TREE MANAGEMENT PLAN

Town of Clarence, New York

November 2019

Prepared for:
Town of Clarence
One Town Place
Clarence, New York 14031

Prepared by:
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MISSION STATEMENT

The Town of Clarence will facilitate the care and expansion of its public tree program. We will practice environmental stewardship in our decision-making, ensuring the quality of our public trees for the benefit and enjoyment of existing and future generations. Through maintenance of our existing trees and replacement of previously removed trees to new tree planting, the Town of Clarence will pursue all opportunities to protect and expand its public trees network.

ACKNOWLEDGMENTS

This plan was completed by joint efforts of Town Officials, Staff, Boards, and Committees with professional guidance and expertise by Davey Resource Group, Inc. “DRG”. The contents herein shall serve as an addendum to Clarence 2030, the Town’s Comprehensive Plan, providing a framework for future decision-making and guidance to local leaders.

Funding of this plan was made possible by the New York State Department of Conservation, through an Urban and Community Forestry Grant Program.

Town Officials

Patrick Casilio, Supervisor

Peter DiCostanzo, Deputy Supervisor

Robert Geiger, Councilman

Christopher Greene, Councilman

Paul Shear, Councilman

James Dussing, Superintendent of Highways

Nancy Metzger, Town Clerk

Tree Management Plan Committee

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EXECUTIVE SUMMARY

This plan was developed for the town of Clarence by DRG with a focus on addressing short-term and long-term maintenance needs for inventoried public trees. DRG completed a tree inventory in May 2019 for a select segment of public trees to gain an understanding of the needs of the existing urban forest and to project a recommended maintenance schedule for tree care. Analysis of inventory data and information about the town's existing program and vision for the urban forest were utilized to develop this *Tree Management Plan*. Also included in this plan are economic, environmental, and social benefits provided by the trees through an i-Tree Eco analysis.

State of the Existing Urban Forest

The May 2019 inventory included trees, stumps, and planting sites along town-selected public street rights-of-way (ROW). A total of 5,570 sites were recorded during the inventory: 2,813 trees, 45 stumps, and 2,757 planting sites. Analysis of the tree inventory data found the following:

- Two species, *Picea pungens* (blue spruce) and *Acer platanoides* (Norway maple), comprise a large percentage of the selected inventory (13% and 12%, respectively) and threaten biodiversity.
- The diameter size class distribution of the inventoried tree population trends toward the ideal, with a greater number of older trees than young trees, creating a future concern for tree population numbers.
- The overall condition of the inventoried tree population is rated Fair.
- Approximately 38% of the inventoried trees had dead or dying parts identified.
- Approximately 4% of the inventoried trees had an overhead clearance issue.
- Ambrosia beetle and Asian longhorned beetle pose the biggest threats to the health of the inventoried population.
- The inventoried trees have an estimated structural value of approximately $6 million dollars. This includes $385,000 in amassed carbon storage of the inventoried trees.
- Trees provide approximately $11,000 in the following functional annual ecobenefits:
    - *Air quality*: 1,630 pounds of pollutants removed valued at $180 per year.
    - *Annual carbon sequestered*: 25.94 tons valued at $4,420 per year.
    - *Avoided stormwater runoff:* 98,340 ft^3 valued at $6,570 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, stump removal, routine pruning (RP cycle), young tree training (YTT cycle), and tree planting. Maintenance should be prioritized by addressing trees with the highest risk first. High Risk 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.

Clarence'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 90 young trees should be structurally pruned each year during the young tree training cycle, and approximately 1,800 trees should be cleaned each year during the routine pruning cycle.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind). DRG recommends planting at least 50 trees of a variety of species each year to offset these losses, increase canopy, maximize benefits, and account for ash tree loss.

Tree planting should focus on replacing tree canopy recommended for removal and establishing new canopy in areas that promote economic growth, such as business districts, recreational areas, trails, parking lots, areas near buildings with insufficient shade, and areas where there are gaps in the existing canopy. Various tree species should be planted; however, the planting of *Acer* (maple) should be limited until the species distribution normalizes.

Urban Forest Program Needs

Adequate funding will be needed for the town to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this five-year program is $120,000. This total will decrease to approximately $80,000 by Year 5 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 typically involves proactive maintenance, which is generally less costly. Budgets for later years are thus projected to be lower. It is important to note the above budget estimates include the planting and maintenance of 50 trees planted annually which is approximately $25,000.

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 complement other infrastructure. Keeping the inventory up-to-date using TreeKeeper® or similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

Clarence 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. The below budget figures are only based upon the town-specified sections of the inventory and not the entire possible inventory of all the public trees managed by Clarence.

FY 2020 / Year 1 **$119,322**

- 21 High Risk Removals
- 1 High Risk Prune
- 24 Moderate or Low Risk Removals
- 8 Stump Removals
- 50 Trees Recommended for Planting and Follow-Up Care
- Routine Pruning Cycle: 1/5 of Public Trees Cleaned (5-year cycle)
- Young Tree Training Cycle: 30 Trees (3-year cycle)
- Newly Found Priority Tree Work: Costs TBD

FY 2021 / Year 2 **$107,590**

- 50 Moderate and Low Risk Removals
- 16 Stump Removals
- Routine Pruning Cycle: 1/5 of Public Trees Cleaned (5-year cycle)
- Young Tree Training Cycle: 30 Trees (3-year cycle)
- 50 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work: Costs TBD

FY 2022 / Year 3 **$95,284**

- 56 Moderate and Low Risk Removals
- 15 Stump Removals
- Routine Pruning Cycle: 1/5 of Public Trees Cleaned (5-year cycle)
- Young Tree Training Cycle: 30 Trees (3-year cycle)
- 50 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work: Costs TBD

FY 2023 / Year 4 **$88,043**

- 65 Moderate and Low Risk Removals
- 6 Stump Removals
- Routine Pruning Cycle: 1/5 of Public Trees Cleaned (5-year cycle)
- Young Tree Training Cycle: 30 Trees (3-year cycle)
- 50 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work: Costs TBD

FY2024 / Year 5 **$81,410**

- 6 Stump Removals
- Routine Pruning Cycle: 1/5 of Public Trees Cleaned (5-year cycle)
- Young Tree Training Cycle: 30 Trees (3-year cycle)
- 50 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work: Costs TBD

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INTRODUCTION

The town of Clarence is home to more than 32,000 full-time residents who enjoy the beauty and benefits of their urban forest. The town's forestry program is segmented into two parts. The Highway Department is responsible for the street trees and the Parks Department is responsible for the trees in the parks.

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 May 2019, Clarence 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. There were town-designated areas where the inventory occurred. Appendix A in this report provides details of the areas inventoried. 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 Streets benefits analysis conducted for Clarence.
- *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 July 2019, DRG arborists assessed and inventoried trees, stumps, and planting sites along specific locations within the Town of Clarence. Appendix A provides the town-supplied map and designated streets including the inventoried sites. A total of 5,615 sites were collected during the inventory: 2,813 trees, 45 stumps, and 2,757 planting sites. Figure 1 provides a detailed breakdown of the number and type of sites inventoried.

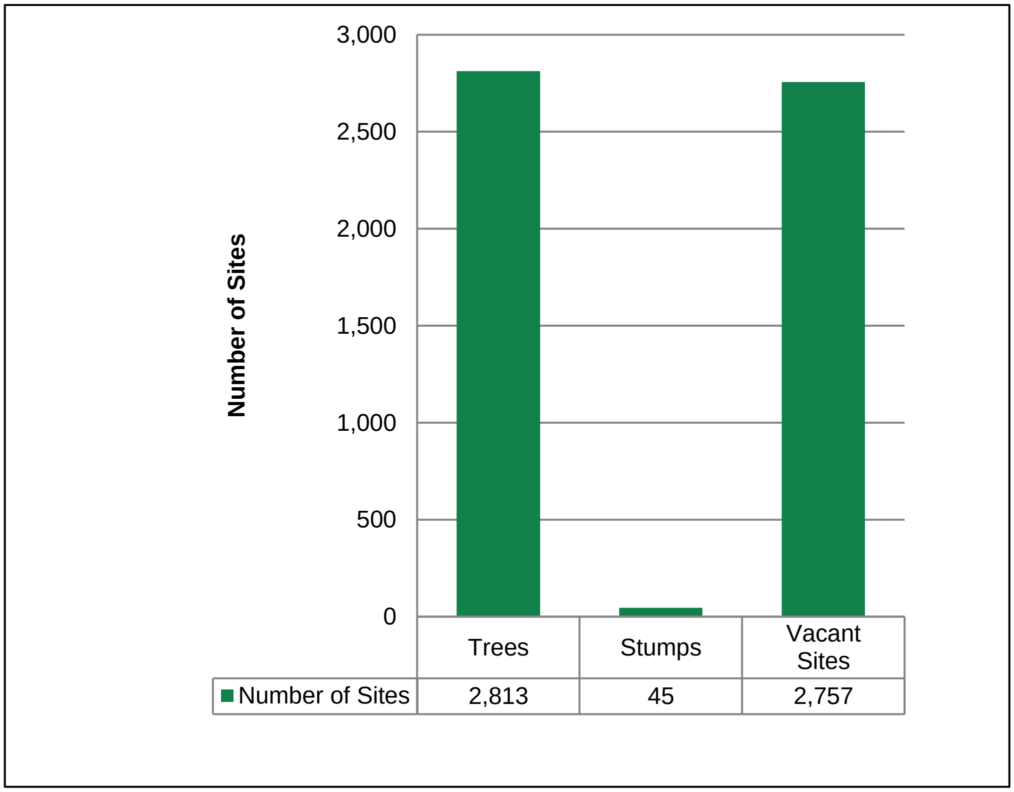


Figure 1. Sites collected during the 2019 inventory.

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 B for more information on data collection and site location methods. In this plan, the following criteria and indicators of the inventoried tree population were assessed:

- *Species Diversity*, the variety of species in a specific population, affects the population's ability to withstand threats from invasive pests and diseases. Species diversity also impacts tree maintenance needs and costs, tree planting goals, and canopy continuity.

- *Diameter Size Class Distribution Data*, the statistical distribution of a given tree population's trunk-size class, is used to indicate the relative age of a tree population. The diameter size class distribution affects the valuation of tree-related benefits as well as the projection of maintenance needs and costs, planting goals, and canopy continuity.
- *Condition*, the general health of a tree population, indicates how well trees are performing given their site-specific conditions. General health affects both short-term and long-term maintenance needs and costs as well as canopy continuity.

Photograph 1. *Davey's ISA Certified Arborists inventoried trees along select areas to collect information about trees that could be used to assess the state of the urban forest.*

- *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.

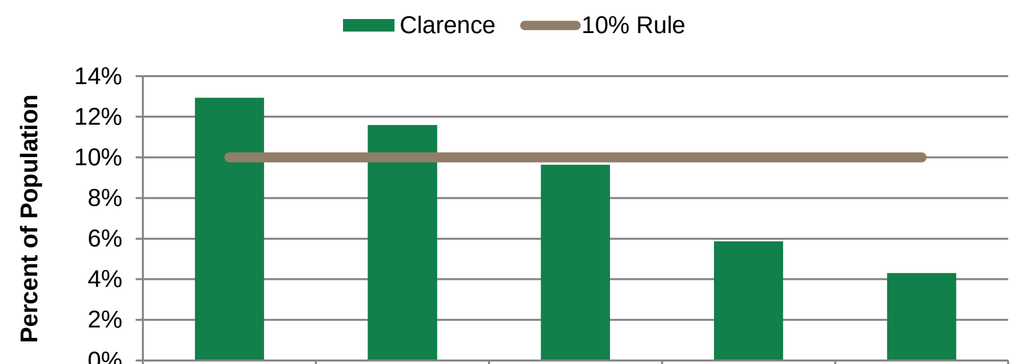
Species Diversity

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 northeastern communities were stripped of most of their mature shade trees, creating a drastic void in canopy cover. Many of these communities have replanted to replace the lost elm trees. Ash and maple trees were popular replacements for American elm in the wake of Dutch elm disease. Unfortunately, some of the replacement species for American elm trees are now overabundant, which is a biodiversity concern. Emerald ash borer (EAB) 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. Currently, the ash population has had severe losses throughout the Northeast and Midwest due to the expanding range of EAB.

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

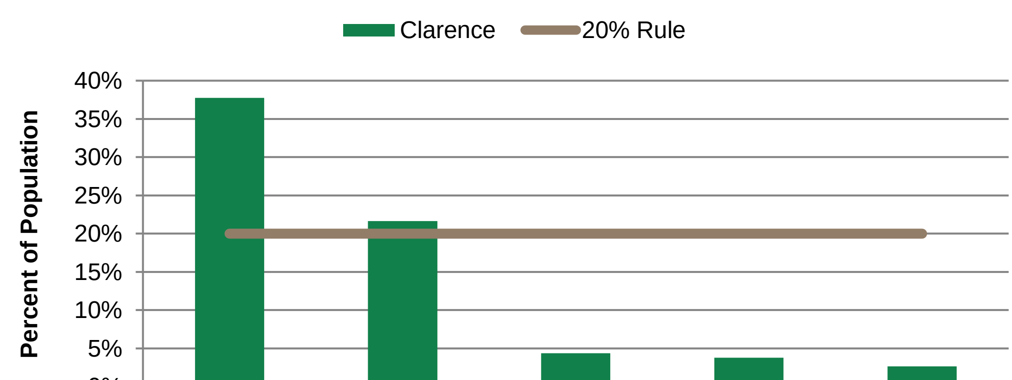
Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory of the identified segments of Clarence. *Picea pungens* (blue spruce) and *Acer platanoides* (Norway maple) exceed the recommended 10% maximum for a single species in a population, comprising 13% and 12% of the inventoried tree population, respectively. *Acer saccharinum* (silver maple) has reached the 10% threshold.



	blue spruce	Norway maple	silver maple	Norway spruce	callery pear
Clarence	13%	12%	10%	6%	4%
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 of the specified populations. *Acer* (maple) and *Pyrus* (pear) exceed the recommended 20% maximum for a single genus in a population, comprising 38% and 22%, respectively, of the inventoried tree population.



	maple	pear	lilac	apple	ash
Clarence	38%	22%	4%	4%	3%
20% Rule	20%	20%	20%	20%	20%

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

Discussion/Recommendations

Acer (maple) dominate the inventory. 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 Clarence's urban forest is sustainable and resilient to future invasive pest infestations.

Considering the large quantity of *Acer* (maple) in Clarence's inventoried trees, consider planting other genera to add diversity to the plantings. See Appendix C for a recommended tree species list for planting in the region.

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.

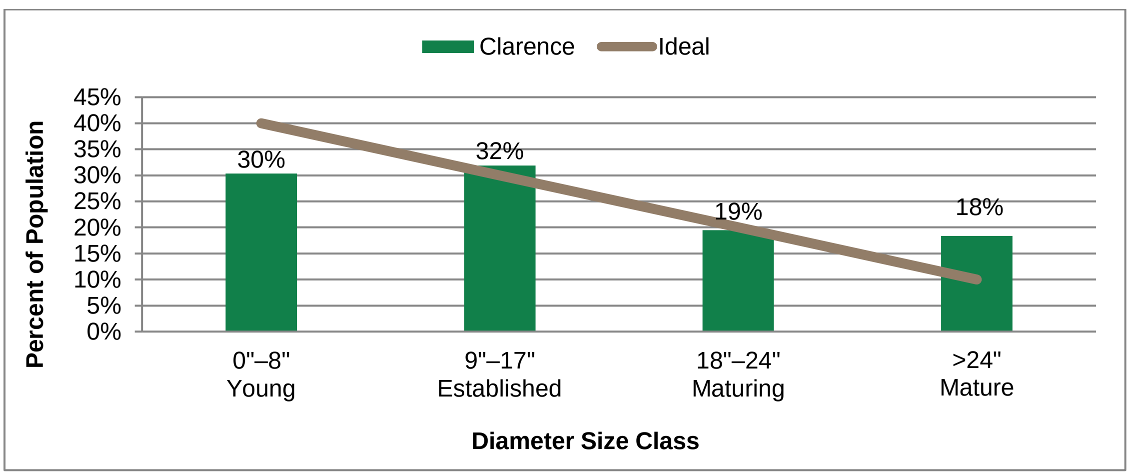


Figure 4. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Findings

Figure 4 compares Clarence's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). Clarence's select distribution trends toward the ideal, but there is some concern with the mature and young tree cohorts. Within the inventoried trees, there are considerably fewer young trees and larger than ideal mature trees. The established and maturing trees are in an acceptable range.

Discussion

There can be a multitude of reasons of why a street tree population is away from the ideal guideline. In this case, there may be issue with evaluating defined segments within the entire street tree population. Evaluating the entire inventory should provide additional insight.

Clarence should 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. Evaluation of the potential site for correct tree species is important for longer term survival of the tree. The town must promote tree preservation and proactive tree care to ensure the long-term survival of older trees. See Appendix C for a recommended tree species list for planting. See Appendix D for more information on risk assessment and priority maintenance. Additionally, tree planting and tree care will allow the distribution to normalize over time.

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.

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.

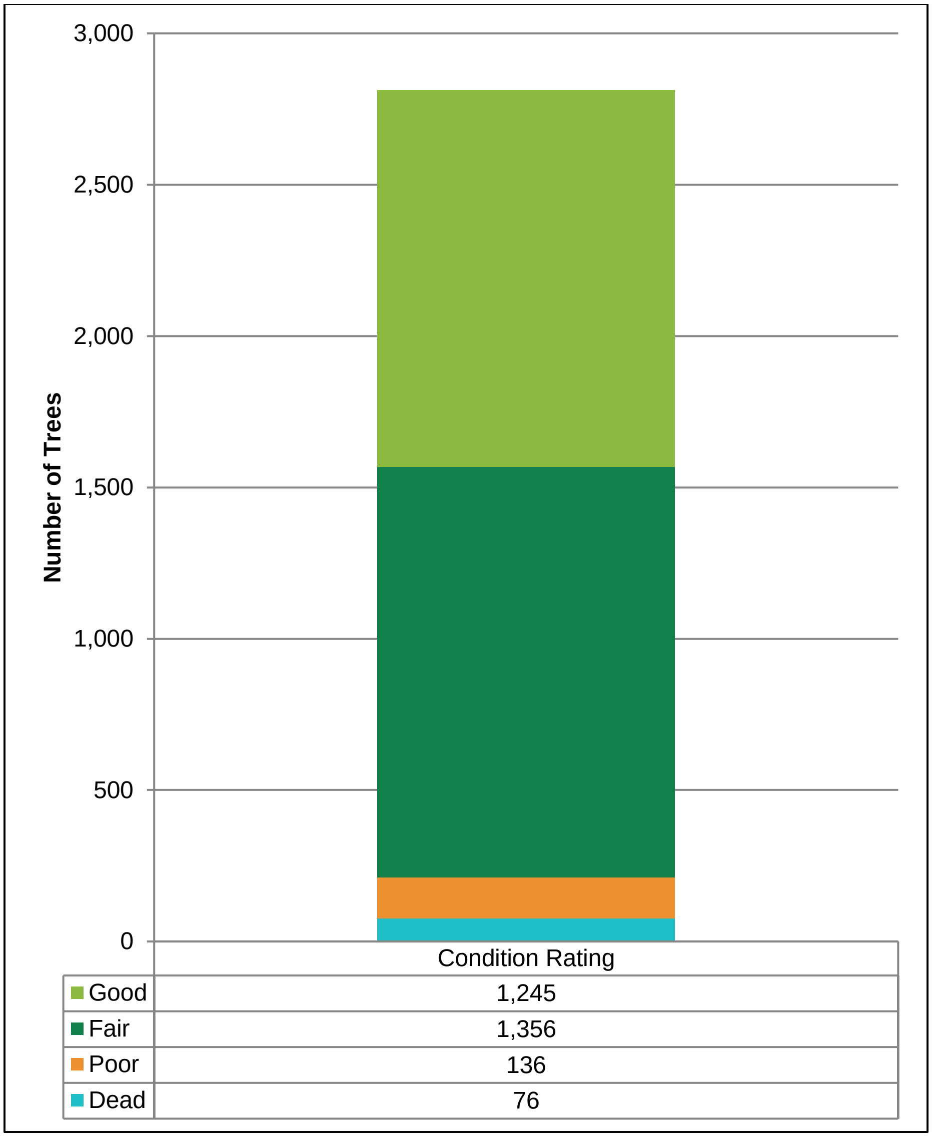


Figure 5. Conditions of inventoried trees.

Findings

Most of the inventoried trees were recorded to be in Good or Fair condition, 44% and 48%, 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 condition, and that most of the mature trees were rated to be in Fair condition.

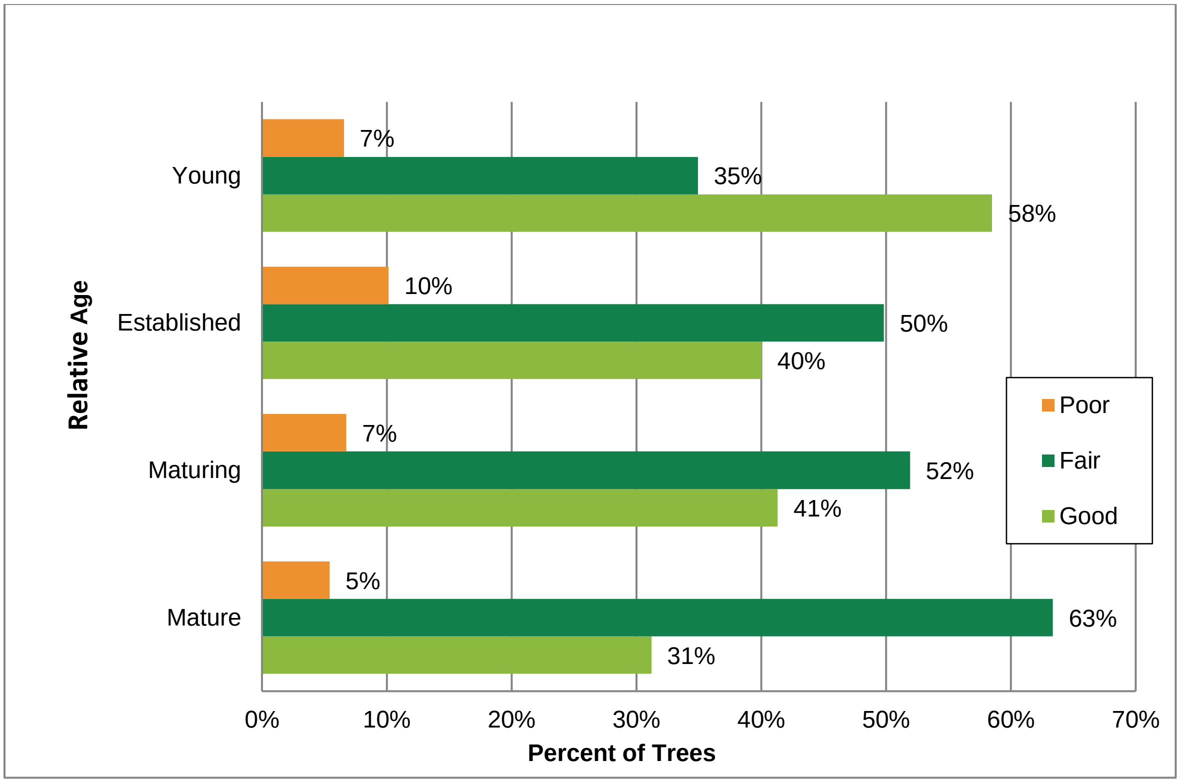


Figure 6. Tree condition by relative age during the 2019 inventory.

Discussion

Data analysis has provided the following insight into maintenance needs and historical maintenance practices:

- The similar trend in condition across the inventory reveals that growing conditions and/or past management of trees were consistent.
- Trees in Poor condition of younger age require further inspection to validate removal. Because of their failed health, these trees will likely not recover, even with increased care.
- 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.
- 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).
- 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 Clarence's, stocking level is used to estimate the total number of sites along the street ROW that could contain trees. Park trees and public property trees are excluded from this measurement.

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

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

Findings

The town owns 124.75 center lane miles of road; the scope of the inventory mileage was 41.19 miles. The partial inventory found 2,757 planting sites. Of the inventoried sites, 606 were potential planting sites for large-size trees (8-foot-wide and greater growing space size); 1,198 were potential sites for medium-size trees (6- to 7-foot-wide growing space sizes); and 953 were potential sites for small-size trees (4- to 5-foot-wide growing space sizes). Based on the data collected during this partial inventory, Clarence's current street ROW tree stocking level is 50%.

Based on a 100% theoretical stocking level, Clarence has 124.75 linear miles of street ROW (Town of Clarence website, accessed October 2019). In theory, an average street should have growing space for 1 tree every 50 feet along each side of a street, or 211 trees per mile. This suggests that there is room for 26,322 street trees in Clarence to reach full stocking potential.

Based upon the partial inventory, the scope of work inventoried 41.19 miles, with a full theoretical potential of 8,691 tree. The inventory is 2,813 which is 32% of theoretical. The actual count of vacant sites noted in the inventory was 2,757 for a combined total inventory 5,615. The limits of the theoretical bounds are higher than the actual site inspection count. The site may have limiting factors, such as no planting space or utility conflicts, which would not be considered feasible to count as a possible planting site.

Discussion

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 town should consider improving its street ROW population's stocking level of 50% and work toward achieving the ideal of 90% or better. Generally, this entails a planned program of planting, care, and maintenance for the town's street trees.

The town of Clarence estimates that it plants less than 25 trees per year. With a current total of 2,757 planting sites in the partial inventory, it would be over 100 years of planting to reach the recommended stocking level of 90%. The takeaway from this discussion is if budgets allow, Clarence should increase the number of new trees planted each year. A complete inventory may yield a different number of recommended plantings. For the purposes of this report, the recommended number for annual new tree plantings is 50.

Although the suggested planting costs may appear daunting, the wealth of plantings sites is beneficial. With nearly 2,800 planting sites, selecting the best possible sites for tree success is an opportunity for the future. Choosing the right tree for the right site will better prepare for impending disease or pest threats and to increase the return of benefits provided by the urban forest.

Another way of determining the number of recommended tree plantings is to evaluate the trees per capita. The more residents and greater housing density a town possesses, the greater the need for trees to provide benefits. A complete tree inventory was not completed at this time; however, a mean ratio of 0.37 is reported for 22 U.S. cities (McPherson and Rowntree 1989). In all of New York state, the number of trees per person is 513 based on the most recent 2007 survey from the U.S. Forest Service.

Infrastructure Conflicts

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

- *Clearance Requirements*—The inventory noted trees blocking the visibility of traffic signs or signals, streetlights, or other safety devices. This information should be used to schedule pruning activities.
- *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 230 trees recorded with a utility clearance issue. All were related to overhead utility conflicts. There were 230 trees with utilities directly above, or passing through, the tree canopy. Of those trees, 57% were between 9 to 22 inches DBH. There were 4 trees in Dead condition and 21 in Poor condition which were conflicting with overhead utilities.

Table 1. Trees Noted to be Conflicting with Infrastructure

Conflict	Presence	Number of Trees	Percent
Overhead Utilities	Present and Conflicting	230	4.10%
	Present and Not Conflicting	1,623	28.90%
	Not Present	3,762	67.00%
Total		**5,615**	**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. Completing these secondary maintenance recommendations will reduce conflicts with infrastructure and citizens.

Growing Space

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

- Island—surrounded by pavement or hardscape (for example, parking lot divider)
- Median—located between opposing lanes of traffic
- Open/Restricted—open sites with restricted growing space on 2 or 3 sides
- Open/Unrestricted—open sites with unrestricted growing space on at least 3 sides
- Raised Planter—in an above-grade or elevated planter
- Tree Lawn/Parkway—located between the street curb and the public sidewalk
- Unmaintained/Natural Area—located in areas that do not appear to be regularly maintained
- Well/Pit—at grade level and completely surrounded by sidewalk

Findings

The inventory included sites and trees. Of the 2,757 vacant sites, most (80%) of the sites were in tree lawns that were larger than 8 feet. Small vacant sites in the 0–4 feet range numbered 122 (4%), and there were 414 (15%) sites in the 4–8 feet range.

For the trees, the vast majority (96%) were within sites that were greater than 8 feet. Small sites from 0–4 feet were very low at 13 (0.4%), and there were 93 medium sites from 4–8 feet (3.2%).

Discussion

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.

Consider the 'right tree, right place' paradigm. Select trees which will flourish in the limits of the 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, town staff should investigate as soon as possible to determine corrective actions.

Findings

DRG recommended 475 (17%) trees for further inspection. There were 38 trees noted for insect/disease monitoring, 324 for multi-year annual inspections, and 113 Level III assessments recommended.

Only 1 tree was noted as High Risk. Figure 7 below indicates the defects and inspection needs.

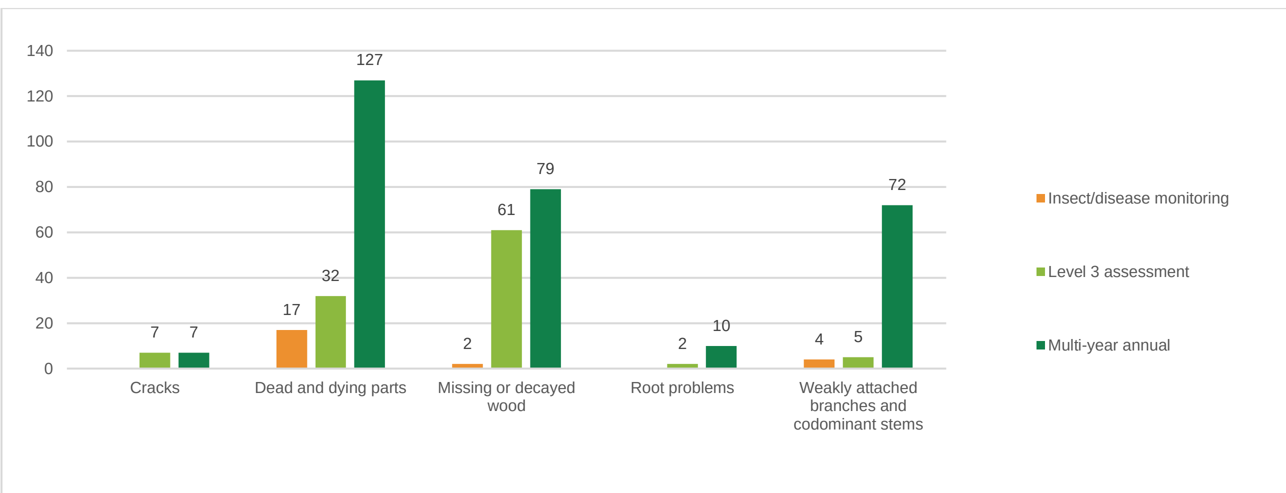


Figure 7. Trees requiring further inspection and their identified defects.

Discussion

An ISA Certified Arborist should perform additional inspections of the 113 Level III trees. If it is determined that these trees exceed the threshold for acceptable risk, the defective part(s) of the trees should be corrected or removed, or the entire tree may need to be removed.

Use the tools in TreeKeeper® to assist work direction and intervene where needed to facilitate the right tree, right place concept.

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 Clarence's inventoried 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 8). It is important to note that the figure only presents data collected from the designated inventory. Many more trees throughout Clarence, including those on public and private property, may be susceptible to these invasive pests.

Findings

Granulate ambrosia beetle (*Xylosandrus crassiusculus*) and Asian longhorned beetle (ALB or *Anoplophora glabripennis*) are known threats to a large percentage of the inventoried street trees (55% and 37%, respectively). These pests were not detected in Clarence, but if they were detected, the town could see severe losses in its tree population.

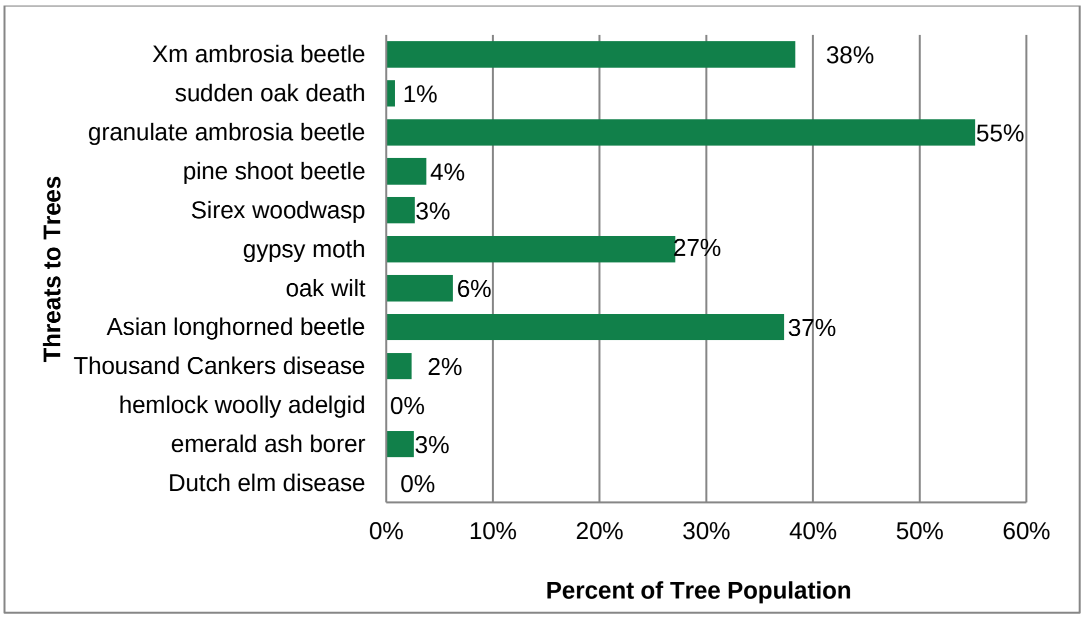


Figure 8. Potential impact of insect and disease threats noted during the 2019 select inventory.

Discussion

Clarence 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.

For best results, seek diversity within tree selections. Monocultures, or many trees of the same species, along the streets offer the potential of losing many trees at once. This can overwhelm budget constraints and the loss of great number of trees will affect the community in many ways.

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 hard appearance of urban landscapes and streetscapes. Scientists and researchers have studied the positive effects of trees on air quality, stormwater runoff, human behavior, and lower crime rates. 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. This section will highlight each element of the collective benefits the trees in the inventory provide.

Both the functional and structural benefits of trees can be assessed by i-Tree Eco. The functional benefits of trees are associated with their ability to provide ecosystem benefit. 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 municipalities the means to advocate for the funding needed to manage trees effectively. i-Tree Streets has moved into a legacy role, and the new Eco v6, which includes the functionality of the Streets model, is the most up-to-date eco-benefit estimator available. Trees are evaluated based upon the population (collective group of species) and individual tree performances within the inventory data collected.

i-Tree Eco can be utilized with a complete inventory to simplify the benefit quantification process. Regional data, including energy prices 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 United States Forest Service (USFS) for the local climate zone. The entire inventory collected during in the 2019 collection was uploaded into i-Tree Eco v6 model to generate benefit estimates.

Functional benefits include atmospheric removal of 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 by i-Tree Eco through tree growth algorithms incorporating tree data supplied by the inventory. 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), CO_2, ozone (O_3), and small particulates less than ten 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.

When location in the landscape is matched with healthy, high-quality tree species, tree valuation 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 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).

Structural values are on the comparable cost of replacing the specific tree with a similar tree. i-Tree Eco determines these values via an appraisal methodology utilized by the Council of Tree and Landscape Appraisers. Carbon storage is considered a structural value, as it is not considered an annual benefit but is amassed over the life of the tree. Carbon storage and sequestration will be discussed in the same section, although they are separate classes of ecological benefits.

Planting trees in strategic areas can augment the function of existing stormwater infrastructure, 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 USFS indicates that 100 mature tree crowns intercept about 100,000 gallons of rainfall per year, reducing runoff and providing cleaner water (United States Department of Agriculture (USDA) Forest Service, 2003(a)). Trees will retain approximately 10 million gallons of rainwater per year.

Trees are associated with 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 following graphic summarizes the science behind the community tree benefits provided by the 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

Clarence currently receives $11,177 annually in total functional ecological benefits from the identified trees in the 2019 inventory (not including unknown trees). These cumulative benefits can be valued at an annual average of approximately $4 per tree in the inventory. Figure 9 displays the annual dollar amounts for each functional benefit.

Functional Values

The annual functional benefits of the select inventory is $11,177.

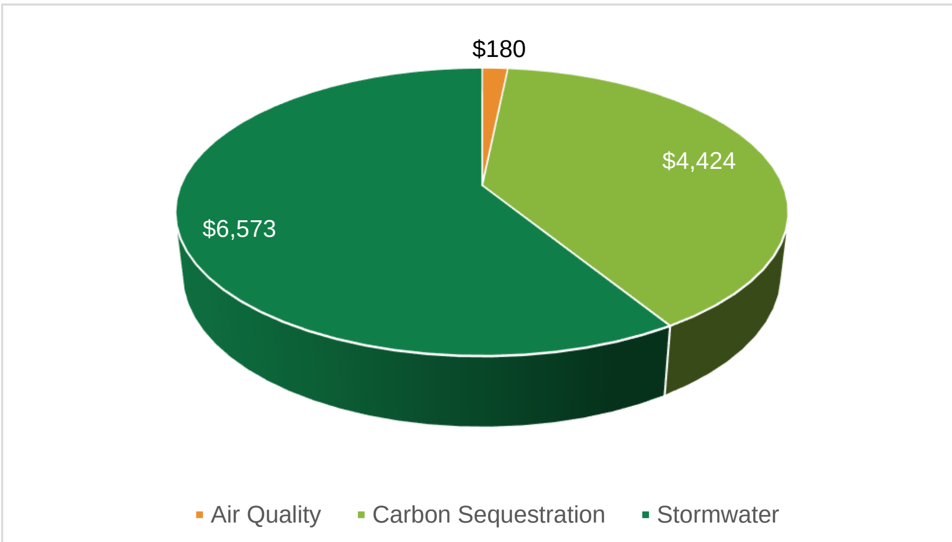


Figure 9. Annual functional benefits of the inventoried trees.

Air Quality

The inventoried tree population annually removes 1,630 pounds of air pollutants, including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter, the latter through deposition. Figure 10 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 69.2 tons per year of oxygen. Table 2 presents the top performing individual trees in the 2019 inventory.

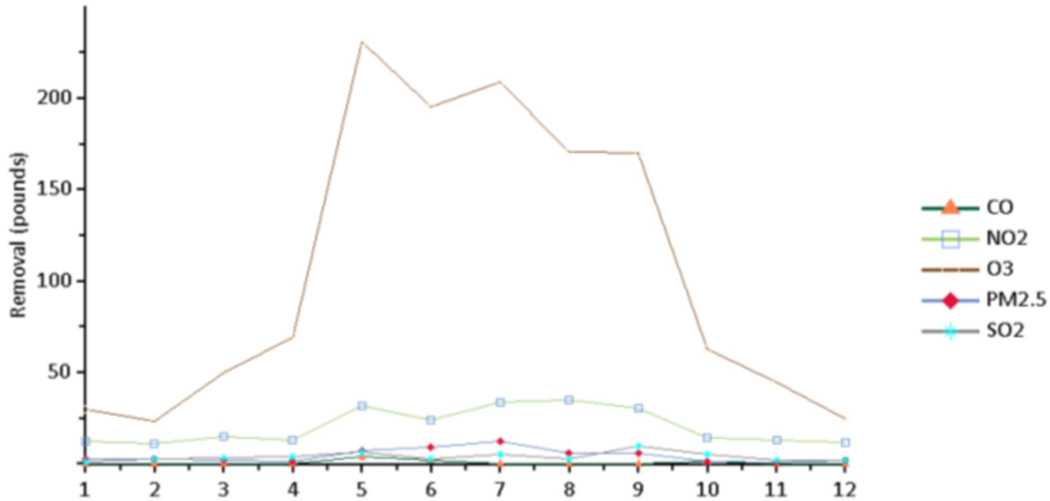


Figure 10. Monthly air pollutants removed per contaminant in Clarence.

Table 2. Top Air Quality Benefits per Individual Tree in Inventory

Species Name	CO	O_3	NO_2	SO_2	$PM_{2.5}$	Total Oz. Year Poll	CO	O_3	NO_2	SO_2	$PM_{2.5}$	Total Value
eastern cottonwood	0.20	41.90	8.00	1.50	1.70	53.30	0.01	0.11	0.00	0.00	0.24	$0.36
eastern cottonwood	0.20	35.00	6.70	1.30	1.40	44.60	0.01	0.09	0.00	0.00	0.20	$0.30
eastern cottonwood	0.20	32.00	6.10	1.20	1.30	40.80	0.01	0.08	0.00	0.00	0.19	$0.28
eastern cottonwood	0.20	31.60	6.00	1.20	1.30	40.30	0.01	0.08	0.00	0.00	0.18	$0.27
eastern cottonwood	0.20	31.60	6.00	1.20	1.30	40.30	0.01	0.08	0.00	0.00	0.18	$0.27
eastern cottonwood	0.20	29.40	5.60	1.10	1.20	37.50	0.01	0.08	0.00	0.00	0.17	$0.26
eastern cottonwood	0.20	29.40	5.60	1.10	1.20	37.50	0.01	0.08	0.00	0.00	0.17	$0.26
eastern cottonwood	0.20	29.40	5.60	1.10	1.20	37.50	0.01	0.08	0.00	0.00	0.17	$0.26
silver maple	0.20	29.20	5.60	1.10	1.20	37.30	0.01	0.08	0.00	0.00	0.17	$0.26
eastern cottonwood	0.20	29.00	5.50	1.10	1.20	37.00	0.01	0.08	0.00	0.00	0.17	$0.26
black walnut	0.20	29.00	5.50	1.10	1.20	37.00	0.01	0.08	0.00	0.00	0.17	$0.26
black walnut	0.20	29.00	5.50	1.10	1.20	37.00	0.01	0.08	0.00	0.00	0.17	$0.26
black walnut	0.20	29.00	5.50	1.10	1.20	37.00	0.01	0.08	0.00	0.00	0.17	$0.26
silver maple	0.20	28.80	5.50	1.10	1.20	36.80	0.01	0.08	0.00	0.00	0.17	$0.26
black walnut	0.20	28.00	5.30	1.00	1.20	35.70	0.01	0.07	0.00	0.00	0.16	$0.24
black walnut	0.20	28.00	5.30	1.00	1.20	35.70	0.01	0.07	0.00	0.00	0.16	$0.24
eastern cottonwood	0.20	27.50	5.20	1.00	1.10	35.00	0.01	0.07	0.00	0.00	0.16	$0.24
eastern cottonwood	0.20	27.50	5.20	1.00	1.10	35.00	0.01	0.07	0.00	0.00	0.16	$0.24
silver maple	0.20	27.30	5.20	1.00	1.10	34.80	0.01	0.07	0.00	0.00	0.16	$0.24
silver maple	0.20	26.90	5.10	1.00	1.10	34.30	0.01	0.07	0.00	0.00	0.16	$0.24
Total of Inventory	**122.00**	**20,465.90**	**3,896.00**	**754.90**	**845.30**	**26,084.10**	**5.26**	**53.76**	**1.01**	**0.07**	**119.57**	$179.67

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 air quality net benefit. The inventory produces 509 pounds of isoprenes and 509 pounds per monoterpenes annually. Total VOCs per year are 1,013 pounds. The inventoried trees removed or avoided more pollutants than they emitted, resulting in a positive economic value. Table 3 lists the largest emitters of BVOCs in the current inventory. As a group, the populations of Norway spruce and blue spruce produced the most VOCs.

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.

Table 3. Trees with Highest Emitting VOCs in the Inventory

Species Name	Isoprene (oz / yr)	Monoterpene (oz / yr)	VOCs (oz / yr)
eastern cottonwood	78.30	0.60	79.00
eastern cottonwood	65.50	0.50	66.10
eastern cottonwood	59.90	0.50	60.30
eastern cottonwood	59.00	0.50	59.50
eastern cottonwood	59.00	0.50	59.50
Norway spruce	25.00	32.40	57.40
Norway spruce	25.00	32.40	57.40
Norway spruce	25.00	32.40	57.40
Norway spruce	25.00	32.40	57.40
Norway spruce	25.00	32.40	57.40
Norway spruce	25.00	32.40	57.40
Norway spruce	24.80	32.10	56.80
eastern cottonwood	55.00	0.50	55.50
eastern cottonwood	55.00	0.50	55.50
eastern cottonwood	55.00	0.50	55.50
northern red oak	54.00	0.90	54.90
eastern cottonwood	54.30	0.40	54.80
northern red oak	52.80	0.90	53.60
Norway spruce	23.20	30.10	53.30
Total of Inventory	8,059.90	8,144.50	16,204.30

Carbon Sequestration and Storage

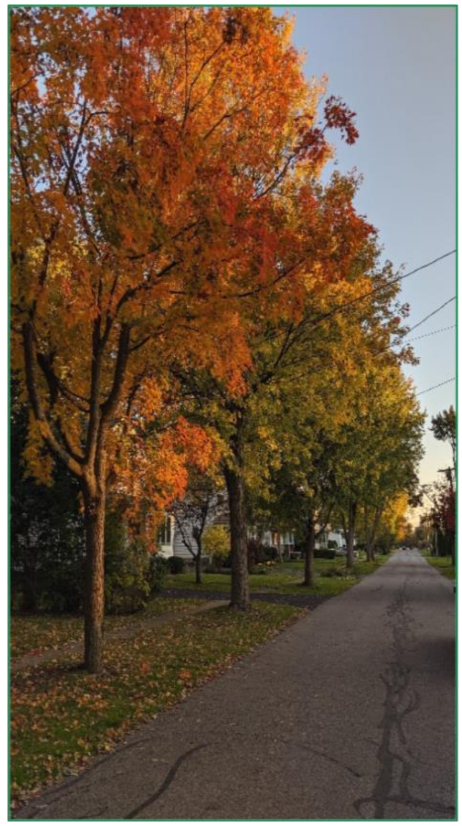
Trees store some of the carbon dioxide (CO_2) they absorb. This prevents CO_2 from reaching the upper atmosphere, where it can react with other compounds and form harmful gases like ozone, which adversely affects air quality. These trees also sequester some of the CO_2 during growth (Nowak et al. 2013).

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.

The selected tree inventory sequesters 25.94 tons of carbon annually, based on reduction amounts of atmospheric carbon which is valued at $4,424 annually. The carbon storage amount reflects the amount of carbon the trees have amassed during their lifetimes. The total carbon storage of this partial inventory was 2,159.4 tons and valued at $368,000. At the time of inventory, the average carbon storage per tree was valued at $132, with an average annual carbon sequestration amount of $1.59 per tree.

Per the partial inventory, silver maple led both categories of carbon storage per individual tree and per species. One specific silver maple led the inventory with storing over 16,000 pounds. The silver maple species led the inventory with storing over 604 tons.

Table 4 lists the top performing carbon storage individual trees, followed by Table 5 as the top performing species population in the overall inventory for carbon storage.



Photograph 2. *Trees improve quality of life and help enhance the character of a community. Trees filter air, water, and sunlight, moderate local climate, slow wind and stormwater, shade homes, and provide shelter to animals and recreational areas for people.*

Table 4. Top 25 Performing Individual Trees for Carbon Storage

Species Name	Carbon Storage (lb)	% of Total
silver maple	16,534.70	0.40
northern red oak	15,175.30	0.40
silver maple	14,548.10	0.30
silver maple	14,548.10	0.30
silver maple	14,548.10	0.30
willow spp	14,525.00	0.30
Babylon weeping willow	14,525.00	0.30
northern red oak	14,386.20	0.30
northern red oak	14,386.20	0.30
silver maple	12,946.30	0.30
Freeman maple	12,660.00	0.30
silver maple	12,435.90	0.30
silver maple	12,435.90	0.30
northern red oak	12,166.10	0.30
silver maple	11,438.80	0.30
silver maple	11,438.80	0.30
silver maple	10,952.80	0.30
bur oak	10,522.40	0.20
silver maple	10,478.80	0.20
silver maple	10,478.80	0.20
silver maple	10,478.80	0.20
oak spp	10,088.50	0.20
silver maple	10,026.50	0.20
eastern cottonwood	9,867.50	0.20
white oak	9,637.60	0.20
Total	**4,318,753.20**	**100%**

Table 5. Top Performing Individual Tree Species for Carbon Storage

Species	Carbon Storage (ton)	Carbon Storage (%)	CO_2 Equivalent (ton)
silver maple	604.30	28.0%	2,216.10
Norway maple	253.80	11.8%	930.80
sugar maple	144.00	6.7%	528.00
Freeman maple	121.10	5.6%	444.20
blue spruce	99.80	4.6%	366.00
eastern cottonwood	98.50	4.6%	361.40
Norway spruce	91.20	4.2%	334.30
Crimson king Norway maple	88.80	4.1%	325.70
black walnut	80.70	3.7%	296.10
northern red oak	80.20	3.7%	294.10
bur oak	62.20	2.9%	228.20
red maple	60.90	2.8%	223.20
Siberian elm	31.00	1.4%	113.70
honeylocust	27.10	1.3%	99.30
callery pear	18.00	0.8%	65.80
horse chestnut	17.40	0.8%	63.80
boxelder	15.20	0.7%	55.80
bitternut hickory	14.90	0.7%	54.80
American basswood	14.80	0.7%	54.10
apple spp	14.50	0.7%	53.20
black locust	14.10	0.7%	51.80
black cherry	13.20	0.6%	48.40
littleleaf linden	13.20	0.6%	48.40
oak spp	12.40	0.6%	45.60
white ash	11.40	0.5%	41.90
Total for Inventoried Trees	2,159.40	100%	7,918.40

Stormwater Benefits

Trees intercept rainfall, which helps lower the cost of managing stormwater runoff. In the absence of trees, precipitation results in quicker supersaturation of the soil which increases peak stormwater flows. Leaf area attenuates the precipitation and the trees' uptake of some of the water. The inventoried trees in Clarence intercept 98.34 thousand cubic feet of rainfall annually based on 170 acres of total leaf area. The total avoided runoff and the annual savings for Clarence in stormwater runoff management is $6,570. 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 versus zero leaf area for the same geography.

In the inventory, silver maple contributed the most annual stormwater benefits. This is attributable to the prevalence of silver maple in the specified inventory, the size of these trees, and their combined leaf area. The population of silver maple (9% of the inventory) intercepted approximately 18,000 cubic feet of rainfall. Table 6 lists the top performing tree species for stormwater benefits in the inventory.

On a per tree basis, large trees with leafy canopies provided the most value. The average for the population was $2.36 per tree. Eastern cottonwood led the inventory with $5.37 per tree average avoided runoff value. White oak, red oak, black walnut, London planetree, and other large-statured trees with big canopies are other top performers. Table 7 lists the top individual trees for stormwater benefits in the inventory.

Table 6. Top Performing Tree Species for Stormwater Benefits

Species Name	Number of Trees	Leaf Area (acres)	Potential Evapotranspiration ft^3/year	Evaporation ft^3/year	Transpiration ft^3/year	Water Intercepted ft^3/year	Avoided Runoff ft^3/year	Avoided Runoff Value $
silver maple	271	32.62	321,472	91,840	106,240	92,043	18,924	$1,265.01
Norway maple	326	25.70	253,263	72,354	83,698	72,513	14,909	$996.60
Norway spruce	165	14.53	143,175	40,903	47,316	40,993	8,428	$563.40
blue spruce	364	12.05	118,760	33,928	39,248	34,003	6,991	$467.33
Crimson king Norway maple	110	9.18	90,485	25,850	29,903	25,907	5,327	$356.06
eastern cottonwood	61	8.45	83,231	23,778	27,506	23,830	4,900	$327.52
black walnut	67	8.16	80,434	22,979	26,582	23,030	4,735	$316.51
sugar maple	111	7.71	75,965	21,702	25,105	21,750	4,472	$298.93
Freeman maple	74	7.22	71,120	20,318	23,504	20,363	4,187	$279.86
red maple	114	5.54	54,543	15,582	18,025	15,617	3,211	$214.63
northern red oak	57	3.75	36,922	10,548	12,202	10,571	2,174	$145.29
bur oak	35	2.93	28,887	8,253	9,547	8,271	1,701	$113.67
American basswood	50	2.20	21,677	6,193	7,164	6,207	1,276	$85.30
Siberian elm	26	2.09	20,564	5,875	6,796	5,888	1,211	$80.92
littleleaf linden	25	1.78	17,539	5,011	5,796	5,022	1,032	$69.02
callery pear	121	1.75	17,237	4,924	5,696	4,935	1,015	$67.83
eastern white pine	29	1.57	15,503	4,429	5,123	4,439	913	$61.00
white spruce	48	1.32	13,005	3,715	4,298	3,723	766	$51.17
apple species	67	1.28	12,630	3,608	4,174	3,616	744	$49.70
Douglas fir	23	1.21	11,935	3,410	3,944	3,417	703	$46.96
honeylocust	58	1.21	11,924	3,406	3,941	3,414	702	$46.92
boxelder	26	1.20	11,840	3,382	3,913	3,390	697	$46.59
horse chestnut	14	1.15	11,351	3,243	3,751	3,250	668	$44.67
tree of heaven	18	0.86	8,512	2,432	2,813	2,437	501	$33.50
white ash	19	0.82	8,078	2,308	2,670	2,313	476	$31.79
Total	**2,788**	**169.53**	**1,670,506**	**477,239**	**552,067**	**478,292**	**98,338**	**$6,573.51**

Table 7. Top Performing Individual Trees for Stormwater Benefits in the Inventory

Species Name	Number of Trees	Leaf Area (ac)	Potential Evapotranspiration ft^3/year	Evaporation ft^3/year	Transpiration ft^3/year	Water Intercepted ft^3/year	Avoided Runoff ft^3/year	Avoided Runoff Value $	Per Tree Value
eastern cottonwood	61	8.45	83,231	23,778	27,506	23,830	4,900	$327.52	**$5.37**
black walnut	67	8.16	80,434	22,979	26,582	23,030	4,735	$316.51	**$4.72**
silver maple	271	32.62	321,472	91,840	106,240	92,043	18,924	$1,265.01	**$4.67**
white oak	2	0.21	2,071	592	685	593	122	$8.15	**$4.08**
London plane	5	0.52	5,138	1,468	1,698	1,471	302	$20.22	**$4.04**
Freeman maple	74	7.22	71,120	20,318	23,504	20,363	4,187	$279.86	**$3.78**
swamp white oak	1	0.10	952	272	315	273	56	$3.75	**$3.75**
Chinese chestnut	1	0.09	931	266	308	267	55	$3.66	**$3.66**
American chestnut	1	0.09	878	251	290	251	52	$3.45	**$3.45**
Norway spruce	165	14.53	143,175	40,903	47,316	40,993	8,428	$563.40	**$3.41**
European beech	1	0.08	829	237	274	237	49	$3.26	**$3.26**
bur oak	35	2.93	28,887	8,253	9,547	8,271	1,701	$113.67	**$3.25**
striped maple	1	0.08	824	235	272	236	48	$3.24	**$3.24**
Crimson king Norway maple	110	9.18	90,485	25,850	29,903	25,907	5,327	$356.06	**$3.24**
horse chestnut	14	1.15	11,351	3,243	3,751	3,250	668	$44.67	**$3.19**
oriental spruce	1	0.08	794	227	262	227	47	$3.12	**$3.12**
Siberian elm	26	2.09	20,564	5,875	6,796	5,888	1,211	$80.92	**$3.11**
American beech	1	0.08	789	225	261	226	46	$3.10	**$3.10**
Norway maple	326	25.70	253,263	72,354	83,698	72,513	14,909	$996.60	**$3.06**
Babylon weeping willow	1	0.08	757	216	250	217	45	$2.98	**$2.98**
osage orange	2	0.14	1,421	406	470	407	84	$5.59	**$2.80**
littleleaf linden	25	1.78	17,539	5,011	5,796	5,022	1,032	$69.02	**$2.76**
tulip tree	5	0.35	3,475	993	1,148	995	205	$13.67	**$2.73**
sugar maple	111	7.71	75,965	21,702	25,105	21,750	4,472	$298.93	**$2.69**
northern red oak	57	3.75	36,922	10,548	12,202	10,571	2,174	$145.29	**$2.55**
northern catalpa	2	0.13	1,244	355	411	356	73	$4.90	**$2.45**
Total	2788	169.53	1,670,506	477,239	552,067	478,292	98,338	$6,573.51	$2.36

Structural Values

The total structural value of the select inventory was $6,450,816 which includes the carbon storage value and the combined tree value of the inventory.

The most straightforward way to establish a monetary value for an urban forest is by establishing a structural value. Generally, this value represents the amount it would cost to replace all of the trees in the urban forest. The 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 $368,283 and reviewed in the previous carbon sequestration and carbon heading.

Tree Values

The structural value of the entire inventory is valued at $6 million dollars, with a per tree average of $2,100. The 25 highest valued populations in the inventory are listed in Table 8. The population of eastern white pine was found to be the highest valued street tree species. Table 9 lists the 30 highest valued individual trees in the inventory; silver maple was the top average valued tree.

Table 8. Individual Trees with Highest Structural Value in the Inventory

Species	Number of Trees	Carbon Storage $	Carbon Sequestration $/yr	Avoided Runoff ($/yr)	Pollution Removal ($/yr)	Structural Value Species ($)	Structural Value per Tree
silver maple	271	$103,069.46	$784.35	$1,265.01	$34.58	$1,000,746.10	**$3,692.79**
Norway maple	326	$43,289.14	$572.34	$996.60	$27.24	$734,485.33	**$2,253.02**
Norway spruce	165	$15,549.36	$239.85	$563.40	$15.40	$531,331.48	**$3,220.19**
blue spruce	364	$17,024.35	$284.59	$467.33	$12.77	$475,056.49	**$1,305.10**
sugar maple	111	$24,557.04	$282.70	$298.93	$8.17	$439,477.86	**$3,959.26**
Freeman maple	74	$20,657.52	$208.70	$279.86	$7.65	$277,553.70	**$3,750.73**
Crimson King Norway maple	110	$15,150.39	$227.07	$356.06	$9.73	$259,129.44	**$2,355.72**
northern red oak	57	$13,680.13	$152.93	$145.29	$3.97	$253,367.81	**$4,445.05**
black walnut	67	$13,770.34	$175.92	$316.51	$8.65	$241,421.27	**$3,603.30**
red maple	114	$10,379.63	$167.01	$214.63	$5.87	$227,414.45	**$1,994.86**
bur oak	35	$10,615.32	$125.69	$113.67	$3.11	$193,279.40	**$5,522.27**
honeylocust	58	$4,620.26	$86.59	$46.92	$1.28	$114,161.71	**$1,968.31**
eastern cottonwood	61	$16,806.90	$187.55	$327.52	$8.95	$107,439.17	**$1,761.30**
callery pear	121	$3,061.80	$87.81	$67.83	$1.85	$93,510.26	**$772.81**
American basswood	50	$2,516.30	$39.70	$85.30	$2.33	$91,928.04	**$1,838.56**
eastern white pine	29	$1,847.40	$31.14	$61.00	$1.67	$85,269.36	**$2,940.32**
littleleaf linden	25	$2,250.77	$33.91	$69.02	$1.89	$82,661.08	**$3,306.44**
white spruce	48	$1,863.79	$38.46	$51.17	$1.40	$72,057.30	**$1,501.19**
apple species	67	$2,474.80	$54.18	$49.70	$1.36	$57,841.90	**$863.31**
Douglas fir	23	$1,032.71	$13.87	$46.96	$1.28	$46,182.21	**$2,007.92**
Siberian elm	26	$5,286.97	$51.26	$80.92	$2.21	$42,104.31	**$1,619.40**
bitternut hickory	12	$2,548.39	$36.54	$26.48	$0.72	$38,885.14	**$3,240.43**
horse chestnut	14	$2,968.32	$33.51	$44.67	$1.22	$35,708.82	**$2,550.63**
white ash	19	$1,948.08	$28.92	$31.79	$0.87	$34,013.60	**$1,790.19**
black locust	21	$2,407.67	$31.43	$31.49	$0.86	$31,571.28	**$1,503.39**
oak species	6	$2,121.38	$18.61	$13.59	$0.37	$26,177.74	**$4,362.96**
black cherry	18	$2,250.13	$31.03	$28.54	$0.78	$25,615.09	**$1,423.06**
Scots pine	15	$564.84	$11.06	$18.89	$0.52	$24,814.10	**$1,654.27**
ash species	40	$951.29	$14.92	$23.15	$0.63	$21,878.36	**$546.96**
red pine	12	$742.97	$12.70	$15.76	$0.43	$21,589.31	**$1,799.11**
Total	2788	$368,283.69	$4,424.00	$6,573.51	$179.67	$6,082,533.01	**$2,181.68**

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. Trees manage stormwater through rainfall interception, provide shade and windbreaks to reduce energy usage, and store and sequester CO_2.

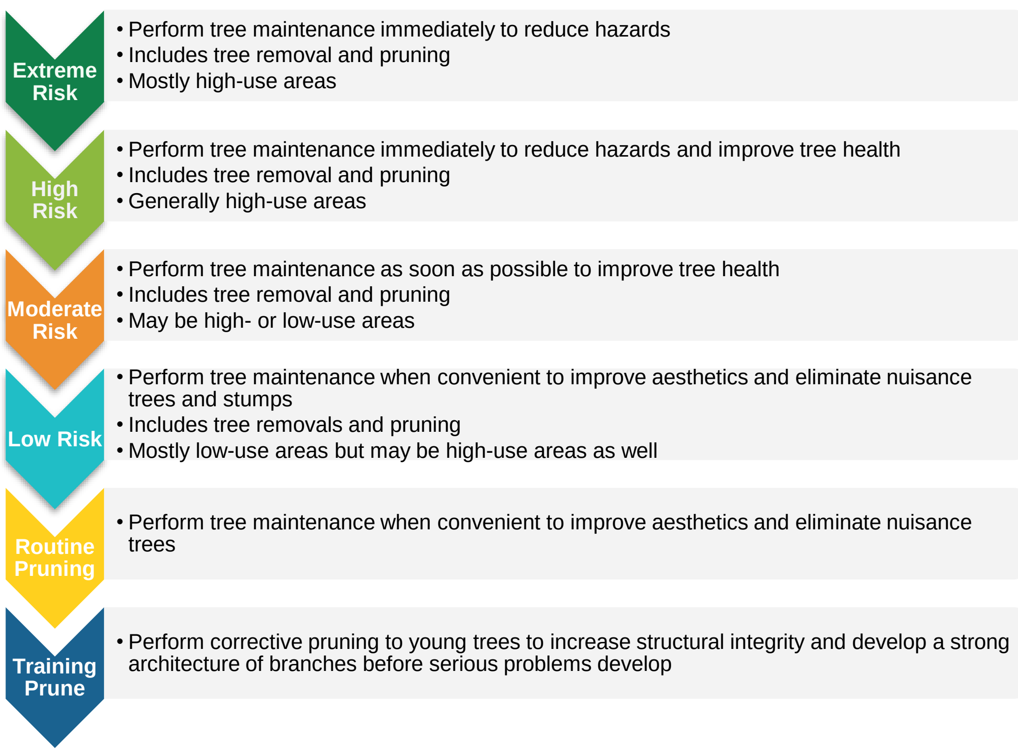
To increase the benefits that its street trees provide, the town should prioritize planting large-statured tree species where site conditions permit. Working with the i-Tree species tool in conjunction with site analysis can provide appropriate tree selections for future plantings (https://species.itreetools.org/). This tool permits the user to select which benefits are of interest to the community's stakeholders. If the goal is stormwater attenuation, the tool can be tailored to provide a list of species for that purpose. This is a good guide for plantings, but be aware of planting too many similar species; seek diversity in planting genera and create palettes for identity.

SECTION 3: TREE MANAGEMENT PROGRAM

This tree management program was developed to uphold Clarence'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.



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

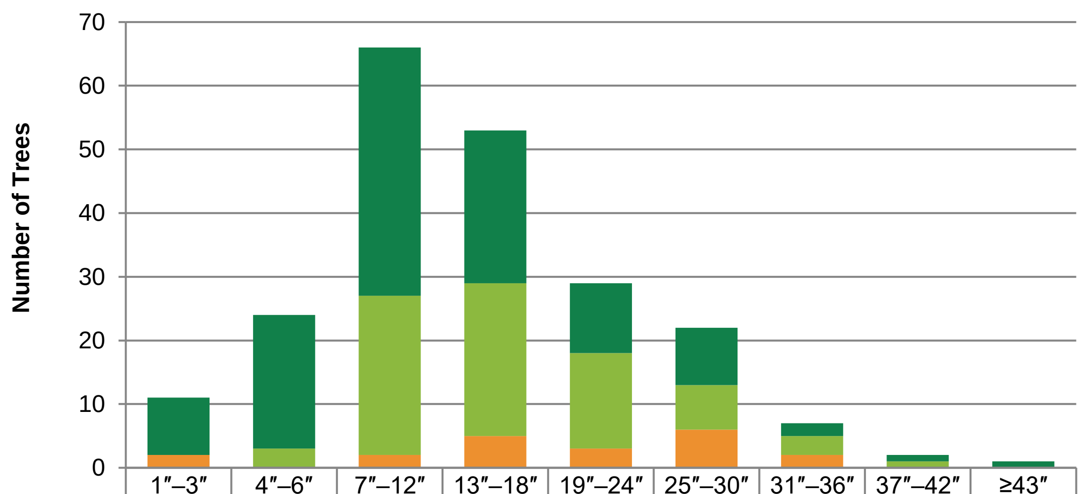
Priority Tree and Stump Removal

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



	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Low	9	21	39	24	11	9	2	1	1
Moderate	0	3	25	24	15	7	3	1	0
High	2	0	2	5	3	6	2	0	0

Diameter Size Class

Figure 11. Tree removals by risk rating and diameter size class.

The inventory identified 20 High Risk trees, 78 Moderate Risk trees, and 117 Low Risk trees that are recommended for removal.

The diameter size classes for High Risk trees ranged between 13–18 inches diameter at breast height (DBH) and 25–30 inches DBH. These trees should be removed immediately based on their assigned risk. High Risk removals and pruning can be performed concurrently.

Most Moderate Risk trees were smaller than 24 inches DBH. These trees should be removed as soon as possible after all High Risk removals and pruning have been completed.

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

The inventory identified 46 ash trees recommended for removal.

The inventory identified 45 stumps recommended for removal. Stump removals should occur when convenient. Begin from largest to smallest.

Recommendations

Unless already slated for removal, trees noted as having dead and dying parts (1,068 trees) or missing or decayed wood (352 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.

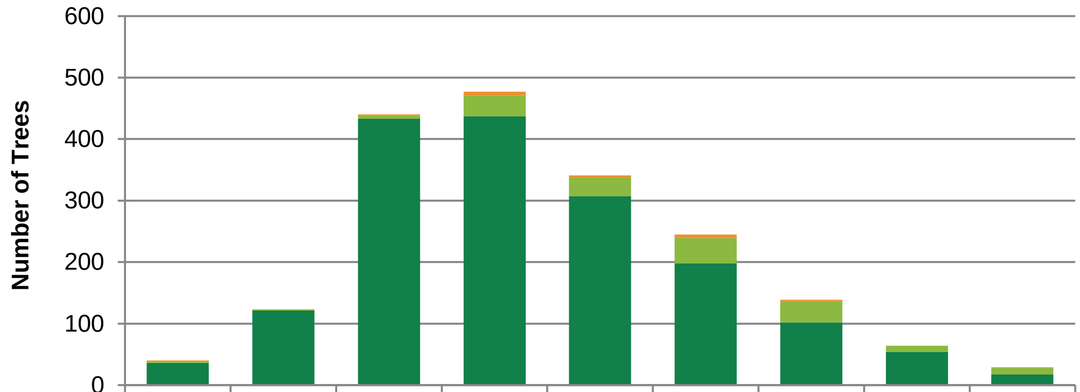
Updating the tree inventory data can streamline workload management and lend insight into setting accurate budgets and staffing levels. Inventory updates should be made electronically and can be implemented using TreeKeeper® or similar computer software.

Priority Tree Pruning

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

Findings

Figure 12 presents the number of 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″
High	2	0	2	6	3	6	2	0	1
Moderate	2	2	5	34	31	41	35	10	11
Low	36	121	433	437	307	198	102	54	17

Diameter Size Class

Figure 12. Recommended pruning by risk and diameter size class.

Recommendations

The inventory identified 22 High Risk trees, and 171 Moderate Risk trees recommended for pruning. High Risk trees ranged in diameter size classes from 13–18 inches DBH to 25–30 inches DBH. This pruning should be performed immediately based on assigned risk and may be performed concurrently with other 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.

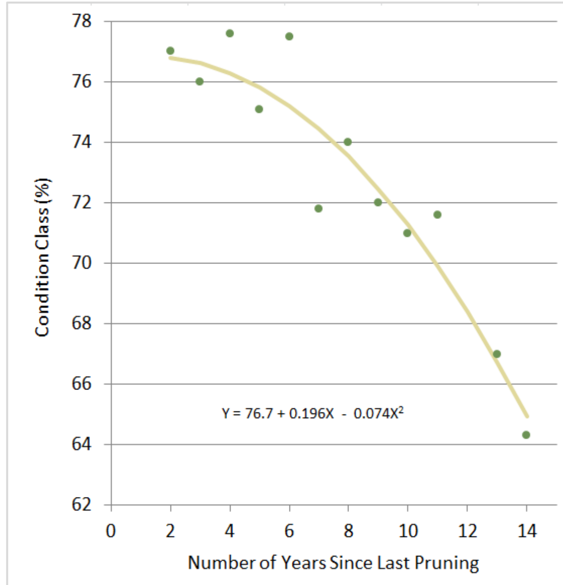


Figure 13. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

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 3 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

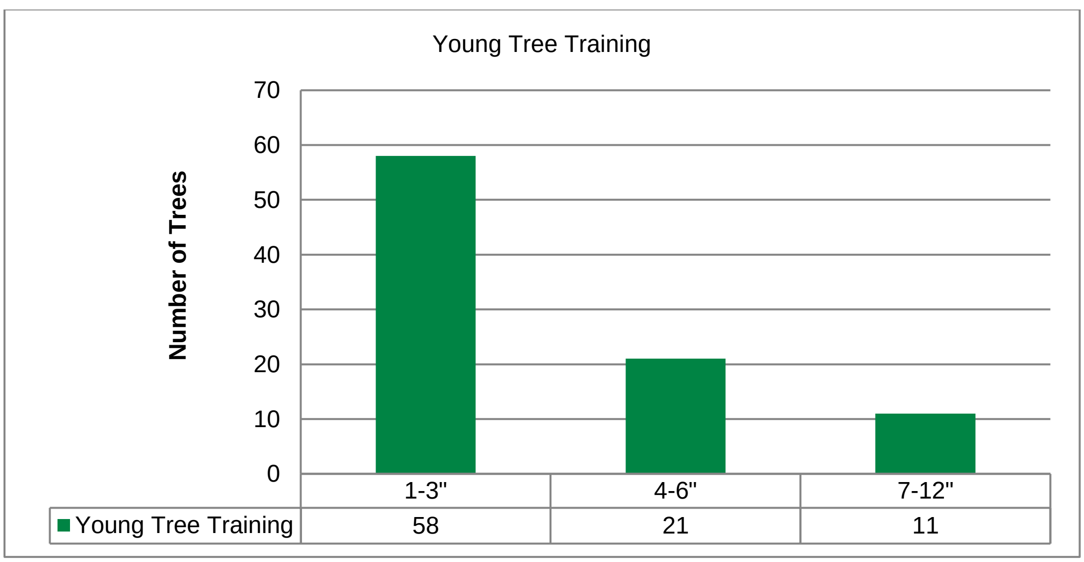


Figure 14. Trees recommended for the YTT Cycle by diameter size class.

Recommendations

Clarence should implement a three-year YTT Cycle to begin after all High Risk trees are removed or pruned. The YTT Cycle will include existing young trees. During the inventory, 79 trees smaller than 7 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 90 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 2–3 years after planting depending on the caliber of the tree initially planted.

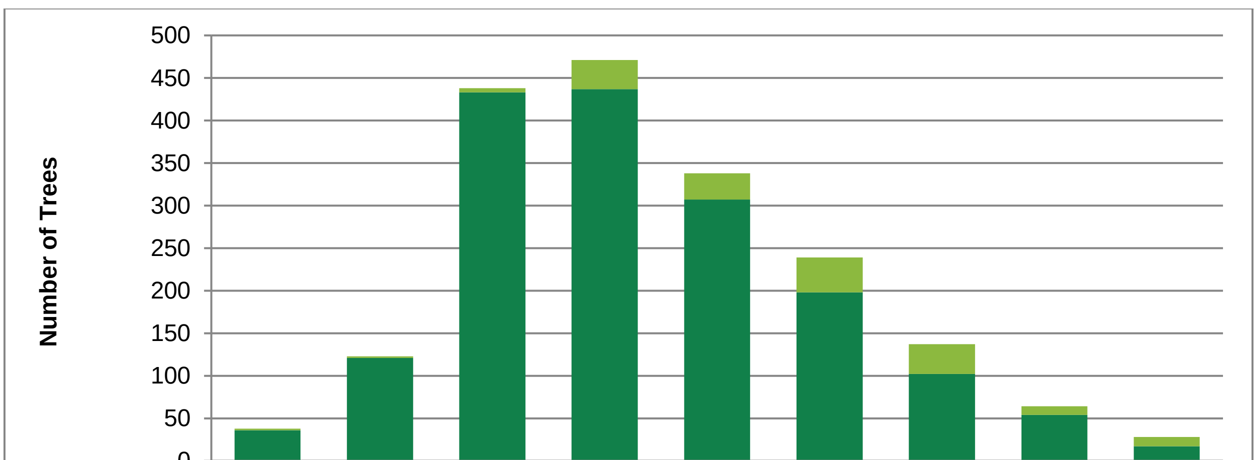
In future years, the number of trees in the YTT Cycle will be based on tree planting efforts and growth rates of young trees. The town should strive to prune approximately one-third of its young trees each year. These numbers will increase when the entire inventory is completed.

Routine Pruning Cycle

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

The length of the RP Cycle is based on the size of the tree population and what was assumed to be a reasonable number of trees for a program to prune per year. Generally, the RP Cycle recommended for a tree population is 5 years but may extend to 7 years if the population is large.

Findings



Risk Rating	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Moderate	2	2	5	34	31	41	35	10	11
Low	36	121	433	437	307	198	102	54	17

Figure 15. Trees recommended for the RP Cycle by diameter size class.

Trees in either Moderate or Low Risk were included in this chart. High Risk trees are not part of the routine pruning program, but rather should be dealt with before the routine cycle begins.

Recommendations

The town should establish a five-year RP Cycle in which approximately one-fifth of the tree population is to be pruned each year. The 2019 select tree inventory identified approximately 1,876 trees that should be pruned over a five-year RP Cycle. An average of 380 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 High Risk trees are pruned.

The inventory found a majority of trees (67%) inventoried needed routine pruning. Figure 15 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 select tree inventory, an annual maintenance schedule was developed that details the number and type of tasks recommended for completion each year. Budget projections use industry knowledge and public bid tabulations. A summary of the maintenance schedule is presented; a complete table of estimated costs for a five-year tree management program follows.

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

To implement the maintenance schedule, the tree maintenance budget should be no less than $119,322 for the first year of implementation, no less than $107,590 for the second and third years, and no less than $95,284 for the final two years of the maintenance schedule. Annual budget funds are needed to ensure that High Risk trees are remediated and that crucial YTT and RP Cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

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

Table 9. Estimated Costs for Five-Year Urban Forestry Management Program

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
High Risk Removals	1-3"	$28	2	$55	0	$0	0	$0	0	$0	0	$0	$55
	4-6"	$58	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$138	2	$275	0	$0	0	$0	0	$0	0	$0	$275
	13-18"	$314	6	$1,881	0	$0	0	$0	0	$0	0	$0	$1,881
	19-24"	$605	3	$1,815	0	$0	0	$0	0	$0	0	$0	$1,815
	25-30"	$825	6	$4,950	0	$0	0	$0	0	$0	0	$0	$4,950
	31-36"	$1,045	2	$2,090	0	$0	0	$0	0	$0	0	$0	$2,090
	37-42"	$1,485	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$2,035	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**21**	**$11,066**	0	$0	0	$0	0	$0	0	$0	**$11,066**
Moderate and Low Risk Removals	1-3"	$28	0	$0	0	$0	0	$0	9	$248	0	$0	$248
	4-6"	$58	0	$0	0	$0	0	$0	24	$1,380	0	$0	$1,380
	7-12"	$138	0	$0	0	$0	32	$4,400	32	$4,400	0	$0	$8,800
	13-18"	$314	0	$0	24	$7,524	24	$7,524	0	$0	0	$0	$15,048
	19-24"	$605	0	$0	26	$15,730	0	$0	0	$0	0	$0	$15,730
	25-30"	$825	16	$13,200	0	$0	0	$0	0	$0	0	$0	$13,200
	31-36"	$1,045	5	$5,225	0	$0	0	$0	0	$0	0	$0	$5,225
	37-42"	$1,485	2	$2,970	0	$0	0	$0	0	$0	0	$0	$2,970
	43"+	$2,035	1	$2,035	0	$0	0	$0	0	$0	0	$0	$2,035
Activity Total(s)			**24**	**$23,430**	**50**	**$23,254**	**56**	**$11,924**	**65**	**$6,028**	0	$0	**$64,636**
Stump Removals	1-3"	$18	0	$0	0	$0	0	$0	2	$35	2	$35	$70
	4-6"	$28	0	$0	0	$0	0	$0	4	$110	4	$110	$220
	7-12"	$44	0	$0	0	$0	15	$660	0	$0	0	$0	$660
	13-18"	$72	0	$0	10	$715	0	$0	0	$0	0	$0	$715
	19-24"	$94	0	$0	6	$561	0	$0	0	$0	0	$0	$561
	25-30"	$110	4	$440	0	$0	0	$0	0	$0	0	$0	$440
	31-36"	$138	2	$275	0	$0	0	$0	0	$0	0	$0	$275
	37-42"	$160	1	$160	0	$0	0	$0	0	$0	0	$0	$160
	43"+	$182	1	$182	0	$0	0	$0	0	$0	0	$0	$182
Activity Total(s)			**8**	**$1,056**	**16**	**$1,276**	**15**	**$660**	**6**	**$145**	**6**	**$145**	**$3,282**
High Risk Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$120	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	19-24"	$170	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$225	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31-36"	$305	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$590	1	$590	0	$0	0	$0	0	$0	0	$0	$590
Activity Total(s)			**1**	**$590**	0	$0	0	$0	0	$0	0	$0	**$590**
Routine Pruning (5-year cycle)	1-3"	$20	8	$160	8	$160	8	$160	7	$140	7	$140	$760
	4-6"	$30	25	$750	25	$750	25	$750	24	$720	24	$720	$3,690
	7-12"	$75	88	$6,600	88	$6,600	88	$6,600	87	$6,525	87	$6,525	$32,850
	13-18"	$120	95	$11,400	94	$11,280	94	$11,280	94	$11,280	94	$11,280	$56,520
	19-24"	$170	68	$11,560	68	$11,560	68	$11,560	67	$11,390	67	$11,390	$57,460
	25-30"	$225	48	$10,800	48	$10,800	48	$10,800	48	$10,800	47	$10,575	$53,775
	31-36"	$305	28	$8,540	28	$8,540	27	$8,235	27	$8,235	27	$8,235	$41,785
	37-42"	$380	13	$4,940	13	$4,940	13	$4,940	13	$4,940	12	$4,560	$24,320
	43"+	$590	6	$3,540	6	$3,540	6	$3,540	5	$2,950	5	$2,950	$16,520
Activity Total(s)			**379**	**$58,290**	**378**	**$58,170**	**377**	**$57,865**	**372**	**$56,980**	**370**	**$56,375**	**$287,680**
Young Tree Training Pruning (3-year cycle)	1-3"	$20	19	$380	19	$380	20	$400	19	$380	19	$380	$1,920
	4-8"	$30	7	$210	7	$210	7	$210	7	$210	7	$210	$1,050
	7-12"	$75	4	$300	4	$300	3	$225	4	$300	4	$300	$1,425
Activity Total(s)			**30**	**$890**	**30**	**$890**	**30**	**$835**	**30**	**$890**	**30**	**$890**	**$4,395**
Replacement Tree Planting	Purchasing	$170	50	$8,500	50	$8,500	50	$8,500	50	$8,500	50	$8,500	$42,500
	Planting	$110	50	$5,500	50	$5,500	50	$5,500	50	$5,500	50	$5,500	$27,500
Activity Total(s)			**100**	**$14,000**	**100**	**$14,000**	**100**	**$14,000**	**100**	**$14,000**	**100**	**$14,000**	**$70,000**
Replacement Young Tree Maintenance	Mulching	$100	50	$5,000	50	$5,000	50	$5,000	50	$5,000	50	$5,000	$25,000
	Watering	$100	50	$5,000	50	$5,000	50	$5,000	50	$5,000	50	$5,000	$25,000
Activity Total(s)			**100**	**$10,000**	**100**	**$10,000**	**100**	**$10,000**	**100**	**$10,000**	**100**	$10,000	**$50,000**
Activity Grand Total			**563**		**574**		**578**		**573**		**506**		
Cost Grand Total				**$119,322**		**$107,590**		**$95,284**		**$88,043**		**$81,410**	**$491,649**

SECTION 4: PLANTING PLAN

The 2019 Clarence select tree inventory collected data on potential planting locations for new tree installations and identified a total of 2,757 vacant potential planting sites. The identification and analysis of these sites will inform future development of the Clarence urban forest and community. Data analysis of site density and distribution will allow the city to target planting efforts in geographic locations that maximize community benefits, such as in the identified potential environmental justice areas within Clarence.

The sites are areas identified as suitable for tree planting and can be located within the street right-of-way. Clarence provided the select area in which to collect the inventory data, and these planting sites do not represent the entirety of the town.

Potential planting sites were characterized based on the size of tree at maturity best suited for the identified location. The inventory used the following size class distinctions:

- *Small vacant sites.* These sites require a minimum growing space width of 3 feet and a minimum total of growing space size of 32 square feet. Where overhead utilities are present, the recommended size is typically always small. Small sites are situated 20 feet on center from existing trees or other potential planting sites.
- *Medium vacant sites.* These sites require a minimum growing space width of 6 feet. Medium planting sites are located 30 feet on center from existing trees or other potential planting sites.
- *Large vacant sites.* These sites require a minimum growing space width of 8 feet and are situated 40 feet on center from existing trees or potential planting sites.

Additional planting site parameters were determined based on DRG best management practices and augmented by the constraints of the urban environment and infrastructure. In general, DRG arborists used the following guidelines in determining suitable locations for potential planting sites:

- No planting within 35 feet of an intersection.
- No planting within 15 feet of a fire hydrant.
- No planting within 10 feet of a driveway, the front of a street sign, water meter, electric box, telephone/utility pole, storm drain, manhole.
- No planting within 10 feet of existing structures.
- The overall landscape and existing planting scheme were also taken into account for the spacing and sizes of recommended planting sites.

The Clarence 2019 select tree inventory recorded information on the presence of overhead utilities and whether or not a conflict exists between the tree and the utility line. As an example, Photograph 3 shows a utility pole with primary lines above the transformer. The oak behind the pole is too close to the lines and has an unbalanced crown from previous pruning to clear the wires. Where the inventory noted the presence of overhead utility wires, the default recommended planting site is recorded as small, regardless of the available growing space. There are some locations with overhead utilities where a medium-size tree would be acceptable.

Photograph 3. *Representative photo of tree inventory identified tree conflicts with the higher voltage primary transmission lines, above the transformer.*

The town may always choose to plant a smaller or larger tree than recommended here. See Appendix C for suggested tree species by size.

Findings

i-Tree Landscape

The i-Tree Landscape tool is an excellent beginning to a priority planting plan. Using census block as the resolution for the plan, the tool deciphers planting areas by user-chosen parameters. This tool was utilized by evaluating 15 census blocks to gauge priority planting areas of Clarence compared to neighboring blocks. Figure 16 is the produced map from the tool. Clarence is located east of the parent city of Buffalo, approximately 11 miles east of Buffalo Niagara International Airport and 40 minutes away from Niagara Square in downtown Buffalo. The density of urban impact on the land lessens radially away from the east coast of Lake Erie and away from the central business district of Buffalo. From Clarence, the Tonawanda Indian Reservation is 12 miles northeast. Census blocks to the west of Clarence had a higher priority of need for coverage, which yields to the theme of easterly development path

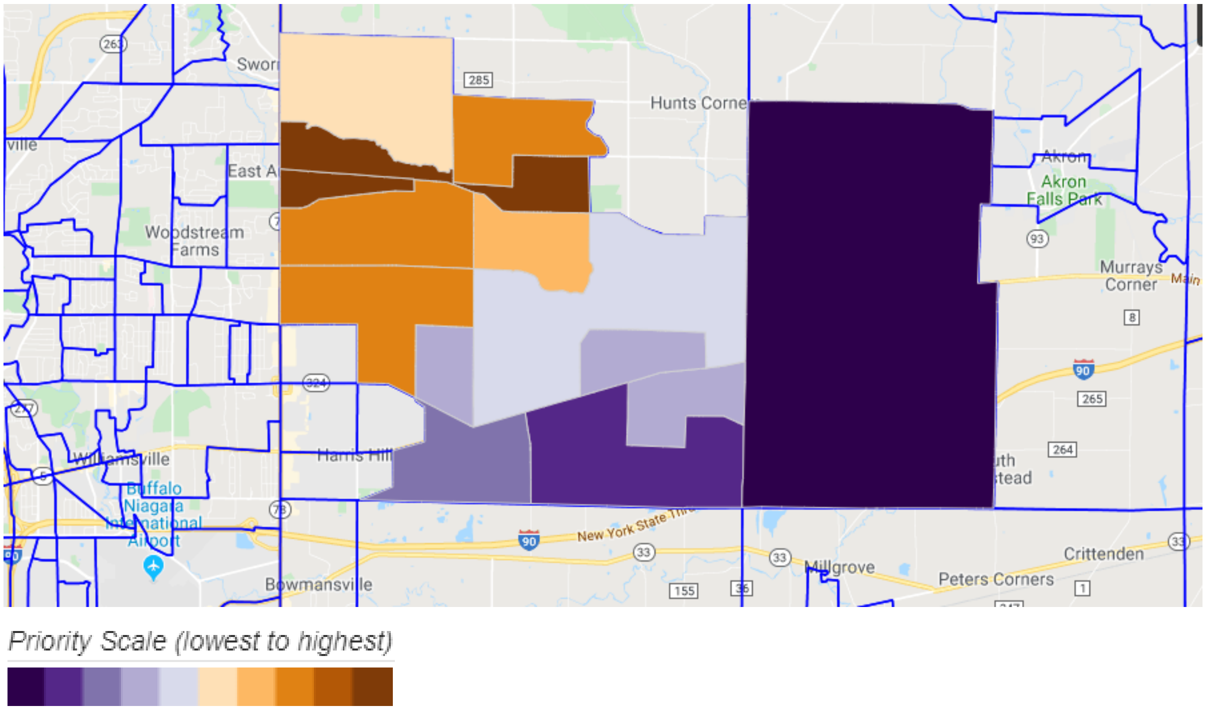


Figure 16. i-Tree Landscape output map for planting priorities for census block ground in and around Clarence.

The i-Tree Landscape tool provided a map of planting priorities based on census blocks. The blue outlines in the map above are census blocks and become smaller in size as urbanization increases. This i-Tree tool utilizes satellite photography and evaluates all of the trees (public and private) not only the specified inventory. Figure 17 shows the color ramp, priority index score, and block group identification numbers for the selected groups.

Type	ID	Highlight	Priority Index
Block Group	360290147022	☐	29
Block Group	360290147021	☐	30
Block Group	360290147025	☐	47
Block Group	360290147024	☐	11
Block Group	360290147023	☐	64
Block Group	360290147011	☐	94
Block Group	360290147012	☐	78
Block Group	360290146033	☐	36
Block Group	360290146042	☐	74
Block Group	360290146031	☐	79
Block Group	360290146043	☐	51
Block Group	360290146044	☐	99
Block Group	360290146041	☐	100
Block Group	360290148034	☐	0
Block Group	360290146011	☐	21

Figure 17. i-Tree Landscape output of hierarchy of block groups.

Priority Planting by Inventoried Sites

The tree inventory found a total of 2,757 vacant planting sites distributed throughout the select areas in Clarence (Table 10). Of the inventoried sites, 43% of the sites were rated medium sized.

Table 10. Vacant Planting Sites

Planting Site Size	Total	% of Total
Large (8 ft +).	606	22%
Medium (6–7 ft.)	1,198	43%
Small (4–5 ft.)	953	35%
Total	2,757	100%

Locations with a high density of vacant planting sites are generally areas with less existing overall canopy cover and thus good candidates for new planting initiatives. Planting in areas with a high density of vacant sites will help save costs through increased operational efficiencies during installation and will also help maximize benefits to the community and the urban forest.

The inventory found 45 stumps with 44 of these stumps within a grow space of greater than 8 feet. Further inspection of these sites for suitability should be noted when removing the stumps. Some of these locations with stumps would be suitable for planting sites.

Figures 18, 19, and 20 show the distribution of large, medium, and small vacant planting sites by priority class within the select inventory. Streets with higher densities of vacant sites are considered higher priority for new planting installations.

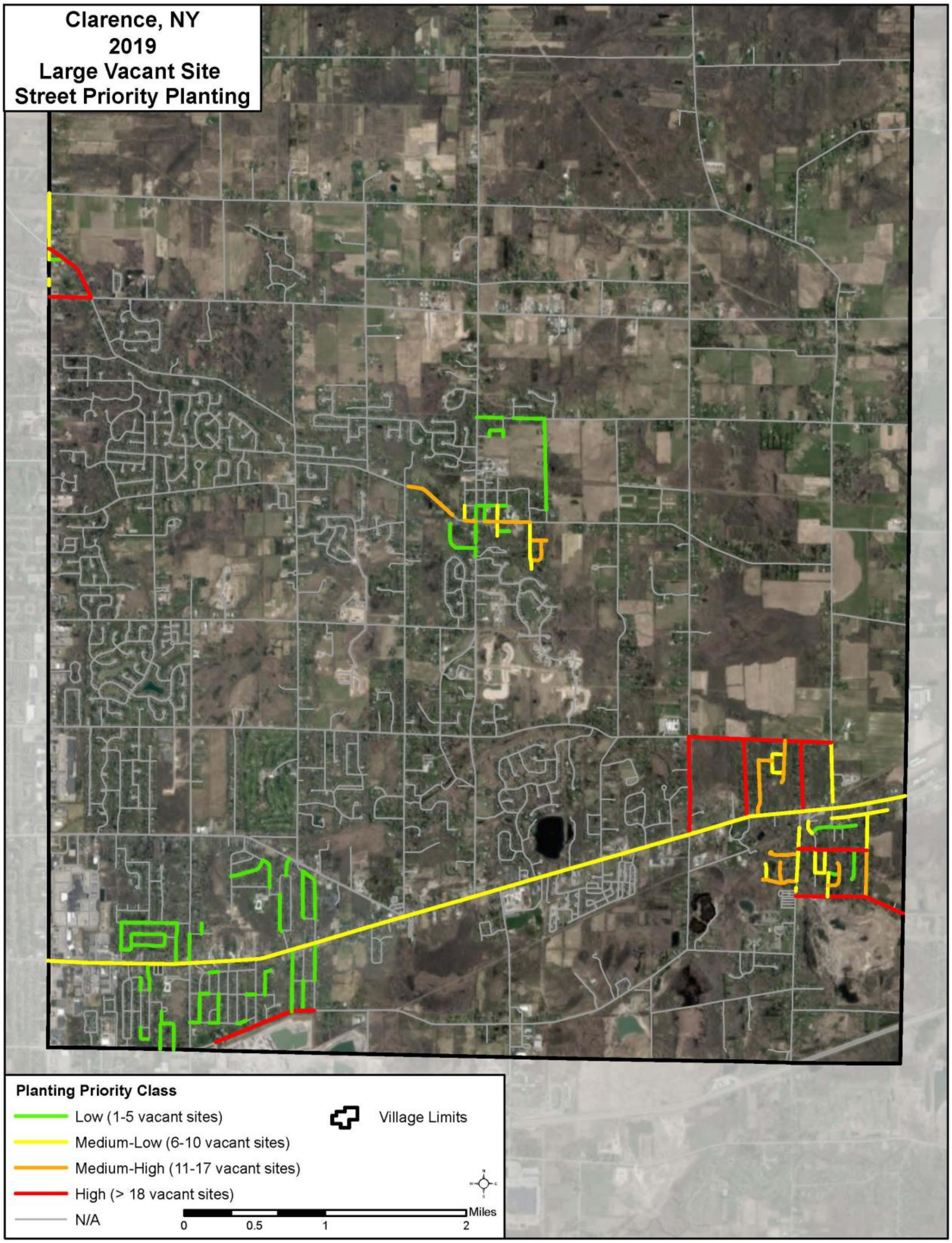


Figure 18. Large planting sites in the select inventory by priority class.

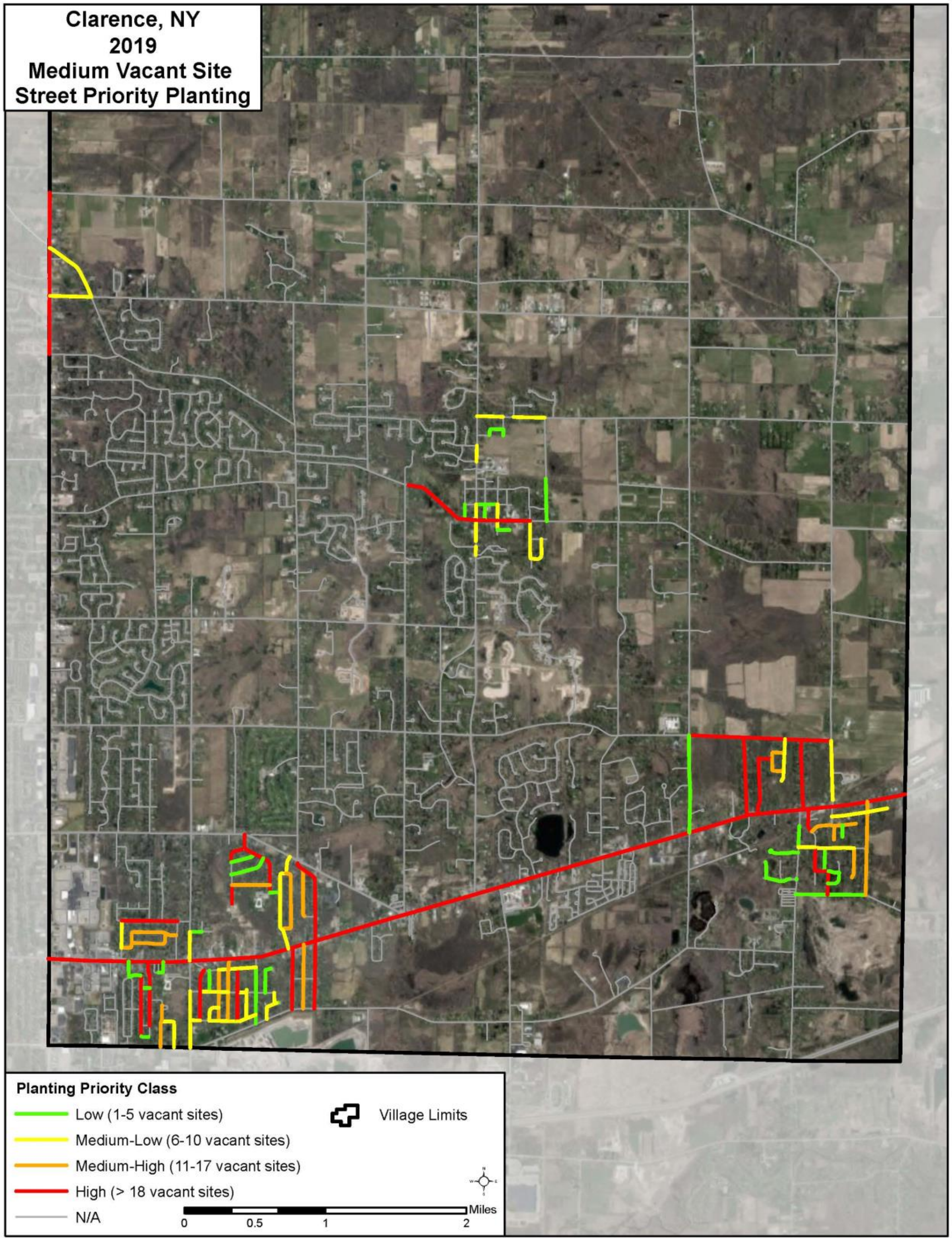


Figure 19. Medium planting sites in the select inventory by priority class.

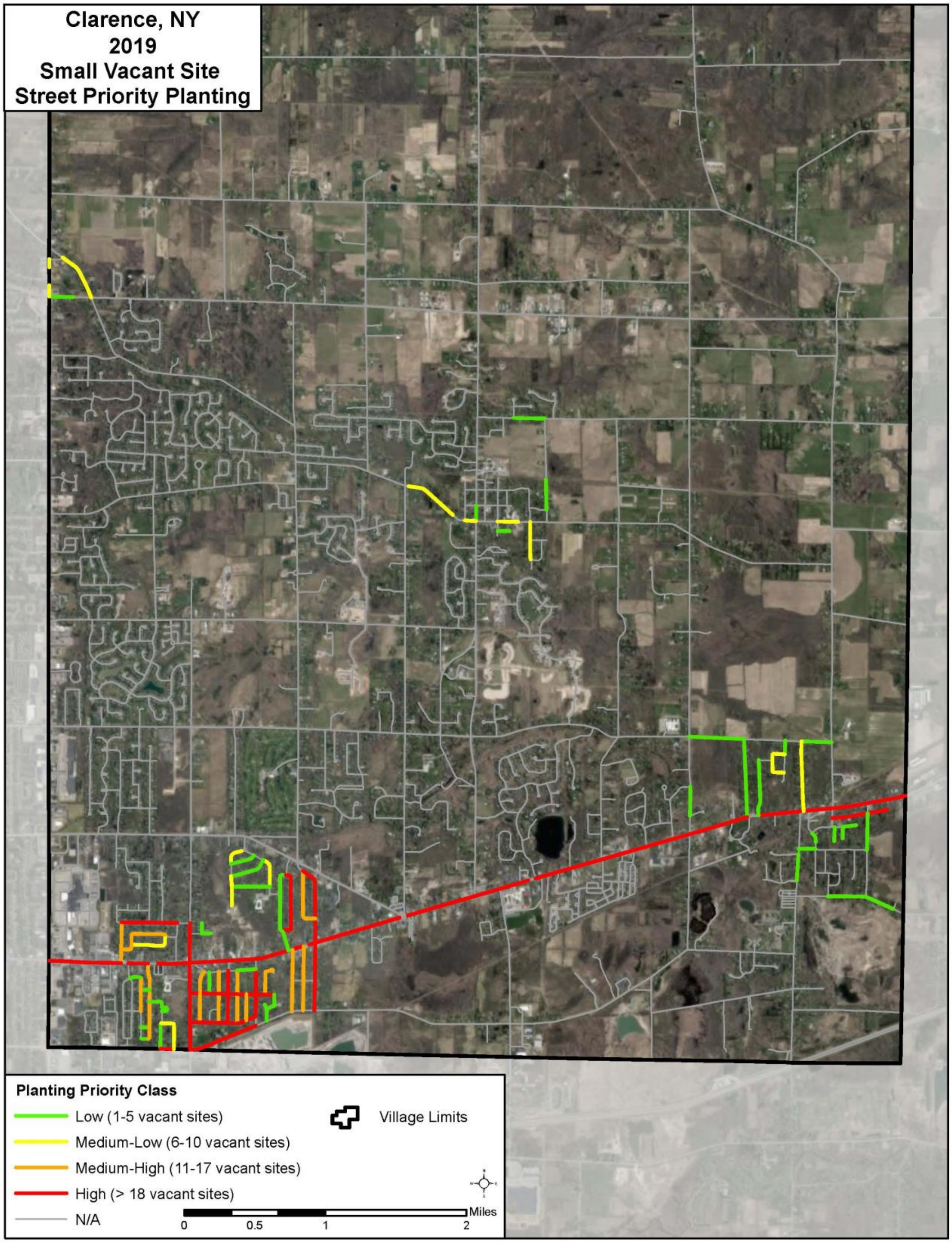


Figure 20. Small planting sites in the select inventory by priority class.

Discussion

Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted in appropriate locations. Improper species selection, improper site selection, and inappropriate planting methods can mean that a newly planted tree may become a future problem instead of a benefit to the community.

The majority of the vacant planting sites identified by the inventory are medium sites best suited for species with a modest growth habit. The data analysis provides the diversity framework for future planting locations; various trees for various site sizes allows for a mix of tree palettes.

Photograph 4. *Potential sidewalk damage may occur– choose the right tree for the right place.*

If not managed properly, a significant portion of the potential planting sites will become a challenge over time, particularly trees planted in the small planting site locations. The smaller the available growspace, the higher the likelihood that there could be conflicts with infrastructure as a tree grows. Damage to curbs and lifting, or cracking sidewalks, are common symptoms of a tree outgrowing its planting site, and this is clearly evidenced by the example sidewalk infrastructure (Photograph 4). Additionally, small planting sites with restricted grow spaces can limit the community benefits that trees provide, especially if the proper trees are not planted in those sites. Trees that are planted in sites that restrict root growth will often put undue stress on the tree and limit its ability to reach its full growth potential, as well as increase the tree's likelihood of failure. Selecting the appropriate species for the available grow space is critical for optimizing the environmental, economic, and social benefits that the tree is capable of providing to the community. Choose the largest tree for the site restrictions to gain the maximum value of ecobenefits.

While it is good to have a mix of planting site sizes, large trees provide more economic benefits to the community than small trees. A study by Geiger (2003) found that cities that were using small trees to reduce initial planting costs found a short-term savings, but over the long term found themselves with fewer benefits as the trees aged. While large vacant planting sites currently only make up 22% of the total number of vacant sites within ROWs, Clarence should take advantage of the large-sized planting sites when possible.

Improve Existing Growspaces

Creating larger growing sites for trees in the municipal ROW can be the single most beneficial management practice to improve the survival rate of planted and developing trees. Increasing planting space can also reduce the amount of tree-related infrastructure conflicts, as the trees will be planted further from curbs and sidewalks. However, species selection for these areas is very important as the presence of utility lines can mean clearance issues in the future. Depending on the site, there are several methods available to create and/or increase the growing space for newly planted trees:

- Install tree wells/pits in existing sidewalks of sufficient width. Ideally, the minimum growing space of a small-sized tree is 32 square feet. Where Clarence has sidewalks of a sufficient width and length, the city could install a tree pit while also leaving enough room for the sidewalk to still comply with American Disability Act (ADA) standards. Where tree pits do exist but are too small and the sidewalk width is sufficient, these pits can be enlarged.
- Planting trees 4 feet behind a curb with no sidewalk, or 4 feet behind an existing sidewalk, can be a low-cost alternative to more construction intensive methods. Using this method will result in less damage to the sidewalk and give the trees' roots room to grow into the open soil.
- Re-routing the sidewalk around an area to create designated large tree-growing spaces is a relatively cost-effective method to increase growing spaces. This method can also be applied to existing tree locations, where a tree's roots have already come in conflict with the sidewalk. The residential and commercial areas around 1st and 2nd Streets would be a suitable location for this strategy.
- A landscape bump-out, or curb extension, is a vegetative area that protrudes into the parking lane of a street, to provide a growing space for plants or trees. These spaces can be used quite effectively by municipalities to beautify a streetscape, provide greater storm water retention, along with the added benefit of slowing car speeds at the bump-out location. Streets where there is designated parking would be great locations for landscape bump-outs.
- Suspended pavement over noncompacted soil, or the implementation of structural cells, can greatly reduce the conflict between tree roots and infrastructure, as well as provide an ideal urban growing environment for the tree. The development of these types of planting sites can be costly and are typically taken on during larger capital improvement projects, due to their construction intensive nature.

While Clarence can expand tree canopy on city rights-of-way and publicly owned lands, fully realizing potential tree canopy coverage, for both public and private land, will require the cooperation of business owners and private residents. Generally, this may be accomplished through a variety of strategies designed specifically for each municipality. Such strategies may include public outreach and education, volunteer opportunities, new policies, and cost-share programs.

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.

Clarence is located in United States Department of Agriculture (USDA) Hardiness Zone 6a, which is identified as a climatic region with average annual minimum temperatures between -10°F and 5°F. Tree species selected for planting should be appropriate for this zone.

Tree species should be selected for their durability and low-maintenance characteristics. These attributes are highly dependent on the below ground characteristics of the planting site (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 and hardscape as it grows taller, wider, and deeper. If the tree at maturity will reach overhead lines, or conflict with sidewalks and curbs, it is best to choose another tree or a different location. Taking the time to consider location before planting can prevent power disturbances and improper utility pruning practices.

Too much of a single tree species can lead to significant canopy losses. Low species diversity can lead to severe losses in the event of species-specific epidemics, such as the devastating results of emerald ash borer (EAB, *Agrilus planipennis*). The ideal distribution for a tree population should follow the 10-20-30 rule for species diversity: a single species should represent no more than 10% of the population, a single genus no more than 20%, and a single family no more than 30% of the population.

A list of suggested tree species is provided in Appendix C. These tree species are specifically selected for the climate of Clarence. This list is not exhaustive but can be used as a guideline for species that meet community objectives and to enhance any existing list of approved species. Another popular tool is the i-Tree species tool, where tree lists can be complied based on the user's desired benefit (https://species.itreetools.org/).

Tips for Planting Trees

To ensure a successful tree planting effort, the following measures should be taken:

- Purchase high-quality trees, a caliper size of 2 to 2.5 inches is recommended for the size of the tree. All trees should be inspected to ensure that they meet the size and proportion guidelines set out in the American Standard for Nursery Stock (ANSI Z60.1). Some of the characteristics of healthy nursery trees include free of bark injuries and wounds, healthy root systems, balanced branch distribution, proper taper, and good vigor. There is no substitute for purchasing high-quality trees.
- 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 flare 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.
- 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.
- 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.

CONCLUSIONS

Every hour of every day, public trees in Clarence are supporting and improving the quality of life. The select inventory trees provide an annual functional benefit of $11,000 and have a structural value of over $6 million dollars. 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.

Focus on planting a diversity of trees. There were ample planting sites noted in the select inventory; pick the best suitable sites for tree success.

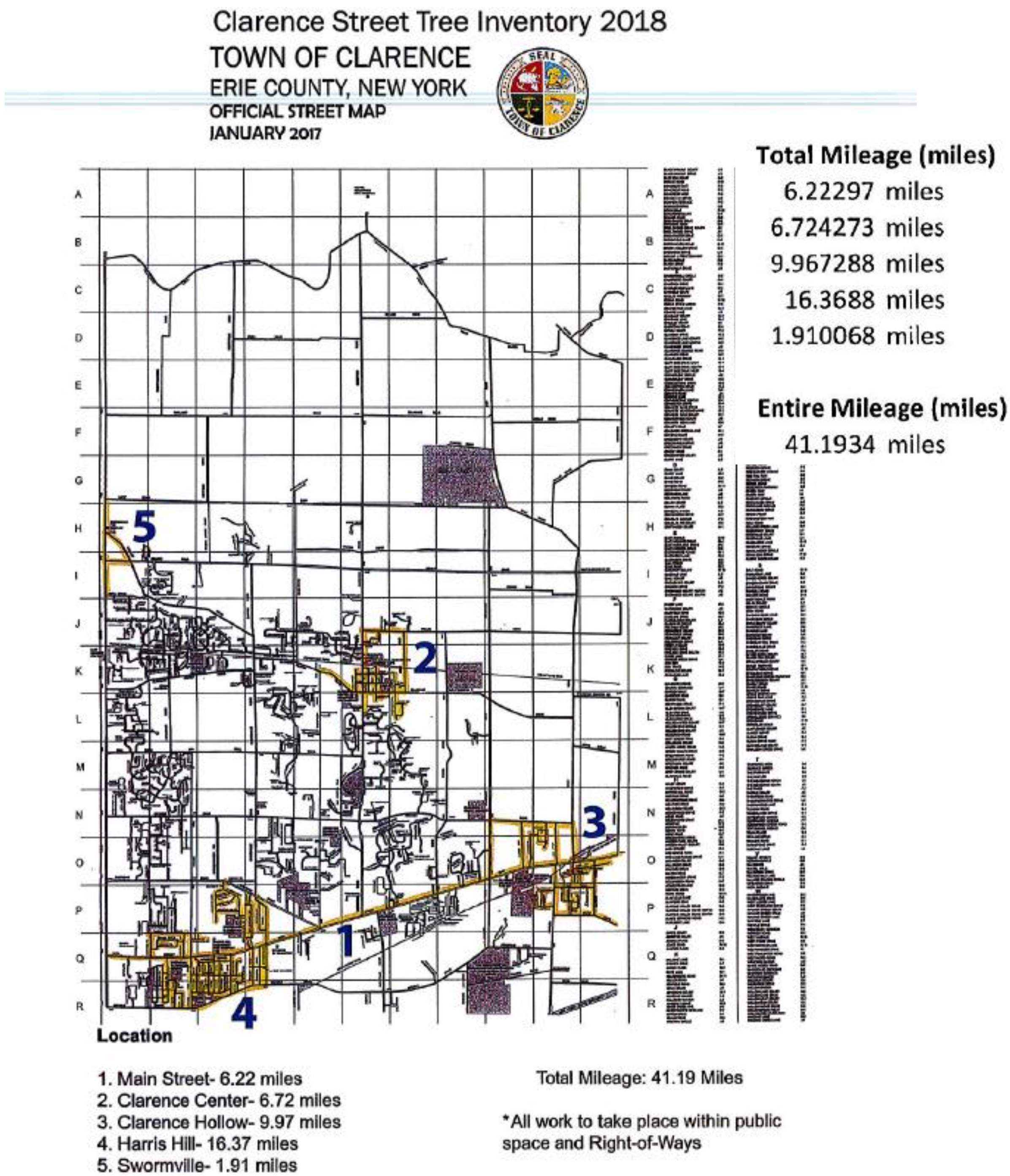
The town must carefully consider these challenges to fully understand the needs of maintaining an urban forest. With the knowledge and wherewithal to address the needs of the trees, Clarence is well positioned to thrive. If the management program is successfully implemented, the health and safety of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

Inventory and Plan Updates

It is recommended the inventory and management plan be updated using an appropriate computer software program in order to sustain this existing inventory and urban forestry 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 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® 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 5 years, or a portion of the population (1/5) every year over the course of 5 years.
- Revise the *Tree Management Plan* after 5 years when the re-inventory has been completed.

APPENDIX A
CLARENCE INVENTORY AREAS



	Corridor	Street Name	Street Length (feet)
1	Main Street	Main Street (Transit Road to Newstead)	32,857.28 feet
			Total length (feet)
			32,857.28 feet

	Hamlet	Street Name	Street Length (feet)
2	Clarence Center	Clarence Ctr (Thompson to Herr)	5750.48 feet
		Long Street	1421.73 feet
		Brookside Drive	692.4 feet
		Goodrich (Brookside to Keller)	4878.59 feet
		Maple Street	1733.9 feet
		High Street	2394.37 feet
		Railroad Street	1851.03 feet
		Village Mill Lane	231.75 feet
		Elm Street	2108.38 feet
		Hartwig Drive	401.48 feet
		Eastwood Street	572.71 feet
		Creekview Drive	1,692.51 feet
		Fairlane Drive	1219.07 feet
		Kamner Drive	1682.67 feet
		Hilton Drive	652.88 feet
		Herr Road	3851.04 feet
		Keller (Goodrich to Herr)	2524.84 feet
		Countryside Court	1172.87 feet
		Mayfair Drive	671.46 feet
			Total length (feet)
			35504.16 feet

	Hamlet	Street Name	Street Length (feet)
3	Clarence Hollow	Strickler Road	3647.22 feet
		Hillcrest Drive	2917.96 feet
		Alexander Drive	2561.46 feet
		Elmcroft Court	1524.63 feet
		Brockhaven Drive	1524.24 feet
		Bank Street	2601.46 feet
		Salt Road (Main to Greiner)	2450.13 feet
		Greiner Road (Salt to Strickler)	5311.71 feet
		Ransom Road (Main to Stage)	3170.15 feet
		Stoneway	1224.03 feet
		Royal Oak Drive	1507.68 feet
		Oakwood Lane	547.92 feet

		Pepperwood Lane	787.75 feet
		Stage Road (until Newstead)	4154.2 feet
		Sawmill Road	3765.35 feet
		Pine Manor	1114.38 feet
		Manorwood	398.8 feet
		Bickert Drive	850.19 feet
		Boyd Drive	2561.86 feet
		Margaret Drive	1034.2 feet
		Schurr Road	3482.92 feet
		Academy Street	686 feet
		Bodine Road	2172.95 feet
		South Park Avenue	799.23 feet
		Park Avenue	894.81 feet
		West Avenue	514.2 feet
		East Avenue	421.85 feet
			Total length (feet)
			52627.28 feet

	Hamlet	**Street Name**	**Street Length (feet)**
4	**Harris Hill**	Westwood Drive	1513.34 feet
		Vernon Circle	2596.03 feet
		Kimberly Road	1613.06 feet
		Ericson Drive	2707.95 feet
		Arondale Drive	1506.2 feet
		Merrihurst Drive	812.42 feet
		Darcy Lane	364.69 feet
		Susan Drive	2799.82 feet
		W Susan Drive	324.2 feet
		Clardon Drive	2292.17 feet
		Karen Place	326.24 feet
		Donna Place	328.7 feet
		David Road	2204.66 feet
		David Court	465.4 feet
		Elma Road	1398.26 feet
		Harris Hill (Wehrle to Ericson)	4726.05 feet
		Wehrle (David Road to Shimerville)	6048.79 feet
		Nottingham Terrace	2478.77 feet
		Oakwood Drive	1896.67 feet
		Fireside Drive	770.45 feet
		Wildwood Drive	1898.9 feet
		S. Fireside Drive	742.21 feet
		Circle Court	2325.43 feet
		Trailing Drive	1957.71 feet
		Vinewood Drive	1059.76 feet
		Connection Drive	2503.5 feet

Howard Drive	3149.92 feet
Sunset Drive	2488.89 feet
Fairfield Road	1324.25 feet
Old Hickory Lane	434.86 feet
Heather Drive	1196.69 feet
James Court	141.57 feet
Roxbury Drive	2315.53 feet
Cameron Drive	2410.17 feet
Howard Drive East	826.64 feet
Shimerville (Wehrle to Sheridan)	5870.67 feet
Boncrest Road	698.58 feet
Boncrest Drive West	3299.08 feet
Bondview Terrace	925.24 feet
Rebecca Drive	1403.88 feet
Sheridan Hill Drive	1410.54 feet
Boncrest Drive East	2130.41 feet
Reiser Road	347.71 feet
Overlook Drive	1725.24 feet
West Overlook Drive	2335.48 feet
East Overlook Drive	2169.11 feet
Christian Drive	2161.43 feet
	Total length (feet)
	86427.27 feet

	Hamlet	Street Name	Street Length (feet)
5	**Swormville**	Transit Road (Miles to Lapp)	6053.62 feet
		County Road (Transit to Stahley)	1554.56 feet
		Stahley Road (Transit to County)	2476.98 feet
			Total length (feet)
			10085.16 feet

	Totals	**All Highlighted Roads**
	Hamlet/Corridor	**Total length (feet)**
1	**Main Street**	32,857.28 feet
2	**Clarence Center**	35,504.16 feet
3	**Clarence Hollow**	52,627.28 feet
4	**Harris Hill**	86,427.27 feet
5	**Swormville**	10,085.16 feet
		Entire length (feet)
	All Hamlets	217,501.15 feet

APPENDIX B
DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

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

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

- Last Change (collector name)
- Inspection Date
- Notes (thoughts during inspection)
- ID (Unique Tree Number)
- Inventory Date
- Inspection Time
- Species
- DBH*
- Multi-Stem
- Condition
- Primary Maintenance Task
- Inspection Recommendation
- Overhead Utility
- ResiRisk
- Assessment Recommendation
- Parcel ID
- Defects
- Risk Assessment (multiple fields)
- Growing Space
- Address
- X and Y Location
- Long / Lat Location

* 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). *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture [ISA] 2017).

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

Site Location Methods

Equipment and Base Maps

Inventory arborists use CF-19 Panasonic Toughbook® unit(s) and Trimble® GPS Pathfinder® ProXH™ receiver(s).

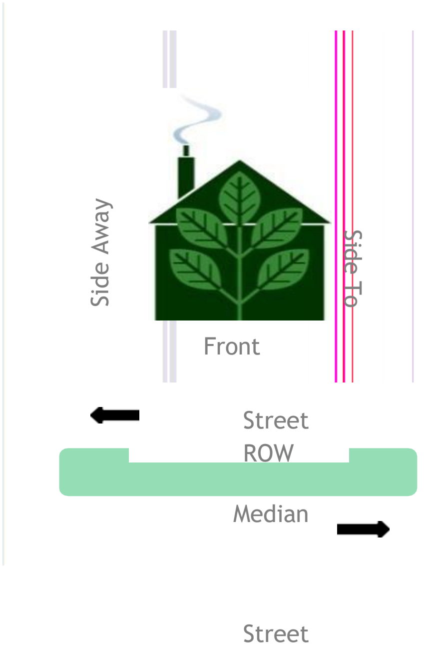
Base map layers were loaded onto these unit(s) to help locate sites during the inventory. The table below lists the base map layers, utilized along with source and format information for each layer.

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Erie County GIS	2018	NAD 1983StatePlane NY Central; Feet
NYGIS Clearinghouse ttp://gis.ny.gov/	2018	NAD 1983StatePlane NY Central; 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.



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). The *front side* is the side that faces the address street. *Side to* is the name of the street the arborist walks toward 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.

<u>Corner Lot A</u>		**<u>Corner Lot B</u>**	
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Side To / 1	Side/Site Number:	Side To / 1
On Street:	Taft St.	On Street:	Davis St.
From Street:	E Mac Arthur St.	From Street:	Hoover St.
To Street:	Hoover St.	To Street:	E Mac Arthur St.
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Side To / 2	Side/Site Number:	Front / 1
On Street:	Taft St.	On Street:	E Mac Arthur St.
From Street:	E Mac Arthur St.	From Street:	Davis St.
To Street:	Hoover St.	To Street:	Taft St.
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Side To / 3	Side/Site Number:	Front / 2
On Street:	Taft St.	On Street:	E Mac Arthur St.

APPENDIX C
SUGGESTED TREE SPECIES

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in most soil and climate conditions found throughout the eastern United States. Another resource is the i-Tree Species tool.

Large Trees: Greater than 50 Feet in Height When Mature

Scientific Name	Common Name	Cultivar
Acer rubrum	red maple	'Autumn Flame' 'Bowhall' 'Brandywine' 'Karpick' 'Northwood' 'October Glory' 'Red Sunset'
Acer saccharum	sugar maple	'Commemoration' 'Green Mountain' 'Legacy'
Acer × freemanii	Freeman maple	'Armstrong' 'Autumn Blaze' 'Celebration' 'Scarlet Sentinel'
Celtis laevigata	sugar hackberry	'All Seasons'
Celtis occidentalis	hackberry	'Prairie Pride'
Eucommia ulmoides	hardy rubber tree	
Ginkgo biloba	ginkgo	(Choose male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	hademaster' 'Skyline'
Gymnocladus dioicus	Kentucky coffeetree	Prairie Titan®
Liquidambar styraciflua	sweetgum	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	black tupelo	
Platanus × acerifolia	London planetree	'Bloodgood'
Quercus acutissima	sawtooth oak	
Quercus bicolor	swamp white oak	
Quercus ellipsoidalis	northern pin oak	
Quercus imbricaria	shingle oak	
Quercus macrocarpa	bur oak	
Quercus palustris	pin oak	

Large Trees: Greater than 50 Feet in Height When Mature (Continued)

Scientific Name	Common Name	Cultivar
Quercus robur	English oak	'Attention' 'Skymaster' 'Skyrocket'
Quercus rubra	northern red oak	'Splendens'
Quercus shumardii	shumard oak	
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia cordata	littleleaf linden	'Chancole' 'Corzam' 'Fairview' 'Glenleven' 'Greenspire'
Tilia americana	American linden	'Redmond'
Tilia tomentosa	silver linden	'Sterling'
Tilia × euchlora	Crimean linden	
Ulmus ×	hybrid elm	'Frontier' 'Homestead' 'Pioneer' 'Regal' 'Urban' 'Accolade'
Zelkova serrata	Japanese zelkova	'Green Vase' 'Halka' 'Village Green'

Medium Trees: 26 to 49 Feet in Height When Mature

Scientific Name	Common Name	Cultivar
Acer campestre	hedge maple	'Queen Elizabeth' 'St. Gregory'
<u>*Acer miyabei*</u>	Miyabe maple	'State Street'
<u>*Acer truncatum ×*</u>	Norwegian sunset maple	'Keithsform'
<u>*Acer truncatum ×*</u>	Pacific sunset maple	'Warrenred'
<u>*Aesculus × carnea*</u>	red horsechesnut	'Briotii'
Carpinus betulus	European hornbeam	
Carpinus caroliniana	American hornbeam	
Cercidiphyllum japonicum	Katsura	
Cladrastis kentukea	American yellowwood	'Rosea'
Corylus colurna	Turkish filbert	
Gleditsia triacanthos inermis	thornless honeylocust	'Imperial'
Halesia tetraptera	Carolina silverbell	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	American hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense	Amur corktree	'Macho'
Styphnolobium japonicum	Japanese pagodatree	'Princeton Upright' 'Regent'
Ulmus parvifolia	lacebark elm	'Dynasty' 'Ohio'

Small Trees: 10 to 25 Feet in Height when Mature

Scientific Name	Common Name	Cultivar
Acer buergerianum	trident maple	
Acer tataricum ssp. ginnala	Amur maple	Red Rhapsody ™
Acer griseum	paperbark maple	
Acer pensylvanicum	stripled maple	
Amelanchier spp.	serviceberry.	
Cercis canadensis	eastern redbud	'Forest Pansy'
Chionanthus retusus	Chinese fringetree	
Cornus kousa	Kousa dogwood	'Galzam' 'Milky Way' 'Propzam' 'Samzam' 'Satomi'
Cornus racemosa	gray dogwood	'Cuyzam' 'Ottzam'
Crataegus species	hawthorn	
Malus species	flowering crabapple	(Disease resistant only)
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

Special Use Trees

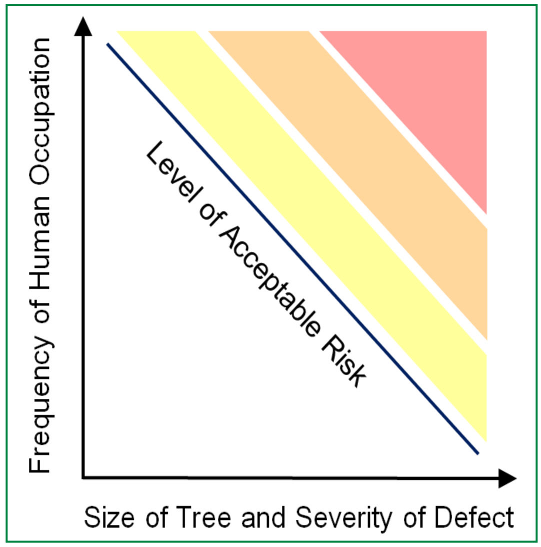
In certain areas of the city, such as the downtown business district or in areas of restricted aboveground space, the best tree choice may be those varieties that grow more upright in what is termed a fastigiate, or columnar, manner. This form achieves two purposes—because of their tighter, upright habit, there is minimal storefront blockage; and they will not be wide branching, thus avoiding sidewalk clearance concerns. The following tree species and varieties offer the described characteristics and should be considered for tight space situations:

Scientific Name	Common Name	Cultivar
Acer campestre	hedge maple	'Evelyn'
Acer rubrum	red maple	'Bowhall' 'Karpick'
Amelanchier arborea	downy serviceberry	'Cumulus' 'Robin Hill'
Carpinus betulus	European hornbeam	'Fastigiata'
Ginkgo biloba	ginkgo	'Lakeview' Princeton Sentry®
Malus species	flowering crabapple	'Centurion' 'Harvest Gold' Madonna™ 'Sentinel'
Prunus sargentii	sargent cherry	'Columnaris'
Prunus serrulata	Japanese flowering cherry	'Amanogawa'
Quercus robur	English oak	'Regal Prince' ™ 'Skyrocket'
Quercus robur x bicolor	English oak hybrid	'Long'

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. The newest iteration of Dirr's book is written with Keith Warren and is titled, "The Tree Book – Superior Selection for Landscapes Streetscapes, and Gardens." It was released in Spring 2019.

APPENDIX D
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 **toward** 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.

Risk Rating Matrix Table

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, staff may decide that cabling, bracing, or moving the target may be the best option for reducing risk.

Determination of acceptable risk ultimately lies with municipal 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

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 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 cleanup costs. Keeping these pests and diseases out of the country is the number one priority of the USDA's Animal and Plant Inspection Service (APHIS). Updated maps can be found at: https://www.nrs.fs.fed.us/tools/afpe/maps/

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.

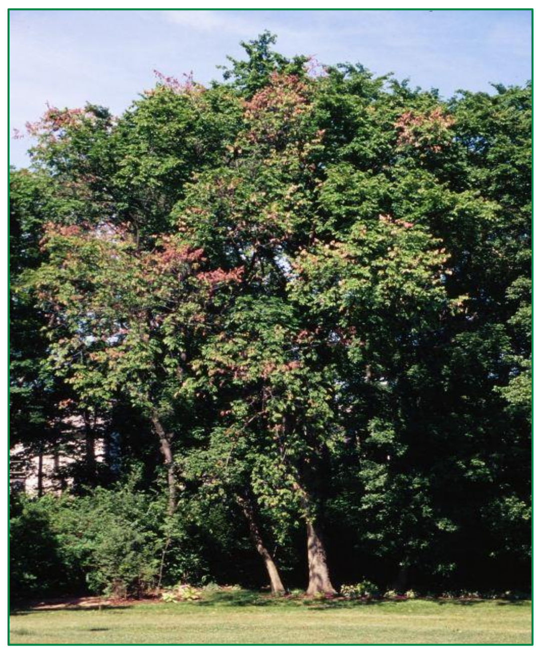
Adult Asian longhorned beetle

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 elm. Today, DED covers about two-thirds of the eastern United States, including Illinois, and annually kills many of the remaining and newly planted elm. 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.



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

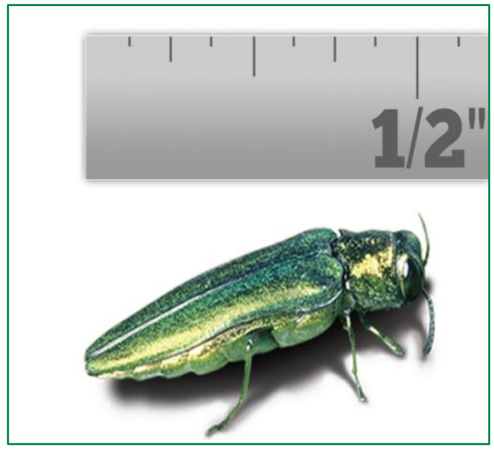
Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011)

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 elm by elm bark beetles. Two species carry the fungus: native elm bark beetle (*Hylurgopinus rufipes*) and European elm bark beetle (*Scolytus multistriatus)*.

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

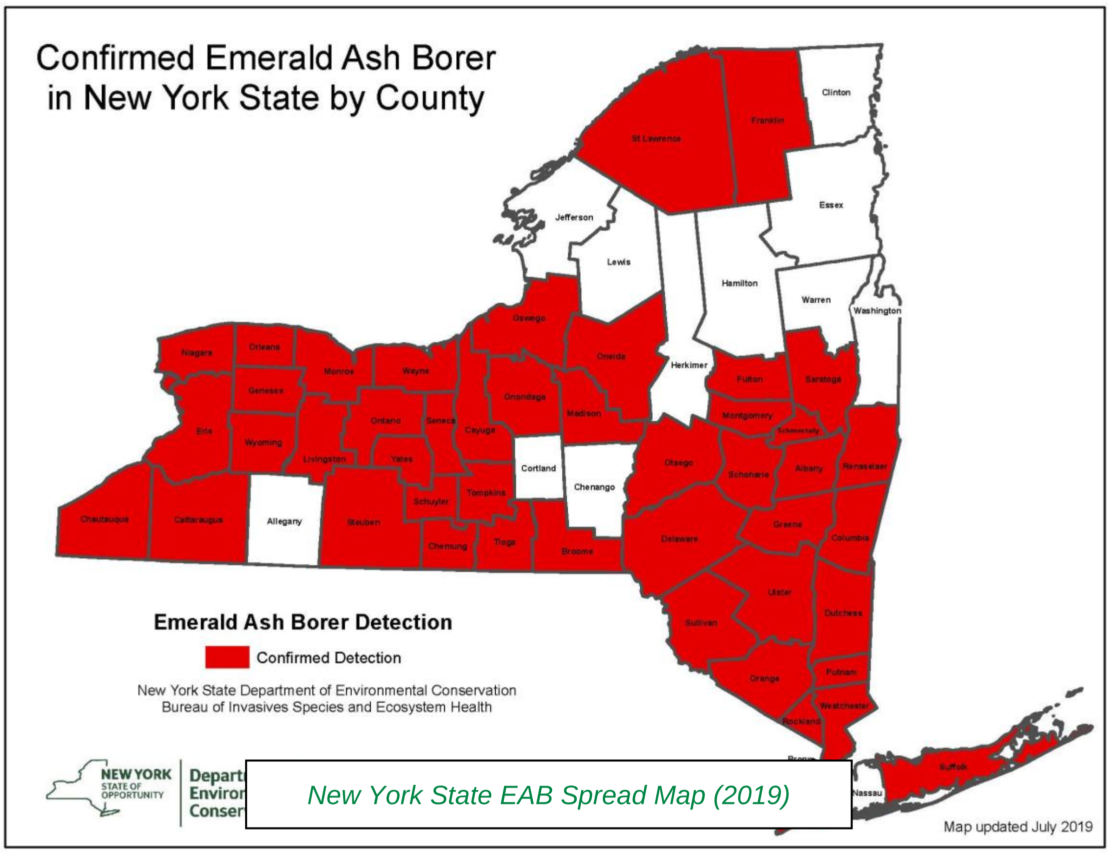
Emerald Ash Borer

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



Close-up of the emerald ash borer
Photograph courtesy of APHIS (2011)

Adult beetles are slender and 1/2-inch long. Males are smaller than females. Color varies but adults are usually bronze or golden green overall with metallic, emerald-green wing covers. The top of the abdomen under the wings is metallic, purplish-red and can be seen when the wings are spread. The EAB-preferred host tree species are in the genus *Fraxinus* (ash).



New York State EAB Spread Map (2019)

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.

Xm Ambrosia Beetle

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

Xm ambrosia beetle

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

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

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

Hemlock Woolly Adelgid

Hemlock woolly adelgids on a branch
Photograph courtesy of USDA Forest Service (2011a)

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

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

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

Oak Wilt

Oak wilt symptoms on red and white oak leaves

Photograph courtesy of USDA Forest Service (2011a)

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

Just as with DED, oak wilt disease is caused by a fungus that clogs the vascular system of oaks and results in decline and death of the tree. The fungus is carried from tree to tree by several borers common to oak, 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. Oak wilt has been identified in the Finger Lakes Region (Canadaigua, New York).

Pine Shoot Beetle

Mined shoots on a Scotch pine Photograph courtesy of USDA Forest Service (1993)

The pine shoot beetle (*Tomicus piniperda L.*), a native of Europe, is an introduced pest of *Pinus* (pine) in the United States. It was first discovered in the United States at a Christmas tree farm near Cleveland, Ohio in 1992. Following the first detection in Ohio, the beetle has been detected in parts of 19 states (Connecticut, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin).

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

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

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

Sirex Woodwasp

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

Close-up of female Sirex Woodwasp

Photograph courtesy of USDA (2005)

Woodwasps (or horntails) are large robust insects, usually 1.0 to 1.5 inches long. Adults have a spear-shaped plate (cornus) at the tail end; in addition, females have a long ovipositor under this plate. Larvae are creamy white, legless, and have a distinctive dark spine at the rear of the abdomen. More than a dozen species of native horntails occur in North America.

Sirex woodwasps can attack living pines, while native woodwasps attack only dead and dying trees. At low populations, sirex woodwasp selects suppressed, stressed, and injured trees for egg laying. Foliage of infested trees initially wilts, and then changes color from dark green to light green, to yellow, and finally to red, during the 3 to 6 months following attack. Infested trees may have resin beads or dribbles at the egg laying sites, but this is more common at the mid-bole level. Larval galleries are tightly packed with very fine sawdust. As adults emerge, they chew round exit holes that vary from 1/8 to 3/8 inch in diameter.

Southern Pine Beetle

The southern pine beetle (SPB, *Dendroctonus frontalis*) is the most destructive insect of pest pine in the southern United States. It attacks and kills all species of southern yellow pines including *P. strobus* (eastern white pine). Trees are killed when beetles construct winding, S-shaped egg galleries underneath the bark. These galleries effectively girdle the tree and destroy the conductive tissues that transport food throughout the tree. Furthermore, the beetles carry blue staining fungi on their bodies that clog the water conductive tissues (wood), which transport water within the tree. Signs of attack on the outside of the tree are pitch tubes and boring dust, known as frass, caused by beetles entering the tree.

Adult southern pine beetles

Photograph courtesy of Forest Encyclopedia Network (2012)

Adult SPBs reach an ultimate length of only 1/8 inch, similar in size to a grain of rice. They are short-legged, cylindrical, and brown to black in color. Eggs are small, oval-shaped, shiny, opaque, and pearly white.

Sudden Oak Death

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

Drooping tanoak shoot

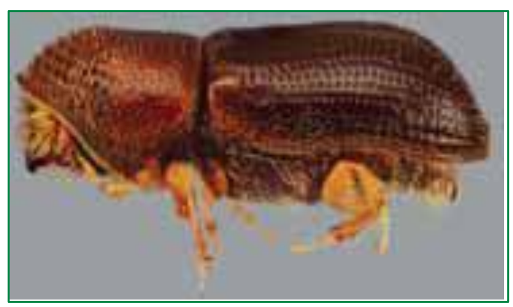
Photograph courtesy of Indiana Department of Natural Resources (2012)

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

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

Thousand Cankers Disease

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



Walnut twig beetle, side view

Photograph courtesy of USDA Forest Service (2011b)

TCD results from the combined activity of the *Geosmithia morbida* fungus and the walnut twig beetle (WTB, *Pityophthorus juglandis*). The WTB has expanded both its geographical and host range over the past 2 decades, and coupled with the *Geosmithia morbida* fungus, *Juglans* (walnut) mortality has manifested in Arizona, California, Colorado, Idaho, New Mexico, Oregon, Utah, and Washington. In July 2010, TCD was reported in Knoxville, Tennessee. The infestation is believed to be at least 10 years old and was previously attributed to drought stress. This is the first report east of the 100th meridian, raising concerns that large native populations of *J. nigra* (black walnut) in the eastern United States may suffer severe decline and mortality.

The tree species preferred as hosts for TCD are walnuts.

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