provide numerous environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

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

The town 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 town's trees, Warwick is well positioned to thrive. If the management program is successfully implemented, the health and safety of Warwick's trees and citizens will be maintained for years to come.

GLOSSARY

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

address number (data field): The address number was recorded based on the visual observation by the Davey Resource Group arborist at the time of the inventory of the actual address number posted on a building at the inventoried site. In instances where there was no posted address number on a building or sites were located by vacant lots with no GIS parcel addressing data available, the address number assigned was matched as closely as possible to opposite or adjacent addresses by the arborist(s) and an "X" was added to the number in the database to indicate that the address number was assigned.

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

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

American National Standards Institute (ANSI): ANSI is a private, nonprofit organization that facilitates the standardization work of its members in the United States. ANSI's goals are to promote and facilitate voluntary consensus standards and conformity assessment systems, and to maintain their integrity.

ANSI A300**:** Tree care performance parameters established by ANSI that can be used to develop specifications for tree maintenance.

arboriculture: The art, science, technology, and business of commercial, public, and utility tree care.

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

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

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

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.

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

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

community forest: see **urban forest**.

condition (data field): The general condition of each tree rated during the inventory according to the following categories adapted from the International Society of Arboriculture's rating system: Excellent (100%), Very Good (90%), Good (80%), Fair (60%), Poor, (40%), Critical (20%), Dead (0%).

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

diameter: See **tree size**.

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

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

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

Extreme Risk tree: Applies in situations where tree failure is imminent, there is a high likelihood of impacting the target, and the consequences of the failure are "severe." In some cases, this may mean immediate restriction of access to the target zone area in order to prevent injury.

failure: In terms of tree management, failure is the breakage of stem or branches, or loss of mechanical support of the tree's root system.

further inspection (data field): Notes that a specific tree may require an annual inspection for several years to make certain of its maintenance needs. A healthy tree obviously impacted by recent construction serves as a prime example. This tree will need annual evaluations to assess the impact of construction on its root system. Another example would be a tree with a defect requiring additional equipment for investigation.

genus: A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature, the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.

geographic information system (GIS): A technology that is used to view and analyze data from a geographic perspective. The technology is a piece of an organization's overall information system framework. GIS links location to information (such as people to addresses, buildings to parcels, or streets within a network) and layers that information to provide a better understanding of how it all interrelates.

global positioning system (GPS): GPS is a system of earth-orbiting satellites that make it possible for people with ground receivers to pinpoint their geographic location.

grow space size (data field): Identifies the minimum width of the tree grow space for root development.

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

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

High Risk tree: The High Risk category applies when consequences are "significant" and likelihood is "very likely" or "likely," or consequences are "severe" and likelihood is "likely." In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.

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

invasive, exotic tree: A tree species that is out of its original biological community. Its introduction into an area causes or is likely to cause economic or environmental harm, or harm to human health. An invasive, exotic tree has the ability to thrive and spread aggressively outside its natural range. An invasive species that colonizes a new area may gain an ecological edge since the insects, diseases, and foraging animals that naturally keep its growth in check in its native range are not present in its new habitat.

inventory: See **tree inventory**.

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

i-Tree Streets: i-Tree Streets is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase.

i-Tree Tools: State-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. The i-Tree Tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide.

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

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

Low Risk tree: The Low Risk category applies when consequences are "negligible" and likelihood is "unlikely"; or consequences are "minor" and likelihood is "somewhat likely." Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required.

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

mapping coordinate (data field): Helps to locate a tree; X and Y coordinates were generated for each tree using GPS.

Moderate Risk tree: The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.

monoculture: A population dominated by one single species or very few species.

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

Nitrogen Dioxide (NO_2): Nitrogen dioxide is a compound typically created during the combustion processes and is a major contributor to smog formation and acid deposition.

None (risk rating): Equal to zero. It is used only for planting sites and stumps.

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

notes (data field): Describes additional pertinent information.

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

ordinance: See **tree ordinance**.

overhead utilities (data field): The presence of overhead utility lines above a tree or planting site.

Ozone (O_3): A strong-smelling, pale blue, reactive toxic chemical gas with molecules of three oxygen atoms. It is a product of the photochemical process involving the Sun's energy. Ozone exists in the upper layer of the atmosphere as well as at the Earth's surface. Ozone at the Earth's surface can cause numerous adverse human health effects. It is a major component of smog.

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

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

Plant Tree (Primary Maintenance Need): If collected during an inventory, this data field identifies planting sites as small, medium, or large (indicating the ultimate size that the tree will attain), depending on the growspace available and the presence of overhead wires.

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

Primary Maintenance Need (data field): The type of tree work needed to reduce immediate risk.

pruning: The selective removal of plant parts to meet specific goals and objectives.

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

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

Removal (Primary Maintenance Need): Data field collected during the inventory identifying the need to remove a tree. Trees designated for removal have defects that cannot be cost-effectively or practically treated. Most of the trees in this category have a large percentage of dead crown.

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.

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

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

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

street right-of-way (ROW): A strip of land generally owned by a public entity over which facilities, such as highways, railroads, or power lines, are built.

street tree: A street tree is defined as a tree within the right-of-way.

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

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

Sulfur Dioxide (SO_2): A strong-smelling, colorless gas that is formed by the combustion of fossil fuels. Sulfur oxides contribute to the problem of acid rain.

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

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

topping: Characterized by reducing tree size using internodal cuts without regard to tree health or structural integrity; this is not an acceptable pruning practice.

tree: A tree is defined as a perennial woody plant that may grow more than 20 feet tall. Characteristically, it has one main stem, although many species may grow as multi-stemmed forms.

tree benefit: An economic, environmental, or social improvement that benefits the community and results mainly from the presence of a tree. The benefit received has real or intrinsic value associated with it.

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

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

tree inventory: Comprehensive database containing information or records about individual trees typically collected by an arborist.

tree ordinance: Tree ordinances are policy tools used by communities striving to attain a healthy, vigorous, and well-managed urban forest. Tree ordinances simply provide the authorization and standards for management activities.

tree size (data field): A tree's diameter measured to the nearest inch in 1-inch size classes at 4.5 feet above ground, also known as diameter at breast height (DBH) or diameter.

urban forest: All of the trees within a municipality or a community. This can include the trees along streets or rights-of-way, in parks and greenspaces, in forests, and on private property.

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

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

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

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

Young Tree Train (Primary Maintenance Need): Data field based on *ANSI A300* standards, this maintenance activity is characterized by pruning of young trees to correct or eliminate weak, interfering, or objectionable branches to improve structure. These trees can be up to 20 feet tall and can be worked with a pole pruner by a person standing on the ground.

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APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

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

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

- address/location
- species
- tree size*
- multi-stem
- condition
- primary maintenance
- defects
- risk assessment complete
- hardscape damage
- further inspection
- overhead utilities
- date of inspection
- risk rating
- notes

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

Maintenance needs are based on *ANSI A300 (Part 1)* (ANSI 2008). Risk assessment and risk rating are based on *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture [ISA] 2011).

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

Site Location Methods

Equipment and Base Maps

Inventory arborists use CZ-G1 Panasonic Toughpad®

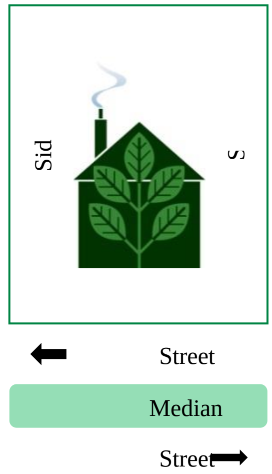
Base map layers were loaded onto these unit(s) to help locate sites during the inventory. The table below lists the base map layers, utilized along with source and format information for each layer.

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Shapefiles provided by Westchester County Data Warehouse https://giswww.westchestergov.com/wcgis/	2016-2018	NAD 1983 UTM Zone, 18N; Meters
Aerial Imagery provided by NYS GIS Clearinghouse https://gis.ny.gov/	2016, 6in	NAD 1983 UTM Zone, 18N; Meters

Street ROW Site Location

Individual street ROW sites (trees, stumps, or planting sites) were located using a methodology that identifies sites by *address number*, and *street name*. This methodology was developed by DRG 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*. Side values include: *front*, *side*, *median* (includes islands), or *rear* based on the site's location in relation to the lot's street frontage. The *front side* is the side that faces the address street. *Side* is the name of the street the arborist walks towards and away as data are being collected. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

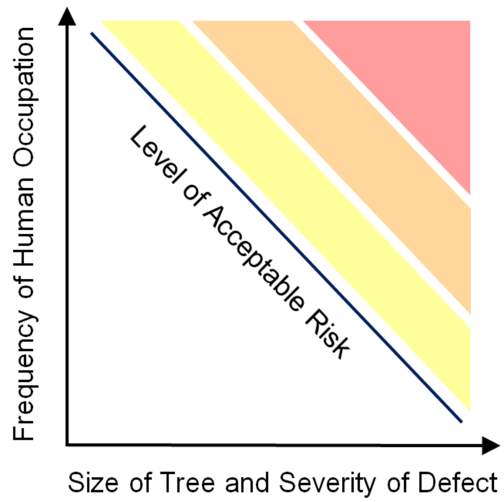
Park and/or Public Space Site Location

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

APPENDIX B
RISK ASSESSMENT/PRIORITY AND PROACTIVE MAINTENANCE

Risk Assessment

Every tree has an inherent risk of tree failure or defective tree part failure. During the inventory, DRG performed a Level 2 qualitative risk assessment for each tree and assigned a risk rating based on the ANSI A300 (Part 9), and the companion publication *Best Management Practices: Tree Risk Assessment* (ISA 2011). Trees can have multiple failure modes with various risk ratings. One risk rating per tree will be assigned during the inventory. The failure mode having the greatest risk will serve as the overall tree risk rating. The specified time period for the risk assessment is one year.



- **Likelihood of Failure**—Identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions.
    - Improbable—The tree or branch is not likely to fail during normal weather conditions and may not fail in many severe weather conditions within the specified time period.
    - Possible—Failure could occur but is unlikely during normal weather conditions within the specified time period.
    - Probable—Failure may be expected under normal weather conditions within the specified time period.
- **Likelihood of Impacting a Target**—The rate of occupancy of targets within the target zone and any factors that could affect the failed tree as it falls towards the target.
    - Very low—The chance of the failed tree or branch impacting the target is remote.
        - Rarely used sites
        - Examples include rarely used trails or trailheads
        - Instances where target areas provide protection
    - Low—It is not likely that the failed tree or branch will impact the target.
        - Occasional use area fully exposed to tree
        - Frequently used area partially exposed to tree
        - Constant use area that is well protected
    - Medium—The failed tree or branch may or may not impact the target.
        - Frequently used areas that are partially exposed to the tree on one side
        - Constantly occupied area partially protected from the tree
    - High—The failed tree or branch will most likely impact the target.
        - Fixed target is fully exposed to the tree or tree part

- **Categorizing Likelihood of Tree Failure Impacting a Target**—The likelihood for failure and the likelihood of impacting a target are combined in the matrix below to determine the likelihood of tree failure impacting a target.

Likelihood of Failure	Likelihood of Impacting Target			
	Very Low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very Likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

- **Consequence of Failure**—The consequences of tree failure are based on the categorization of target and potential harm that may occur. Consequences can vary depending upon size of defect, distance of fall for tree or limb, and any other factors that may protect a target from harm. Target values are subjective and should be assessed from the client's perspective.
    - Negligible—Consequences involve low value damage and do not involve personal injury.
        - Small branch striking a fence
        - Medium-sized branch striking a shrub bed
        - Large tree part striking structure and causing monetary damage
        - Disruption of power to landscape lights
    - Minor—Consequences involve low to moderate property damage, small disruptions to traffic or communication utility, or very minor injury.
        - Small branch striking a house roof from a high height
        - Medium-sized branch striking a deck from a moderate height
        - Large tree part striking a structure, causing moderate monetary damage
        - Short-term disruption of power at service drop to house
        - Temporary disruption of traffic on neighborhood street
    - Significant—Consequences involve property damage of moderate to high value, considerable disruption, or personal injury.
        - Medium-sized part striking a vehicle from a moderate or high height
        - Large tree part striking a structure resulting in high monetary damage
        - Disruption of distribution of primary or secondary voltage power lines, including individual services and street-lighting circuits
        - Disruption of traffic on a secondary street
    - Severe—Consequences involve serious potential injury or death, damage to high-value property, or disruption of important activities.
        - Injury to a person that may result in hospitalization
        - Medium-sized part striking an occupied vehicle
        - Large tree part striking an occupied house

- Serious disruption of high-voltage distribution and transmission power line disruption of arterial traffic or motorways

- **Risk Rating**—The overall risk rating of the tree will be determined based on combining the likelihood of tree failure impacting a target and the consequence of failure in the matrix below.

Likelihood of Failure	Consequences			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

Trees have the potential to fail in more than one way and can affect multiple targets.

Tree risk assessors will identify the tree failure mode having the greatest risk, and report that as the tree risk rating. Generally, trees with the highest qualitative risk ratings should receive corrective treatment first. The following risk ratings will be assigned:

- None—Used for planting and stump sites only.
- Low—The Low Risk category applies when consequences are "negligible" and likelihood is "unlikely"; or consequences are "minor" and likelihood is "somewhat likely." Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required.
- Moderate—The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.
- High—The High Risk category applies when consequences are "significant" and likelihood is "very likely" or "likely," or consequences are "severe" and likelihood is "likely." In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.
- Extreme—The Extreme Risk category applies in situations where tree failure is imminent and there is a high likelihood of impacting the target, and the consequences of the failure are "severe." In some cases, this may mean immediate restriction of access to the target zone area to avoid injury to people.

Trees with elevated (Extreme or High) risk levels are usually recommended for removal or pruning to eliminate the defects that warranted their risk rating. However, in some situations, risk may be reduced by adding support (cabling or bracing) or by moving the target away from the tree. DRG recommends only removal or pruning to alleviate risk. But in special situations, such as a memorial tree or a tree in a historic area, 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 town managers. Since there are inherent risks associated with trees, the location of a tree is an important factor in the determination and acceptability of risk for any given tree. The level of risk associated with a tree increases as the frequency of human occupation increases in the vicinity of the tree. For example, a tree located next to a heavily traveled street will have a higher level of risk than a similar tree in an open field.

Priority Maintenance

Identifying and ranking the maintenance needs of a tree population enables tree work to be assigned priority based on observed risk. Once prioritized, tree work can be systematically addressed to eliminate the greatest risk and liability first (Stamen 2011).

Risk is a graduated scale that measures potential tree-related hazardous conditions. A tree is considered hazardous when its potential risks exceed an acceptable level. Managing trees for risk reduction provides many benefits, including:

- Lower frequency and severity of accidents, damage, and injury
- Less expenditure for claims and legal expenses
- Healthier, long-lived trees
- Fewer tree removals over time
- Lower tree maintenance costs over time

Regularly inspecting trees and establishing tree maintenance cycles generally reduce the risk of failure, as problems can be found and addressed before they escalate.

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 campus 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 majority of soil and climate conditions throughout Zone 5 on the USDA Plant Hardiness Zone Map.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer nigrum	black maple	
Acer saccharum	sugar maple	'Legacy'
*Aesculus flava**	yellow buckeye	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
*Castanea mollissima**	Chinese chestnut	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(numerous exist)
Ginkgo biloba	ginkgo	(male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Juglans regia**	English walnut	'Hansen'
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	Cherokee™
Liriodendron tulipifera	tuliptree	'Fastigiatum'
Maclura pomifera	osage-orange	'White Shield','Witchita'
*Magnolia acuminata**	cucumbertree magnolia	(numerous exist)
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	black tupelo	
Platanus × acerifolia	London planetree	'Yarwood'
*Platanus occidentalis**	American sycamore	
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus ellipsoidalis	northern pin oak	

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

Scientific Name	Common Name	Cultivar
Quercus frainetto	Hungarian oak	
Quercus imbricaria	shingle oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus phellos	willow oak	
Quercus robur	English oak	Heritage®
Quercus rubra	northern red oak	'Splendens'
Quercus shumardii	Shumard oak	
Quercus texana	Texas oak	
Styphnolobium japonicum	Japanese pagodatree	'Regent'
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Greenspire'
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	
Cladrastis kentukea	American yellowwood	'Rosea'
Eucommia ulmoides	hardy rubbertree	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	eastern hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense	amur corktree	'Macho'
Prunus maackii	amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
Sorbus alnifolia	Korean mountainash	'Redbird'

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 pensylvanicum**	striped maple	
Acer truncatum	Shantung 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 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'
*Magnolia × soulangiana**	saucer magnolia	'Alexandrina'
*Magnolia stellata**	star magnolia	'Centennial'
*Magnolia tripetala**	umbrella magnolia	
*Magnolia virginiana**	sweetbay magnolia	Moonglow®
Malus spp.	flowering crabapple	(disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
Prunus subhirtella	Higan cherry	pendula
Prunus virginiana	common chokecherry	'Schubert'
Styrax japonicus	Japanese snowbell	'Emerald Pagoda'
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

Note: * denotes species **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'
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
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	
Psedotsuga menziesii	Douglasfir	
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	
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 pine	

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

APPENDIX D
TREE PLANTING

Tree Planting

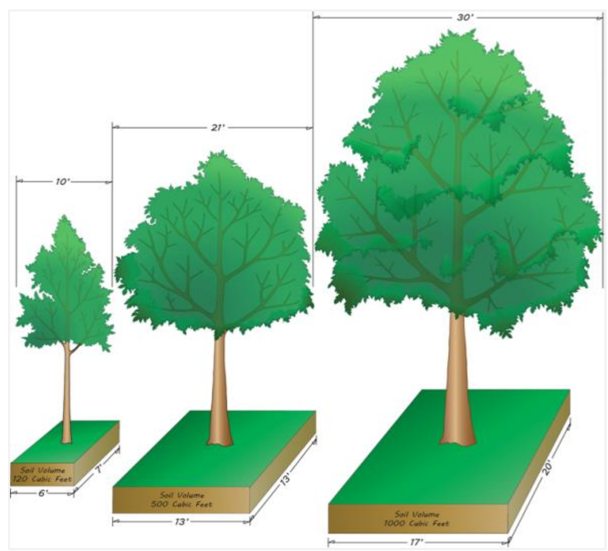
Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the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

When planting trees, it is important to be cognizant of the following:

- Consider the specific purpose of the tree planting.
- Assess the site and know its limitations (i.e., confined spaces, overhead wires, and/or soil type).
- Select the species or cultivar best suited for the site conditions.
- Examine trees before buying them and buy for quality.

Inventoried Street ROW Planting Space

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



um 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 99 planting sites, of which 0% are designated for small-sized mature trees, 29% for medium-sized trees, and 71% 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.

Warwick is located in USDA Hardiness Zone 5, which is identified as a climatic region with average annual minimum temperatures between −20°F and −10°F. Tree species selected for planting in Warwick should be appropriate for this zone.

Tree species should be selected for their durability and low-maintenance characteristics. These attributes are highly dependent on site characteristics below ground (soil texture, soil structure, drainage, soil pH, nutrients, road salt, and root spacing). Matching a species to its favored soil conditions is the most important task when planning for a low-maintenance landscape. Plants that are well matched to their environmental site conditions are much more likely to resist pathogens and insect pests and will, therefore, require less maintenance overall.

The Right Tree in the Right Place is a mantra for tree planting used by the Arbor Day Foundation and many utility companies nationwide. Trees come in many different shapes and sizes, and often change dramatically over their lifetimes. Some grow tall, some grow wide, and some have extensive root systems. Before selecting a tree for planting, make sure it is the right tree—know how tall, wide, and deep it will be at maturity. Equally important to selecting the right tree is choosing the right spot to plant it. Blocking an unsightly view or creating some shade may be a priority, but it is important to consider how a tree may impact existing utility lines as it grows taller, wider, and deeper. If the tree's canopy, at maturity, will reach overhead lines, it is best to choose another tree or a different location. Taking the time to consider location before planting can prevent power disturbances and improper utility pruning practices.

A major consideration for street trees is the amount of litter dropped by mature trees. Trees such as *Acer saccharinum* (silver maple) have weak wood and typically drop many small branches during a growing season. Others, such as *Liquidambar styraciflua* (American sweetgum), drop high volumes of fruit. In certain species, such as *Ginkgo biloba* (ginkgo), female trees produce large odorous fruit; male ginkgo trees, however, do not produce fruit. Furthermore, a few species of trees, including *Crataegus* spp. (hawthorn) and *Gleditsia triacanthos* (honeylocust), may have substantial thorns. These species should be avoided in high-traffic areas.

Seasonal color should also be considered when planning tree plantings. Flowering varieties are particularly welcome in the spring, and deciduous trees that display bright colors in autumn can add a great deal of appeal to surrounding landscapes.

DRG recommends limiting the planting of *Acer rubrum* and *Prunus serotina* until the species distribution normalizes. Of the inventoried population, *Acer rubrum* and *Prunus serotina* already occupy 22% and 10%, 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 town 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 township'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 township'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 township's urban forestry program and encourage tree planting on private property. The township should encourage citizens to water trees on the ROW adjacent to their homes and to reach out to the township 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.

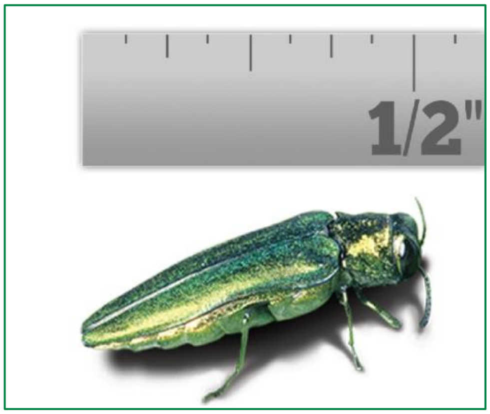
Adult Asian longhorned beetle

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.

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).

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

Photograph courtesy of APHIS (2011b)

Granulate Ambrosia Beetle

Adult granulate ambrosia beetle

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

The granulate ambrosia beetle (*Xylosandrus crassiusculus*), formerly the Asian ambrosia beetle, was first found in the United States in 1974 on peach trees near Charleston, South Carolina. The native range of the granulate ambrosia beetle is probably tropical and subtropical Asia. The beetle is globally present in countries such as equatorial Africa, Asia, China, Guinea, Hawaii, India, Japan, New South Pacific, Southeast Indonesia, Sri Lanka, and the United States. In the United States, this species has spread along the lower Piedmont region and coastal plain to East Texas, Florida, Louisiana, and North Carolina. Populations were found in Oregon and Virginia in 1992, and in Indiana in 2002.

Adults are small and have a reddish-brown appearance with a downward facing head. Most individuals have a reddish head region and a dark-brown to black elytra (hard casings protecting the wings). Light-colored forms that appear almost yellow have also been trapped. A granulated (rough) region is located on the front portion of the head and long setae (hairs) can be observed on the back end of the wing covers. Females are 2–2.5mm and males are 1.5mm long. Larvae are C-shaped with a defined head capsule.

The granulate ambrosia beetle is considered an aggressive species and can attack trees that are not highly stressed. It is a potentially serious pest of ornamentals and fruit trees and is reported to be able to infest most trees and some shrubs (azalea, rhododendron) but not conifers. Known hosts in the United States include: *Acer* (maple); *Albizia* (albizia); *Carya* (hickory); *Cercis canadensis* (eastern redbud); *Cornus* (dogwood); *Diospyros* (persimmon); *Fagus* (beech); *Gleditsia* or *Robinia* (locust); *Juglans* (walnut); *Koelreuteria* (goldenrain tree); *Lagerstroemia* (crapemyrtle); *Liquidambar styraciflua* (sweetgum); *Liriodendron tulipifera* (tulip poplar); *Magnolia* (magnolia); *Populus* (aspen); *Prunus* (cherry); *Quercus* (oak); and *Ulmus parvifolia* (Chinese elm). *Carya illinoinensis* (pecan) and *Pyrus calleryana* (Bradford pear) are commonly attacked in Florida and in the southeastern United States.

Xm Ambrosia Beetle

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).

Hemlock Woolly Adelgid

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

In their native range, populations of HWA cause little damage to the hemlock trees, as they feed on natural enemies and possible tree resistance has evolved with this insect. In eastern North America and in the absence of natural control elements, HWA attacks both *Tsuga canadensis* (eastern or Canadian hemlock) and *T. caroliniana* (Carolina hemlock), often damaging and killing them within a few years of becoming infested.

Hemlock woolly adelgids on a branch

Photograph courtesy of USDA Forest Service (2011a)

The HWA is now established from northeastern Georgia to southeastern Maine and as far west as eastern Kentucky and Tennessee.

Oak Wilt

Oak wilt was first identified in 1944 and is caused by the fungus *Ceratocystis fagacearum*. While considered an invasive and aggressive disease, its status as an exotic pest is debated since the fungus has not been reported in any other part of the world. This disease affects the oak genus and is most devastating to those in the red oak subgenus, such as *Quercus coccinea* (scarlet oak),
Q. imbricaria (shingle oak), *Q. palustris* (pin oak), *Q. phellos* (willow oak), and *Q. rubra* (red oak). It also attacks trees in the white oak subgenus, although it is not as prevalent and spreads at a much slower pace in these trees.

Oak wilt symptoms on red and white oak leaves

Photograph courtesy of USDA Forest Service (2011a)

Just as with DED, oak wilt disease is caused by a fungus that clogs the vascular system of oaks and results in decline and death of the tree. The fungus is carried from tree to tree by several borers common to oaks, but the disease is more commonly spread through root grafts. Oak species within the same subgenus (red or white) will form root colonies with grafted roots that allow the disease to move readily from one tree to another.

Pine Shoot Beetle

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).

Mined shoots on a Scotch pine

Photograph courtesy of USDA Forest Service (1993)

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

Adult pine shoot beetles range from 3 to 5 millimeters long, or about the size of a match head. They are brown or black and cylindrical. The legless larvae are about 5 millimeters long with a white body and brown head. Egg galleries are 10–25 centimeters long. From April to June, larvae feed and mature under the pine bark in separate feeding galleries that are 4–9 centimeters long. When mature, the larvae stop feeding, pupate, and then emerge as adults. From July through October, adults tunnel out through the bark and fly to new or 1-year-old pine shoots to begin maturation feeding. The beetles enter the shoot 15 centimeters or less from the shoot tip and move upwards by hollowing out the center of the shoot for a distance of 2.5–10 centimeters. Affected shoots droop, turn yellow, and eventually fall off during the summer and fall.

P. sylvestris (Scots pine) is preferred, but other pine species, including *P. banksiana* (jack pine), *P. nigra* (Austrian pine), *P. resinosa* (red pine), and *P. strobus* (eastern white pine), have been infested in the Great Lakes region.

Sirex Woodwasp

Sirex woodwasp (*Sirex noctillio*) has been the most common species of exotic woodwasp detected at United States ports-of-entry associated with solid wood-packing materials. Recent detections of sirex woodwasp outside of port areas in the United States have raised concerns because this insect has the potential to cause significant mortality of pines. Awareness of the symptoms and signs of a sirex woodwasp infestation increases the chance of early detection, thus increasing the rapid response needed to contain and manage this exotic forest pest.

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 Lanternlfy

The spotted lanternfly (SLF, *Lycorma delicatula*) is native to China and was first detected in Pennsylvania in September 2014. Spotted lanternfly feeds on a wide range of fruit, ornamental and woody trees, with tree-of-heaven being one of the preferred hosts. Spotted lanternflies are invasive and can be spread long distances by people who move infested material or items containing egg masses. If allowed to spread in the United States, this pest could seriously impact the country's grape, orchard, and logging industries.

Profile of spotted lanternfly adult at rest

Photograph courtesy of Pennsylvania Department of Agriculture

Adult spotted lanternflies are approximately 1 inch long and one-half inch wide, and they have large and visually striking wings. Their forewings are light brown with black spots at the front and a speckled band at the rear. Their hind wings are scarlet with black spots at the front and white and black bars at the rear. Their abdomen is yellow with black bars. Nymphs in their early stages of development appear black with white spots and turn to a red phase before becoming adults. Egg masses are yellowish-brown in color, covered with a gray, waxy coating prior to hatching.

The spotted lanternfly lays its eggs on smooth host plant surfaces and on non-host material, such as bricks, stones, and dead plants. Eggs hatch in the spring and early summer, and nymphs begin feeding on a wide range of host plants by sucking sap from young stems and leaves. Adults appear in late July and tend to focus their feeding on tree-of-heaven (A. altissima) and grapevine (Vitis vinifera). As the adults feed, they excrete sticky, sugar-rich fluid similar to honeydew. The fluid can build up on plants and on the ground underneath infested plants, causing sooty mold to form.

Thousand Cankers Disease

A complex disease referred to as Thousand Cankers disease (TCD) was first observed in Colorado in 2008 and is now thought to have existed in Colorado as early as 2003. TCD is considered to be native to the United States and is attributed to numerous cankers developing in association with insect galleries.

Walnut twig beetle, side view

Photograph courtesy of USDA Forest Service (2011b)

TCD results from the combined activity of the *Geosmithia morbida* fungus and the walnut twig beetle (WTB, *Pityophthorus juglandis*). The WTB has expanded both its geographical and host range over the past two decades, and coupled with the *Geosmithia morbida* fungus, *Juglans* (walnut) mortality has manifested in Arizona, California, Colorado, Idaho, New Mexico, Oregon, Utah, and Washington. In July 2010, TCD was reported in Knoxville, Tennessee. The infestation is believed to be at least 10 years old and was previously attributed to drought stress. This is the first report east of the 100th meridian, raising concerns that large native populations of *J. nigra* (black walnut) in the eastern United States may suffer severe decline and mortality.

The tree species preferred as hosts for TCD are walnuts.

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