TREE MANAGEMENT PLAN

Village of Rhinebeck, New York
January 2020

Prepared for:

Village of Rhinebeck
Rhinebeck Village Clerk
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ACKNOWLEDGMENTS

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

The Village Clerk also recognizes the support of its Mayor and the Village Clerk council:

NAMES/TITLES

OTHER ENTITIES AS APPROPRIATE

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

EXECUTIVE SUMMARY

This plan was developed for the Village of Rhinebeck, New York 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 village's existing program and vision for the urban forest were utilized to develop this *Tree Management Plan*. Also included in this plan are economic, environmental, and social benefits provided by the trees in Rhinebeck.

State of the Existing Urban Forest

The November 2019 inventory included trees, stumps, and planting sites along public street rights-of-ways (ROW), and in specified parks and public facilities. The parks selected for the inventory include: Lions Park, Legion Park, Rhinebeck Cemetery, and the Village Library. A total of 2,706 sites were recorded during the inventory: 1,964 trees, 39 stumps, and 703 planting sites. Analysis of the tree inventory data found the following:

- Two species, *Acer platanoides* (Norway maple) and *A. saccharum* (sugar maple), comprise a large percentage of the street ROW (17% and 9%, respectively) and threaten biodiversity.
- *Acer platanoides* (Norway maple) was found in abundance (17%), which is a concern for the Village of Rhinebeck's biodiversity.
- The diameter size class distribution of the inventoried tree population trends towards the ideal.
- The overall condition of the inventoried tree population is rated Fair.
- Approximately 45% of the inventoried trees had dead and dying parts.
- Overhead utilities interfering with street trees occur among 4% of the population.
- Hardscape lifting from street trees occurs among 11% of the population.
- Granulate ambrosia beetle (*Xylosandrus crassiusculus*) and spotted lantern fly (*Lycorma delicatula)* pose the biggest threats to the health of the inventoried population.
- Trees provide approximately $5,248 in the following annual benefits:
    - *Air quality*: 609 pounds of pollutants removed valued at $985 per year.
    - *Net total carbon sequestered and avoided*: 13.93 tons valued at $2,375.33 per year.
    - *Stormwater peak flow reductions:* 1,065,160 gallons intercepted valued at $1887.66 per year.

Tree Maintenance and Planting Needs

Trees provide many environmental and economic benefits that justify the time and money invested in planting and maintenance. Recommended maintenance needs include: Tree Removal (3%); Stump Removal (1%); Routine Pruning (58%); Young Tree Train (9%); and Plant Tree (26%). Maintenance should be prioritized by addressing trees with the highest risk first. The inventory noted Extreme and High Risk trees (0% and 1% of trees assessed, respectively); these trees should be removed or pruned immediately to promote public safety. Low and Moderate Risk trees should be addressed after all elevated risk tree maintenance has been completed. Trees should be planted to mitigate removals and create canopy.

REMOVAL	**Total = 99 trees** **Extreme Risk = 0 trees** **High Risk = 5 trees** **Moderate Risk = 59 trees**
PRIORITY PRUNING	**Total = 955 trees** **High Risk = 21 trees** **Moderate Risk= 103 trees**
ROUTINE PRUNING CYCLE	**Total = 1,580 trees** **Number of trees in cycle each year = approximately 301**
YOUNG TREE TRAINING CYCLE	**Total = 234 trees** **Number of trees in cycle each year = at least 56**
TREE PLANTING	**Number of trees each year = at least 141** **Number of trees to replant = at least 99**

Rhinebeck's urban forest will benefit greatly from a three-year young tree training cycle and a five-year routine pruning cycle. Proactive pruning cycles improve the overall health of the tree population and may eventually reduce program costs. In most cases, pruning cycles will correct defects in trees before they worsen, which will avoid costly problems. Based on inventory data, at least 56 young trees should be structurally pruned each year during the young tree training cycle, and approximately 301 trees should be cleaned each year during a routine pruning cycle.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind). DRG recommends planting at least 703 trees of a variety of species each year to offset these losses, increase canopy, maximize benefits, and account for ash tree loss.

Village 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, trails, parking lots, areas near buildings with insufficient shade, and areas where there are gaps in the existing canopy. Various tree species should be planted; however, the planting of *Acer platanoides* (Norway maple) should be limited until the species distribution normalizes. The village's existing planting list offers smart choices for species selection. Due to the species distribution and impending threats from emerald ash borer (EAB, *Agrilus planipennis*), all *Fraxinus* spp. (ash) trees should be temporarily removed from the planting list or planted only when a landscape plan is in place.

Urban Forest Program Needs

Adequate funding will be needed for the village to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this five-year program is $319,133. This total will decrease to approximately $36,327 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 village infrastructure. Keeping the inventory up to date using TreeKeeper® 7.7 or similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

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

FY 2020

$36,327

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 56 Trees
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2019

$36,327

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 56 Trees
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2018

$68,808

- 35 Low Risk Removals
- 35 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 56 Trees
- 35 Trees Recommended for Planting and Follow-up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2017

$78,160

- 30 Moderate Risk Removals
- 85 Moderate Risk Prunes
- 30 Stump Removals
- RP Cycle: 1/5 of Trees Cleaned
- YTT Cycle: 56 Tree
- 30 Trees Recommended for Planting and Follow-up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2016

$99,511

- 5 Extreme and High Risk Removals
- 21 Extreme and High Risk Prunes
- 29 Moderate or Low Risk Removals
- 18 Moderate Risk Prunes
- 34 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 56 Trees
- 34 Trees Recommended for Planting and Follow-up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

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INTRODUCTION

The Village of Rhinebeck is home to more than 2,600 full-time residents who enjoy the beauty and benefits of their urban forest. The village's forestry program manages and maintains trees on public property, including trees, stumps, and planting sites in specified parks, public facilities, and along the street rights-of-ways (ROW). For many years Rhinebeck has maintained staff committed to developing a strong urban forest.

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 November 2019, The Village of Rhinebeck worked with DRG to inventory trees and develop a management plan. This plan considers the diversity, distribution, and general condition of the inventoried trees, but also provides a prioritized system for managing public trees. The following tasks were completed:

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

This plan is divided into 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 an i-Tree Eco benefits analysis conducted for Rhinebeck.
- *Section 3: Tree Management Program* utilizes the inventory data to develop a prioritized maintenance schedule and projected budget for the recommended tree maintenance over a five-year period.

SECTION 1: TREE INVENTORY ANALYSIS

In November 2019, DRG arborists assessed and inventoried trees, stumps, and planting sites along the street ROW, specified parks, and public facilities. A total of 2,706 sites were collected during the inventory: 1,964 trees, 39 stumps, and 703 planting sites. Of the 2,076 sites collected, 84% were collected along the street ROW, and the remaining 16% were collected in parks. Figure 1 provides a detailed breakdown of the number and type of sites inventoried.

The village's public street rights-of-way were selected by Rhinebeck for the inventory.

Three project areas, Rhinebeck Library, and Rhinebeck cemetery, and two community parks, were selected by The Village of Rhinebeck for the tree inventory. Inventoried parks include: Legion Park and Rhinebeck's Mini Lion's Park.

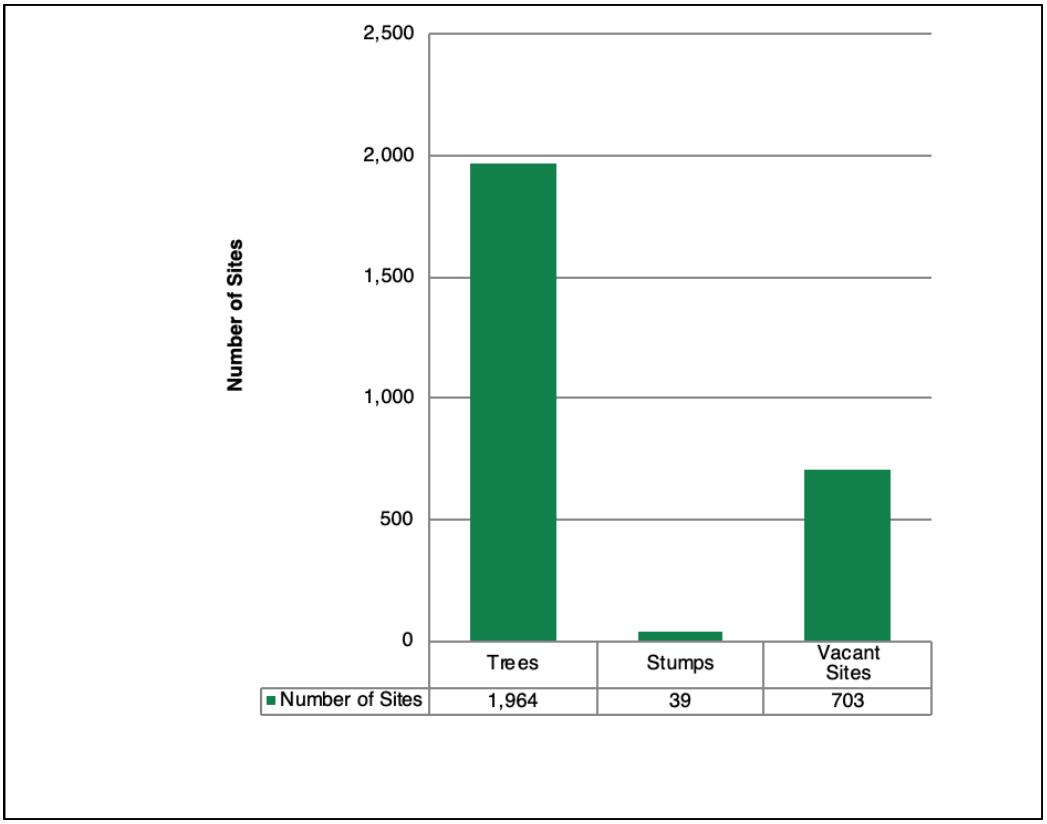


Figure 1. Sites collected during the 2019 inventory.

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:

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

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

Species Diversity

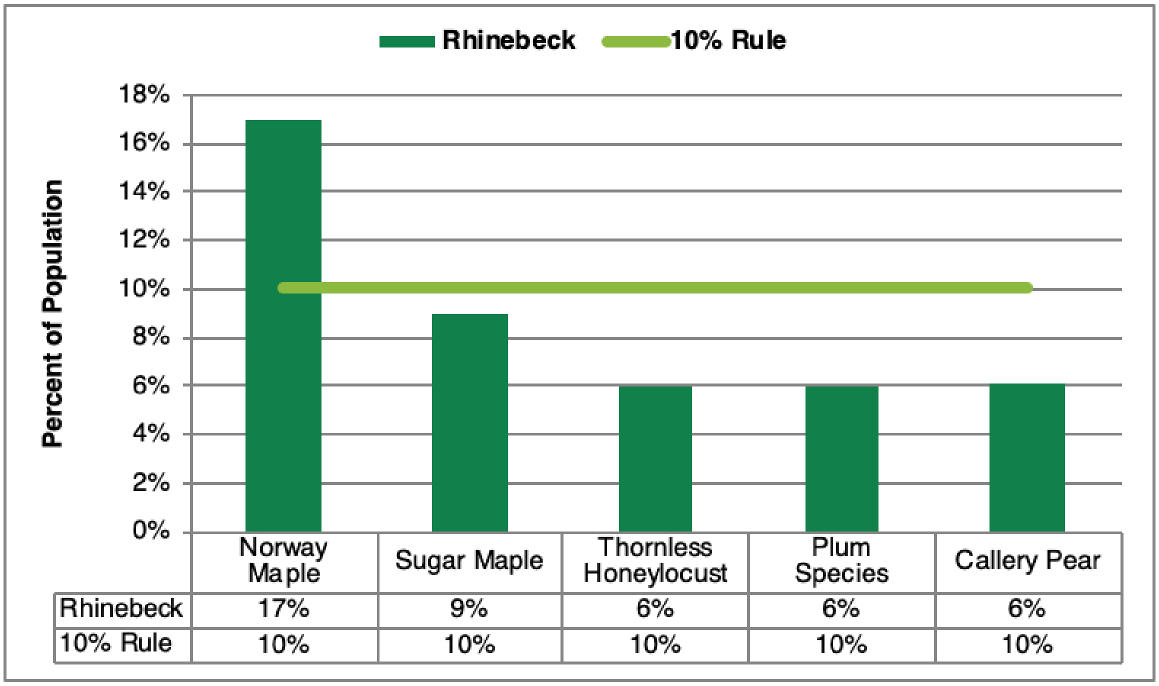
Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics,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

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

Findings

Analysis of Rhinebeck's tree inventory data indicated that the park tree population had relatively good diversity, with 34 genera and 62 species represented. Along the street ROW, diversity was very good and with the overall inventoried population containing 102 distinct species.

Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory to the park and street tree populations. *Acer platanoides* (Norway maple) far exceed the recommended 10% maximum for a single species in a population, comprising 17% of the inventoried tree population. *Acer saccharum* (sugar maple), *Gleditsia triacanthos inermis* (thornless honeylocust), *Prunus species* (plum spp.), and *Pyrus calleryana* (callery pear) are approaching the 10% threshold.



	Norway Maple	Sugar Maple	Thornless Honeylocust	Plum Species	Callery Pear
Rhinebeck	17%	9%	6%	6%	6%
10% Rule	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 to the park and street tree populations. *Acer* (maple) far exceed the recommended 20% maximum for a single genus in a population, comprising 24% of the inventoried tree population, respectively. *Gleditsia* (honeylocust), *Quercus* (oak), pine (*Pinus*), and *Tsuga* (hemlock) are the next largest populations.

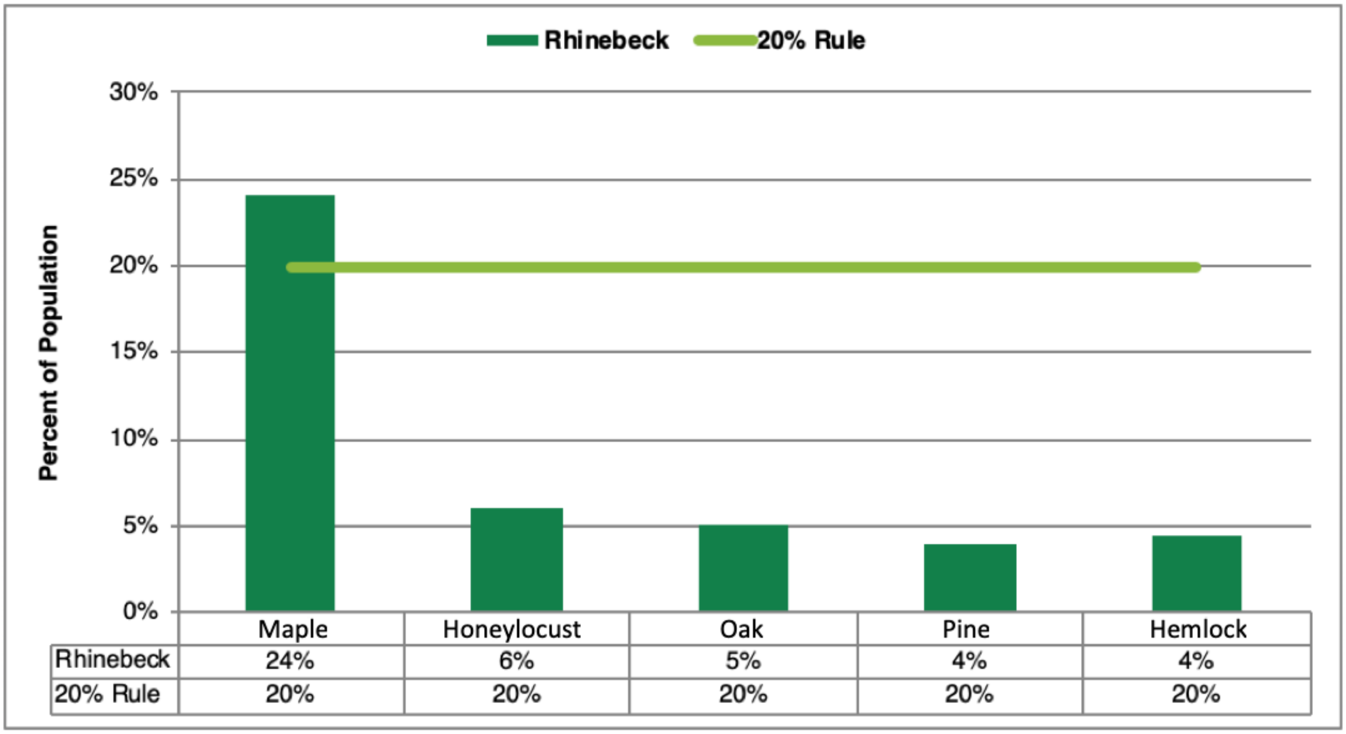


Figure 3. Five most abundant genera of the inventoried population compared to the 20% Rule.

Discussion/Recommendations

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

Considering the large quantity of *Acer platanoides* (Norway maple) in Rhinebeck's population, along with their susceptibility to Asian Longhorned Beetle, the planting of *Acer platanoides* (Norway maple) should be limited to minimize the potential for loss in the event that the Asian longhorned beetle threatens Rhinebeck'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.

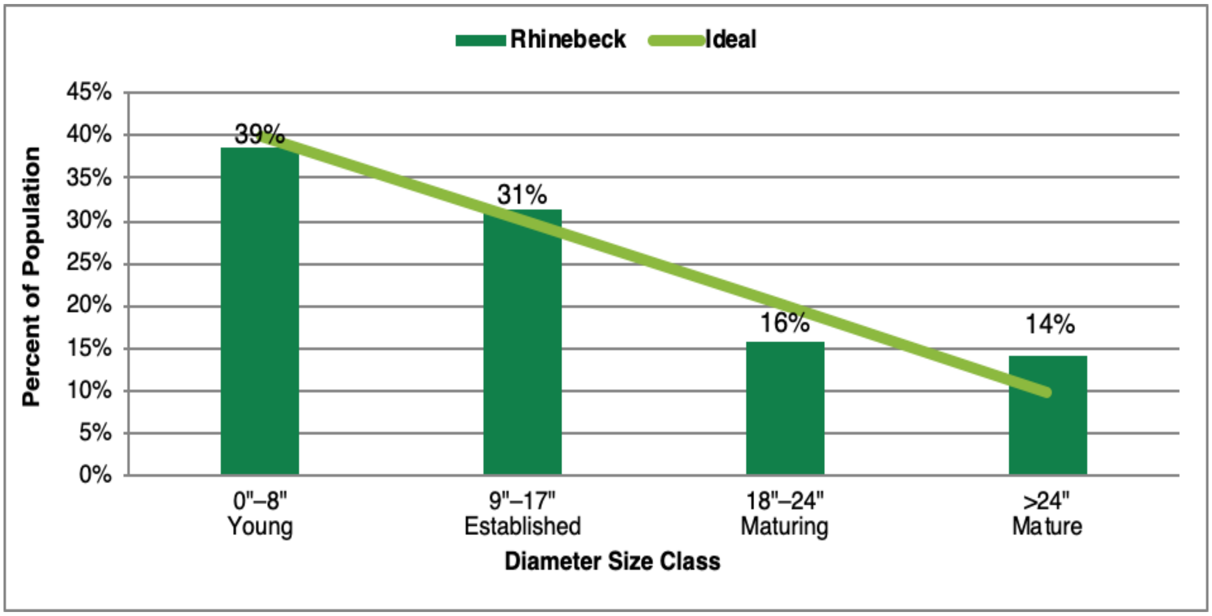


Figure 4. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Findings

Figure 4 compares The Village of Rhinebeck's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). Rhinebeck's distribution trends towards the ideal; young trees fall short of the ideal by 1%, while larger diameter size classes surpass the ideal by 4%. Established trees exceed the ideal by 1%, whereas maturing trees fall short of the ideal by 4%.

Discussion/Recommendations

One of Rhinebeck's objectives is to have an uneven-aged distribution of trees at street, park, and village wide levels. Rhinebeck's diameter size class distribution is very close to the ideal. DRG recommends that The Village of Rhinebeck 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 village 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 remain the same 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 Good, Fair, Poor, or Dead.

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

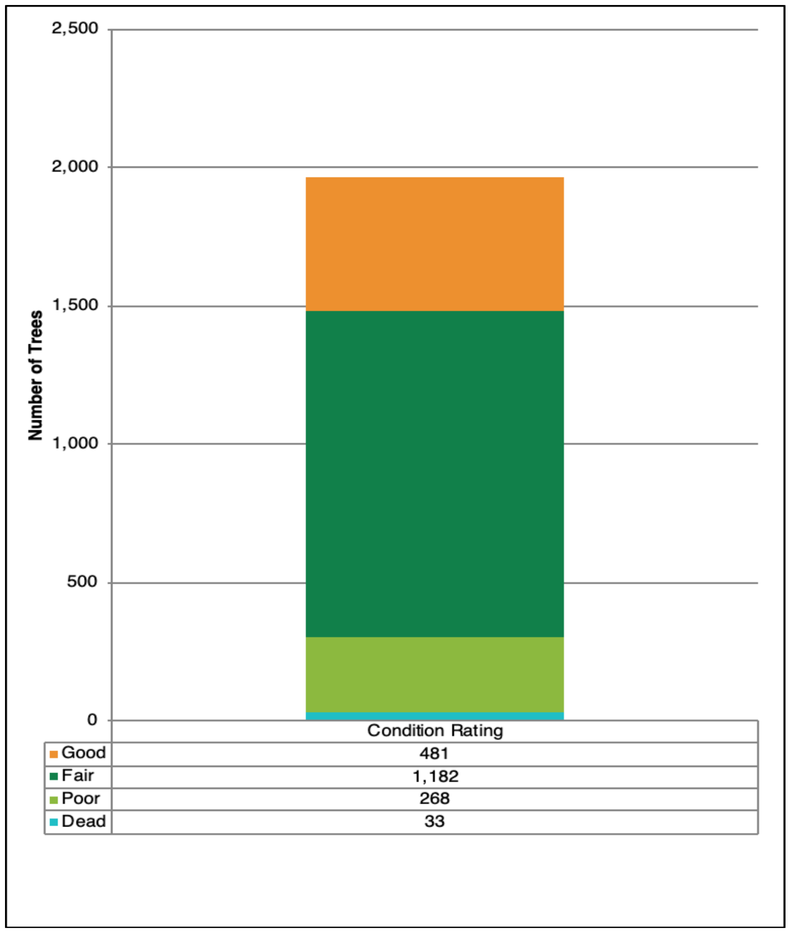


Figure 5. Conditions of inventoried trees.

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 Good or Fair condition, 24% and 60%, 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, and maturing trees were rated to be in Good and Fair condition, and that most of the mature trees were rated to be in Fair condition.

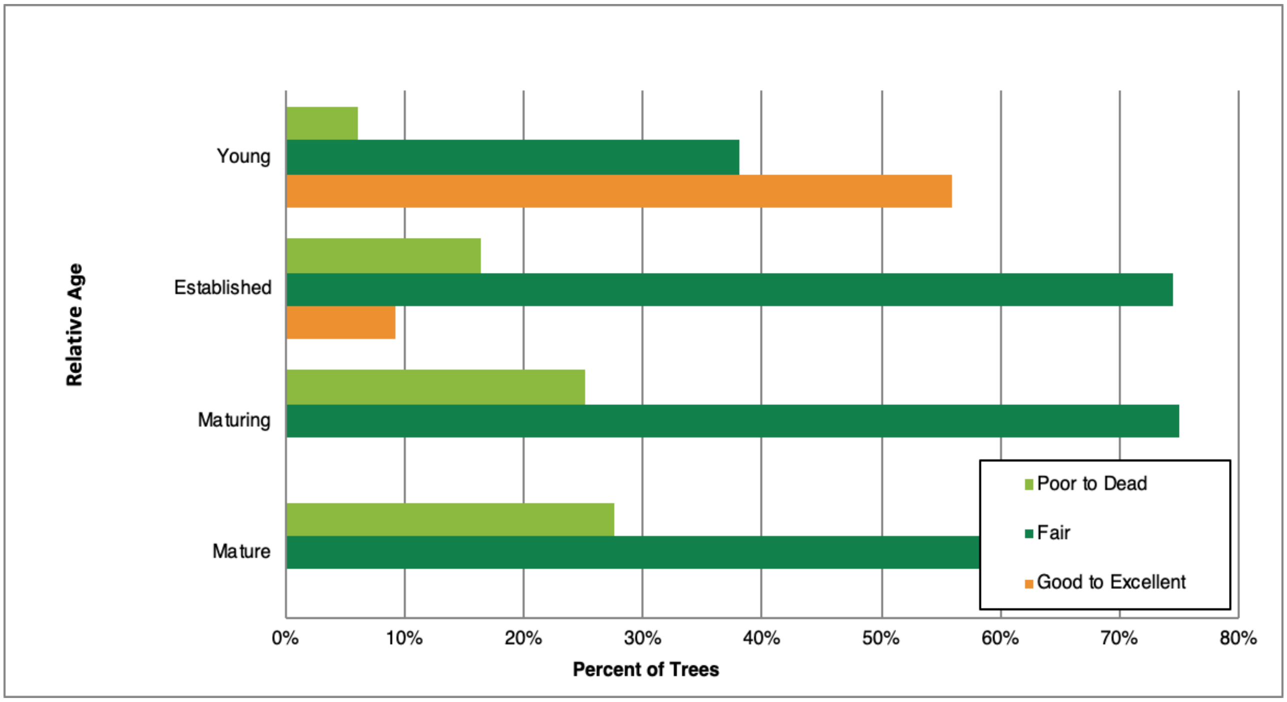


Figure 6. Tree condition by relative age during the 2019 inventory.

Discussion/Recommendations

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

- The similar trend in condition across street and park trees reveals that growing conditions and/or past management of trees were consistent.
- Dead trees and trees in Critical condition should be removed because of their failed health; these trees will likely not recover, even with increased care.
- Younger trees rated in Fair or Poor condition may benefit from improvements in structure that may improve their health over time. Pruning should follow *ANSI A300 (Part 1)* (ANSI 2008).
- Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.

- Proper tree care practices are needed for the long-term general health of the urban forest. Many of the newly planted trees were improperly mulched or had staking hardware attached to them long after they should have been removed. Following guidelines developed by ISA and those recommended by *ANSI A300 (Part 6)* (ANSI 2012) will ensure that tree maintenance practices ultimately improve the health of the urban forest.

Street ROW Stocking Level

Stocking is a traditional forestry term used to measure the density and distribution of trees. For an urban/community forest such as Rhinebeck, 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.

Findings

The inventory found 703 planting sites. Of the inventoried sites, 152 were potential planting sites for large-size trees (8-foot-wide and greater growing space size); 147 were potential sites for medium-size trees (6- to 7-foot-wide growing space sizes); and 404 were potential sites for small-size trees (4- to 5-foot-wide growing space sizes). Based on the data collected during this inventory, Rhinebeck's current street ROW tree stocking level is 72%.

Discussion/Recommendation

Fully stocking the street ROW with trees is an excellent goal. Inadequate tree planting and maintenance budgets, along with tree mortality, will result in lower stocking levels. Nevertheless, working to attain a fully stocked street ROW is important to promote canopy continuity and environmental sustainability. The village should consider improving its street ROW population's stocking level of 72% and work towards achieving the ideal of 90% or better. Generally, this entails a planned program of planting, care, and maintenance for the village's street trees.

The Village of Rhinebeck estimates that it plants 97 trees per year. With a current total of 703 planting sites along the street ROW, it would take approximately 5 years for the village to reach the recommended stocking level of 90%. If budgets allow, DRG recommends that Rhinebeck increase the number of trees planted to 141. If possible, exceed this recommendation to better prepare for impending threats and to increase the benefits provided by the urban forest.

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

Rhinebeck's ratio of street trees per capita is 0.75, which falls above the mean ratio of 0.37 reported for 22 U.S. cities (McPherson and Rowntree 1989). According to the citywide study, there is 1 tree for every 3.3 residents.

Infrastructure Conflicts

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

- *Overhead Utilities*—The presence of overhead utility lines above a tree or planting site was noted; it is important to consider these data when planning pruning activities and selecting tree species for planting.
- *Hardscape Damage*—Trees can adversely impact hardscape, which affects tree root and trunk systems. The inventory recorded damage related to trees, causing curbs, sidewalks, and other hardscape features to lift. These data should be used to schedule pruning and plan repairs to damaged infrastructure. To limit hardscape damage caused by trees, trees should only be planted in growing spaces where adequate above ground and below ground space is provided.

Findings

There were 746 trees with utilities directly above, or passing through, the tree canopy. Of those trees, 4% were large- or medium-size trees.

Hardscape damage was minimal: 11% of the tree population raised sidewalk slabs or curbs.

Table 1. Trees Noted to be Conflicting with Infrastructure

Conflict	Presence	Number of Trees	Percent
Overhead Utilities	Present and Conflicting	85	4.33%
	Present and Not Conflicting	661	33.66%
	Not Present	1,218	62.02%
Hardscape Damage	Present	216	11.00%
	Not Present	1,748	89.00%
Total		1,964	100%

Discussion/Recommendations

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

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

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

Secondary maintenance needs were identified during the inventory and relate to managing trees for infrastructure compatibility. Of the 1,964 trees recorded during the inventory, 38 (2%) should be raised and 283 (14%) should be reduced. Completing these secondary maintenance recommendations will reduce conflicts with Rhinebeck's infrastructure and citizens.

Growing Space

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

- Residential Yard—open sites with unrestricted growing space on at least three sides.
- Planting Strip—located between the street curb and the public sidewalk.
- Unmaintained/Natural Area—located in areas that do not appear to be regularly maintained.
- Well/Pit—at grade level and completely surrounded by sidewalk.

Findings

Three percent of the tree population is located in planting strips that range between 4 feet and 23 feet wide. A majority of the suggested planting sites are on residential yards, both within the ROW (29%) and beyond the ROW (24%).

Discussion/Recommendations

To prolong the useful life of street trees, small-growing tree species should be planted in tree lawns 4–5 feet wide, medium-size tree species in tree lawns 6–7 feet wide, and large-growing tree species in tree lawns at least 8 feet wide. The useful life of a public tree ends when the cost of maintenance exceeds the value contributed by the tree. This can be due to increased maintenance required by a tree in decline, or it can be due to the costs of repairing damage caused by the tree's presence in a restricted site.

Further Inspection

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

Photograph 2. *This tree requires further inspection. Observations from the ground were inconclusive. The frass and sap oozing from its wounds indicated that there is a large possibility that there was rot. An ISA Certified Arborist should perform the additional inspection.*

Findings

DRG recommended 43 trees for further inspection.

Discussion/Recommendations

An ISA Certified Arborist should perform additional inspections of the 43 trees marked for further inspection. 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.

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 Rhinebeck's trees and includes websites where more detailed information can be found.

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

Finding

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 (54% and 33%, respectively). These pests were not detected in Rhinebeck, but if they were detected, the village could see severe losses in its tree population.

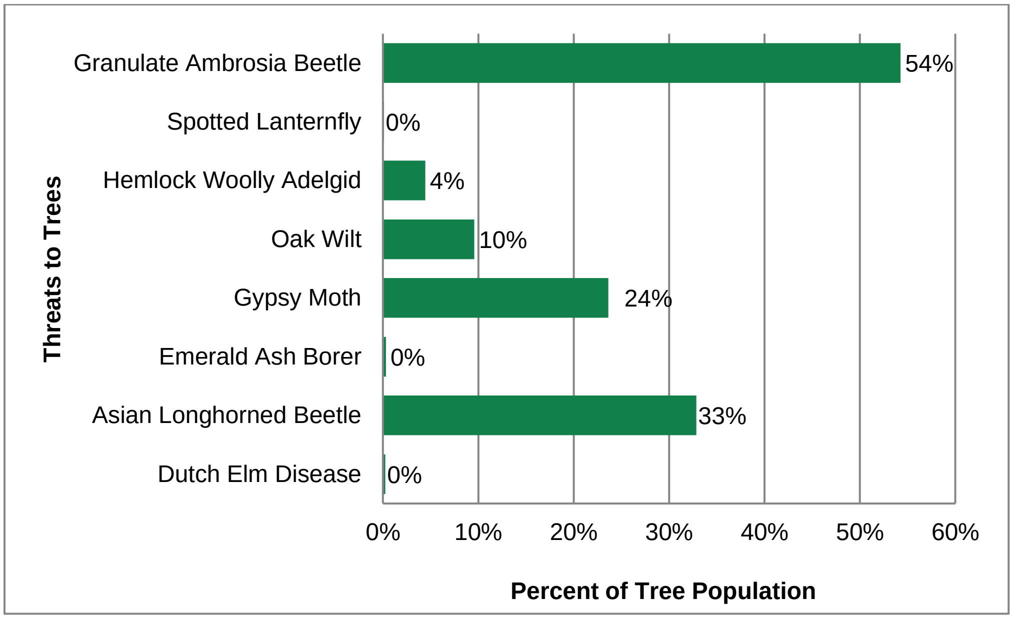


Figure 7. Potential impact of insect and disease threats noted during the 2019 inventory.

Discussion/Recommendations

Rhinebeck should be aware of the signs and symptoms of potential infestations and should be prepared to act if a significant threat is observed in its tree population or a nearby community. An integrated pest management plan should be established. The plan should focus on identifying and monitoring threats, understanding the economic threshold, selecting the correct treatment, properly timing management strategies, recordkeeping, and evaluating results.

SECTION 2: BENEFITS OF THE URBAN FOREST

There is a growing understanding and validation of the importance of trees to a community. 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 economic, environmental, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

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 Eco uses frequently updated economic inputs for georeferenced locations selected by the USDA FS for the climate zone in which your community is located. The entire dataset collected during the 2019 inventory was uploaded into the i-Tree Eco v6 model to produce these benefit results. This section will highlight each element of the collective benefits the trees of Rhinebeck provide.

i-Tree Eco can be utilized with a complete inventory to simplify the benefit quantification process. When location in the landscape is matched with healthy, high–quality tree species, the benefits can be readily quantified utilizing the Council of Tree and Landscape Appraiser's methodology within the i-Tree Eco suite of software. The monetary values of trees are based on four characteristics, which are condition, location, species, and trunk area. This information has been complemented with United States Forest Service (USFS) software programs like i-Tree Eco to provide benefit-based assessments of what trees are worth on an economic level (McPherson, 2007) and (Nowak et al. 2008).

Trees improve air quality. During photosynthesis, trees remove carbon dioxide (CO_2) from the atmosphere to form carbohydrates that are used in plant structure/function and return oxygen (O_2) back to the atmosphere as a byproduct. Trees, therefore, act as a carbon sink. Urban forests cleanse the air by intercepting and slowing particulate materials and by absorbing pollutant gases on their leaf surfaces. Pollutants partially controlled by trees include nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), ozone (O_3), and small particulates less than 10 microns in size (PM_{10}). Coder (1996) found that trees could reduce cemetery level air pollution by up to 60%. Lovasi et al., (2008) suggested that children who live in communities with an abundance of trees have lower rates of asthma.

Planting trees in strategic areas can augment the function of existing stormwater infrastructure by increasing its capacity, delaying onsets of peak flows, and improving water quality. Because trees act as mini-reservoirs, planting trees can reduce the long-term costs to manage runoff. Leafy tree canopies catch precipitation before it reaches the ground, allowing some water to gently drip and the rest to evaporate. This lessens the initial impact of storms and reduces runoff and erosion. For every 5% of tree cover added to a community, stormwater runoff is reduced by approximately 2% (Coder, 1996). Research by the U.S. Department of Agriculture (USDA) Forest Service indicates that 100 mature tree crowns intercept about 100,000 gallons of rainfall per year, reducing runoff and providing cleaner water (USDA Forest Service, 2003(a)). A typical community forest of 10,000 trees will retain approximately 10 million gallons of rainwater per year (USDA Forest Service, 2003(b)).

Scientists and researchers have studied the effects of trees on air quality, stormwater runoff, human behavior, and crime rates.

Research has shown that trees can lead to reduced crime rates, decreased amounts of human stress, and shorter lengths of hospital stays. Kuo and Sullivan (2001(a)) studied apartment buildings in Chicago and found that buildings with high levels of greenery had 52% fewer crimes than those without any trees, and buildings with medium amounts of greenery had 42% fewer crimes. Trees create a sense of serenity and add to the overall landscape athletics of a location. Ulrich (1984, 1986) found that hospital patients who were recovering from surgery and 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. The below graphic provides support to the science behind the tree benefits given to the community by their urban forest.

Environmental Benefits

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

Economic Benefits

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

Social Benefits

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

Findings

Both the functional and structural benefits of trees can be assessed when utilizing i-Tree Eco. The functional benefits of trees are associated with their ability to provide pollution reduction and ecosystem services. The benefit of utilizing i-Tree Eco is that it provides a better understanding of the structure and function of trees as a resource. It also provides cities the means to advocate for the necessary funding to manage trees appropriately. I-Tree Streets has moved into a legacy role and the new Eco v6 is the most up to date eco-benefit estimator available which includes the functionality of the Streets model. Trees are evaluated based upon the population (collective group of species) and individual tree performances within the inventory collected.

For functional benefits, concerns removed from atmosphere includes carbon (C), ozone (O_3), nitrogen dioxide (NO_2), particulate matter up to the tenth of a micron (PM_{10}), and sulfur dioxide (SO_2). These services are quantifiable within i-Tree Eco through a process that utilizes tree growth algorithms within tree benefits model supply by the tree inventory.

Structural values are calculated using comparison-based appraisal methodology of the physical resource - This is the comparable cost of replacing the specific tree with a similar tree. I-Tree Eco determines these values by utilizing the Council of Tree and Landscape Appraisers. Carbon storage is also considered a structural value as it is amassed over the life of the tree, not an annual benefit. Carbon storage and sequestration will be discussed in the same section, although they are separate classes of ecological benefits.

Functional Values

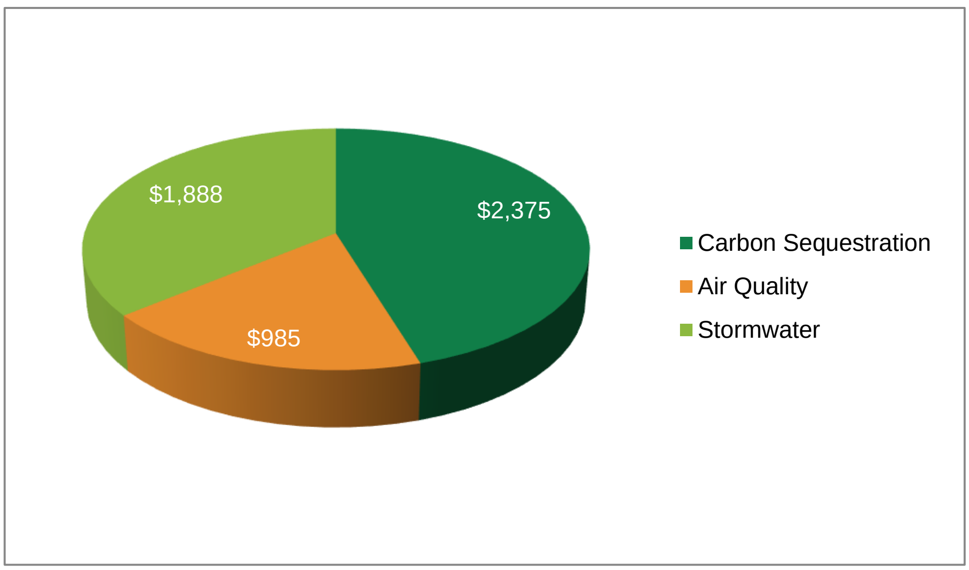


Figure 8. Annual functional benefits of the inventoried trees

Air Quality

Rhinebeck currently receives $5,247.88 annually in total functional ecological benefits from the 1,964 trees in the i-Tree Eco survey. Figure 8 displays the dollar amounts for each functional benefit per year. The functional benefits of trees are associated with their ability to provide pollution reduction and ecosystem services through sequestration. Pollution removed from the inventoried trees includes carbon (C), ozone (O_3), nitrogen dioxide (NO_2), particulate matter up to the tenth of a micron (PM_{10}), and sulfur dioxide (SO_2).

These functional benefits are quantifiable within i-Tree Eco through a process that utilizes tree growth algorithms which are part of a tree benefits model. The inventoried trees provide numerous functional benefits to the community. These cumulative benefits can be valued at an annual average of approximately $2.67 per tree in the inventory. The inventoried tree population annually removes 609.14 pounds of air pollutants (including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter) through deposition. Figure 9 conveys the months of the year where the trees provide the highest return to the community in the form of improved air quality. The total inventory produces 37.1 tons per year of oxygen.

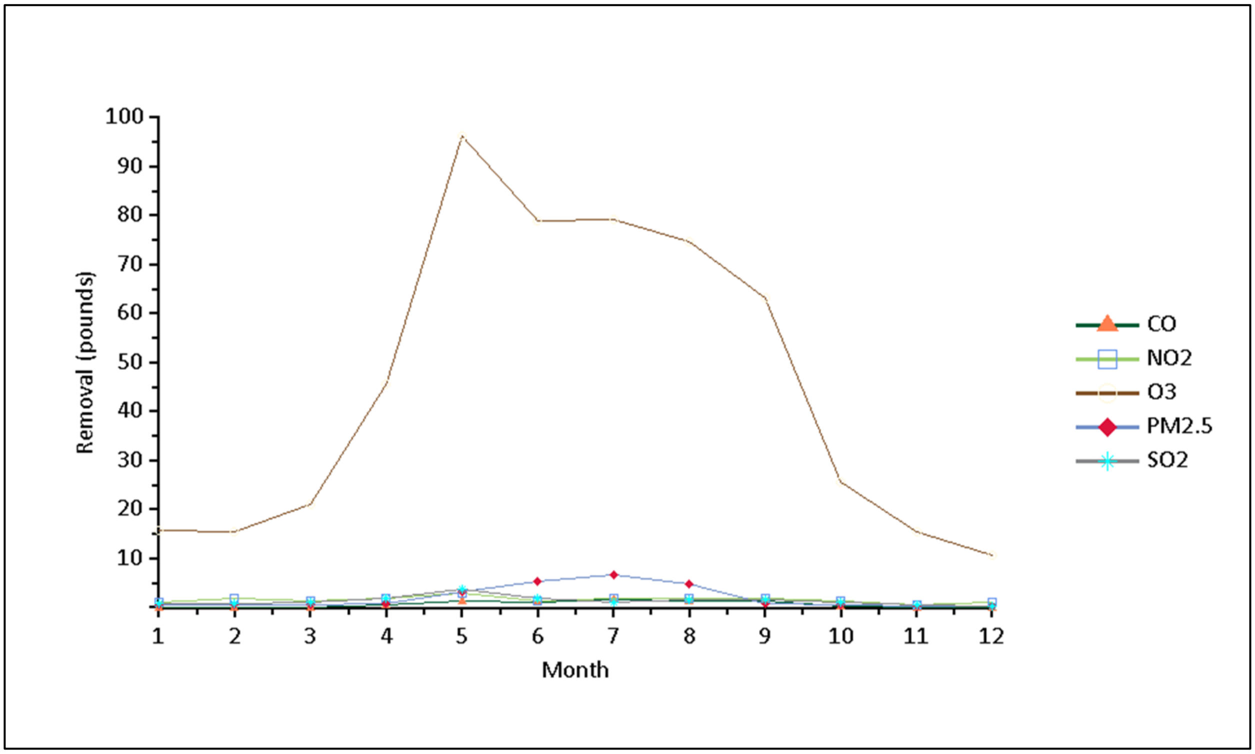


Figure 9. Monthly air pollutants removed per contaminant in Rhinebeck.

Table 2. Top Pollution Removal Benefits per Tree Species in the Inventory

Species	Tree Count	Pollution Removal (ton/yr)	($/yr)
Norway maple	335	0.09	$298.10
sugar maple	154	0.04	$128.70
black walnut	42	0.02	$55.89
red maple	62	0.01	$33.95
silver maple	32	0.01	$39.01
honeylocust	120	0.01	$28.89
Norway spruce	66	0.01	$35.79
eastern white pine	50	0.01	$27.13
plum spp	118	0.01	$27.67
callery pear	101	0.01	$18.31
scarlet oak	22	0.01	$17.56
pin oak	27	0.01	$21.61
northern red oak	39	0.01	$37.58
black locust	45	0.01	$22.90
castern hemlock	87	0.01	$24.47
Total Eco Inventory	1,964	0.3	$984.99

i-Tree Tools

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

The i-Tree Eco calculation takes into account the biogenic volatile organic compounds (BVOC's) that are released from trees. 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 pollution removal net benefit. The inventory produces 170.5 pounds per year of monoterpenes and 252.1 pounds per year of isoprenes. In total the inventoried trees produced 422.5 pounds of VOC's per year. The inventoried trees removed or avoided more pollutants than they emitted, resulting in a positive economic value. Table 3 is list of the largest emitters of BVOCs in the current inventory.

Table 3. Tree Species with Highest Emitting BVOCs in the Inventory.

Species	Amount in Inventory	Monoterpene (lb/yr)	Isoprene (lb/yr)	Total VOCs (lb/yr)
northern red oak	39	1	75.6	76.6
Norway spruce	66	36.9	37.5	74.4
pin oak	27	0.6	49.4	50
Norway maple	335	41	0.6	41.6
scarlet oak	22	0.4	32.3	32.7
black walnut	42	21.4	0.2	21.6
sugar maple	154	19.8	0.3	20
blue spruce	33	8.6	8.7	17.3
eastern white pine	50	10.8	0.1	10.9
white spruce	20	4.7	4.8	9.5
London plane	30	0.1	7.2	7.3
black locust	120	0.4	6.2	6.6
red maple	62	5.8	0.1	5.9
white oak	5	0.1	5.7	5.8
Katsura tree	6	0.6	4.8	5.4
Total Eco Inventory	1,964	170.5	252.1	422.5

Carbon Sequestration and Storage

Trees store some of the carbon dioxide (CO_2) they ab sorb. 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).

The i-Tree Eco 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.

Photograph 3. *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.*

Rhinebeck's tree inventory sequesters 13.93 tons of carbon annually, based on reduction amounts of atmospheric carbon. The carbon storage amount reflects the amount of carbon the trees have amassed during their lifetimes. The total carbon storage of the complete inventory was valued at $241,406.48, with an annual sequestration total of $2,375.33. The average carbon storage per tree was valued at $122.92, with an average $1.21 per tree.

Per the entire inventory, the population of sugar maple provided the most carbon benefits, with each tree storing an average of $372.37 worth of carbon and annually sequestering $2.74 worth of carbon. All sugar maples in the inventory have amassed $57,344.87 worth of carbon. Table 4 is a listing of the top performing populations of trees in the inventory.

Individually, the top performing carbon storing tree in terms of dollars was the pin oak at an average of $461.51 per tree. This species also had the highest dollar amount of annual carbon sequestration at an average of $4.44 per tree. Existing overall population, DBH and tree species characteristics all contribute to these figures. Table 5 is a listing of the top performing individual trees in the inventory.

Table 4. Top Performing Tree Populations for Carbon Storage and Sequestration

Species	Tree Count	Total Carbon Storage(ton)	Total Carbon Storage ($)	Total Carbon Sequestration(ton/yr)	Carbon Sequestration($/yr)
sugar maple	154	336.23	$57,344.87	2.47	$421.59
Norway maple	335	274.48	$46,812.22	2.92	$498.86
northern red oak	39	104.58	$17,836.86	0.75	$128.42
silver maple	32	78.7	$13,422.12	0.41	$69.70
honeylocust	120	73.81	$12,588.46	0.94	$159.53
pin oak	27	60.31	$10,286.07	0.51	$86.72
black locust	45	57.86	$9,867.29	0.49	$82.75
red maple	62	56.67	$9,665.78	0.53	$89.87
black walnut	42	55.61	$9,483.70	0.54	$92.73
scarlet oak	22	43.76	$7,463.65	0.38	$65.04
Norway spruce	66	27.89	$4,755.91	0.31	$53.30
plum spp	118	27.87	$4,754.04	0.54	$91.41
callery pear	101	19.74	$3,367.19	0.43	$73.75
eastern white pine	50	17.22	$2,936.19	0.23	$38.70
European beech	2	14.5	$2,473.27	0.05	$8.44
American sycamore	6	13.82	$2,357.32	0.08	$13.55
black maple	6	11.77	$2,007.79	0.1	$16.49
paper birch	6	11.6	$1,978.22	0.12	$20.38
eastern hemlock	87	10.9	$1,859.18	0.21	$35.75
apple spp	79	9.04	$1,542.28	0.21	$35.58
blue spruce	33	8.92	$1,521.14	0.11	$18.97
black cherry	10	8.82	$1,504.93	0.09	$15.72
American basswood	5	8.05	$1,372.92	0.06	$9.82
Japanese zelkova	36	7.98	$1,360.29	0.11	$18.86
Japanese maple	34	7.87	$1,341.72	0.14	$23.67
Total	1,936	1415.45	$241,406.48	13.93	$2,375.33

Table 5. Top Performing Individual Tree for Carbon Storage and Sequestration

Tree ID	Species Name	DBH	Total Carbon Storage(ton)	Total Carbon Storage ($)	Total Carbon Sequestration(ton/yr)	Carbon Sequestration($/yr)
1402	northern red oak	57	16534.7	$1,410.00	27.6	$2.35
2030	silver maple	61	16534.7	$1,410.00	27.6	$2.35
2716	European beech	52	16534.7	$1,410.00	27.6	$2.35
2726	sugar maple	50	16534.7	$1,410.00	27.6	$2.35
1407	northern red oak	47	15989.3	$1,363.49	89.3	$7.61
2698	sugar maple	47	15662.7	$1,335.65	55.3	$4.71
1374	northern red oak	46	15175.3	$1,294.08	86.6	$7.38
1428	northern red oak	46	15175.3	$1,294.08	86.6	$7.38
1729	pin oak	44	14898.3	$1,270.46	59.1	$5.04
723	silver maple	55	14548.1	$1,240.60	40.1	$3.42
2864	American sycamore	48	14452.1	$1,232.41	52.2	$4.45
2020	sugar maple	45	14169.4	$1,208.30	78.4	$6.68
2681	sugar maple	45	14169.4	$1,208.30	78.4	$6.68
918	red maple	46	13628.1	$1,162.14	75.7	$6.46
1496	red maple	46	13628.1	$1,162.14	75.7	$6.46
2080	sugar maple	44	13454.4	$1,147.33	50.7	$4.33
1973	scarlet oak	42	13104.2	$1,117.47	84.2	$7.18
1379	northern red oak	43	12881.9	$1,098.51	78.6	$6.71
1386	northern red oak	43	12881.9	$1,098.51	78.6	$6.71
983	sugar maple	43	12760.2	$1,088.13	73.9	$6.30
1461	sugar maple	43	12760.2	$1,088.13	73.9	$6.30
1596	pin oak	40	12633.4	$1,077.32	84.4	$7.20
2561	black locust	45	12589.8	$1,073.61	57.1	$4.87
2722	European beech	43	12468.6	$1,063.27	71.4	$6.09
2830	scarlet oak	41	12339	$1,052.21	81.2	$6.93

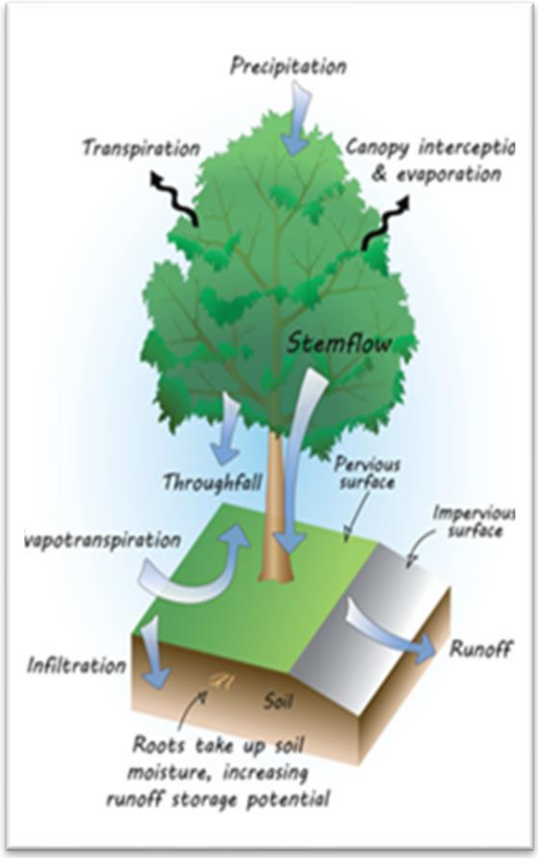
Stormwater Benefits

Trees intercept rainfall, which helps lower costs to manage stormwater runoff. Increased precipitation without trees results in faster supersaturation of the soil which increases runoff. Leaf area attenuates the precipitation and the trees utilize the water – see graphic at the right. The avoided runoff model is based on local weather station data and computed rainfall interception. i-Tree Eco models contrast the calculated leaf area for a given geography with zero leaf area for the same geography.

The inventoried trees in Rhinebeck intercept 1,065,228.94 gallons of rainfall annually based on 77.80 acres of total leaf area. The total avoided runoff is 211,242.39 gallons which equates to an annual savings for the village in stormwater runoff management of $1,887.66.

Of the inventory, Norway maple contributed most of the annual stormwater benefits. This is attributed to the supply of Norway maple in the inventory, size of these trees, and combined leaf area. The population of Norway maple (17.1% of the Eco inventory) intercepted approximately 322,364.98 gallons of rainfall each year. Table 6 is a list of top performing populations for stormwater benefits in the inventory.

On a per-tree basis, large trees with leafy canopies provided the most value. An American sycamore led the inventory with 3,211.39 gallons of intercepted rainfall and 636.59 gallons of avoided runoff. This American sycamore provided $5.69 of stormwater benefits annually. Pin oaks, red oaks, black walnuts and London planetrees are all top individual performers. These large-statured trees with big canopies offered the greatest benefits. Table 7 is the individual top performers per tree in the inventory.



- *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.*

Table 6. Top Performing Tree Populations for Stormwater Benefits in Rhinebeck

Top 20 Trees for Avoided Runoff in Dollars		Number of Trees on the ROW	Percent of Total Trees in Eco	Total Rainfall Interception	Total Avoided Runoff
Common Name	Leaf Area (acres)		1,964	Gallons / Year	Dollars / Year
Norway maple	23.55	335	17%	322,386	$571.29
sugar maple	10.17	154	8%	139,188	$246.65
black walnut	4.41	42	2%	60,447	$107.12
silver maple	3.08	32	2%	42,186	$74.76
northern red oak	2.97	39	2%	40,641	$72.02
Norway spruce	2.83	66	3%	38,703	$68.58
red maple	2.68	62	3%	36,717	$65.06
honeylocust	2.28	120	6%	31,242	$55.36
plum spp	2.19	118	6%	29,920	$53.02
eastern white pine	2.14	50	3%	29,335	$51.98
eastern hemlock	1.93	87	4%	26,459	$46.89
black locust	1.81	45	2%	24,761	$43.88
pin oak	1.71	27	1%	23,372	$41.42
callery pear	1.45	101	5%	19,798	$35.08
scarlet oak	1.39	22	1%	18,990	$33.65
London plane	1.03	30	2%	14,074	$24.94
apple spp	0.91	79	4%	12,423	$22.01
Japanese maple	0.91	34	2%	12,414	$22.00
tulip tree	0.71	15	1%	9,713	$17.21
blue spruce	0.65	33	2%	8,841	$15.67

Table 7. Top Performing Individual Trees in Inventory

Tree ID	Species Name	Leaf Area (ft^2)	Potential Evapotranspiration (gal/yr)	Evaporation	Transpiration (gal/yr)	Water Intercepted	Avoided Runoff (gal/yr)	Avoided Runoff Value
2864	American sycamore	10216.6	21,252.8	$428.20	8,024.9	$429.30	636.6	$5.69
2030	silver maple	10082.4	20,973.7	$422.50	7,919.4	$423.60	628.4	$5.62
2849	American sycamore	8515.3	17,714.3	$356.90	6,688.0	$357.80	531.2	$4.74
1402	northern red oak	8172.8	17,001.3	$342.50	6,419.4	$343.40	509.5	$4.55
602	black walnut	7387.2	15,367.5	$309.60	5,802.3	$310.40	460.8	$4.11
1419	black walnut	7387.2	15,367.5	$309.60	5,802.3	$310.40	460.8	$4.11
1438	black walnut	7387.2	15,367.5	$309.60	5,802.3	$310.40	460.8	$4.11
1445	black walnut	7387.2	15,367.5	$309.60	5,802.3	$310.40	460.8	$4.11
1787	black walnut	7387.2	15,367.5	$309.60	5,802.3	$310.40	460.8	$4.11
897	silver maple	7340.5	15,270.2	$307.60	5,765.6	$308.40	457.8	$4.09
2074	silver maple	6971.3	14,501.9	$292.20	5,475.3	$292.90	434.6	$3.88
1407	northern red oak	6810.9	14,168.3	$285.40	5,349.7	$286.20	424.9	$3.79
2716	European beech	6716.5	13,972.3	$281.50	5,275.6	$282.20	418.9	$3.74
2722	European beech	6716.5	13,972.3	$281.50	5,275.6	$282.20	418.9	$3.74
1374	northern red oak	6676.1	13,887.7	$279.80	5,243.4	$280.50	415.9	$3.72
1428	northern red oak	6676.1	13,887.7	$279.80	5,243.4	$280.50	415.9	$3.72
2146	black walnut	6434.9	13,386.5	$269.70	5,054.2	$270.40	401.0	$3.58
714	silver maple	6358.9	13,227.9	$266.50	4,994.3	$267.20	396.5	$3.54
1476	silver maple	6358.9	13,227.9	$266.50	4,994.3	$267.20	396.5	$3.54
39	London plane	6231	12,962.3	$261.10	4,894.1	$261.80	388.3	$3.47
726	black walnut	6188.5	12,873.3	$259.40	4,860.4	$260.00	386.0	$3.45
1379	northern red oak	6202.2	12,902.5	$259.90	4,871.6	$260.60	386.8	$3.45
1386	northern red oak	6202.2	12,902.5	$259.90	4,871.6	$260.60	386.8	$3.45
1414	black walnut	6188.5	12,873.3	$259.40	4,860.4	$260.00	386.0	$3.45
2647	silver maple	6187	12,870.3	$259.30	4,859.7	$260.00	386.0	$3.45

Structural Values

The most straightforward way to establish a monetary value for a forest is by establishing a structural value. Generally, this value represents the amount it would cost to replace all trees in the urban forest. Assessing Rhinebeck's structural value provides an approximation of the investment in planning, resources, and time that have gone into the establishment and maintenance of the urban forest. Carbon storage is considered a structural value and is noted as $241,406.48 and reviewed in the previous carbon sequestration and carbon heading.

Tree Values

The structural value of the entire inventory is valued at $3,479,668.69, with a per tree average of $1,797.35. The 25 highest valued populations in the inventory are noted in Table 8. The population of sugar maple is noted as the highest valued population. Table 9 is a list of 25 highest valued individual trees in the inventory, a northern red oak claims the top valued tree.

Table 8. Populations with Highest Structural Value in the Inventory

Tree Species	Trees in Inventory	Structural Value in Dollars	Average Structural Value per Tree in Dollars
sugar maple	154	$731,645.93	$4,750.9
Norway maple	335	$628,774.12	$1,876.9
northern red oak	39	$235,972.22	$6,050.6
honeylocust	120	$200,781.78	$1,673.2
red maple	62	$131,466.72	$2,120.4
black walnut	42	$127,783.32	$3,042.5
pin oak	27	$123,958.98	$4,591.1
Norway spruce	66	$120,720.27	$1,829.1
eastern white pine	50	$106,452.60	$2,129.1
scarlet oak	22	$96,646.88	$4,393.0
silver maple	32	$94,688.59	$2,959.0
black locust	45	$91,638.66	$2,036.4
plum spp	118	$80,141.47	$679.2
callery pear	101	$77,662.12	$768.9
eastern hemlock	87	$63,703.57	$732.2
northern white cedar	26	$44,115.77	$1,696.8
apple spp	79	$39,348.82	$498.1
blue spruce	33	$35,362.87	$1,071.6
black maple	6	$28,962.08	$4,827.0
American basswood	5	$28,291.08	$5,658.2
European beech	2	$28,198.59	$14,099.3
Japanese zelkova	36	$27,023.24	$750.6
Japanese maple	34	$26,765.88	$787.2
London plane	30	$26,761.37	$892.0
American sycamore	6	$25,100.19	$4,183.4
Total	1,964	$3,479,668.69	$1,771.7

Table 9. Individual Trees in the Inventory with Highest Structural Values

Tree ID	Tree Species	DBH	Structural Value per Tree in Dollars
1402	northern red oak	57	$17,298.13
2716	European beech	52	$15,721.37
2726	sugar maple	50	$15,045.56
1407	northern red oak	47	$13,983.51
1374	northern red oak	46	$13,616.60
1428	northern red oak	46	$13,616.60
2020	sugar maple	45	$13,243.25
2681	sugar maple	45	$13,243.25
1379	northern red oak	43	$12,477.21
1386	northern red oak	43	$12,477.21
983	sugar maple	43	$12,477.21
1461	sugar maple	43	$12,477.21
2722	European beech	43	$12,477.21
1729	pin oak	44	$12,204.78
890	northern red oak	42	$12,084.53
2526	sugar maple	42	$12,084.53
2711	sugar maple	42	$12,084.53
2728	sugar maple	42	$12,084.53
929	sugar maple	41	$11,685.40
2060	sugar maple	41	$11,685.40
2084	sugar maple	41	$11,685.40
918	red maple	46	$11,521.68
1496	red maple	46	$11,521.68
1973	scarlet oak	42	$11,466.85
2670	Norway spruce	42	$11,466.85

Discussion

The i-Tree Eco analysis found that the inventoried trees provide environmental and economic benefits to the community by virtue of their mere presence on the streets. The property value increase provided by trees is important to stimulate economic growth. In addition to increasing and property values, trees manage stormwater through rainfall interception, provide shade and windbreaks to reduce energy usage, and store and sequester CO_2. Trees work to intercept rainfall and reduce runoff. While air quality is sometimes countered by high-BVOCs emitting trees, this effect can be offset by smart tree-planting efforts.

To increase the benefits the urban forest provides, the village 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. Working with the i-Tree species tool and adjusting the parameters to the needs of the community will provide valid tree selections for Rhinebeck (https://species.itreetools.org/).

Salient Facts from Rhinebeck’s Trees Benefit i-Tree Eco Analysis

- The net air quality improvement provided by the total tree inventory is valued at approximately $984.89 per year with the removal of 609.14 pounds annually. Norway maple and sugar maple are the largest contributors to air quality improvements due to number of individual trees in the inventory.
- Carbon sequestration is 13.93 tons per year and valued at $2,375.33 annually.
- Carbon storage in the form of tree biomass of the inventory amounts to 1,415.45 tons, which accounts for an estimated value of $241,406.48.
- Oxygen produced by the sample tree population amounts to 37.1 tons annually.
- The inventory intercepts 1,065,228.94 gallons of stormwater per year and 211,242.39 gallons of avoided runoff. This is an average of 108 gallons per tree. The total annual value of this benefit is $1,887.66 for an average value of $0.96 per tree.
- The structural value of the inventoried trees of Rhinebeck is $3.5 million dollars (replacement cost).
- The inventory covers 16.19 acres of tree cover and 77.8 acres of leaf area.

SECTION 3: TREE MANAGEMENT PROGRAM

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

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

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

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® 7.7 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. Rhinebeck has a large population of trees that are susceptible to pests and diseases, such as ash, oak, and maple.

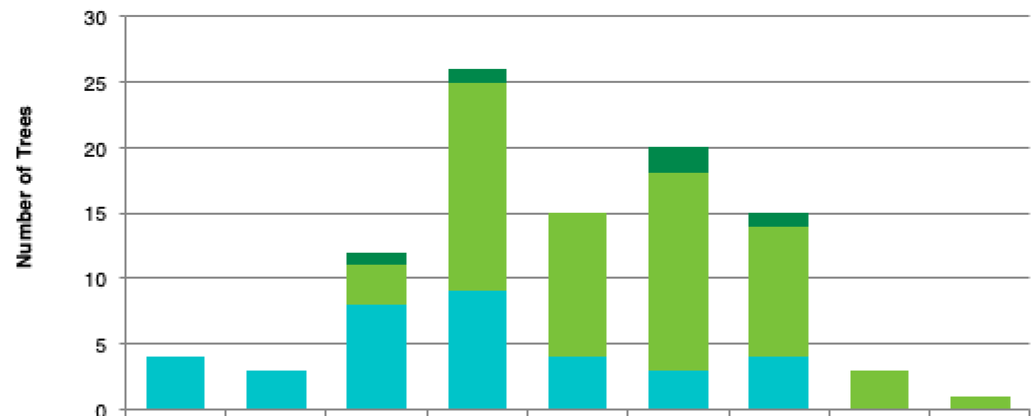
Priority Tree and Stump Removal

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.

Findings

Figure 10 presents tree removals by risk rating and diameter size class. The following sections briefly summarize the recommended removals identified during the inventory.



Risk Rating	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Extreme	0	0	0	0	0	0	0	0	0
High	0	0	1	1	0	2	1	0	0
Moderate	0	0	3	16	11	15	10	3	1
Low	4	3	8	9	4	3	4	0	0

Diameter Size Class

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

The inventory identified 0 Extreme Risk trees, 5 High Risk trees, 56 Moderate Risk trees, and 35 Low Risk trees that are recommended for removal.

The diameter size classes for High Risk trees ranged between 7–18 inches diameter at breast height (DBH) and 25–36 inches DBH. These trees should be removed immediately based on their assigned risk. Extreme and High Risk removals and pruning can be performed concurrently.

Most Moderate Risk trees were smaller than 43 inches DBH. These trees should be removed as soon as possible after all Extreme and High Risk removals and pruning have been completed.

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

The inventory identified 39 stumps recommended for removal. Almost all of these stumps were larger than 4 inches in diameter. Stump removals should occur when convenient.

Recommendations

Unless already slated for removal, trees noted as having poor structure (86 trees) or cavity or decay (147 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.

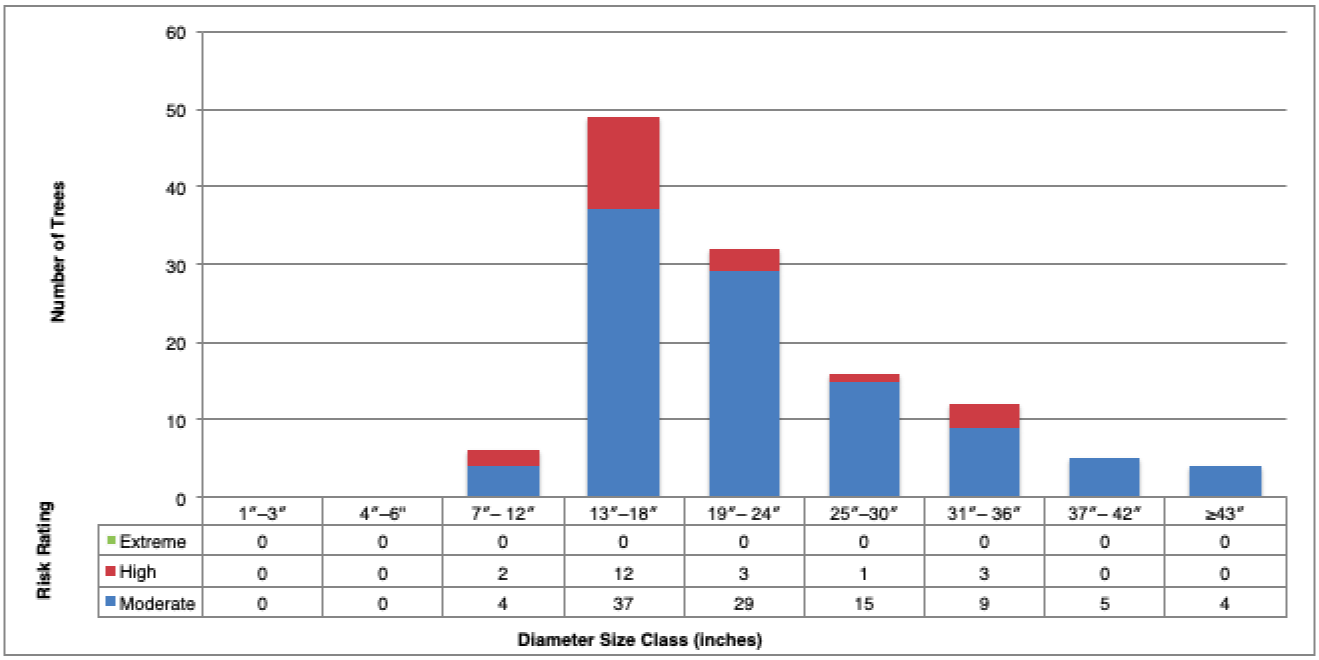
Updating the tree inventory data can streamline workload management and lend insight into setting accurate budgets and staffing levels. Inventory updates should be made electronically and can be implemented using TreeKeeper® 7.7 or similar computer software.

Priority Tree Pruning

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

Findings

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



Risk Rating	1"–3"	4"–6"	7"– 12"	13"–18"	19"– 24"	25"–30"	31"– 36"	37"– 42"	≥43"
Extreme	0	0	0	0	0	0	0	0	0
High	0	0	2	12	3	1	3	0	0
Moderate	0	0	4	37	29	15	9	5	4

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

Recommendations

The inventory identified 0 Extreme Risk trees, 18 High Risk trees, and 103 Moderate Risk trees recommended for pruning.

High Risk trees ranged in diameter size classes from 7–36 inches DBH. This pruning should be performed immediately based on assigned risk and may be performed concurrently with other Extreme and High Risk removals and pruning. Moderate and Low Risk trees recommended for pruning should be included in a proactive, routine pruning cycle after all the higher risk trees are addressed.

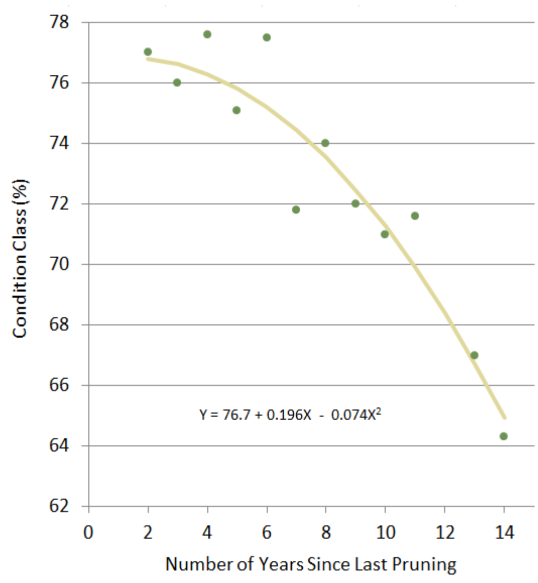


Figure 12. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

Proactive Pruning Cycles

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

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

Why Prune Trees on a Cycle?

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

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

Young Tree Training Cycle

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

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

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

Findings

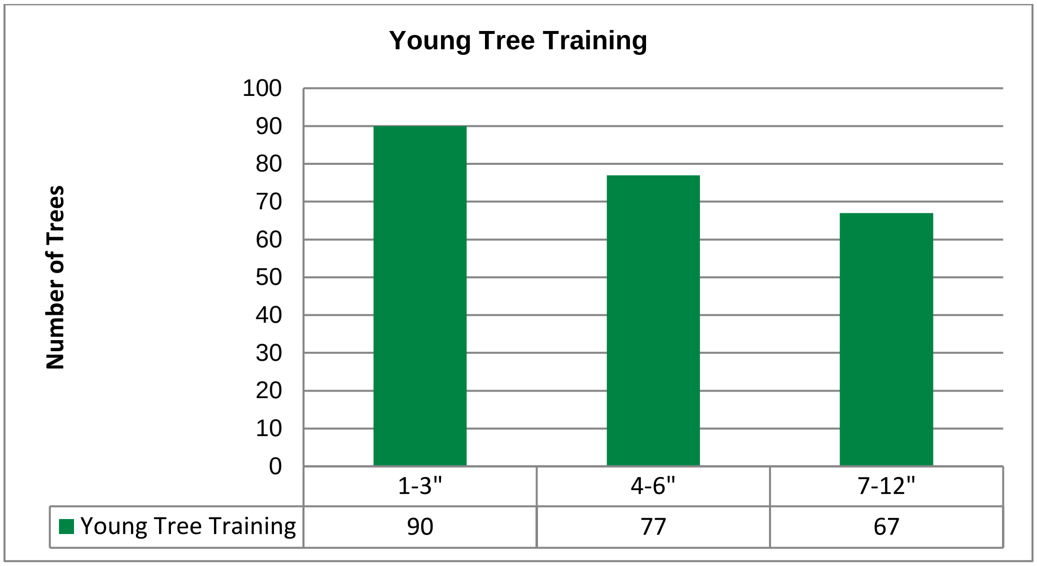


Figure 13. Trees recommended for the YTT Cycle by diameter size class.

Recommendations

DRG recommends that Rhinebeck implement a three-year YTT Cycle to begin after all Extreme and High Risk trees are removed or pruned. The YTT Cycle will include existing young trees. During the inventory, 234 trees smaller than 12 inches DBH were inventoried and recommended for young tree training. Since the number of existing young trees is relatively small, and the benefit of beginning the YTT Cycle is substantial, DRG recommends that an average of 78 trees be structurally pruned each year over 3 years, beginning in Year One of the management program.

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

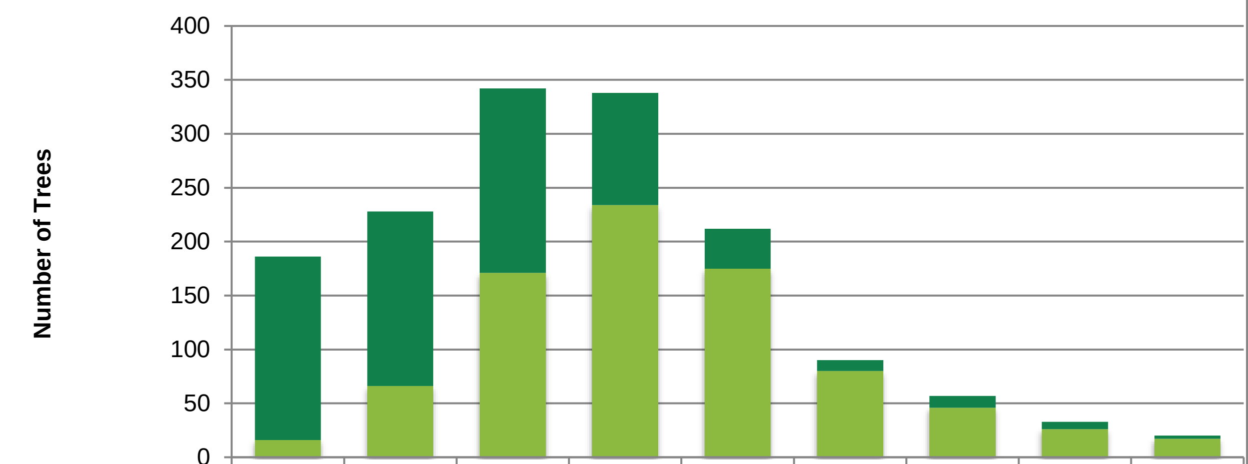
In future years, the number of trees in the YTT Cycle will be based on tree planting efforts and growth rates of young trees. The village should strive to prune approximately one-third of its young trees each year.

Routine Pruning Cycle

The RP Cycle includes established, maturing, and mature trees (mostly greater than 8 inches DBH) that need cleaning, crown raising, and reducing to remove deadwood and improve structure. Over time, routine pruning can reduce reactive maintenance, minimize instances of elevated risk, and provide the basis for a more defensible risk management program. Included in this cycle are Low Risk trees with the primary maintenance being prune or discretionary. These trees 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.

Findings



	1	2	3	4	5	6	7	8	9
Discetionary	170	162	171	104	37	10	11	7	3
Low Risk Prune	16	66	171	234	175	80	46	26	17

Diameter Size Class

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

Recommendations

DRG recommends that the village establish a five-year RP Cycle in which approximately one-fifth of the tree population is to be pruned each year. The 2019 tree inventory identified approximately 1,505 trees that should be pruned over a five-year RP Cycle. An average of 301 trees should be pruned each year over the course of the cycle. DRG recommends that the RP Cycle begin in Year One of this five-year plan, after all Extreme and High Risk trees are pruned.

The inventory found that most trees (80%) on the street ROW needed routine pruning. Figure 14 shows that a variety of tree sizes will require pruning; however, most of the trees that require routine pruning were smaller than 24 inches DBH.

Maintenance Schedule and Budget

Utilizing data from the 2019 Village of Rhinebeck 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 Rhinebeck.

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

To implement the maintenance schedule, the village's tree maintenance budget should be no less than $99,511 for the first year of implementation, no less than $78,160 for the second year, no less than $68,808 for the third year, and no less than $36,327 for the final two years of the maintenance schedule. Annual budget funds are needed to ensure that Extreme and High Risk trees are remediated and that crucial YTT and RP Cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

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

Table 10. Estimated Costs for Five-Year Urban Forestry Management Program

Estimated Costs for Each Activity			2017		2018		2019		2020		2021		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Extreme and High Risk Removal	1-3"	$25	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$105	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$220	2	$440	0	$0	0	$0	0	$0	0	$0	$440
	13-18"	$355	4	$1,420	0	$0	0	$0	0	$0	0	$0	$1,420
	19-24"	$525	4	$2,100	0	$0	0	$0	0	$0	0	$0	$2,100
	25-30"	$845	7	$5,915	0	$0	0	$0	0	$0	0	$0	$5,915
	31-36"	$1,140	8	$9,120	0	$0	0	$0	0	$0	0	$0	$9,120
	37-42"	$1,470	2	$2,940	0	$0	0	$0	0	$0	0	$0	$2,940
	43"+	$1,850	4	$7,400	0	$0	0	$0	0	$0	0	$0	$7,400
Activity Total(s)			**31**	**$29,335**	0	$0	0	$0	0	$0	0	$0	**$29,335**
Moderate and Low Risk Removal	1-3"	$25	0	$0	4	$100	0	$0	0	$0	0	$0	$100
	4-6"	$105	0	$0	2	$210	0	$0	0	$0	0	$0	$210
	7-12"	$220	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$355	0	$0	1	$355	0	$0	0	$0	0	$0	$355
	19-24"	$525	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$845	0	$0	2	$1,690	0	$0	0	$0	0	$0	$1,690
	31-36"	$1,140	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$1,470	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$1,850	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			0	$0	**9**	**$2,355**	0	$0	0	$0	0	$0	**$2,355**
Stump Removal	1-3"	$25	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$25	0	$0	1	$25	0	$0	0	$0	0	$0	$25
	7-12"	$25	0	$0	3	$75	0	$0	0	$0	0	$0	$75
	13-18"	$40	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	19-24"	$60	0	$0	1	$60	0	$0	0	$0	0	$0	$60
	25-30"	$85	0	$0	3	$255	0	$0	0	$0	0	$0	$255
	31-36"	$110	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$130	0	$0	3	$390	0	$0	0	$0	0	$0	$390
	43"+	$160	0	$0	1	$160	0	$0	0	$0	0	$0	$160
Activity Total(s)			0	$0	**12**	**$965**	0	$0	0	$0	0	$0	**$965**
High Risk Prune	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$120	1	$120	0	$0	0	$0	0	$0	0	$0	$120
	19-24"	$170	4	$680	0	$0	0	$0	0	$0	0	$0	$680
	25-30"	$225	8	$1,800	0	$0	0	$0	0	$0	0	$0	$1,800
	31-36"	$305	14	$4,270	0	$0	0	$0	0	$0	0	$0	$4,270
	37-42"	$380	7	$2,660	0	$0	0	$0	0	$0	0	$0	$2,660
	43"+	$590	3	$1,770	0	$0	0	$0	0	$0	0	$0	$1,770
Activity Total(s)			**37**	**$11,300**	0	$0	0	$0	0	$0	0	$0	**$11,300**
Routine Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	4	$120	4	$120	4	$120	4	$120	4	$120	$600
	7-12"	$75	13	$975	13	$975	13	$975	13	$975	13	$975	$4,875
	13-18"	$120	18	$2,160	18	$2,160	18	$2,160	18	$2,160	18	$2,160	$10,800
	19-24"	$170	10	$1,700	10	$1,700	10	$1,700	10	$1,700	10	$1,700	$8,500
	25-30"	$225	9	$2,025	9	$2,025	9	$2,025	9	$2,025	9	$2,025	$10,125
	31-36"	$305	5	$1,525	5	$1,525	5	$1,525	5	$1,525	5	$1,525	$7,625
	37-42"	$380	2	$760	2	$760	2	$760	2	$760	2	$760	$3,800
	43"+	$590	2	$1,180	2	$1,180	2	$1,180	2	$1,180	2	$1,180	$5,900
Activity Total(s)			**63**	**$10,445**	**63**	**$10,445**	**63**	**$10,445**	**63**	**$10,445**	**63**	**$10,445**	**$52,225**
Young Tree Training Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	18	$540	18	$540	18	$540	18	$540	18	$540	$2,700
	7-12"	$75	7	$525	7	$525	7	$525	7	$525	7	$525	$2,625
Activity Total(s)			**25**	**$1,065**	**25**	**$1,065**	**25**	**$1,065**	**25**	**$1,065**	**25**	**$1,065**	**$5,325**
Tree Planting	Purchasing	$110	35	$3,850	35	$3,850	35	$3,850	35	$3,850	35	$3,850	$19,250
	Planting	$110	35	$3,850	35	$3,850	35	$3,850	35	$3,850	35	$3,850	$19,250
Activity Total(s)			**70**	**$7,700**	**70**	**$7,700**	**70**	**$7,700**	**70**	**$7,700**	**70**	**$7,700**	**$38,500**
Activity Grand Total			**226**		**179**		**158**		**158**		**158**		**879**
Cost Grand Total				**$59,845**		**$22,530**		**$19,210**		**$19,210**		**$19,210**	**$140,005**

CONCLUSIONS

Every hour of every day, public trees in Rhinebeck are supporting and improving the quality of life. The village's trees provide an annual benefit of $5,247.88. 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 village 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 village's trees, Rhinebeck is well positioned to thrive. If the management program is successfully implemented, the health and safety of Rhinebeck's trees and citizens will be maintained for years to come.

Photograph 4. *A street well stocked with trees provides economic, environmental, and social benefits, including temperature moderation, reduction of air pollutants, energy conservation, and increased property values.*

Inventory and Plan Updates

DRG recommends that the inventory and management plan be updated using an appropriate computer software program so that the village 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 village 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® 7.7 as work is performed. Add new tree work to the schedule when work is identified through inspections or a citizen call process.
- Re-inventory the street ROW, and update all data fields in five years, or a portion of the population (1/5) every year over the course of five years.
- Revise the *Tree Management Plan* after five years when the re-inventory has been completed.

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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:

- overhead utilities
- address
- block side
- street
- on street
- area
- hardscape damage
- primary maintenance needs
- secondary maintenance
- mapping coordinates
- inventory date
- risk assessment completion
- risk assessment
- risk rating
- residual risk
- species
- stems
- location (ROW or BROW)
- tree size*
- condition
- defect
- grow space type
- further inspection
- 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 electronic ESRI® shapefile, Access™ database, and Microsoft Excel™ spreadsheet that accompanies this plan.

Site Location Methods

Equipment and Base Maps

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

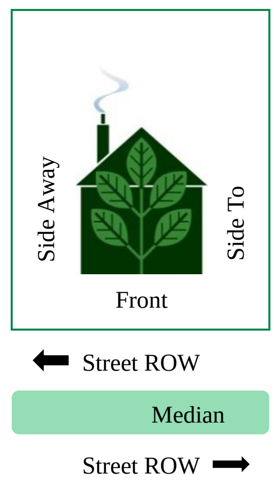
Base map layers were loaded onto these unit(s) to help locate sites during the inventory. The table below lists the base map layers, utilized along with source and format information for each layer.

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
1ft Aerial Imagery NY GIS Clearinghouse	2016	NAD 1983 StatePlane New York East; Feet
Basemaps Dutchess County GIS	2018-2019	NAD 1983 StatePlane New York East; Feet

Street ROW Site Location

Individual street ROW sites (trees, stumps, or planting sites) were located using a methodology that identifies sites by *address number*, *street name*, *side*, *site number*, or *block side*. 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 and Site Number

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

All sites at an address are assigned a *site number*. Site 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 was a two-way street; therefore, some site numbers will oppose traffic.

A separate site number sequence is used for each side value of the address (*front*, *side to*, *side away*, *median*, or *rear*). For example, trees at the front of an address may have site numbers from 1 through 999; if trees are located on the *side to*, *side away*, *median*, or *rear* of that same address, each side will also be numbered consecutively beginning with the number 1.

Block Side

Block side information for a site includes the *on street*, *from street*, and *to street*.

- The *on street* is the street on which the site is located. The *on street* may not match the address street. A site may be physically located on a street that is different from its street address (i.e., a site located on a side street).
- The *from street* is the first cross street encountered when proceeding along the street in the direction of traffic flow.
- The *to street* is the second cross street encountered when moving in the direction of traffic flow.

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*, *from street*, and *to street* would be the park and/or public space's name (not street names).

Site Location Examples

The tree trimming crew in the truck traveling westbound on E. Mac Arthur Street is trying to locate an inventoried tree with the following location information:

Address/Street Name:	226 E. Mac Arthur Street
Side:	Side To
Site Number:	1
On Street:	Davis Street
From Street:	Taft Street
To Street:	E. Mac Arthur Street

The tree site circled in red signifies the crew's target site. Because the tree is located on the side of the lot, the *on* street is Davis Street, even though it is addressed as 226 East Mac Arthur Street. Moving with the flow of traffic, the *from* street is Taft Street, and the *to* street is East Mac Arthur Street.

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

Corner Lot A

Address/Street Name: 205 Hoover St.
Side/Site Number: Side To / 1
On Street: Taft St.
From Street: E Mac Arthur St.
To Street: Hoover St.

Address/Street Name: 205 Hoover St.
Side/Site Number: Side To / 2
On Street: Taft St.
From Street: E Mac Arthur St.
To Street: Hoover St.

Address/Street Name: 205 Hoover St.
Side/Site Number: Side To / 3
On Street: Taft St.
From Street: 19th St.
To Street: Hoover St.

Address/Street Name: 205 Hoover St.
Side/Site Number: Front / 1
On Street: Hoover St.
From Street: Taft St.
To Street: Davis St.

Corner Lot B

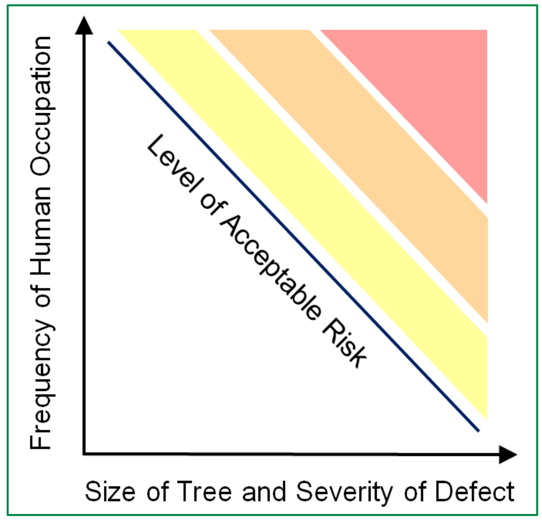
Address/Street Name: 226 E Mac Arthur St.
Side/Site Number: Side To / 1
On Street: Davis St.
From Street: Hoover St.
To Street: E Mac Arthur St.

Address/Street Name: 226 E Mac Arthur St.
Side/Site Number: Front / 1
On Street: E Mac Arthur St.
From Street: Davis St.
To Street: Taft St.

Address/Street Name: 226 E Mac Arthur St.
Side/Site Number: Front / 2
On Street: E Mac Arthur St.
From Street: Davis St.
To Street: Taft St.

APPENDIX B
RISK ASSESSMENT/PRIORITY AND PROACTIVE MAINTENANCE

Risk Assessment



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

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

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

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

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

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

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

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

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

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

Trees with elevated (Extreme or High) risk levels are usually recommended for removal or pruning to eliminate the defects that warranted their risk rating. However, in some situations, risk may be reduced by adding support (cabling or bracing) or by moving the target away from the tree. DRG recommends only removal or pruning to alleviate risk. But in special situations, such as a memorial tree or a tree in a historic area, 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 Village 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

Priority Maintenance

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

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

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

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

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

Proactive Maintenance

Proactive tree maintenance requires that trees are managed and maintained under the responsibility of an individual, department, or agency. Tree work is typically performed during a cycle. Individual tree health and form are routinely addressed during the cycle. When trees are planted, they are planted selectively and with purpose. Ultimately, proactive tree maintenance should reduce crisis situations in the urban forest, as every tree in the inventoried population is regularly visited, assessed, and maintained. DRG recommends proactive tree maintenance that includes pruning cycles, inspections, and planned tree planting.

APPENDIX C
RECOMMENDED SPECIES FOR FUTURE PLANTING

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout Zones 5 and 6 on the USDA Plant Hardiness Zone Map.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
*Betula alleghaniensis**	yellow birch	
*Betula lenta**	sweet birch	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
*Carya illinoensis**	pecan	
*Carya lacinata**	shellbark hickory	
*Carya ovata**	shagbark hickory	
*Castanea mollissima**	Chinese chestnut	
Celtis laevigata	sugarberry	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(Numerous exist)
Ginkgo biloba	ginkgo	(Choose male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Juglans nigra**	black walnut	
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
*Liriodendron tulipifera**	tuliptree	'Fastigiatum'
*Magnolia acuminata**	cucumbertree magnolia	(Numerous exist)
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	blackgum	
*Platanus occidentalis**	American sycamore	
Platanus × acerifolia	London planetree	'Yarwood'
Quercus alba	white oak	

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

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

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus × carnea	red horsechestnut	
Alnus cordata	Italian alder	
*Asimina triloba**	pawpaw	
Cladrastis kentukea	American yellowwood	'Rosea'
Corylus colurna	Turkish filbert	
Eucommia ulmoides	hardy rubber tree	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	American hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense	Amur corktree	'Macho'
Pistacia chinensis	Chinese pistache	
Prunus maackii	Amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
*Pterocarya fraxinifolia**	Caucasian wingnut	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
*Sassafras albidum**	sassafras	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	(Numerous exist)
Amelanchier laevis	Allegheny serviceberry	
*Carpinus caroliniana**	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
Chionanthus virginicus	white fringetree	
Cornus alternifolia	pagoda dogwood	
Cornus kousa	kousa dogwood	(Numerous exist)
Cornus mas	corneliancherry dogwood	'Spring Sun'
Corylus avellana	European filbert	'Contorta'
*Cotinus coggygria**	common smoketree	'Flame'
*Cotinus obovata**	American smoketree	
Crataegus phaenopyrum*	Washington hawthorn	Princeton Sentry™
Crataegus viridis	green hawthorn	'Winter King'
*Franklinia alatamaha**	Franklinia	
*Halesia tetraptera**	Carolina silverbell	'Arnold Pink'
Laburnum × watereri	goldenchain tree	
Maackia amurensis	Amur maackia	
*Magnolia × soulangiana**	saucer magnolia	'Alexandrina'
*Magnolia stellata**	star magnolia	'Centennial'
*Magnolia tripetala**	umbrella magnolia	
*Magnolia virginiana**	sweetbay magnolia	Moonglow®
Malus spp.	flowering crabapple	(Disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
Prunus subhirtella	Higan cherry	'Pendula'
Prunus virginiana	common chokecherry	'Schubert'
*Staphylea trifolia**	American bladdernut	
Stewartia ovata	mountain stewartia	
*Styrax japonicus**	Japanese snowbell	'Emerald Pagoda'
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

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

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

APPENDIX D
TREE PLANTING

Tree Planting

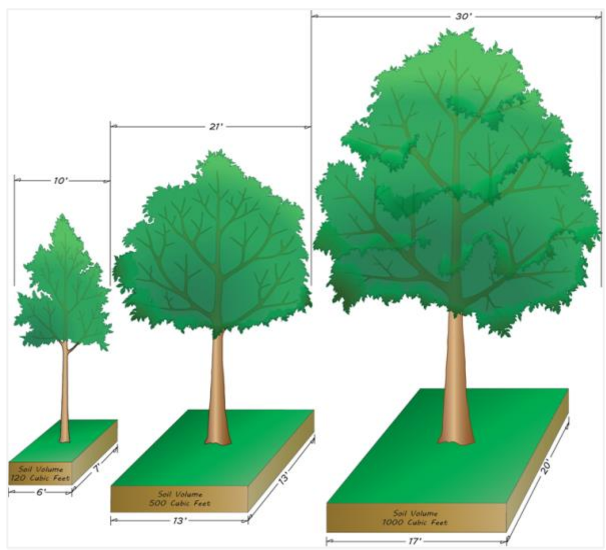
Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the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

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

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

Inventoried Street ROW Planting Space

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



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

Findings

The inventory found 703 planting sites, of which 22% are designated for small-sized mature trees, 21% for medium-sized trees, and 57% 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.

Rhinebeck is located in USDA Hardiness Zone 5b, which is identified as a climatic region with average annual minimum temperatures between −15°F and −10°F. Tree species selected for planting in Rhinebeck should be appropriate for this zone.

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

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

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

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

DRG recommends limiting the planting of *Acer* (maple) species until the species distribution normalizes. Of the inventoried population, *Acer platanoides (*Norway maple) already occupied 17%, 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 village 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 village'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 village'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 village's urban forestry program and encourage tree planting on private property. Rhinebeck should encourage citizens to water trees on the ROW adjacent to their homes and to reach out to the village 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

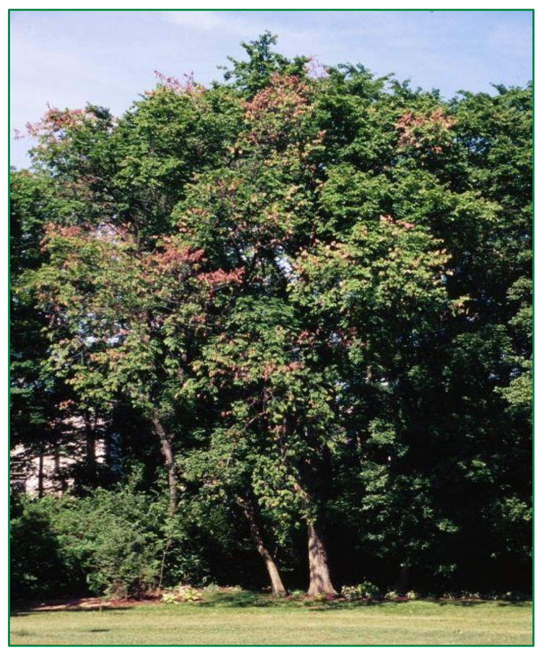
Adults are large (3/4- to 1/2-inch long) with very long, black and white banded antennae. The body is glossy black with irregular white spots. Adults can be seen from late spring to fall depending on the climate. ALB has a long list of host species; however, the beetle prefers hardwoods, including several 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).

Dutch Elm Disease

Considered by many to be one of the most destructive, invasive diseases of shade trees in the United States, Dutch elm disease (DED) was first found in Ohio in 1930; by 1933, the disease was present in several East Coast cities. By 1959, it had killed thousands of elms. Today, DED covers about two-thirds of the eastern United States, including Illinois, and annually kills many of the remaining and newly planted elms. The disease is caused by a fungus that attacks the vascular system of elm trees blocking the flow of water and nutrients, resulting in rapid leaf yellowing, tree decline, and death.

There are two closely-related fungi that are collectively referred to as DED. The most common is *Ophiostoma novo-ulmi*, which is thought to be responsible for most of the elm deaths since the 1970s. The fungus is transmitted to healthy elms by elm bark beetles. Two species carry the fungus: native elm bark beetle (*Hylurgopinus rufipes*) and European elm bark beetle (*Scolytus multistriatus)*.

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

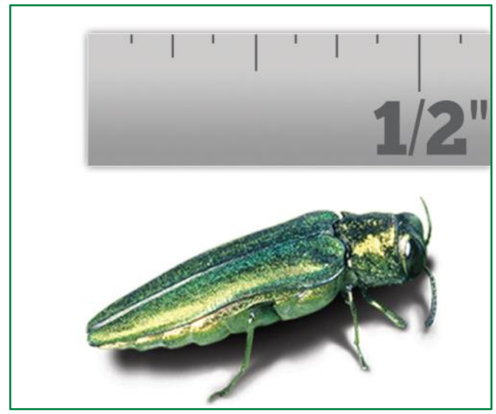


Branch death, or flagging, at multiple locations in the crown of a diseased elm

Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011)

Emerald Ash Borer

Emerald ash borer *(EAB) (Agrilus planipennis*) is responsible for the death or decline of tens of millions of ash trees in 14 states in the American Midwest and Northeast. Native to Asia, EAB has been found in China, Japan, Korea, Mongolia, eastern Russia, and Taiwan. It likely arrived in the United States hidden in wood-packing materials commonly used to ship consumer goods, auto parts, and other products. The first official United States identification of EAB was in southeastern Michigan in 2002.



Close-up of the emerald ash borer

Photograph courtesy of APHIS (2011)

Adult beetles are slender and 1/2-inch long. Males are smaller than females. Color varies but adults are usually bronze or golden green overall with metallic, emerald-green wing covers. The top of the abdomen under the wings is metallic, purplish-red and can be seen when the wings are spread.

The EAB-preferred host tree species are in the genus *Fraxinus* (ash).

Gypsy Moth

The gypsy moth (GM) *(Lymantria dispar*) is native to Europe and first arrived in the United States in Massachusetts in 1869. This moth is a significant pest because its caterpillars have an appetite for more than 300 species of trees and shrubs. GM caterpillars defoliate trees, which makes the species vulnerable to diseases and other pests that can eventually kill the tree.

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

Photograph courtesy of APHIS (2011b)

Male GMs are brown with a darker brown pattern on their wings and have a 1/2-inch wingspan. Females are slightly larger with a 2-inch wingspan and are nearly white with dark, saw-toothed patterns on their wings. Although they have wings, the female GM cannot fly.

The GMs prefer approximately 150 primary hosts but feed on more than 300 species of trees and shrubs. Some trees are found in these common genera: *Betula* (birch), *Juniperus* (cedar), *Larix* (larch), *Populus* (aspen, cottonwood, poplar), *Quercus* (oak), and *Salix* (willow).

Granulate Ambrosia Beetle

Adult granulate ambrosia beetle

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

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

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

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

Spotted Lanternlfy

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

Profile of spotted lanternfly adult at rest

Photograph courtesy of Pennsylvania Department of Agriculture

Adult spotted lanternfly are approximately 1 inch long and 1/2 inch wide, and they have large and visually striking wings. Their forewings are light brown with black spots at the front and a speckled band at the rear. Their hind wings are scarlet with black spots at the front and white and black bars at the rear. Their abdomen is yellow with black bars. Nymphs in their early stages of development appear black with white spots and turn to a red phase before becoming adults. Egg masses are yellowish-brown in color, covered with a gray, waxy coating prior to hatching.

The spotted lanternfly lays its eggs on smooth host plant surfaces and on non-host material, such as bricks, stones, and dead plants. Eggs hatch in the spring and early summer, and nymphs begin feeding on a wide range of host plants by sucking sap from young stems and leaves. Adults appear in late July and tend to focus their feeding on tree-of-heaven (*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.

Hemlock Woolly Adelgid

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

Hemlock woolly adelgids on a branch

Photograph courtesy of USDA Forest Service (2011a)

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

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

Oak Wilt

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

Oak wilt symptoms on red and white oak leaves

Photograph courtesy of USDA Forest Service (2011a)

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

Sudden Oak Death

The causal agent of sudden oak death (SOD, also known as *Phytophthora* canker disease), *Phytophthora ramorum*, was first identified in 1993 in Germany and the Netherlands on ornamental rhododendrons. In 2000, the disease was found in California. Since its discovery in North America, SOD has been confirmed in forests in California and Oregon and in nurseries in British Columbia, California, Oregon, and Washington. SOD has been potentially introduced into other states through exposed nursery stock. Through ongoing surveys, APHIS continues to define the extent of the pathogen's distribution in the United States and limit its artificial spread beyond infected areas through quarantine and a public education program.

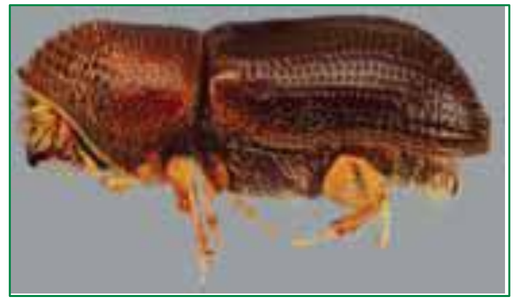
Drooping tanoak shoot

Photograph courtesy of Indiana Department of Natural Resources (2012)

- Identification and symptoms of SOD may include large cankers on the trunk or main stem accompanied by browning of leaves. Tree death may occur within several months to several years after initial infection. Infected trees may also be infested with ambrosia beetles (*Monarthrum dentiger* and *M. scutellarer*), bark beetles (*Pseudopityophthorus pubipennis*), and sapwood rotting fungus (*Hypoxylon thouarsianum*). These organisms may contribute to the death of the tree. Infection on foliar hosts is indicated by dark grey to brown lesions with indistinct edges. These lesions can occur anywhere on the leaf blade, in vascular tissue, or on the petiole. Petiole lesions are often accompanied by stem lesions. Some hosts with leaf lesions defoliate and eventually show twig dieback.

This pathogen is devastating to *Quercus* (oak) but also affects several other plant species.

Thousand Cankers Disease



Walnut twig beetle, side view

Photograph courtesy of USDA Forest Service (2011b)

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.

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 walnut.

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