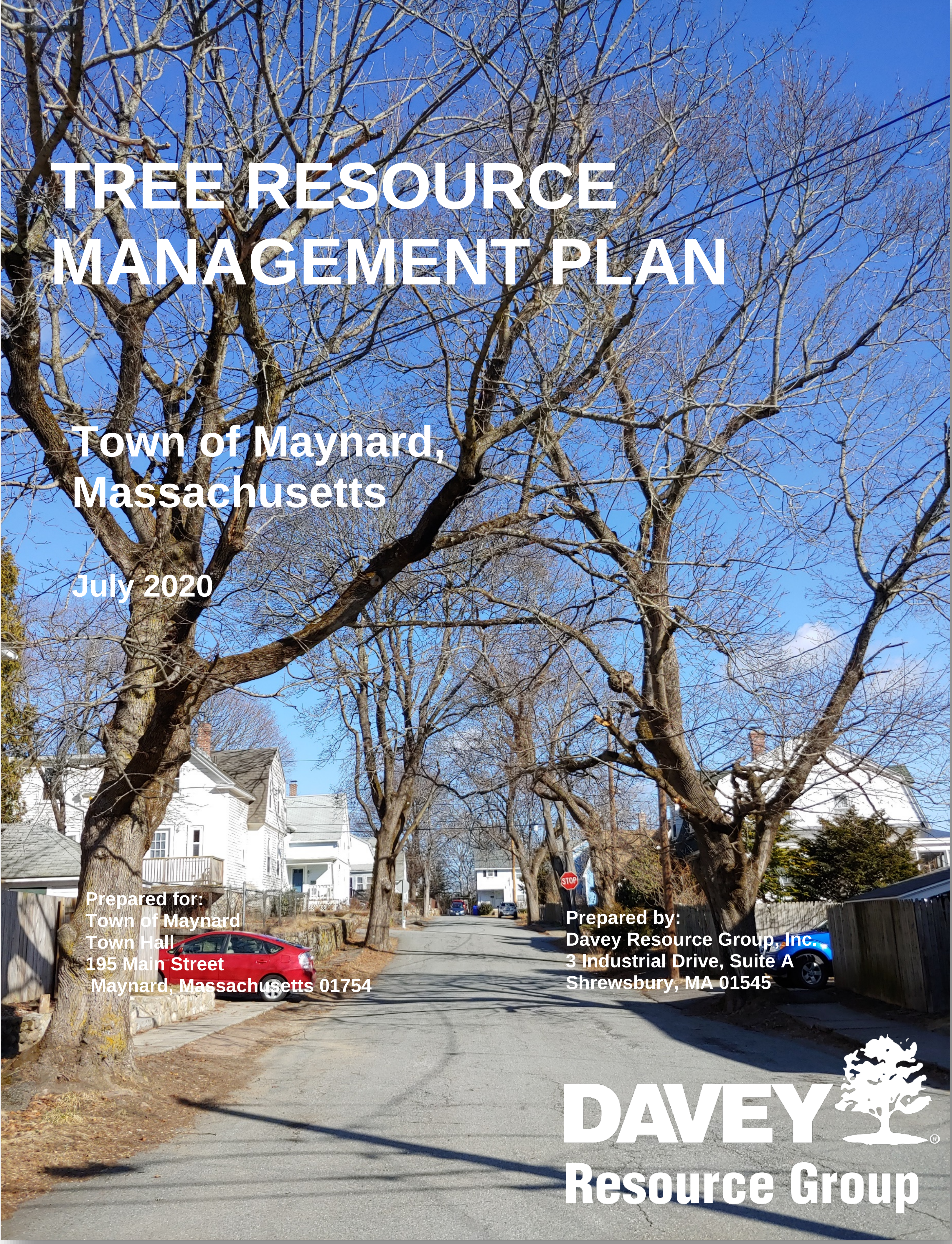

TREE RESOURCE MANAGEMENT PLAN

Town of Maynard, Massachusetts

July 2020

Prepared for:
Town of Maynard
Town Hall
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DAVEY Resource Group

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ACKNOWLEDGMENTS

This project supports the Town of Maynard's vision to promote and enhance community well-being through public tree conservation and improved forestry management practices. This management plan, informed by Maynard's public tree inventory, offers expertise in keeping and expanding urban canopy so the environmental and economic benefits it provides continue for generations.

Maynard is thankful for the grant funding it received from the Massachusetts Department of Conservation and Recreation (DCR) through its Urban and Community Forestry (U&CF) Challenge Grant Program. The U&CF Challenge Grant Program is designed to encourage communities to create and support sustainable urban forestry programs throughout the state of Massachusetts.

Maynard also recognizes the support of:

The Board of Selectmen: Chris DiSilva (Chairman), Melissa Ann Levine-Piro (Clerk), David Gavin (Selectman), Armand Diarbekirian (Selectman), Justine St. John (Selectman)

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Kaitlin Young (Conservation Agent/Assistant Planner)

Justin DeMarco (DPW Director/Maynard Tree Warden)

Aaron Miklosko (former DPW Director/Maynard Tree Warden)

Friends of Maynard Trees

DPW Staff

EXECUTIVE SUMMARY

The Town of Maynard *Tree Resource Management Plan*, written by Davey Resource Group Inc. "DRG", focuses on quantifying the benefits provided by the inventoried tree resource and addressing its maintenance needs. DRG completed a tree inventory for the Town of Maynard in February 2020. DRG analyzed this inventory data to understand the structure of Maynard's inventoried tree resource and to recommend a prioritized maintenance schedule for future tree care. DRG also estimated the economic values of the various environmental benefits provided by Maynard's inventoried tree resource by analyzing inventory data with i-Tree Eco.

Structure and Composition of the Tree Resource

The February 2020 inventory included trees, stumps, and planting sites along public street rights-of-way (ROW) and trees and stumps in Glenwood Cemetery. A total of 5,439 sites were recorded during the inventory: 3,354 trees, 360 stumps, and 1,725 planting sites. Analysis of the tree inventory data found the following:

- The genus *Acer* (maple) comprises 43% of Maynard's inventoried tree resource, which is much higher than DRG's recommended threshold of 20% for any genus.
- 43% of the inventoried tree resource is in the *Sapindaceae* family, which exceeds DRG's recommended 30% threshold for any family, but this sub-population is almost entirely maple.
- Maynard's ROW tree resource has fewer young trees (35% versus a 40% ideal) than DRG recommends while having more mature trees (17% versus a 10% ideal) than DRG recommends. Maynard's cemetery tree resource has fewer young trees (13% versus a 40% ideal) and established trees (14% versus a 30% ideal) than DRG recommends while having more maturing trees (28% versus a 20% ideal) and mature trees (45% versus a 10% ideal) than DRG recommends.
- 68% of Maynard's inventoried tree resource is in Fair condition, 24% is in Good condition, 6% is in Poor condition, and 2% is Dead.
- 77% of the inventoried tree resource is a host to spotted lanternfly (*Lycorma delicatula*), and 68% is a host to winter moth (*Operophtera brumata*), making these pests the greatest threats to Maynard's tree resource.
- 23% of inventoried trees are currently conflicting with overhead utilities.

Functions and Benefits of the Tree Resource

Maynard's inventoried tree population provides benefits with an annual estimated total value of $11,415:

- *Runoff Reduction:* An estimated 48,827 cubic feet (~365,222 gallons) per year, valued at $3,264.
- *Pollution Removal:* An estimated 0.74 ton (~1,480 pounds) per year, valued at $2,993.
- *Carbon Sequestration:* An *estimated* 30.24 tons (~60,480 pounds) per year, valued at $5,158.

- The functions of Maynard's inventoried tree population throughout its trees' lifetimes are worth
- an estimated $7,636,590:
- *Carbon Storage:* An estimated 2,972 tons (~5,944,000 pounds) stored, valued at $506,950.
- *Replacement Value:* The cost of replacing Maynard's entire inventoried tree resource is an estimated $7,129,640.

Recommended Management of the Tree Resource

- Breakdown of recommended maintenance tasks include:
- Tree Removal (7% of inventoried trees).
- Routine Pruning Cycle (62% of inventoried trees).
- Young Tree Training Cycle (19% of inventoried trees).
- Stump Removal (7% of inventoried population; including trees, stumps, and vacant sites).
- Tree Planting (32% of inventoried population; including trees, stumps, and vacant sites).
- DRG recommends prioritizing the following maintenance tasks:
- Several Moderate Risk trees were assessed (18 trees, 1% of inventoried trees). These trees are hazardous and should either be removed or pruned immediately to improve public safety.
- The maintenance tasks for all Low Risk trees that were inventoried should be addressed only after all Moderate Risk tree maintenance has been completed.
- Maynard's tree resource would benefit from a three-year Young Tree Training Cycle and a five-year Routine Pruning Cycle. Proactive maintenance improves the overall condition of inventoried trees and may eventually reduce program costs.
- 211 young trees should be structurally pruned each year during the Young Tree Training Cycle to develop or maintain a dominant leader.
- 414 trees should have any dead, dying, diseased, and weakly attached branches removed each year during the Routine Pruning Cycle.
- Tree planting should at least replace all trees recommended for removal and should ideally establish new canopy in areas where there are gaps in the existing canopy (See Appendix A for guidelines on tree planting).
- Planting tree species in the maple (*Acer*) genus and the soapberry (*Sapindaceae*) family should be minimized until the genus and family distribution trends towards the ideal.
- The estimated total cost for the first year of this five-year management program is $261,087. Higher risk removals and pruning is costly, and because this maintenance should be completed immediately, the budget is higher for the first year of this program.
- After hazardous trees have been addressed, the management program will mostly involve proactive maintenance, which is generally less costly. Updating the inventory using TreeKeeper® or a similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

REMOVAL

- Total = 244 trees
- Extreme Risk = 0 trees
- High Risk = 0 trees
- Moderate Risk = 10 trees
- Low Risk = 234 trees
- Stumps = 360

PRIORITY PRUNING

- Total = 8 trees
- Extreme Risk = 0 trees
- High Risk = 0 trees
- Moderate Risk - 8 trees

ROUTINE PRUNING CYCLE

- Total = 2,070 trees
- Number of trees in cycle each year = approximately 414

YOUNG TREE TRAINING CYCLE

- Total = 634 trees
- Number of trees in cycle each year = at least 211

TREE PLANTING

- Number of trees each year = at least 393

FY 2021 $261,087

- 10 Moderate Risk Removals
- 8 Moderate Risk Prunes
- 24 Low Risk Removals
- 31 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 211 Trees
- 393 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2022 $256,434

- 44 Low Risk Removals
- 84 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 211 Trees
- 394 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2023 $249,846

- 42 Low Risk Removals
- 82 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 212 Trees
- 394 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2024 $249,416

- 48 Low Risk Removals
- 82 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 211 Trees
- 394 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY2025 $249,274

- 76 Low Risk Removals
- 81 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 211 Trees
- 394 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

INTRODUCTION

Photograph 1. *The Town of Maynard has been committed to preserving its urban forest for generations. Here, a tree planting ceremony is conducted outside of Emerson Junior High School ca. 1965.* **Photograph courtesy of Oliver Warila & Maynard Historical Society**

The Town of Maynard is home to 10,600 residents (U.S. Census Bureau, 2018, retrieved from: www.census.gov/programs-surveys/acs) benefiting from public trees in their community. The town's Department of Public Works (DPW) manages all trees, stumps, and planting sites along the street rights-of-way (ROW) and throughout public parks. Maynard's staff in the DPW have shown continued commitment to developing a thriving public tree resource, both historically and currently. Urban forestry program budgets are funded by the town's DPW Operations Budget. Maynard has a tree committee which will be helping to develop a tree ordinance in the near future, spends more than $2 per capita on tree maintenance, celebrates Arbor Day, and has been a Tree City USA community for 7 years.

Our Approach to Tree Management

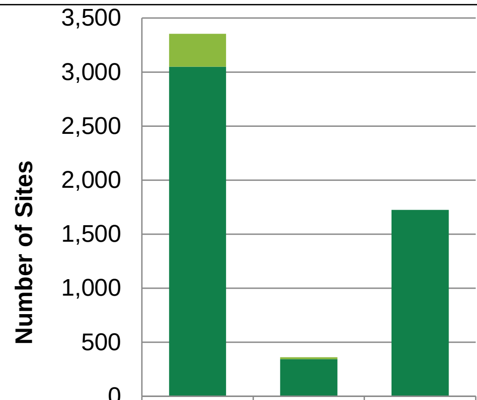
An effective approach to tree resource management follows a proactive and systematic program that sets clear and realistic goals, prescribes future action, and periodically measures progress. A robust urban forestry program establishes tree maintenance priorities and utilizes modern tools, such as a tree inventory accompanied by TreeKeeper® or other asset management software.

In February 2020, the Town of Maynard worked with DRG to inventory its public trees and develop this management plan. Consisting of three sections, this plan considers the diversity, distribution, and condition of the inventoried tree population and provides a prioritized system for managing the inventoried tree population.

- *Section 1: Structure and Composition of the Public Tree Resource* summarizes the tree inventory data by presenting observations and trends to represent the current state of the inventoried trees.
- *Section 2: Functions and Benefits of the Public Tree Resource* summarizes the estimated economic and environmental benefits provided to the community by the inventoried trees' various functions.
- *Section 3: Recommended Management of the Public Tree Resource* presents a prioritized maintenance schedule and an estimated future budget for these maintenance activities over a five-year period.

SECTION 1: STRUCTURE AND COMPOSITION OF THE PUBLIC TREE RESOURCE

In February–March 2020, DRG arborists collected site data on trees, stumps, and planting sites along the street ROW and on trees and stumps in Glenwood Cemetery for a tree inventory contracted by the Town of Maynard (see Appendix B for information on data collection and site location methods used). Of the total 5,439 sites inventoried, 94% were collected along the street ROW, and the remaining 6% were collected in the cemetery. Figure 1 breaks down the total sites inventoried by type for each location, although planting sites were not collected in the cemetery.



	Trees	Stumps	Vacant Sites
Cemetery Sites	305	16	0
ROW Sites	3,049	344	1,725

Figure 1. *Number of inventoried sites by location and type.*

Resilience Through Diversity

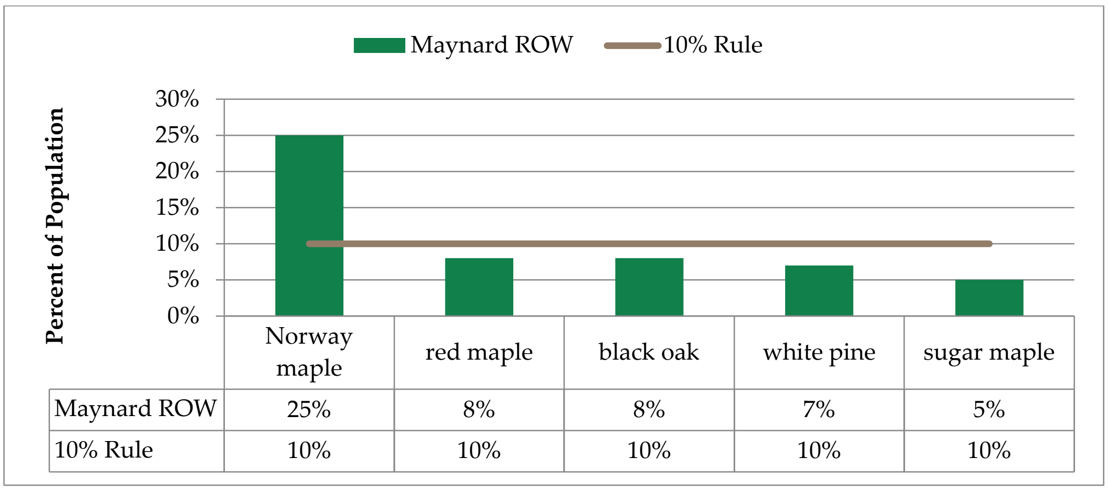
The Dutch elm disease epidemic of the 1930s provides a key historical lesson on the importance of diversity. The disease killed millions of American elm trees, leaving behind enormous gaps in the urban canopy of many Midwestern communities. In the aftermath, Ash trees became popular replacements and were heavily planted along city streets. History repeated itself in 2002 with the introduction of the emerald ash borer into America. This invasive beetle devastated ash tree populations across the Midwest. Other invasive pests spreading across the country threaten urban forests, so it's vital that we learn from history and plant a wider variety of tree genera to develop a resilient public tree resource.

Photograph 2. *DRG arborists inventoried trees, stumps, and planting sites in Maynard during the 2020 tree inventory.*

Species, Genus, and Family Distribution

The 10-20-30 rule is a common standard for tree population distribution, in which a single species should compose no more than 10% of the tree population, a single genus no more than 20%, and a single family no more than 30%.

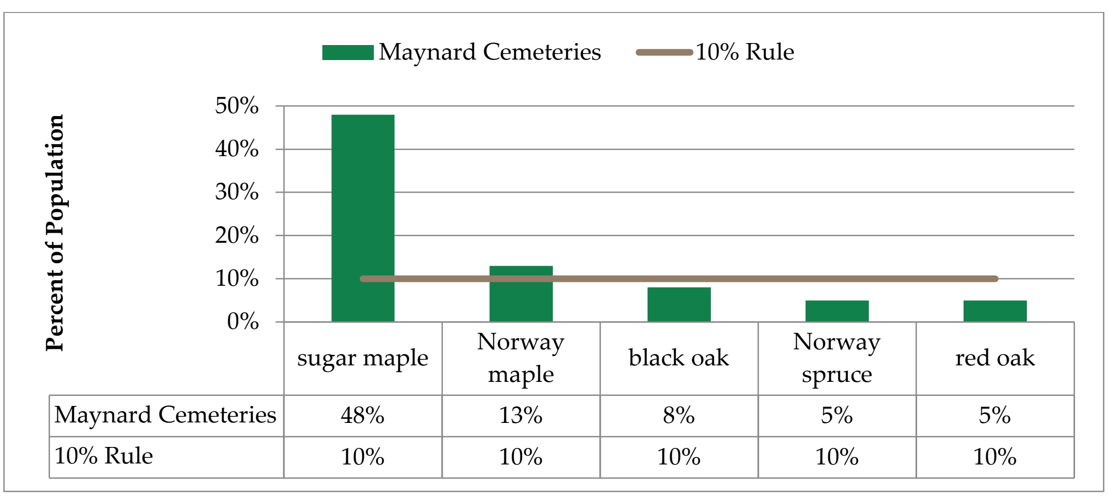
Figure 2 shows Maynard's distribution of the most abundant tree species inventoried in the ROW compared to the 10% threshold. *Acer platanoides* (Norway maple) is the most abundant species, accounting for 25% of the ROW tree population. This is well over the 10% threshold for an individual species and constitutes a diversity concern for the town. *Acer rubrum* (red maple, 8%), *Quercus velutina* (black oak, 8%), and *Pinus strobus* (white pine, 7%) are all close to the 10% threshold as well.



	Norway maple	red maple	black oak	white pine	sugar maple
Maynard ROW	25%	8%	8%	7%	5%
10% Rule	10%	10%	10%	10%	10%

Figure 2. *Inventoried tree population distribution of most abundant species in the ROW.*

Figure 3 shows Maynard's distribution of the most abundant tree species inventoried in the cemetery compared to the 10% threshold. In the cemetery, *Acer saccharum* (sugar maple) is the most abundant species, accounting for 48% of the cemetery tree population. Norway maple is also overly abundant in the cemetery, comprising 13% of the population. While not currently exceeding the 10% threshold, black oak is also very common in the cemetery, comprising 8% of the population.

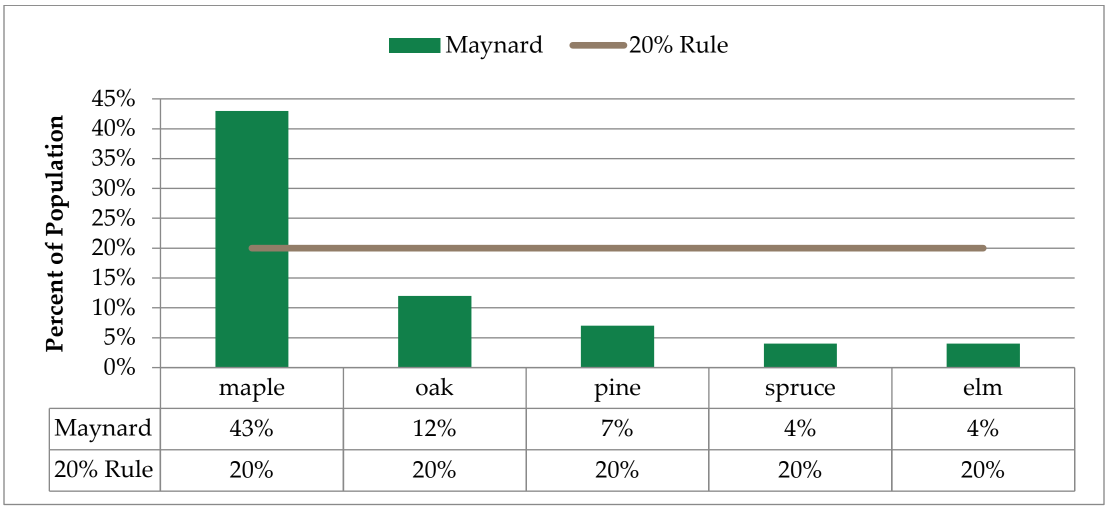


	sugar maple	Norway maple	black oak	Norway spruce	red oak
Maynard Cemeteries	48%	13%	8%	5%	5%
10% Rule	10%	10%	10%	10%	10%

Figure 3. *Inventoried tree population distribution of most abundant species in the cemetery.*

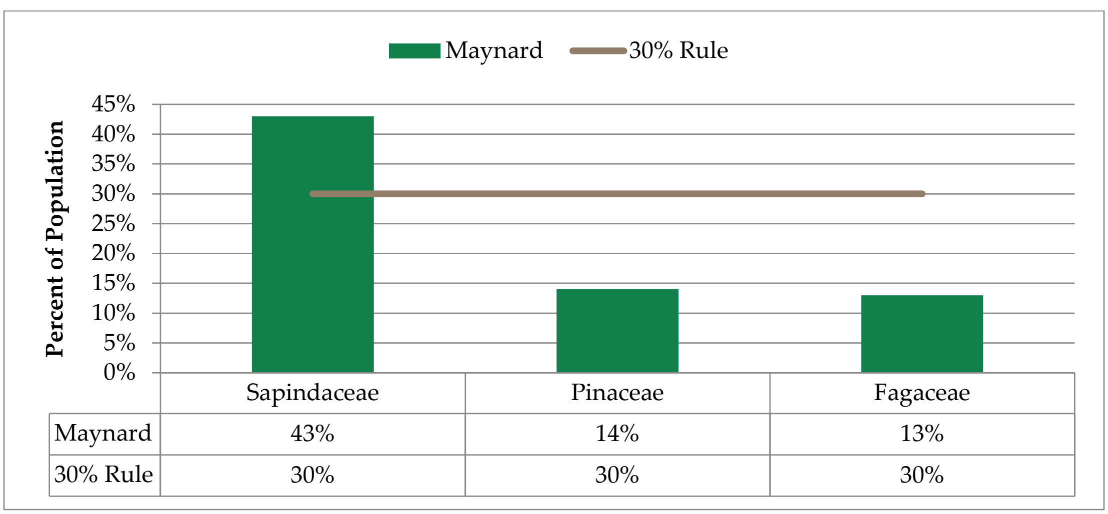
While important to consider, species distribution alone does not completely represent tree population diversity. Genus distribution is an important consideration because some pests, such as emerald ash borer (EAB, *Agrilus planipennis*), target a single genus as its host. Some pests also target a single family as its host, such as the bacterium *Erwinia amylovora*, commonly known as fireblight. Fireblight only affects plants in the rose (*Rosaceae*) family, such as serviceberry, hawthorn, apple/crabapple, hawthorn, cherry/plum, and pear.

Figure 4 shows the town's distribution of the most abundant tree genera inventoried. For the diversity analysis at the genus level, cemetery and ROW populations were very similar and were thus combined. Unsurprisingly, Maynard's *Acer* (maple) population is significantly higher than the 20% threshold. Figure 5 shows the town's distribution of the most abundant tree families inventoried in both the ROW and the cemetery. Again, *Sapindaceae*, the family to which maple belong, greatly exceeds the 30% threshold for a single family. For this reason, the Town of Maynard should restrict maple plantings until this distribution becomes more ideal.



	maple	oak	pine	spruce	elm
Maynard	43%	12%	7%	4%	4%
20% Rule	20%	20%	20%	20%	20%

Figure 4. ***Inventoried tree population distribution of most abundant genera.***



	Sapindaceae	Pinaceae	Fagaceae
Maynard	43%	14%	13%
30% Rule	30%	30%	30%

Figure 5. ***Inventoried tree population distribution of most abundant families.***

Pest Susceptibility

Early diagnosis of disease and infestation is essential to ensuring the health and continuity of Maynard's public tree resource. Appendix C has additional resources and websites where more detailed information can be found.

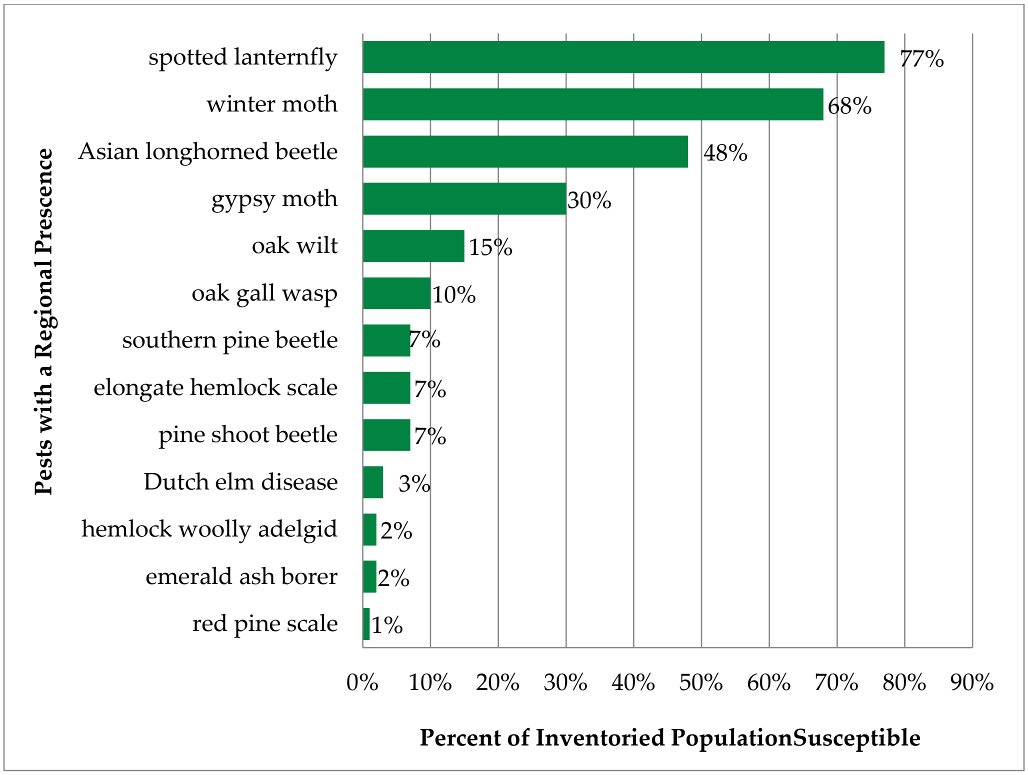


Figure 6. ***Public tree resource susceptibility to pests with a regional presence.***

Photograph 3. *An outbreak of the invasive winter moth ca. 2015 caused extensive damage to Maynard's urban forest. Increasing the diversity of the urban forest can help to mitigate future invasive pest outbreaks.*
Photograph courtesy of David A. Mark

Figure 6 shows the percent of inventoried trees susceptible to some of the known pests in and around Massachusetts. It is important to remember that this figure only represents data collected during the inventory. Many more trees throughout Maynard, especially those on private property, may be susceptible to hosting these invasive pests. Spotted lantern fly (SLF, *Lycorma delicatula*), winter moth (*Operophtera brumata*), and Asian longhorned beetle (ALB, *Anoplophora glabripennis*) are known threats to a large percentage of the inventoried tree resource, 77%, 68%, and 48% respectively.

Recommendations

The overabundance of *Acer* spp. (maple) in Maynard's tree resource is a management concern because it creates unnecessary risk in the event of an invasive pest outbreak. This abundance is not only more tree resource to lose but is also more habitat for the pests it's susceptible to, such as SLF (*L. delicatula*), winter moth (*O. brumata*), or ALB (*A. glabripennis*), making it easier for them to spread. Increasing species diversity is a critical goal that will help Maynard's tree resource be resilient in the event of future pest invasions. Maynard should use its resources to inspect trees in the *Acer* genus for signs of infestation by the aforementioned pest species, as well as other pest species of concern, on a routine basis, so affected trees can be quarantined to contain the pest before an outbreak starts.

Condition

Several factors affecting condition 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 by an arborist as Good, Fair, Poor, or Dead. The general health of the inventoried tree population is characterized by the most prevalent condition assigned during the inventory.

Most of the inventoried trees are recorded to be in Fair or Good condition, 68% and 24%, respectively (Figure 7). Based on these data, the general health of the overall inventoried tree population is rated Fair. Figure 8 illustrates that most of the young trees are rated to be in Good condition and that most of the established, maturing, and mature trees are rated to be in Fair condition.

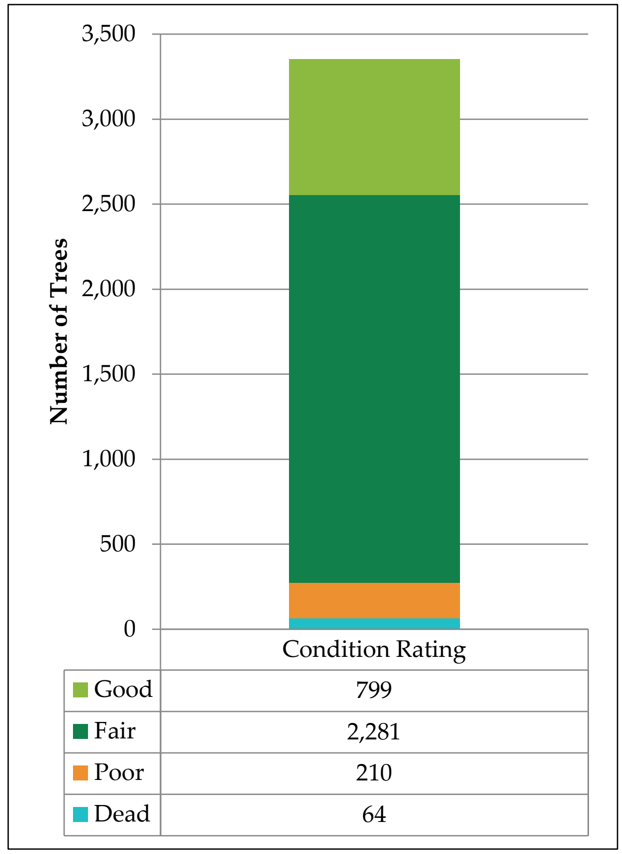


Figure 7. ***Condition of inventoried trees.***

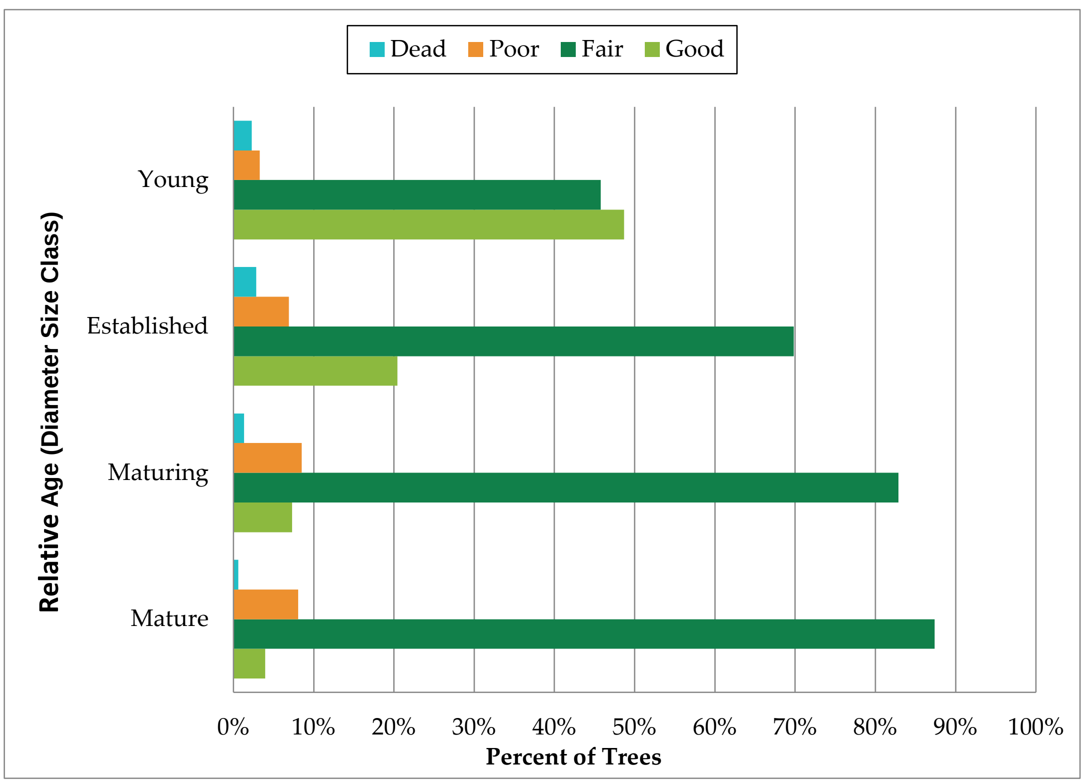


Figure 8. ***Tree condition by relative age.***

Recommendations

Dead trees and certain trees in Poor condition should be removed as soon as possible because the health of these trees is unlikely to recover even with increased care. These trees present a risk to public health and safety which can be mitigated only by removal. Younger trees rated in Fair or Poor condition may benefit from structural pruning to improve their health over time. Pruning should follow *ANSI A300 (Part 1)* guidelines. 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 likely require corrective pruning and intensive plant health care to improve their vigor and should be monitored for deteriorating conditions that may make them hazardous.

Relative Age Distribution

Analysis of a tree population's relative age distribution is performed by assigning age classes to the size classes of inventoried trees, offering insight into the maintenance needs of Maynard's tree resource. The inventoried trees are grouped into the following relative age classes:

- Young trees (0–8 inches DBH)
- Established trees (9–17 inches DBH)
- Maturing trees (18–24 inches DBH)
- Mature trees (greater than 24 inches DBH)

These size classes were chosen so that the inventoried tree resource can be compared to the ideal relative age distribution, which holds that the largest proportion of the inventoried tree population (approximately 40%) should be young trees, while the smallest proportion (approximately 10%) should be mature trees (Richards 1983). Since tree species have different lifespans and mature at different diameters, actual tree age cannot be determined from diameter size class alone, but size classifications can be extrapolated into relative age classes.

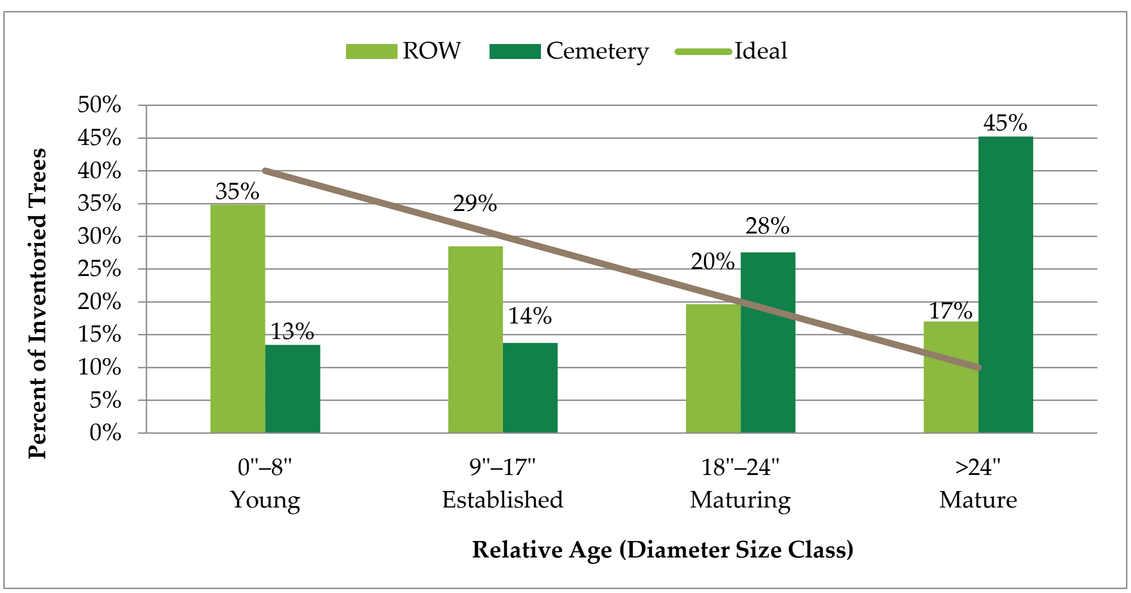


Figure 9. ***Relative age distribution of the inventoried trees.***

Figure 9 compares Maynard's relative age distribution of the inventoried tree population to the ideal. For this analysis, the ROW trees and cemetery trees were considered separately, as they have very different age class distribution trends. The town's inventoried ROW tree resource overall trends toward the ideal; however, mature trees exceed the ideal by 7% while young trees fall short of the ideal by 5%. The town's inventoried cemetery tree resource deviates dramatically from the ideal age distribution, with maturing and mature trees exceeding the ideal by 8% and 35%, respectively, and young and established trees falling short of the ideal by 27% and 16%, respectively.

Figure 8 cross analyzes the condition of the inventoried tree resource with its relative age distribution, providing insight into the inventoried population's stability. Ninety-one percent of mature trees and 90% of maturing trees are rated in Fair condition or better, which matters because these larger trees would have a more damaging impact in the event of failure. Although 90% of established trees and 95% of young trees are rated in Fair condition or better, it's important to provide the maintenance they need to remain healthy as they age and grow.

Recommendations

Maynard has a slight excess of mature trees and a slight shortage of young trees in the ROW. This deviation from the ideal age distribution can be mitigated by planting more young trees within the ROW. The low percentage of trees in Poor condition indicates that young trees have the potential of reaching maturity if they are well maintained. However, the age distribution of cemetery trees is far more skewed toward mature and maturing trees. As these trees age, decline in health, and are removed, they should be replaced with new plantings to help the cemetery tree age profile fall more in line with the ideal. DRG recommends that Maynard implements a robust maintenance program to conserve the condition of young trees as they age so they replace removed trees and fill canopy gaps in maturity. The town should also focus on tree preservation and proactive care, to protect mature and maturing trees from unnecessary removal and to prevent them from succumbing to treatable defects. Tree planting and prioritizing proactive maintenance will shift the relative age distribution towards the ideal over time.

Defect Observations

For each tree inventoried, DRG assessed conditions indicating the presence of structural defects and recorded the most significant defect. Defects were limited to the following categories:

- Dead and dying parts
- Broken and/or hanging branches
- Cracks
- Weakly attached branches and codominant stems
- Missing or decayed wood
- Tree architecture
- Root problems
- Other
- None

Photograph 4. *This tree, which lost a large section of stem to limb failure, was inventoried with the defect "Missing or Decayed Wood." Trees with significant defects, like this one, may need further monitoring to ensure they don't become hazardous.*
Photograph courtesy of Moriah Day, DRG Arborist

Table 1. *Defect observations recorded during the tree inventory*

Defect	Number of Trees	Percent
Dead and Dying Parts	1,210	36%
Missing or Decayed Wood	461	14%
Tree Architecture	292	9%
Weakly Attached Branches and Codominant Stems	288	9%
Broken and/or Hanging Branches	195	6%
Root Problems	43	1%
Cracks	5	0%
Other	4	0%
None	856	26%
Total	**3,354**	**100%**

Recommendations

The three most frequently recorded defect categories were dead and dying parts, none, and missing or decayed wood at 36%, 26%, and 14% of inventoried trees, respectively (Table 1). Of the 1,210 trees with dead and dying parts, 72 were recommended for removal. Of the 461 trees with missing or decayed wood, 54 were recommended for removal. Trees recorded with the defect "None" had no major defects and were in Good condition (856 trees).

When considering the defect recorded for each tree, there are two important qualifiers to keep in mind. First, the categories are broadly inclusive. For example, the "Dead and Dying Parts" category can include trees with just one or two smaller diameter dead limbs as well as trees found with large-diameter dead limbs or entire sections of dead canopy. Therefore, inferences on overall tree condition or risk rating cannot be derived solely from the presence or absence of a defect recorded during the inventory. Second, an inventoried tree may have multiple defects; the 2020 Town of Maynard inventory recorded only the most significant defect observed for each tree. These two qualifiers are important to keep in mind when considering urban forest management planning and the prioritization of maintenance or monitoring activities.

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

- *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.

Table 2 shows that a total of 1,475 trees (44% of the inventoried population) have utilities directly above or passing through the tree canopy; 763 of these trees (23% of the inventoried population) were directly conflicting with an overhead utility. Of those trees, only 1 is in the cemetery. All other cemetery trees do not have overhead utilities present.

Photograph 5. *These two sugar maples are conflicting with overhead utilities in Maynard's ROW.*
Photograph courtesy of Moriah Day, DRG Arborist

Table 2. *Street ROW trees noted to be conflicting with infrastructure*

Overhead Utilities	ROW Trees	Cemetery Trees	Total Trees	Percent Total Trees
Present and Conflicting	762	1	763	23%
Present and Not Conflicting	712	0	712	21%
Not Present	1,575	304	1,879	56%
Total	**3,049**	**305**	**3,354**	**100%**

Recommendations

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

When considering the overhead utility status recorded for each tree, it is important to keep in mind that all overhead utilities, including primary and secondary electric lines, telecommunication lines, and drop lines to buildings, are included in the definition of overhead utility lines. Thus, a tree conflicting with primary electric lines and a tree conflicting with telecom lines are given the same overhead utility status.

Although hardscape damage was not recorded in the 2020 Maynard inventory, it is necessary to consider hardscape restrictions when planning for new tree planting. 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.

Stocking Level

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

Photograph 6. *Stocking level is determined by comparing the number of potential growing sites to the number of existing trees. This street in Maynard has many potential growing sites but very few trees, and thus has a low stocking level.*
Photograph courtesy of Moriah Day, DRG Arborist

Stocking level is the ratio of street ROW spaces occupied by trees to the total street ROW spaces suitable for trees. For example, if a municipality conducts a street tree inventory and finds 750 existing trees and 250 vacant planting sites, then the stocking level would be 75%, based on the following calculation:

750 street trees ÷ (750 street trees + 250 planting sites) = 75% stocked

DRG found that the town had 1,725 planting sites and 344 stumps (which should be considered as possible planting sites). Based on the data collected during this inventory, the current street ROW tree stocking level for the town is 60%. The formulas below show how the stocking level was calculated.

3,049 existing street trees + 1,725 planting sites + 344 sites with stumps

= 5,118 total grow space sites within the ROW

3,049 existing street trees ÷ 5,118 grow spaces = ***60% stocked***

DRG recommends an optimal stocking level of at least 90%. At 60% stocked, the Maynard town public tree resource has a current deficit of 1,557 trees:

5,118 grow spaces × 90% = 4,606 street trees required to reach recommended level

*4,606 recommended trees – 3,049 existing street trees = **1,557 additional trees** to reach 90%*

Recommendations

In general, DRG recommends that urban areas maintain a street ROW stocking level of at least 90%, so that no more than 10% of the potential planting sites along the street ROW are vacant. An ideally stocked urban forest promotes canopy continuity and environmental sustainability. Knowledge of the existing stocking level within a tree population will inform a community's planting needs and associated budget. Generally, this entails a planned planting program that includes new installations, plant health care, and routine maintenance activities. At the current stocking level of 60%, the town needs 1,557 additional trees to achieve the ideal, assuming Maynard's tree resource experiences zero loss in the existing tree population, which is unlikely.

Photographs 7 and 8. *This pair of photographs from 1910 and 2019 show Maple Street in Maynard from the same spot near the intersection with Summer Street. Extensive tree removal has occurred on this street over the hundred years between photographs without replacement, reducing stocking level.*
Photograph courtesy of Maynard Historical Society (left) and David A. Mark (right).

Over the course of the 5-year program, a total of 244 existing trees are recommended for removal (238 in the ROW and 6 in the cemetery). Additionally, the tree resource is susceptible to various threats including storms, invasive pests, and disease. Typical annual mortality rates range from 1–3% of the population. Given the inventoried population's overall condition rating of fair, Maynard's tree resource is more likely to be on the lower end of this range. Using a 1% annual mortality rate of 34 trees per year, the town can anticipate removing an additional 168 trees over a 5-year period. When accounting for scheduled removals and annual mortality, DRG finds it necessary to plant 1,969 trees over the course of 5 years in order to achieve the 90% stocking ideal by Year 5 of the tree management program.

1,557 trees to reach stocking level of 90%

+

244 trees recommended for removal

+

168 additional trees lost over 5 years (+/-1% annual mortality rate of 33.54 trees/year)

=

1,969 total trees required to achieve 90% stocking level by Year 5.

In order to reach the ideal stocking level of 90%, DRG strongly recommends that the Town of Maynard invest in planting at least 393 new trees per year.

SECTION 2: FUNCTIONS AND BENEFITS OF THE PUBLIC TREE RESOURCE

Public trees play an important role in improving the quality of life within a community. For example, a tree's natural beauty can soften the stark appearance of some urban landscapes. When properly maintained, trees provide communities with abundant environmental, economic, and social benefits far exceeding the investments in planting, maintaining, and removing trees throughout their lifespan.

Environmental Benefits

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

Economic Benefits

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

Social Benefits

- Tree-lined streets are safer; traffic speeds and the amount of stress drivers feel are reduced, which likely reduces road rage/aggressive driving (Wolf 1998a, Kuo and Sullivan 2001a).
- Chicago apartment buildings with medium amounts of greenery had 42% fewer crimes than those without any trees (Kuo and Sullivan 2001b).
- Chicago apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Employees who see trees from their desks experience 23% less sick time and report greater job satisfaction than those who do not (Wolf 1998a).
- Hospital patients recovering from surgery who had a view of a grove of trees through their windows required fewer pain relievers, experienced fewer complications, and left the hospital sooner than similar patients who had a view of a brick wall (Ulrich 1984, 1986).
- When surrounded by trees, physical signs of personal stress, such as muscle tension and pulse rate, were measurably reduced within three to four minutes (Ulrich 1991).

Trees occupy a vital role in the urban environment by providing of a wide array of economic, environmental, and social benefits. Scientific research repeatedly demonstrates and validates the importance of this role. Trees reduce air pollution, improve public health outcomes, reduce stormwater runoff, store carbon, reduce energy use, and increase property value. Using advanced analytics, such as i-Tree Eco and the i-Tree software suite, continues to expand understanding of the importance of trees to a community by providing tools to estimate monetary values of the various benefits provided by a tree resource.

i-Tree Eco Analysis

i-Tree Eco utilizes tree inventory data along with local air pollution and meteorological data to quantify the functional benefits of a community's tree resource. By framing trees and their benefits in a way that everyone can understand, dollars saved per year, i-Tree Eco helps a community to understand trees as both a natural resource and an economic investment. Knowledge of the composition, functions, and monetary value of trees helps to inform planning and management decisions, assists in understanding the impact of those decisions on human health and environmental quality, and aids communities in advocating for the necessary funding to manage their vested interest in the public tree resource appropriately.

Key Terms and Methods

Structural value is a compensatory value calculated based on the local cost of having to replace a tree with a similar tree. In other words, it is a measurement of the value of the resource itself. The structural value of an urban forest is the sum of the structural values of all the individual trees contained within. Monetary values are assigned based on valuation procedures of the Council of Tree and Landscape Appraisers using information on species, diameter, condition, and location (McPherson 2007) and (Nowak et al. 2008).

The importance of a single tree species to the community can be derived from measuring the benefits provided by a particular species relative to the size of its population. This **Importance Value** (IV) calculated by the i-Tree Eco model factors in the total number of trees for each species, each species percentage of the total population, and each species total leaf area. Analysis of the IVs can show how reliant the community is on certain tree species to provide ecosystem benefits.

Carbon sequestration refers to the capture and storage of carbon from the earth's atmosphere. The i-Tree Eco analysis reports on the gross annual amount of carbon sequestered as well as the total amount of **carbon stored** over the lifetime of the tree. For this analysis, carbon storage and sequestration values are calculated at a rate of $171 per ton. Carbon storage is considered both a functional benefit and a structural benefit of trees. **Functional benefits** are those which are produced due to physiological processes carried out by trees, while **structural benefits** are those which are produced due to the physical arrangement and composition of trees and tree parts. In i-Tree Eco, functional benefits are estimated on a yearly basis while structural benefits must be estimated over the lifespan of a tree.

Air pollution removal refers to the removal of ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 2.5 microns ($PM_{2.5}$). For this analysis, the pollution removal value is calculated based on the prices of $4,322 per ton of ozone, $427 per ton of sulfur dioxide, $952 per ton of nitrogen dioxide, $1,380 per ton carbon monoxide, and $150,053 per ton of particulate matter less than 2.5 microns.

Avoided runoff measures the amount of surface runoff avoided when trees intercept rainfall during precipitation events. Surface runoff from rainfall contributes to the contamination of streams, rivers, lakes, and wetlands by washing oils, pesticides, and other pollutants, either directly into waterways or into drainage infrastructure that ultimately empties into waterways. For this analysis, annual avoided runoff is calculated based on the estimated amount of intercepted rainfall and the local weather in Bedford, MA, where annual precipitation in 2016 equaled 22.8 inches. The monetary value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series at a rate of $0.07 per cubic foot.

Annual Return on Investment from the Public Tree Resource

The i-Tree Eco analysis of Maynard's inventoried trees quantified the functional benefits of three critical ecosystem services that they provide: air pollution removal, carbon sequestration, and avoided surface runoff.

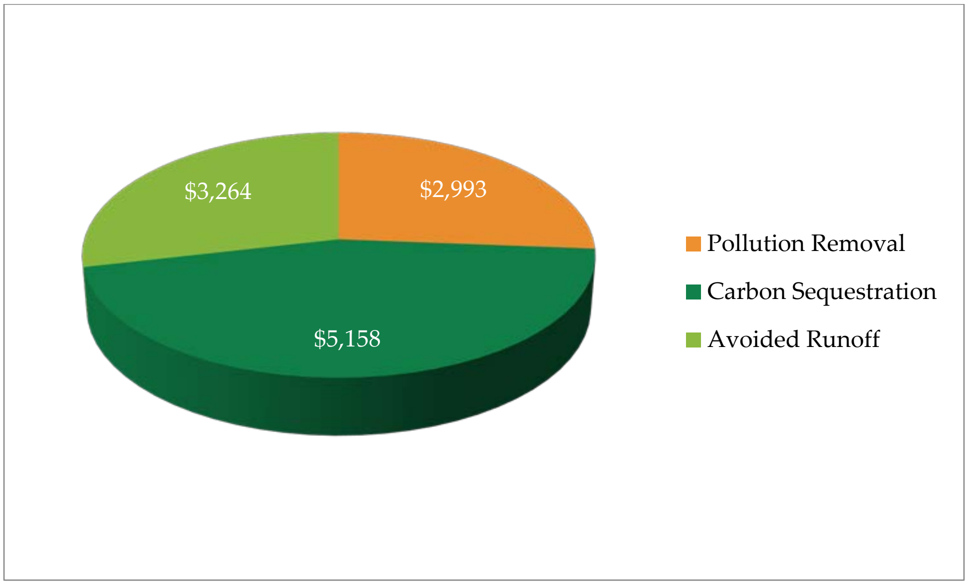


Figure 10. ***Estimated annual value of the inventoried tree resource functional benefits.***

As seen in Figure 10, the estimated annual value of:

- All quantified functional benefits provided by the inventoried tree resource is $11,415.
- Avoided healthcare costs from removing 0.74 ton of airborne pollutants is $2,993.
- Sequestering 30.24 tons of CO_2 is $5,158.
- Avoiding 48,827 cubic feet of runoff is $3,264.

Urban environments have unique challenges that make the functional benefits provided by a public tree resource essential to the community's well-being. Compared to rural landscapes, urban landscapes are characterized by high population and high pollutant emissions in a relatively small area, often harming public health. Avoiding stormwater runoff reduces the risk of flooding and combined sewer overflow, both of which are hazards to people, property, and the environment. Carbon dioxide is also a hazard, as it's the primary greenhouse gas driving climate change, and public trees become a carbon sink by sequestering carbon. Carbon sinks are the opposite of carbon sources; while carbon is emitted from cars, carbon is sequestered and stored in trees.

Table 3. *Functional benefits of inventoried tree species ranked by importance value*

Most Common Trees Collected During Inventory		Number Trees	Percent of Total Trees	Benefits Provided By Trees					Importance Value (IV)
				Carbon Stored	Carbon Sequestered	Avoided Runoff	Pollution Removal	Structural Value	
Common Name	Botanical Name		%	tons	tons / yr	ft^3 / yr	tons / yr	$	scaled 0-100
Norway maple	*Acer platanoides*	813	24.3	637.93	7.38	17,195.51	0.28	1,722,597	29.8
sugar maple	*Acer saccharum*	285	8.5	551.98	4.75	6,243.61	0.10	1,284,990	10.7
red maple	*Acer rubrum*	260	7.8	267.60	2.77	4,344.57	0.07	688,280	8.4
black oak	*Quercus velutina*	254	7.6	614.43	5.43	4,049.15	0.07	847,771	8.0
eastern white pine	*Pinus strobus*	212	6.3	94.59	0.97	2,528.67	0.04	457,595	5.8
Norway spruce	*Picea abies*	76	2.3	63.99	0.60	1,721.72	0.03	225,160	2.9
northern red oak	*Quercus rubra*	81	2.4	129.49	1.16	1,313.87	0.02	241,149	2.6
American elm	*Ulmus americana*	104	3.1	19.68	0.31	846.34	0.01	74,152	2.4
white oak	*Quercus alba*	62	1.8	128.91	1.14	1,100.92	0.02	227,741	2.1
crabapple	*Malus* spp.	105	3.1	13.04	0.34	432.29	0.01	64,307	2.0
northern white cedar	*Thuja occidentalis*	109	3.3	5.21	0.10	213.32	0.00	68,422	1.9
littleleaf linden	*Tilia cordata*	50	1.5	30.24	0.33	814.75	0.01	113,271	1.6
white ash	*Fraxinus americana*	56	1.7	34.62	0.40	529.36	0.01	79,897	1.4
eastern hemlock	*Tsuga canadensis*	59	1.8	10.63	0.16	515.63	0.01	55,836	1.4
other trees	~47 genera of varying species	826	24.5	370.10	4.40	6,976.83	0.06	978,473	19.4
Inventory Total	**~51 genera and ~95 species**	**3,352**	**100.0**	**2,972.44**	**30.24**	**48,826.54**	**0.74**	**7,129,640**	**100.0**

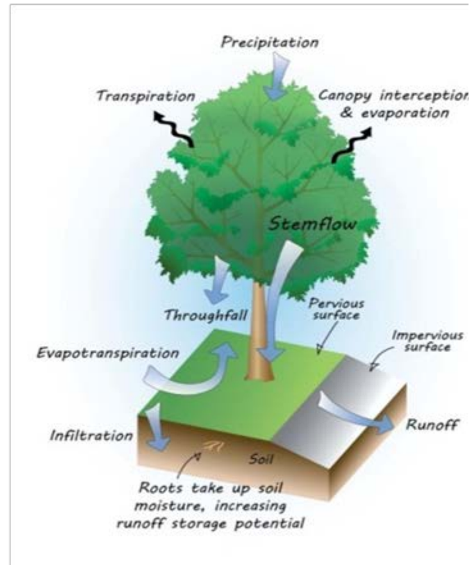
Controlling Stormwater

Trees intercept rainfall, which helps lower stormwater management costs by avoiding runoff. The inventoried trees in the Town of Maynard intercept 48,827 ft^3 (~365,222 gal) of rainfall annually – a service valued at $3,264. Avoided runoff comprises 29% of the functional benefits the inventoried trees provide on a yearly basis.

Photograph 9. *Urban trees help reduce stormwater runoff, helping to mitigate flooding like that seen in Maynard in 2010.*
Photograph courtesy of David A. Mark

Of all species inventoried, *Acer* (Norway maple) contributed the highest annual stormwater benefits. The Norway maple population intercepted over 17,000 ft^3 (128,662 gals,) of rainfall. This is not surprising, considering that Norway maple make up nearly 25% of the inventoried population. On a per-tree basis, large stature trees with leafy canopies provided the largest avoided runoff benefits. *Thuja occidentalis* (northern white cedar) and *Tilia cordata* (littleleaf linden) comprised 3.3% and 1.5% of the inventoried tree resource, respectively. However, littleleaf linden absorbs 815 ft^3 of rainfall per year, almost four times as much as northern white cedar does, despite the northern white cedar population being twice as large as the littleleaf linden population. This illustrates how large-statured trees with wide canopies provide significantly greater benefits than smaller stature trees.

CANOPY FUNCTIONS



Trees provide many functions and benefits simply by existing, such as:

- Catching rainfall in their crown so it drips to the ground or flows down their trunk with less of an impact
- Helping stormwater soak into the ground by slowing down runoff
- Creating more pore space in the soil with their roots, helping stormwater to move through the ground
- Cooling the surrounding landscape by casting shade with their canopy and releasing water from their leaves
- Catching airborne pollutants on their leaves and absorbing them with their roots when they wash off in the rain
- Transforming some pollutants into less harmful substances and preventing other pollutants from forming

Improving Air Quality

The inventoried tree population annually removes 0.74 ton (~1,480 lbs.) of air pollutants, including sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and particulate matter ($PM_{2.5}$). The i-Tree Eco model estimated the annual value of this benefit at $2,993, which is 26% of the value of all annual benefits. As shown in Figure 11, a small reduction in $PM_{2.5}$ is more valuable than any of the other pollutants removed. The trees that provided the highest annual air quality benefits were *Picea abies* (Norway spruce), *Acer saccharum* (sugar maple), and *A. platanoides* (Norway maple), which removed 0.79 lb., 0.70 lb., and 0.69 lb. of pollutants per tree per year, respectively.

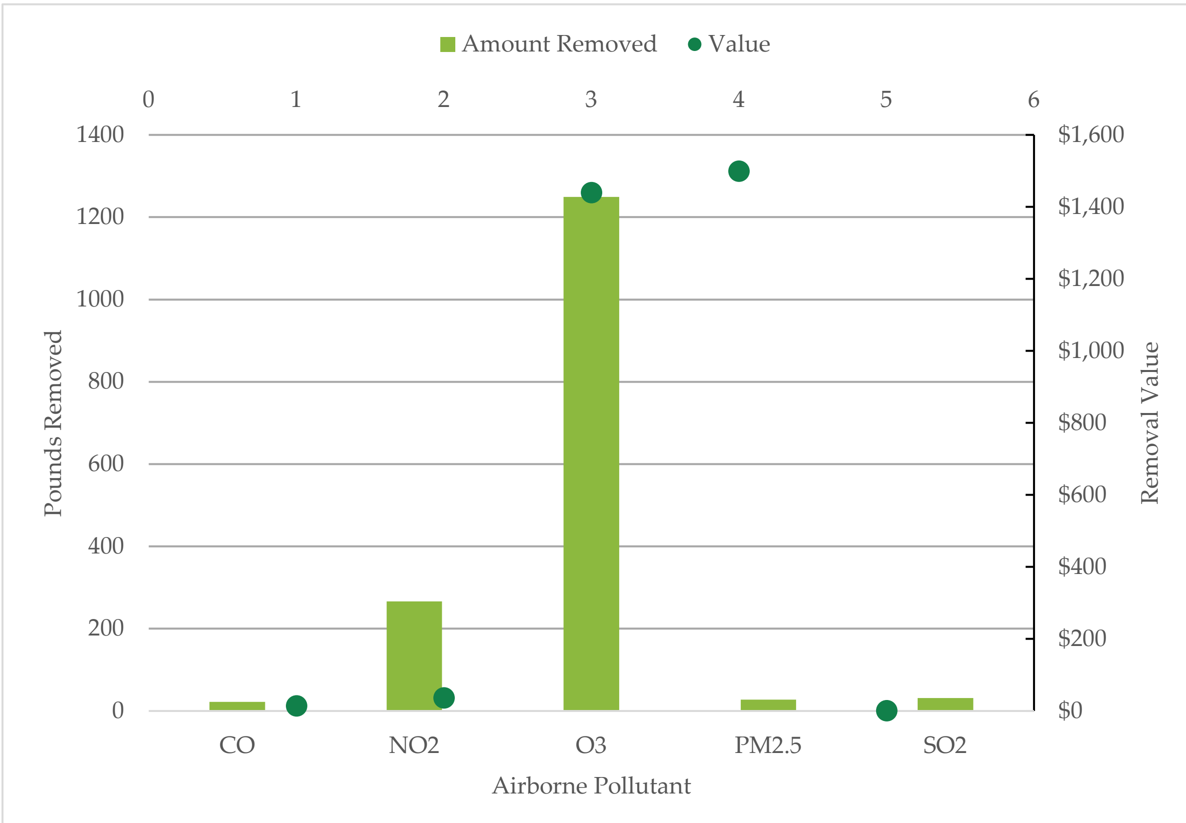


Figure 11. ***Estimated value of removing airborne pollution by weight and type.***

Sequestering and Storing Carbon

Trees sequester carbon (CO_2) during photosynthesis and store it in their tissue as they grow. The i-Tree Eco model estimates both the amount of carbon sequestered per year and total carbon stored during a tree's lifetime. Maynard's inventoried trees store an estimated 2,972 tons (5,944,880 lbs.) of carbon, with an additional 30.24 tons (60,480 lbs.) of carbon sequestered each year. The annual carbon sequestration is valued at $5,158 and accounts for 45% of the total annual functional benefits provided by Maynard's tree resource.

Of all the tree species inventoried, *Acer platanoides* (Norway maple) currently store and sequester the most carbon in Maynard due to their prevalence in the town. However, on a per tree basis, *Quercus velutina* (black oak) and *Quercus alba* (white oak) store and sequester the most carbon. Black oak store ~4,838 lbs. of carbon per tree and sequester another 43 lbs. per tree each year, while white oak store ~4,158 lbs. of carbon per tree and sequester another 37 lbs. per tree per year. In contrast, Norway maple only store ~1,569 lbs. of carbon per tree and sequester only 18 lbs. of carbon per tree per year, well behind oak, *Fraxinus* spp. (ash), *Tilia* spp. (linden), and Acer spp. (maple).

Energy Reduction

Trees cast shade over buildings, causing a natural cooling effect and reducing electricity use for air conditioning in the summer. Trees also divert wind around buildings, reducing natural gas use for heating in the winter. While the i-Tree Eco model used for this analysis did not have all the required inputs to calculate the annual energy benefits provided by Maynard's tree resource, the TreeKeeper® software used for this inventory utilizes a version of i-Tree Streets to calculate some basic energy benefit values for the inventoried tree population. The annual energy reduction caused by inventoried trees is 285,663 kWh of electricity and 103,299 therms of natural gas, an annual energy savings valued at $185,467. This number is not included in the total annual benefits calculation due to the differences in methodology used between i-Tree Eco and i-Tree Streets.

Importance Value (IV)

The importance of a single tree species to the community can be derived from measuring the benefits provided by a species relative to the size of its population. The IV calculated by the i-Tree Eco model factors in the total number of trees for each species, each species' percentage of the total population, and each species' total leaf area. The IV can range from 0 to 200, with higher IV indicating higher reliance on one species to provide ecosystem services. To more easily compare IV and percentage of a species, the IV values in Tables 3 and 4 have been divided by 2, reducing the range of values for IV to 0 to 100. If IV values are greater or less than the percentage of a species on the inventoried tree resource, it indicates that the loss of that species may be more important or less important than its population percentage implies.

Table 4. *Importance values of most abundant species in the inventoried tree resource*

Most Common Trees Collected During Inventory		Number of Trees	Percent of Total Trees	Percent Leaf Area	Importance Value
Common Name	Botanical Name		%	%	scaled 0-100
Norway maple	*Acer platanoides*	813	24.3	35.2	29.75
sugar maple	*Acer saccharum*	285	8.5	12.8	10.65
red maple	*Acer rubrum*	260	7.8	8.9	8.35
black oak	*Quercus velutina*	254	7.6	8.3	7.95
eastern white pine	*Pinus strobus*	212	6.3	5.2	5.75
northern white cedar	*Thuja occidentalis*	109	3.3	0.4	1.85
crabapple	*Malus* spp.	105	3.1	0.9	2.00
American elm	*Ulmus americana*	104	3.1	1.7	2.40
northern red oak	*Quercus rubra*	81	2.4	2.7	2.55
Norway spruce	*Picea abies*	76	2.3	3.5	2.90
white oak	*Quercus alba*	62	1.8	2.3	2.05
black cherry	*Prunus serotina*	60	1.8	0.5	1.15
eastern hemlock	*Tsuga canadensis*	59	1.8	1.1	1.40
white ash	*Fraxinus americana*	56	1.7	1.1	1.40
other trees	*~48 genera of varying species*	816	24.2	15.4	19.85
Inventory Total	**~51 genera and ~95 species**	**3,352**	**100.0**	**100.0**	**100.00**

As shown in Table 4, the i-Tree Eco assessment found that *Acer platanoides* (Norway maple) has the highest IV in Maynard's public tree resource at 29.75. The large IV for Norway maple is likely due, in part, to the species' prevalence in the study area. However, the scaled IV for Norway maple is still slightly higher than Norway maple's percentage of the total inventoried trees (IV=29.75, 24.3%), indicating that the loss of the Norway maple population would be even more environmentally and economically detrimental than its percentage of the population might lead one to believe. The species with the second highest scaled IV was *A. saccharum* (sugar maple) at 10.65, followed by *A. rubrum* (red maple) at 8.35, with *Quercus velutina* (black oak) a close fourth at 7.95. In general, broadleaf tree species, which have more leaf area, provide greater environmental benefits to the community, and have higher IVs than conifer species.

The populations of *Malus* spp. (crabapple) (3.1%), *Ulmus americana* (American elm) (3.1%), *Quercus rubra* (northern red oak) (2.4%), *Picea abies* (Norway spruce) (2.3%), and *Q. alba* (white oak) (1.8%) are not as large as the population of *Thuja occidentalis* (northern white cedar) (3.3%), but their IVs are greater (all ≥2.00 versus 1.85 for northern white cedar). This indicates that, while northern white cedar is an abundant species in Maynard's public tree population, it does not provide a proportionally large share of the ecosystem benefits.

Recommendations

Carbon storage (total value of the carbon stored by trees throughout their lifetimes) and structural value (total cost of replacing all inventoried trees) were valued at $506,949.67 and $7,129,640.42, respectively. With a $7.1 M price tag on the town's inventoried tree population and $11,415 worth of benefits provided every year, it becomes clear why this public resource is worthy of highly prioritized investment. In Maynard, *Acer* spp. (maple) account for nearly half of the inventoried tree resource as well as half of the functional benefits they provide. If this genus was lost to invasive pests, disease, or other threats, the loss would be felt more than the community may realize. It's critical to promote species diversity with future plantings to minimize exposure to future threats, and to plant large-statured broadleaf tree species wherever possible to maximize potential environmental and economic benefits. See Appendix D for a tree species planting list recommended by DRG.

SECTION 3: RECOMMENDED MANAGEMENT OF THE TREE RESOURCE

Extreme & High Risk
- All Extreme and High Risk tree maintenance should be completed as soon as possible, because these trees have hazardous defects that are a public safety risk and liability.

Further Inspection
- Trees with a requirement in the Further Inspection data field could be on their way to becoming hazards and should be assessed by an arborist as soon as possible.

Routine Inspection
- Routine Inspections detect significant defects before they become hazards. Inventoried trees should be routinely inspected from a windshield and attended to as needed.

Moderate Risk
- All Moderate Risk tree maintenance should be performed after all Extreme and High Risk tree maintenance has been completed, because these trees have defects that could become hazards.

Routine Pruning
- Routine Pruning cycles correct defects before they become hazards, and should begin after all Extreme, High, and Moderate Risk tree maintenance has been completed.

Young Tree Training
- Young Tree Training cycles improve tree structure so they do not develop defects that become future hazards, and should begin when Routine Pruning cycles begin.

Low Risk
- All Low Risk tree maintenance should be performed when convenient, after all Extreme, High, and Moderate Risk tree maintenance has been completed.

Stump Removal
- Stump removals should be performed when convenient, ideally before a planting season begins, so additional planting sites become available.

Tree Planting
- Tree planting is important for replacing removed trees, reaching ideal stocking level, and meeting canopy goals, but tree maintenance is often a greater priority.

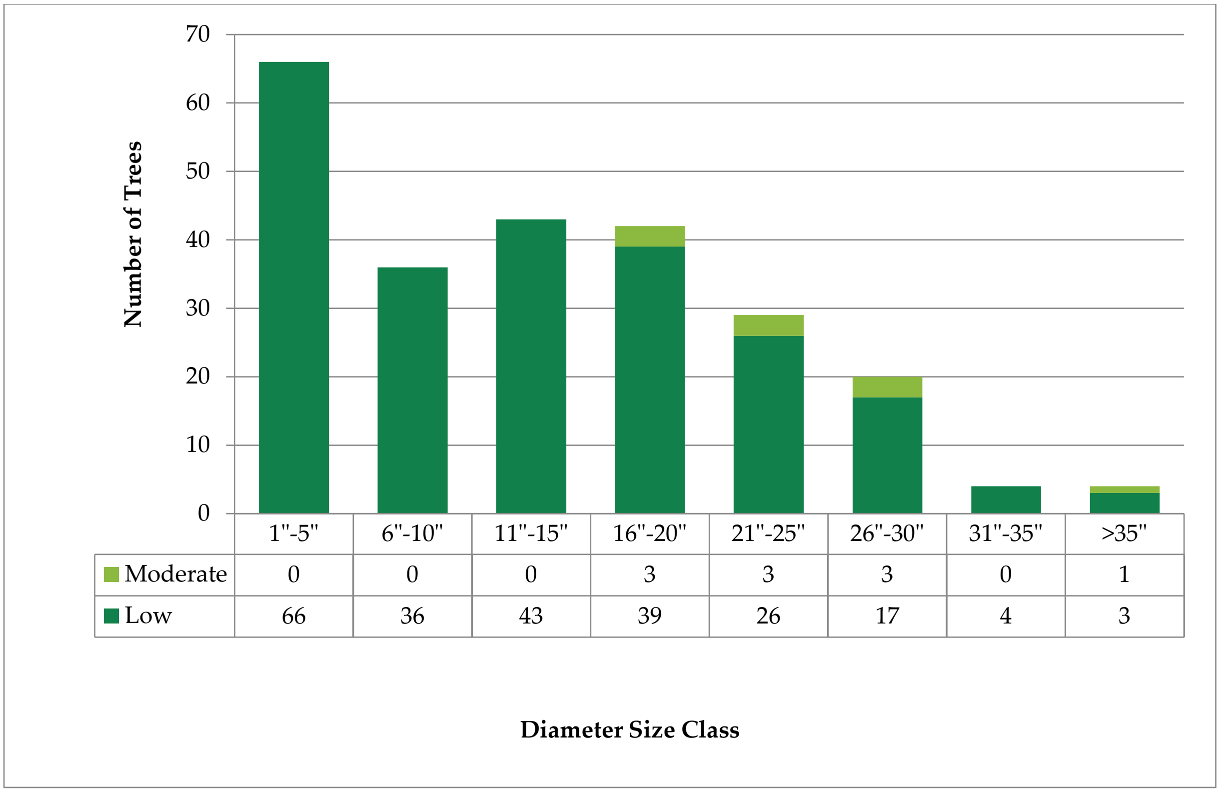
During the inventory, both a risk rating and a recommended maintenance activity were assigned to each tree. DRG recommends prioritizing and completing each tree's recommended maintenance activity based on the assigned risk rating. See Appendix E for further information on the risk assessment and rating system and priority versus proactive maintenance. This five-year tree management program takes a multi-faceted and proactive approach to tree resource management:

- Risk reduction through prioritized pruning and removal of Extreme, High, and Moderate Risk trees.
- Improving tree condition with a routine pruning cycle and young tree training cycle.
- Routine monitoring to identify and systematically address other Extreme, High, or Moderate Risk trees.
- Canopy replacement and expansion with planned, prioritized, and targeted planting.

Risk Management and Recommended Maintenance

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. DRG recommends that tree maintenance activities are prioritized and completed based on the risk rating that was assigned to each tree during the inventory. The following section describes recommended maintenance for each risk rating category.

Trees that cause obstructions or interfere with power lines or other infrastructure should be removed when their defects cannot be corrected through pruning or other maintenance practices. Diseased and nuisance trees also warrant removal. Even though large short-term expenditures may be required, it is important to secure the funding needed to complete priority tree removals. Expedient removal reduces risk and promotes public safety. Figure 12 presents tree removals by risk rating and diameter size class. The following sections briefly summarize the recommended removals identified during the inventory.



	1"-5"	6"-10"	11"-15"	16"-20"	21"-25"	26"-30"	31"-35"	>35"
Moderate	0	0	0	3	3	3	0	1
Low	66	36	43	39	26	17	4	3

Figure 12. ***Recommended removals by size class and risk rating.***

High Priority Recommended Maintenance

Pruning or removing Extreme, High, and Moderate Risk trees is strongly recommended to be prioritized and completed as soon as possible. In general, maintenance activities should be completed first for the largest diameter trees (>25”) that pose the greatest risk. Once addressed, recommended tree maintenance activities should be completed for smaller diameter trees (<25”) that pose the greatest risk. Addressing Extreme, High, and Moderate Risk trees in a timely and proactive manner may require significant resources to be secured and allocated. However, peforming this work expediently will mitigate risk, improve public safety, and reduce long-term costs.

High Priority Removals

This maintenance should be performed immediately based on assigned risk rating and may be performed concurrently with other Extreme, High, and Moderate Risk pruning. Extreme, High, and Moderate Risk trees recommended for removal generally have extensive defects that cannot be resolved through pruning or other maintenance procedures and are located in places where their failure is likely to cause property damage or bodily harm to Maynard’s citizens. Extreme, High, and Moderate Risk removals may be costly, but it is important to secure funding to complete these tasks in a timely manner to improve public safety and mitigate risk.

High Priority Pruning

This maintenance should be performed immediately based on assigned risk rating and may be performed concurrently with other Extreme, High, and Moderate Risk removals. Extreme and High, and Moderate Risk pruning generally requires removing defects such as dead, decaying, and/or broken branches that may be present in the crown of both small and large trees, even when most of the tree is sound. In these cases, pruning the defective branch(es) can correct the problem, reducing risk associated with the tree and promoting healthy growth.

Recommendations

The February 2020 inventory identified no Extreme or High Risk trees. A total of 10 Moderate Risk trees were recommended for removal (Figure 12) and another 8 Moderate Risk trees were recommended for pruning (Figure 13). These Moderate Risk removals and prunings should be carried out right away to promote public safety and mitigate risk. Maynard's tree resource should be inspected annually and after major storm events to identify new Extreme, High, and Moderate Risk trees, and appropriate maintenance should be performed immediately based on the assigned risk rating.

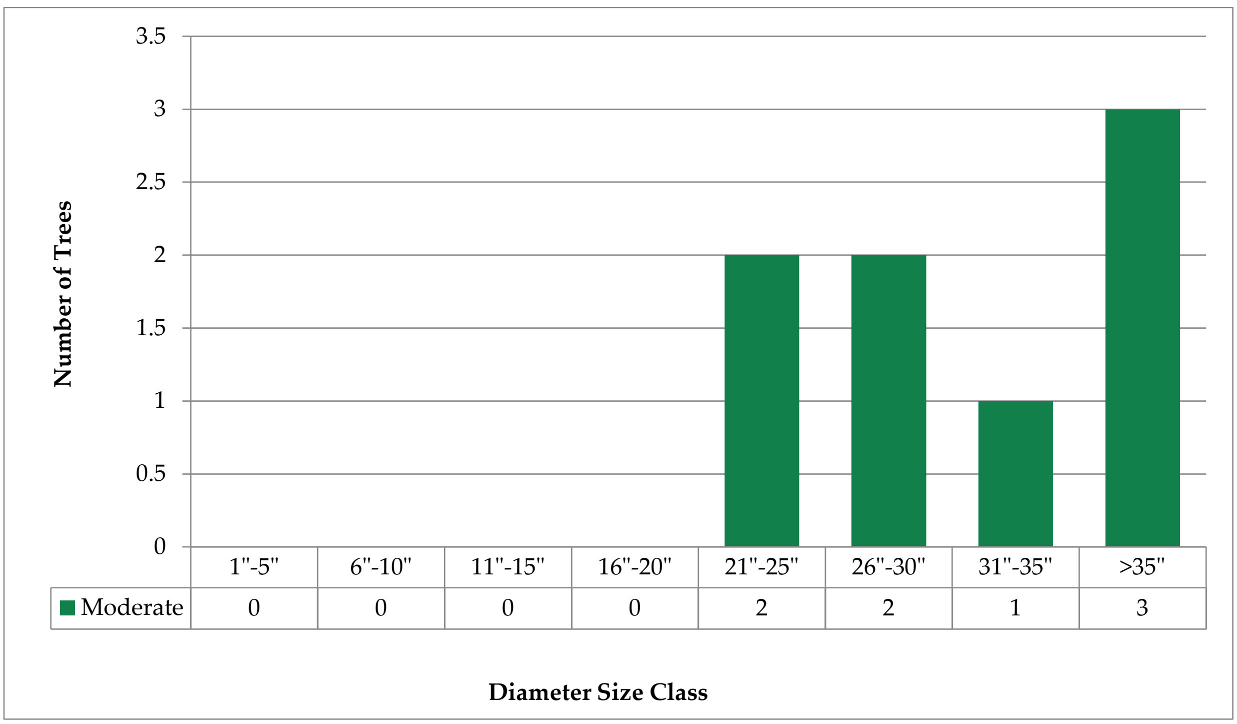


Figure 13. ***Priority pruning by risk rating.***

Low Priority Recommended Maintenance

Tree removals and pruning of Low Risk trees are recommended to be completed after all trees in the Extreme, High, and Moderate Risk categories have been addressed. While no Extreme or High Risk trees were identified in Maynard during the 2020 tree inventory, future discoveries of Extreme, High, and Moderate Risk trees should take priority over Low Risk trees and routine maintenance cycles.

Low Priority Pruning and Removals

The 2020 Maynard inventory identified 2,070 Low Risk trees recommended for pruning and 234 Low Risk trees recommended for removal (Figure 12). Low Risk trees requiring pruning or removal are generally small dead trees, invasive species or trees that have poor form or structure. If corrective pruning cannot address a tree's issues and/or adequately eliminate the hazard than the tree should be removed. Low Risk tree removals should be addressed after all higher risk tree maintenance activities have been completed. Low Risk trees designated for pruning should be included in a proactive Routine Pruning Cycle after all the higher risk trees are addressed.

Recommendations

DRG identified 234 Low Risk trees recommended for removal. 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 Extreme, High, and Moderate Risk removals and pruning have been completed.

DRG identified 2,070 Low Risk trees recommended for pruning. Low Risk prunes may include routine crown cleaning for small dead limbs, structural pruning to correct defects before they become problems, and removal or larger dead limbs or other defects from trees in more remote areas where large defects are unlikely to impact people or property. Tree recommended for Low Risk pruning should be included in a five-year routine pruning cycle once all priority work has been completed.

Further Inspection

In the ANSI A300 system, there are three levels of risk assessment. Each level is built on the one before it. The lowest level is designed to be a cost-effective approach to quickly identifying tree risk concerns; whereas, the highest level is intended to provide in-depth information about a tree. These levels are:

- **Level 1** inspection is defined as a Limited Visual assessment, which is often conducted as a walk through or windshield survey designed to identify obvious defects or specified conditions.
- **Level 2** inspection is defined as a Basic assessment and is a detailed, 360-degree visual inspection of a tree and its surrounding site, and a synthesis of the information collected.
- **Level 3** inspection is an Advanced assessment and is performed to provide detailed information about specific tree parts, defects, targets, or site conditions. A level 3 inspection may use specialized tools or require the input of an expert.

The Further Inspection data field indicates whether a tree requires additional and/or future inspections to assess and/or monitor conditions that may cause it to become a risk to people, property, or other trees. The inventory identified 119 trees (4% of the inventoried tree population) requiring one of three inspection types. Further Inspections are beyond the scope of a standard tree inventory, and can be one of the following:

- Multi-year annual inspection (e.g., a healthy tree that has been impacted by recent construction, weather, or other damage OR a tree with a defect that does not yet merit removal but will likely require extra care or removal in the future).
- Level III risk assessment (e.g., a tree with a defect requiring additional or specialized equipment for investigation).
- Insect/disease monitoring (e.g., a tree that appears to have an emerging insect or disease problem).
- No further inspection required.

A level III inspection was recommended for trees in which a defect was observed during the inventory and it warranted a closer inspection by a TRAQ qualified arborist. These trees may need to be inspected utilizing an aerial bucket to provide the inspector access to the canopy of the tree in which most of the defects are located. Trees with a Further Inspection requirement should be assessed by an ISA certified arborist as soon as possible, because the longer hazardous conditions are left unaddressed, the greater a risk that a tree becomes. For the same reason, the management that the arborist recommends should be performed as soon as possible to minimize risk.

Recommendations

The 2020 Maynard inventory found 6 trees recommended for an advanced Level 3 inspection, 67 trees recommended for annual/multi-year inspections, and 46 trees recommended for insect and disease monitoring. Trees flagged as requiring a Level 3 Risk Assessment (6 trees) were primarily trees with evidence of limb or leader decay above the height that could be adequately investigated in a Level 2 ground survey. These trees should be inspected by a qualified arborist as soon as possible, and appropriate actions taken.

Photograph 10. *Trees that have had roots cut or damaged during new sidewalk or pavement installation may require further inspection to ensure they are recovering well from the damage and not becoming hazardous.*
Photograph courtesy of Moriah Day, DRG Arborist

The 67 trees recommended for annual/multi-year inspections were mostly trees with missing or decayed wood which, while not immediately requiring tree removal, will likely worsen over time and eventually necessitate the removal of these trees. However, if continued surveys of these trees show them to be providing community benefits while posing a low risk to public safety, it is beneficial to retain them. Another common situation which warrants annual/multi-year inspections is trees which may have sustained root damage as a result of new sidewalk or pavement installations (19 trees). While these trees do not immediately necessitate pruning or removal, they are likely to decline over time as a result of root damage and may eventually require removal or other remediating actions.

Forty-six trees were recommended for insect or disease monitoring. Of these, 17 were *Fraxinus* spp. (ash) showing symptoms consistent with infestation by emerald ash borer (EAB, *Agrilus planipennis*), including canopy thinning and crown dieback, epicormic sprouting, and woodpecker damage. Another 25 trees were *Tsuga canadensis* (eastern hemlock) individuals with signs and symptoms of hemlock woolly adelgid (HWA, *Adelges tsugae*) and/or elongate hemlock scale (EHS, *Fiorinia externa*), including canopy thinning and crown dieback, fuzzy white nests on twigs (a sign of HWA), and scale coverings on the underside of needles (a sign of EHS). The remaining 4 trees recommended for insect/disease monitoring were *Ulmus americana* (American elm) individuals with symptoms of Dutch elm disease (DED), including crown dieback, loose and peeling bark, and elm bark beetle galleries. Trees recommended for insect or disease monitoring should be inspected by a qualified arborist to verify the presence of an insect or disease pest, and appropriate mitigation strategies should be taken to avoid or control the spread of the insect or disease pest to uninfected trees.

Unless already designated for removal, the 292 trees with a tree architecture defect and the 461 trees recorded as having missing or decayed wood should be inspected on a regular basis. Corrective action should be taken unless it will not adequately eliminate the hazard, in which case tree removal is likely to be the safest and most cost-effective management. Proactive tree maintenance that actively mitigates elevated risk situations will promote public safety.

Routine 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. Ideally, the arborist will be ISA Certified and hold the ISA Tree Risk Assessment Qualification credential.

Recommendations

All trees along the street ROW should be regularly inspected and attended to as needed. When trees require additional or new work, they should be added to the maintenance schedule. The budget should also be updated to reflect the additional work. Utilize computer management software such as TreeKeeper® to make updates, edits, and keep a log of work records. In addition to locating potential new hazards, inspections also present an opportunity to look for signs and symptoms of pests and diseases. Maynard has a large population of trees that are susceptible to pests and diseases, including ash, maple, and oak.

DRG recommends that Maynard perform inspections of inventoried trees by windshield survey (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* annually and after all severe weather events to identify new potential hazards, signs of pests, and symptoms of disease. When trees need additional maintenance, they should be added to the work schedule immediately. Use asset management software such as TreeKeeper® to update inventory data and schedule work records.

Routine Pruning Cycle

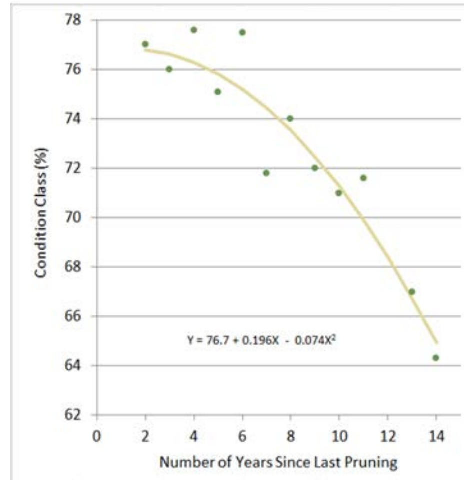
The Routine Pruning Cycle includes all Low Risk trees that received a pruning recommendation during the inventory. Over time, routine pruning can minimize reactive maintenance, limit instances of elevated risk, and provide the basis for a robust risk management program. Included in this cycle are Low Risk trees that require pruning and pose some risk but have a smaller defect size and/or a lower probability of impacting a target.

The length of the Routine Pruning Cycle is primarily driven by the number of trees that a municipality can feasibly prune each year with its budget and is secondarily driven by the size of the public tree resource. The recommended Routine Pruning Cycle duration is five years but may extend to seven years if the inventoried tree population is large. However, extending the Routine Pruning Cycle beyond 7 years is not recommended, because trees that have gone longer without being pruned start to run the risk of having once-minor defects worsen into health concerns that diminish their condition (Miller and Sylvester, 1981).

Recommendations

Maynard's inventory has 2,070 trees that should be routinely pruned, and DRG recommends that the town establish a five-year Routine Pruning Cycle with approximately 414 trees pruned each year. If this isn't feasible for Maynard, a six-year Routine Pruning Cycle with approximately 345 trees pruned each year, or a seven-year Routine Pruning Cycle with approximately 296 trees pruned each year, is acceptable considering the inventoried tree population's size. DRG recommends that the Routine Pruning Cycle begins in Year One of this five-year plan, after all Extreme, High, and Moderate Risk Recommended Maintenance is complete.

PROACTIVE PRUNING



Relationship between tree condition and years since previous pruning. (adapted from Miller and Sylvester 1981)

Miller and Sylvester studied the pruning frequency of 40,000 street trees in Milwaukee, Wisconsin. Trees that had not been pruned for more than 10 years had an average condition rating 10% lower than trees that had been pruned in the previous several years. Their research suggests that a five-year pruning cycle is optimal for urban trees.

Routine pruning cycles help detect and correct most defects before they become hazardous. DRG recommends that pruning cycles begin after all Extreme, High, and Moderate Risk tree maintenance has been completed.

DRG recommends two pruning cycles: a Young Tree Training Cycle and a Routine Pruning Cycle. Newly planted trees will enter the Young Tree Training Cycle once they become established and will move into the Routine Pruning Cycle when they reach maturity. A tree should be removed and eliminated from the Routine Pruning Cycle when it outlives its usefulness.

Approximately 62% of the inventoried tree population would benefit from routine pruning. Figure 14 shows that a variety of size classes were recommended for the routine pruning cycle, however most of the trees were smaller than 21”-25” DBH. Most trees less than 6” DBH were recommended for the Young Tree Training Cycle. Trees less than 6” DBH that were included in the Routine Pruning Cycle were small diameter conifers with minor defects that could be corrected by pruning or that were interfering with overhead utilities.

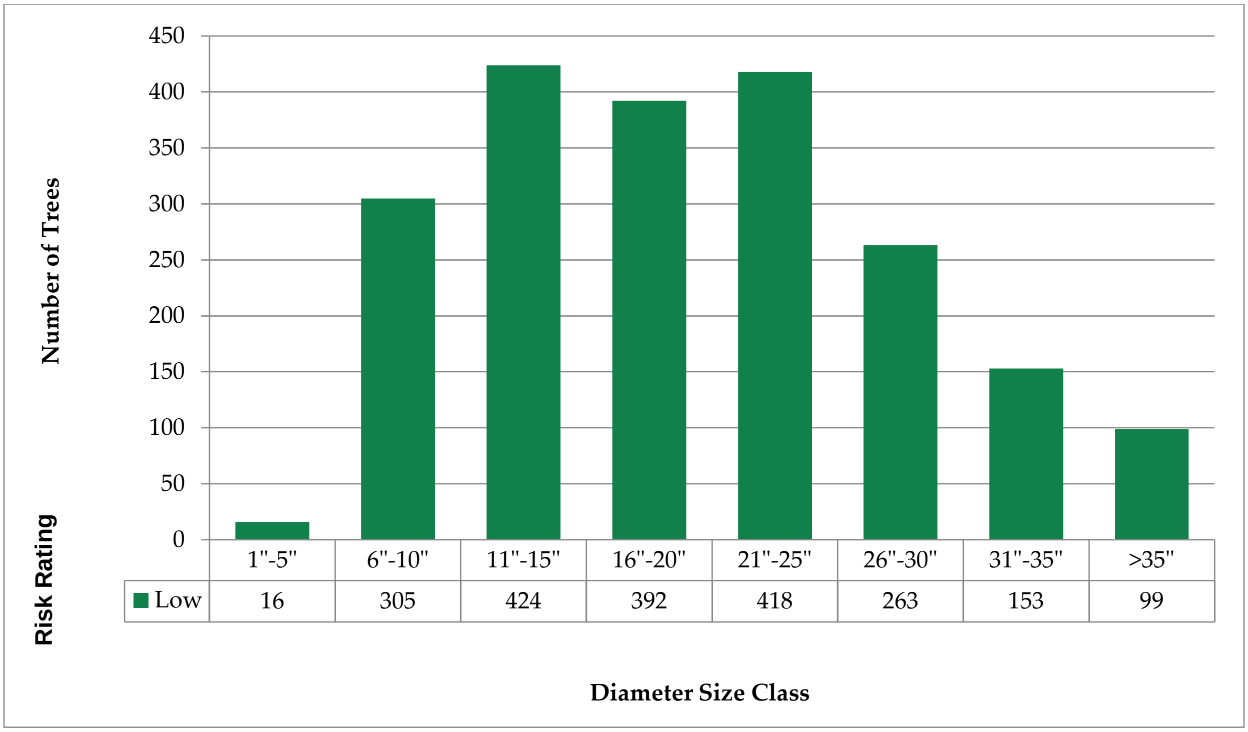


Figure 14. ***RP Cycle by diameter class.***

Young Tree Training Cycle

Trees included in the Young Tree Training Cycle are generally less than 8” 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 its risk rating and creating potential liability. The recommended length of a Young Tree Training Cycle is three years because young trees tend to grow at faster rates than mature trees. Conifers are not included in the Young Tree Training Cycle as they typically do not require structural pruning to develop good tree architecture.

The Young Tree Training Cycle differs from the Routine Pruning Cycle in that the Young Tree Training Cycle generally only includes trees that can be pruned from the ground with a pole pruner or pruning shears.

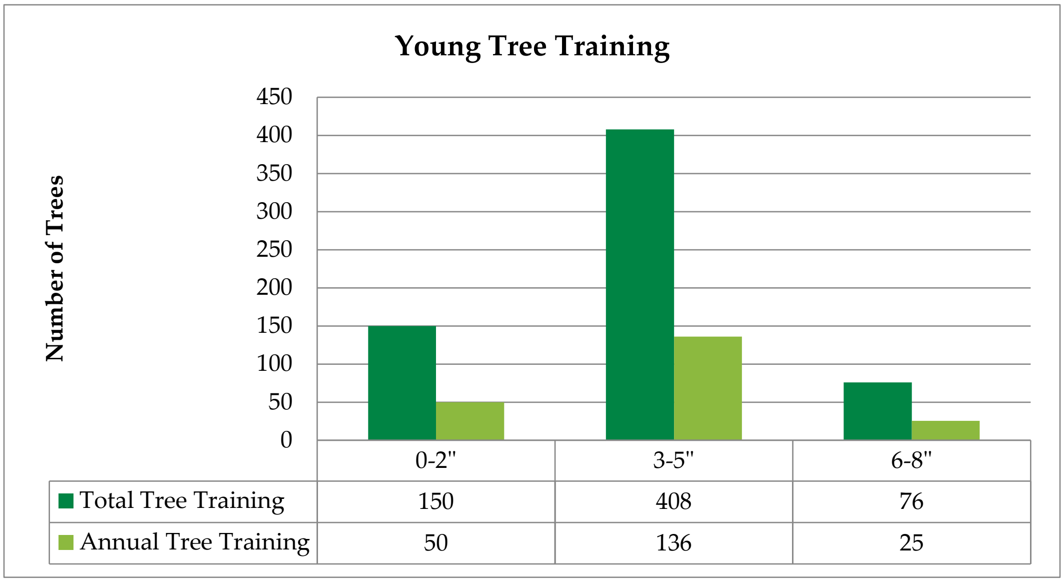


Figure 15. ***YTT Cycle by diameter class.***

DRG recommends that Maynard implement a three-year Young Tree Training Cycle beginning after the completion of all Extreme, High, and Moderate Risk Recommended Maintenance activities. During the inventory, 634 trees less than or equal to 8 inches DBH were inventoried and recommended for young tree training (Figure 15). Since Maynard has so many young trees, the Young Tree Training Cycle is vital for the future condition of the inventoried tree population. DRG recommends that an average of 211 trees be trained with structural pruning each year over three years, beginning in Year One of the management program.

When new trees are planted, they should enter the Young Tree Training Cycle after establishment, typically within 2–3 years after planting. In future years, the number of trees in the Young Tree Training Cycle will be based on tree planting efforts and growth rates of young trees. The town should strive to training prune approximately one-third of its young trees each year.

Tree Planting and Stump Removal

The inventory identified 360 stumps recommended for removal. There was a wide range of sizes from 3” to 65” in DBH. Stump removals should occur when convenient and added to the potential planting site inventory if the site is feasible. The inventory identified 1,725 vacant sites that are suitable for planting. Of these, 25% were suitable for large-stature trees (426 sites), 7% were suitable for medium-stature trees (123 sites), and 68% were suitable only for small-stature trees (1,176 sites). Figure 16 depicts the number and size of vacant sites collected in the 2020 Maynard tree inventory.

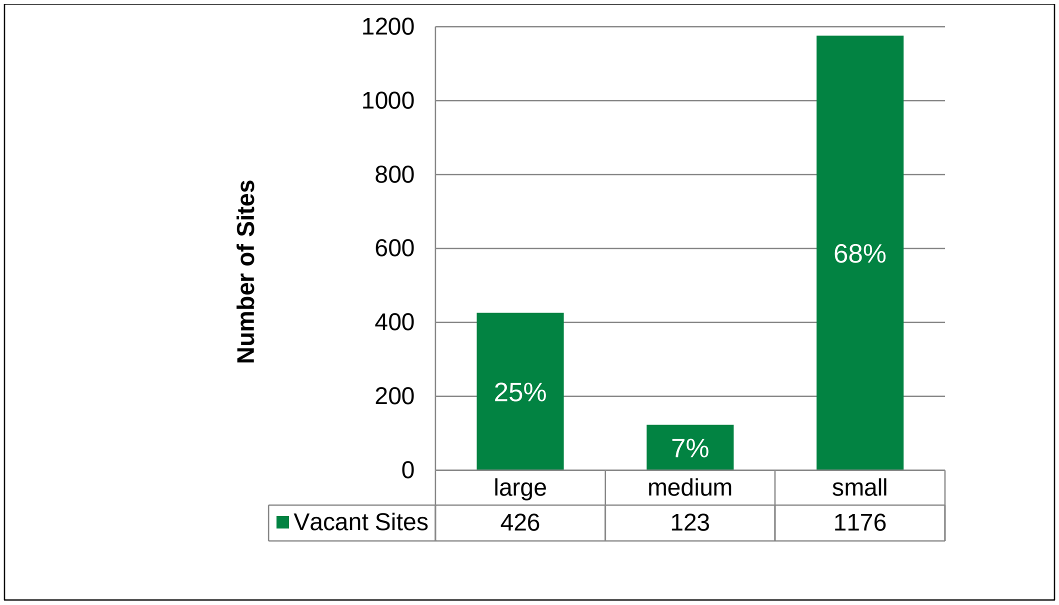


Figure 16. ***Planting sites.***

Recommendations

Planting new trees in areas that have poor canopy continuity is important, especially where there are gaps in the canopy. It's important to plant more trees where there is sparse canopy, because while Maynard receives value from the ecosystem services provided by the public tree resource, those benefits aren't distributed evenly across the town. Certain areas of the town which currently have poor canopy continuity, including downtown and the neighborhood located in the southeastern crook of Parker and Waltham Streets, would require active creation of feasible planting locations, as these areas currently do not have many feasible vacant planting sites. In addition, the majority of the feasible vacant planting sites collected during the 2020 inventory could accommodate only small trees (1,176 small vacant sites, 68% of total vacant sites). Enlarging some of these planting sites to accommodate medium or large stature trees could improve the ecosystem benefits provided by new plantings and maximize the benefit to cost ratio of tree plantings in the long term.

Photograph 11. *New plantings are essential to replace removed trees, increase stocking level, and maximize ecosystem services provided by Maynard's urban forest.* **Photograph courtesy of Moriah Day, DRG Arborist**

Maintenance Schedule and Budget

Utilizing 2020 Town of Maynard tree inventory data, an annual maintenance schedule was developed detailing the recommended tasks to complete each year. DRG made budget projections using industry knowledge and public bid tabulations. A complete table of estimated costs for Maynard's five-year tree management program follows (Table 5).

This schedule provides a framework for completing the recommended inventoried tree maintenance over the next five years. Following this schedule can shift tree maintenance activities from being reactive to a more proactive tree care program.

To implement the maintenance schedule, Maynard's tree maintenance budget should be:

- No less than $261,087 for the first year of implementation.
- No less than $506,280 for the second and third years, combined.
- No less than $498,690 for the final two years of the maintenance schedule, combined.

Annual budget funds are needed to ensure that Extreme, High, and Moderate Risk trees are expediently managed and that the vital Young Tree Training and Routine Pruning Cycles can begin as soon as possible. If routing efficiencies and/or contract specifications allow more tree work to be completed each year, or if this maintenance schedule requires adjustment to meet budgetary or other needs, then it should be modified accordingly. Unforeseen situations such as severe weather events may arise and change the maintenance needs of trees. If maintenance needs change, then budgets, staffing, and equipment should be adjusted to meet the new demands.

Table 5. *Estimated costs for five-year tree management program*

Estimated Costs for Each Activity			2021		2022		2023		2024		2025		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Extreme, High, and Moderate Risk Removals	1-5"	$50	-	-	-	-	-	-	-	-	-	-	$0
	6-10"	$75	-	-	-	-	-	-	-	-	-	-	$0
	11-15"	$100	-	-	-	-	-	-	-	-	-	-	$0
	16-20"	$125	3	$375	-	-	-	-	-	-	-	-	$375
	21-25"	$375	3	$1,125	-	-	-	-	-	-	-	-	$1,125
	26-30"	$565	3	$1,695	-	-	-	-	-	-	-	-	$1,695
	31-35"	$800	-	-	-	-	-	-	-	-	-	-	$0
	>35"	$1,300	1	$1,300	-	-	-	-	-	-	-	-	$1,300
Activity Total(s)			**10**	**$4,495**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$4,495**
Low Risk Removals	1-5"	$50	-	-	-	-	-	-	-	-	66	$3,300	$3,300
	6-10"	$75	-	-	-	-	-	-	26	$1,950	10	$750	$2,700
	11-15"	$100	-	-	-	-	21	$2,100	22	$2,200	-	-	$4,300
	16-20"	$125	-	-	18	$2,250	21	$2,625	-	-	-	-	$4,875
	21-25"	$375	-	-	26	$9,750	-	-	-	-	-	-	$9,750
	26-30"	$565	17	$9,605	-	-	-	-	-	-	-	-	$9,605
	31-35"	$800	4	$3,200	-	-	-	-	-	-	-	-	$3,200
	>35"	$1,300	3	$3,900	-	-	-	-	-	-	-	-	$3,900
Activity Total(s)			**24**	**$16,705**	**44**	**$12,000**	**42**	**$4,725**	**48**	**$4,150**	**76**	**$4,050**	**$41,630**
Extreme, High, and Moderate Risk Pruning	1-5"	$58	-	-	-	-	-	-	-	-	-	-	$0
	6-10"	$113	-	-	-	-	-	-	-	-	-	-	$0
	11-15"	$183	-	-	-	-	-	-	-	-	-	-	$0
	16-20"	$203	-	-	-	-	-	-	-	-	-	-	$0
	21-25"	$253	2	$506	-	-	-	-	-	-	-	-	$506
	26-30"	$283	2	$566	-	-	-	-	-	-	-	-	$566
	31-35"	$323	1	$323	-	-	-	-	-	-	-	-	$323
	>35"	$363	3	$1,089	-	-	-	-	-	-	-	-	$1,089
Activity Total(s)			**8**	**$2,484**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$2,484**
Routine Pruning (5-year cycle based on Low Risk Pruning)	1-5"	$58	3	$174	3	$174	3	$174	3	$174	4	$232	$928
	6-10"	$113	61	$6,893	61	$6,893	61	$6,893	61	$6,893	61	$6,893	$34,465
	11-15"	$183	84	$15,372	85	$15,555	85	$15,555	85	$15,555	85	$15,555	$77,592
	16-20"	$203	78	$15,834	78	$15,834	78	$15,834	79	$16,037	79	$16,037	$79,576
	21-25"	$253	83	$20,999	83	$20,999	84	$21,252	84	$21,252	84	$21,252	$105,754
	26-30"	$283	52	$14,716	52	$14,716	53	$14,999	53	$14,999	53	$14,999	$74,429
	31-35"	$323	30	$9,690	30	$9,690	31	$10,013	31	$10,013	31	$10,013	$49,419
	>35"	$363	19	$6,897	20	$7,260	20	$7,260	20	$7,260	20	$7,260	$35,937
Activity Total(s)			**410**	**$90,575**	**412**	**$91,121**	**415**	**$91,980**	**416**	**$92,183**	**417**	**$92,241**	**$458,100**
Young Tree Training (3-year cycle)	1-6"	$58	211	$12,238	211	$12,238	212	$12,296	211	$12,238	211	$12,238	$61,248
Activity Total(s)			**211**	**$12,238**	**211**	**$12,238**	**212**	**$12,296**	**211**	**$12,238**	**211**	**$12,238**	**$61,248**
Tree Planting	Purchasing	$170	393	$66,810	394	$66,980	394	$66,980	394	$66,980	394	$66,980	$334,730
	Planting	$110	393	$43,230	394	$43,340	394	$43,340	394	$43,340	394	$43,340	$216,590
Activity Total(s)			**786**	**$110,040**	**788**	**$110,320**	**788**	**$110,320**	**788**	**$110,320**	**788**	**$110,320**	**$551,320**
Stump Removals	1-5"	$25	-	-	9	$225	9	$225	9	$225	9	$225	$900
	6-10"	$35	10	$350	10	$350	10	$350	10	$350	10	$350	$1,750
	11-15"	$50	11	$550	11	$550	11	$550	11	$550	11	$550	$2,750
	16-20"	$65	10	$650	10	$650	10	$650	10	$650	10	$650	$3,250
	21-25"	$80	-	-	16	$1,280	15	$1,200	15	$1,200	15	$1,200	$4,880
	26-30"	$100	-	-	11	$1,100	11	$1,100	11	$1,100	10	$1,000	$4,300
	31-35"	$150	-	-	10	$1,500	9	$1,350	9	$1,350	9	$1,350	$5,550
	>35"	$300	-	-	7	$2,100	7	$2,100	7	$2,100	7	$2,100	$8,400
Activity Total(s)			**31**	**$1,550**	**84**	**$7,755**	**82**	**$7,525**	**82**	**$7,525**	**81**	**$7,425**	**$31,780**
Admin, Legal, Outreach, Training				$10,000		$10,000		$10,000		$10,000		$10,000	$50,000
Inspections and Inventory Updates				$3,000		$3,000		$3,000		$3,000		$3,000	$15,000
Infrastructure Repair and Storm Response				$10,000		$10,000		$10,000		$10,000		$10,000	$50,000
Activity Grand Total			**593**		**603**		**614**		**623**		**638**		
Cost Grand Total				**$261,087**		**$256,434**		**$249,846**		**$249,416**		**$249,274**	**$1,266,057**

CONCLUSION

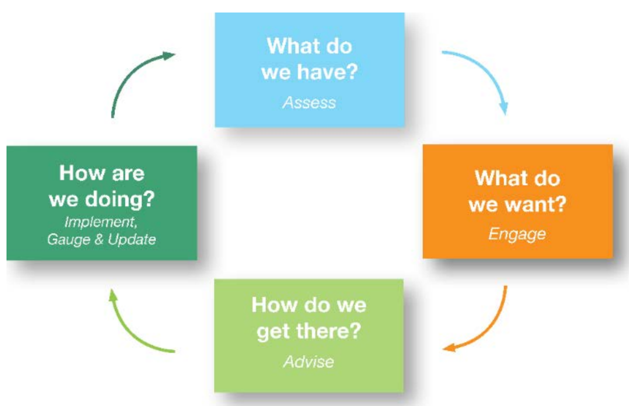
When properly maintained, the valuable benefits trees provide far exceed the time and money invested in planting, pruning, and inevitably removing them. The public trees inventoried provide $11,415 in estimated annual economic value by reducing runoff, removing air pollutants, and sequestering carbon. As the urban forest grows, the benefits enjoyed by the Town of Maynard and its residents will increase as well. Inventoried trees are only a fraction of the total trees in Maynard when including private property, which is why it's important to incentivize private landowners to care for their trees and to plant new ones.

If this management program is successfully implemented, the health of Maynard's public trees and the safety of the town's residents will be maintained in the years to come. The program is ambitious and is a challenge to complete in five years, but priority tree maintenance should be completed as soon as possible while advocating for an increased urban forestry budget to fund the remaining work in the future.

Evaluating and Updating This Plan

This *Tree Resource Management Plan* provides management priorities for the next five years. However, additional management tasks will arise during that time, and it is important to update the tree inventory using TreeKeeper® or similar software as work is completed so the software can provide updated species distribution and benefit estimates. This empowers Maynard to self-assess the town's progress over time and set goals to strive toward. The adaptive management cycle is an effective framework with which to approach urban forest management, represented by the graphic below. Some strategies for implementing an adaptive management cycle include the following:

- Compare Maynard's actual urban forestry budget to the management program's estimate. Is the town's current budget enough to complete all priority maintenance in a reasonable timeframe? If not, demonstrate the need for an increased urban forestry budget.
- Annually compare the number of trees planted to the number of removals during that year and the number of vacant planting sites that remain.



- Establish a Routine Pruning Cycle and Young Tree Training Cycle and compare the number of trees pruned annually with the recommended number.
- Engage public opinion as this plan is implemented and over the years as progress occurs. Seek public opinion for feedback about what is working and which parts need improvement.

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GLOSSARY

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

air pollution removal: In i-Tree Eco, air pollution removal refers to the removal of ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 2.5 microns ($PM_{2.5}$).

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

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

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

assigned address (data field): see **suffix**

avoided runoff: In i-Tree Eco, avoided runoff measures the amount of surface runoff avoided when trees intercept rainfall during precipitation events.

canopy: Branches and foliage that make up a tree's crown.

canopy cover: As seen from above, it is the area of land surface that is covered by tree canopy.

Carbon Monoxide (CO): A colorless, odorless, highly toxic gas formed as a result of the incomplete combustion of a carbon or carbon compound.

carbon sequestration: The capture and storage of carbon from the Earth's atmosphere. In i-Tree Eco, carbon sequestration is calculated as an annual functional benefit of trees.

carbon storage: Storage of carbon in plant tissue. In i-Tree Eco, carbon storage is calculated as a structural benefit over the lifetime of the tree.

comments (data field): Additional comments on the state of the inventoried site. Comments may include the number of stems if the tree was multi-stemmed, additional defects that were significant but not the primary defect, explanations for why further inspection is needed, and other general information considered important by the inventory arborist.

community forest: see **urban forest**.

condition (data field): The general condition of each tree rated during the inventory according to the following categories adapted from the International Society of Arboriculture's rating system: Good, Fair, Poor, or Dead.

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

defect (data field): The primary defect noted by the inventory arborist. Defects include missing or decayed wood, dead or dying parts, broken or hanging branches, weakly attached branches and codominant stems, cracks, root problem, tree architecture, other, and none.

diameter: See **tree size**.

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

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

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

functional benefit: In i-Tree Eco, a benefit which is due to the physiological processes carried out by trees, calculated on an annual basis.

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

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

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

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

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

importance value (IV): A calculation in i-Tree Eco displayed in table form for all species that make up more than 1% of the population. The IV calculated by the i-Tree Eco model factors in the total number of trees for each species, each species' percentage of the total population, and each species' total leaf area. The IV can range from 0 to 200, with higher IVs indicating higher reliance on one species to provide ecosystem services. IVs offer valuable information about a community's reliance on certain species to provide functional benefits.

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

inventory: See **tree inventory**.

i-Tree Eco: i-Tree Eco is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental benefits, including runoff reduction, air pollution reduction, and carbon sequestration, as well as life-long structural benefits trees provide, including carbons storage and structural value.

i-Tree Streets: i-Tree Streets is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase. While i-Tree Streets was not used for the tree benefits analysis in this management plan, it is still used as the basis for the tree benefits tab in TreeKeeper®.

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

location (data field): A data field indicating the physical location of an inventoried tree: either street (ROW), borderline (on or near the ROW boundary), off ROW, or park/public.

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

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

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

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

multi-stem (data field): Indicates whether a tree has multiple trunks splitting less than 1.5 feet above ground level. If a tree had multiple stems, a comment was adding indicating the number of stems.

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

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

on-street (data field): The street a site is physically located on.

ordinance: See **tree ordinance**.

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

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

park name (data field): The name of the park or public area in which a tree is located.

Particulate Matter ($PM_{2.5}$): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

plant (primary maintenance need): If collected during an inventory, this data field identifies planting sites as small, medium, or large (indicating the ultimate size that the tree will attain), depending on the growing space available and the presence of overhead wires.

primary maintenance need (data field): The type of tree work needed to reduce immediate risk.

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

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

residual risk (data field): The risk rating of a tree after the recommended primary maintenance has been carried out. Residual risk may be equal to but never greater than the original risk rating.

right-of-way (ROW): See **street right-of-way**.

risk: Combination of the probability of an event occurring and its consequence.

risk assessment (data fields): see Appendix E.

risk assessment complete (data field): Indicates whether or not the arborist was able to complete a Level 2 qualitative risk assessment. Arborists may not be able to fully assess tree risk due to embankments, homeowner conflicts, fences, or other obstacles to getting a 360 degree view of the tree.

risk rating: Level 2 qualitative risk assessment will be performed on the ANSI A300 (Part 9) and the companion publication *Best Management Practices: Tree Risk Assessment*, published by International Society of Arboriculture (2011). Trees can have multiple failure modes with various risk ratings. One risk rating per tree will be assigned during the inventory. The failure mode having the greatest risk will serve as the overall tree risk rating. The specified time period for the risk assessment is one year.

side (data field): Each site is assigned a side value to aid in locating the site. Side values include: *front*, *side*, *median* (includes islands), and *rear* based on the site's location in relation to the lot's street frontage. The *front* side is the side that faces the address street. *Side* is a side that is one corner away from the side that faces the address street. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

species (data field): Fundamental category of taxonomic classification, ranking below a genus or subgenus, and consisting of related organisms capable of interbreeding.

stem: A woody structure bearing buds and foliage, and giving rise to other stems.

street (data field): The name of a street right-of-way or road identified using posted signage or parcel information. The street to which the parcel a site is on is addressed.

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

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

structural benefit: In i-Tree Eco, a benefit which is produced by the physical arrangement and composition of trees and tree parts and which is calculated as an aggregate over the lifetime of a tree.

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

structural value: In i-Tree Eco, the compensatory value calculated based on the local cost of having to replace a tree with a similar tree.

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

suffix (data field): Data field indicating whether the address was assigned by the arborist.

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

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

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

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

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

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

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

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

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

APPENDIX A: TREE PLANTING

Tree Planting

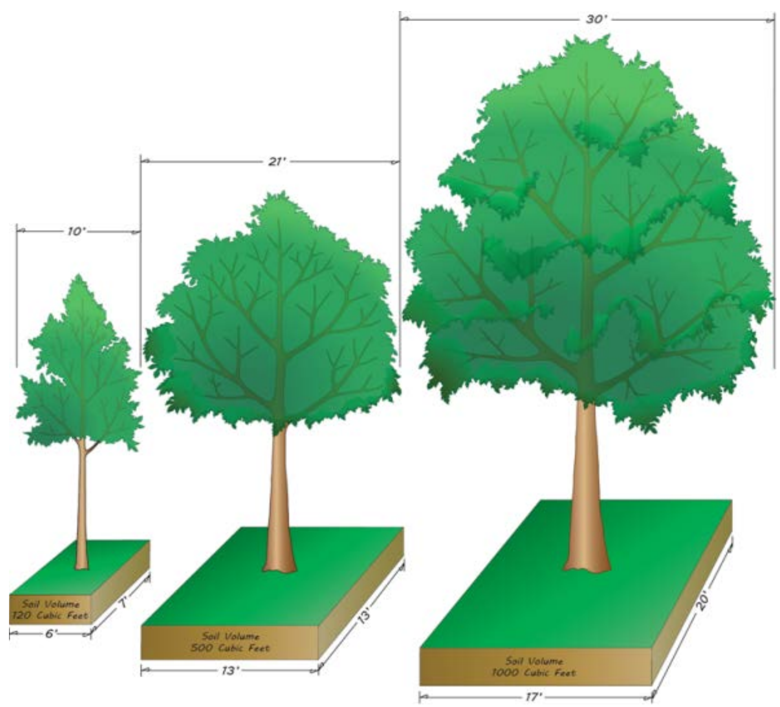
Planting trees is a valuable goal, provided tree species are carefully selected and correctly planted. When trees are planted, they should be planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of an asset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

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

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

Inventoried Street ROW Planting Space

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



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

Vacant Site Methodology

Not all potential sites are suitable to host a healthy and high-value tree. Vacant sites for planting were carefully selected following a set of standard protocols to ensure that new plantings do not interfere with existing trees or infrastructure and to provide the necessary space required for a new planting to grow and thrive. The vacant site standards used to select vacant sites for planting in Maynard are as follows:

- All Vacant Sites must be at least 15 feet from existing infrastructure, including utility poles and buildings; at least 20 feet from fire hydrants; at least 30 feet from intersections; at least 10 feet from driveways; 5–10 feet from underground utilities; and at least 10 feet from important traffic signs (not including parking signs which can be easily relocated).
- Small Vacant Sites must be 4–5.9 feet wide in their smallest dimension; at least 20 feet from all other trees, stumps, or vacant sites; and may be placed underneath overhead utilities.
- Medium Vacant Sites must be 6–7.9 feet wide in their smallest dimension; at least 30 feet from all other trees, stumps, or vacant sites; and must not be placed underneath overhead utilities.
- Large Vacant Sites must be at least 8 feet wide in their smallest dimension; at least 40 feet from all other trees, stumps, or vacant sites; and must not be placed underneath overhead utilities.

The largest possible vacant site was always prioritized in order to maximize the benefits that will be provided by new plantings as they mature.

Findings

The inventory found 1,725 planting sites within the town ROW, of which 68% are designated for small-sized mature trees, 7% for medium-sized trees, and 25% for large-sized trees. It may be worthwhile to invest some time and money in converting some small planting sites into sites suitable for large- or medium-sized trees and adding planting sites in neighborhoods that currently have few feasible locations for new plantings. Larger stature trees will provide greater community benefits than small trees and adding new planting locations in poorly stocked neighborhoods will help to spread the benefits of the urban forest more evenly across the town of Maynard.

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 well, as different tree species react differently to stress. Species diversity helps withstand drought, ice, flooding, strong storms, and wind.

Maynard is located in USDA Hardiness Zone 6a, which is identified as a climatic region with average annual minimum temperatures between −5°F and 10°F. Tree species selected for planting in Maynard should be appropriate for this zone. See Appendix D for a list of suggested tree species for planting within this zone.

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

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

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

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

DRG recommends limiting the planting of *Acer* spp. (maple) and specifically *A. platanoides* (Norway maple) until the species, genus, and family distribution within Maynard normalizes. Norway maple already comprise 25% of the ROW tree population, and maple in general make up 43% of the inventoried population. Excesses of trees in the same species or genus can make the urban forest more vulnerable to pest species and physical stressors and creates a situation where, should a pest species be introduced that attacks the over-abundant genus or species, the town stands to lose a massive portion of its urban canopy.

Tips for Planting Trees

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

- Handle trees with care. Trees are living organisms and are perishable. Protect trees from damage during transport and when loading and unloading. Use care not to break branches, and do not lift trees by the trunk.
- If trees are stored prior to planting, keep the roots moist.
- Dig the planting hole according to the climate. Generally, the planting hole is two to three times wider and not quite as deep as the root ball. The root 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.

- Stake the tree as necessary to prevent it from shifting too much in the wind, but be sure to remove any staking devices after the tree has established to prevent girdling by staking supplies.
- Add a thin layer (1–2 inches) of mulch to help prevent weeds and keep the soil moist around the tree. Do not allow mulch to touch the trunk.

Newly Planted and Young Tree Maintenance

Caring for trees is just as important as planting them. Once a tree is planted, it must receive maintenance for several years.

Watering

Initially, watering is the key to survival; new trees typically require at least 60 days of watering to establish. Determine how often trees should be irrigated based on time of planting, drought status, species selection, and site condition.

Mulching

Mulch can be applied to the growing space 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 growing space is moist. Mulch should be applied in a thin layer, generally 1 to 2 inches, and the growing area should be covered. Mulch should not touch the tree trunk or be piled up around the tree.

Lifelong Tree Care

After the tree is established, it will require routine tree care, which includes inspections, routine pruning, watering, plant health care, and integrated pest management as needed.

Maynard should employ qualified arborists to provide most of the routine tree care. An arborist can determine the type of pruning necessary to maintain or improve the health, appearance, and safety of trees. These techniques may include: eliminating branches that rub against each other; removing limbs that interfere with wires and buildings or that obstruct streets, sidewalks, or signage; removing dead, damaged, or weak limbs that pose a hazard or may lead to decay; removing diseased or insect-infested limbs; creating better structure to reduce wind resistance and minimize the potential for storm damage; and removing branches—or thinning—to increase light penetration.

An arborist can help decide whether a tree should be removed and, if so, to what extent removal is needed. Additionally, an arborist can perform—and provide advice on—tree maintenance when disasters such as storms or droughts occur. Storm-damaged trees can often be dangerous to remove or trim. An arborist can assist in advising or performing the job in a safe manner while reducing further risk of damage to property.

Plant Health Care, a preventive maintenance process that keeps trees in good health, helps a tree better defend itself against insects, disease, and site problems. Arborists can help determine proper plant health so that the town's tree population will remain healthy and provide benefits to the community for as long as possible.

Integrated Pest Management is a process that involves common sense and sound solutions for treating and controlling pests. These solutions incorporate basic steps: identifying the problem, understanding pest biology, monitoring trees, and determining action thresholds. The practice of Integrated Pest Management can vary depending on the site and based on each individual tree. A qualified arborist will be able to make sure that the town's trees are properly diagnosed and that a beneficial and realistic action plan is developed.

The arborist can also help with cabling or bracing for added support to branches with weak attachment, aeration to improve root growth, and installation of lightning protection systems.

Educating the community on basic tree care is a good way to promote Maynard's urban forestry program and encourage tree planting on private property. The town should encourage citizens to water trees on the ROW adjacent to their homes and to reach out to the town if they notice any changes in the trees, such as signs or symptoms of pests, early fall foliage, or new mechanical or vehicle damage.

APPENDIX B: DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

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

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

- address
- assigned address (suffix)
- comments
- condition
- defects
- further inspection
- location
- mapping coordinates
- multi-stem
- on Street
- overhead utilities
- park name
- primary maintenance
- residual risk
- risk assessment complete
- risk rating
- side
- species
- street
- tree size

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

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

The data collected were provided in DRG's TreeKeeper© software, Microsoft Excel™ spreadsheet, KML data file, and an i-Tree Eco Data file.

Site Location Methods

Equipment and Base Maps

Inventory arborists used FZ-G1 Panasonic Toughbook® unit(s) and the included internal GPS receiver(s).

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

Base Map Layers Utilized for Inventory

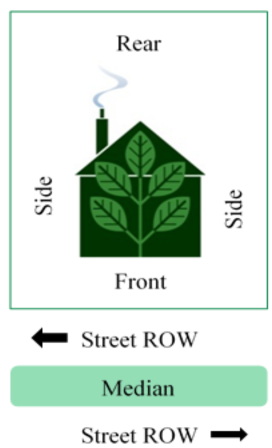
Imagery/Data Source	Date	Projection
Shapefiles MassGIS https://www.mass.gov/orgs/massgis-bureau-of-geographic-information	**2018-2019**	**NAD 1983 StatePlane Massachusetts Mainland; Feet**
Aerial Imagery 1ft Nearmap Inc	**April, 2019**	**NAD 1983 StatePlane Massachusetts Mainland; Feet**

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*, *on street name*, and *side*. This methodology was developed by DRG to help ensure consistent assignment of location.

Address Number

The *address number* was automatically filled based on GIS parcel addressing and was edited in the field as needed 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. If an address was assigned by the arborist, the Suffix (assigned address) field was changed from No to Yes.



Side values for street ROW sites.

Side

Each site was assigned a *side*. Side values include *front*, *side*, *median* (includes islands), or *rear* based on the site's location in relation to the lot's street frontage. The *front* is the side that faces the address street. Sites assigned the side value *front* will have the same street and on street value. *Side* indicates the side of a lot perpendicular to the address street. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front. Sites assigned the side values *side* or *rear* will have different street and on street values.

Street and On Street

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

- The *street* is the street to which the lot is addressed. It is usually (although not always) the street which buildings on the lot face.
- 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). Sites with side value *front* will always have the same street and on street values. Sites with side value *side* or *rear* will never have the same street and on street values.

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

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

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

<u>Corner Lot A</u>

Address:	205
Street:	Hoover St.
On Street:	Taft St.
Side:	side
Address:	205
Street:	Hoover St.
On Street:	Taft St.
Side:	side
Address:	205
Street:	Hoover St.
On Street:	Taft St.
Side:	side
Address:	205
Street:	Hoover St.
On Street:	Hoover St.
Side:	front

<u>Corner Lot B</u>

Address:	226
Street:	E Mac Arthur St.
On Street:	Davis St.
Side:	side
Address:	226
Street:	E Mac Arthur St.
On Street:	E Mac Arthur St.
Side:	front
Address:	226
Street:	E Mac Arthur St.
On Street:	E Mac Arthur St.
Side:	front

APPENDIX C: 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 invasive pest distribution maps can be found at: https://www.nrs.fs.fed.us/tools/afpe/maps/ and updated invasive pest information can be found at: https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/Pest-Tracker.

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, invasive 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

Spotted Lanternfly

The spotted lanternfly (SLF, *Lycorma delicatula*) is native to China and was first detected in Pennsylvania in September 2014. It is suspected to have arrived in the USA on a shipment of stone around 2012. Since then, infestations have been found in Delaware, New Jersey, Virginia, and Maryland. While a single dead SLF was found in Massachusetts in 2018, no established infestation has yet been found in the Commonwealth.

Photograph 12. *Adult spotted lanternfly with wings spread.* **Photograph courtesy of Pennsylvania Department of Agriculture, Bugwood.org (2014)**

Spotted lanternflies feed on a wide range of fruit, ornamental and shade trees, with the invasive tree-of-heaven (*Ailanthus altissima*) being one of the preferred hosts. Adult lanternflies have black-spotted forewings and appear dull while at rest, but when startled, SLFs will hop or fly away, revealing bright red and white hindwings. Nymphs are black with white spots, and the final, forth instar nymph is red, black, and white. SLF can cause significant damage to host plants by feeding on the sap of the plant and excreting honeydew, which then causes sooty mold and attracts other insects that may cause further harm to the affected plant.

Potential spread of SLF is of great concern due to the insect's "hitchhiking" ability – the adult females will deposit egg sacs on nearly any surface, including vehicles, trailers, and outdoor equipment and thus can be easily transported to new areas when people move infested materials. Due to its range of hosts, SLF has the potential to seriously impact a variety of industries, including beer and wine making, apple and other fruit orchards, and ornamental plant nurseries.

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 initially discovered 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.

Photograph 13. *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* spp. (birch); *Platanus* × *acerifolia* (London planetree); *Salix* spp. (willow); and *Ulmus* spp. (elm).

European 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 trees vulnerable to diseases and other pests that can eventually kill the tree.

Photograph 14. *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.

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* spp. (birch); *Juniperus* spp. (cedar); *Larix* spp. (larch); *Populus* spp. (aspen, cottonwood, poplar); *Quercus* spp. (oak); and *Salix* spp. (willow).

Red Pine Scale

Red pine scale (*Matsucoccus matsumarae*) is a diminutive scale insect that feeds on red pine (*Pinus resinsa*) as well as several species of nonnative ornamental pines. It was first reported in Connecticut in 1946 and is thought to have arrived in the USA on exotic pines planted at the New York World's Fair in 1939. It has spread swiftly throughout Massachusetts in the past few years and has decimated red pine stands.

The red pine scale insects themselves are too tiny to easily spot, but the females secrete a white, fuzzy coating for winter insulation that can be seen on twigs. Common symptoms of the scale include discoloration on lower branches followed by rapid crown decline and tree death due to the insects sucking moisture from the phloem of the tree's bark. Once stressed by the red pine scale, host trees are more susceptible to secondary pests which contribute to tree mortality.

Photograph 15. *Red pine killed by red pine scale.* **Photograph courtesy of Allison Kanoti, Maine Forest Service, Bugwood.org (2014)**

Sudden Oak Death

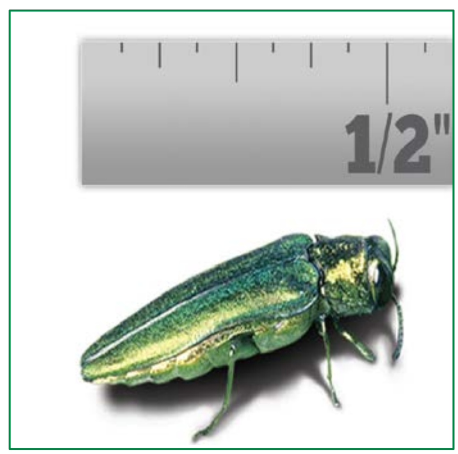
The causal agent of sudden oak death (SOD, also known as *Phytophthora* canker disease), *Phytophthora ramorum*, was first identified in 1993 in Germany and the Netherlands on ornamental rhododendrons. In 2000, the disease was found in California. Since its discovery in North America, SOD has been confirmed 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.

Photograph 16. *Drooping tanoak shoot affected by SOD.*
Photograph courtesy of Indian 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* spp. (oak) but also affects several other plant species.

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.

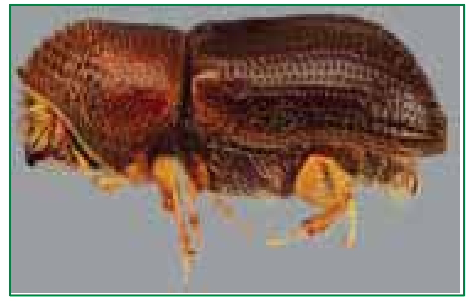


Photograph 17. *Close-up of an adult emerald ash borer.*
Photograph courtesy of APHIS (2011)

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).

Thousand Cankers Disease

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



Photograph 18. *Side view of a walnut twig beetle.*
Photograph courtesy of USDA Forest Service (2011b)

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

Hemlock Woolly Adelgid

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

Photograph 19. *Hemlock woolly adelgids nests on a hemlock twig.*
Photograph courtesy of USDA Forest Service (2011a)

In their native range, populations of HWA cause little damage to the hemlock trees, as they are fed on by 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 infestation.

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

Pine Shoot Beetle

The pine shoot beetle (PSB, *Tomicus piniperda*), 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).

Photograph 20. *PSB mined shoots on a Scots pine.*
Photograph courtesy of USDA Forest Service (1993)

The beetle attacks new shoots of pine trees, stunting the growth of the trees. The PSB 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. Common symptoms of pine shoot beetle infestation include drooping and yellowing of affected shoots which eventually fall off during the summer and fall.

Adult PSB 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. *P. sylvestris* (Scots pine) is PSB's preferred host, 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.

Southern Pine Beetle

The southern pine beetle (SPB, *Dendroctonus frontalis*) is the most destructive insect pest of pine in the southern United States. It attacks and kills all species of southern yellow pine 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 vascular system of the host tree, cutting off the flow of water and nutrients throughout 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.

Photograph 21. *Adult southern pine beetles.*
Photograph courtesy of Forest Encyclopedia Network (2012)

Adult SPBs reach a 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.

Oak Wilt

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

Photograph 22. *Oak wilt symptoms on red oak leaves.*
Photograph courtesy of USDA Forest Service (2011a)

Just as with Dutch elm disease, oak wilt disease is caused by a fungus that clogs the vascular system of oak 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.

Winter Moth

Winter moth (*Operophtera brumata*), a European native, was first detected in North America in the 1930s in Nova Scotia, Canada. It has since been found along Canada's and the USA's western coast and has migrated south from Nova Scotia into coastal New England. Winter moth adults are active during winter months, provided temperatures remain above freezing. Larvae hatch in the spring and are visible as small green inchworms feeding on leaves and buds of *Quercus* spp. (oak), *Acer* spp. (maple), *Ulmus* spp. (elm), *Fraxinus* spp. (ash), *Malus* spp. (crabapple), *Prunus* spp. (cherry), and *Vaccinium* spp. (blueberry), among other plants. Mature larvae balloon down from trees on silk strands to pupate in the soil and emerge as adults in November. Adult male winter moths are small and tan while females are greyish, have reduced wings, and are flightless.

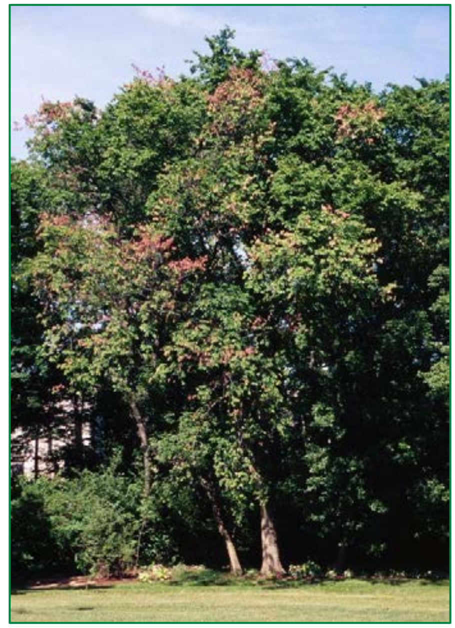
Photograph 23. *Winter moth larva on an oak leaf.*
Photograph courtesy of Milan Zubrik, Forest Research Institute – Slovakia, Bugwood.org (2008)

Winter moth outbreaks are destructive due to the defoliation of host species, which causes severe stress to the plants as they are forced to use stored resources to re-foliate. Repeated defoliation frequently results in partial to complete tree death. A biological control agent, *Cyzenis albicans* (a tachinid fly), has been introduced to Massachusetts and other affected areas and appears to be at least partially successful in controlling winter moth populations.

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 1959, it had killed thousands of elms. Today, DED is present in about two-thirds of the eastern United States and annually kills many of the remaining and newly planted elms. The disease is caused by a fungus that attacks the vascular system of elm trees, blocking the flow of water and nutrients, and resulting in rapid leaf yellowing, tree decline, and death.

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



Photograph 24. *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)

Oak Gall Wasp

The oak gall wasp (*Zapatella davisae*, formerly misidentified as *Callirhytis ceropteroides*), is a recent addition to the pest species threatening trees in Massachusetts. This tiny wasp species caused massive oak dieback on Long Island in the mid-1990s and was identified as the culprit behind widespread oak death on Cape Cod and Martha's Vineyard in the late 2000s. Only recently identified and described as a new species, *Z. davisae* adults are ~2mm long and amber colored.

Photograph 25. *Twig swelling caused by* Z. davisae.
Photograph courtesy of Whitney Cranshaw, Colorado State University, Bugwood.org (2017)

The wasp larvae burrow into oak twigs and feed there, creating a swollen gall that is reminiscent of arthritic fingers. The feeding and galls interrupt vascular flow in the tree, leading to crown dieback and eventually, tree death. This pest primarily affects *Quercus velutina* (black oak) and common symptoms of infestation include dieback, sparse growth, epicormic sprouting, flagging, and galled twigs with pinpoint exit holes, typically starting in the upper crown and moving downward. Research is ongoing as to whether this pest is native or nonnative, the exact mechanism by which it kills host trees, and what biological or chemical controls may be effective against it.

Elongate Hemlock Scale

The elongate hemlock scale (EHS, *Fiorina externa*) was introduced from Japan and was first observed in Queens, NY as early as 1908. It was not considered a major pest until the 2000s when its range and prevalence increased dramatically. This invasive scale insect has been found in 16 states to date, including Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, Nevada, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Tennessee, and Virginia as well as the District of Colombia. The insect is thought to have been spread widely on infested conifer products, including holiday wreaths and Christmas trees.

Photograph 26. *EHS covering the undersides of hemlock needles.*
Photograph courtesy of Eric R. Day, Virginia Polytechnic Institute and State University, Bugwood.org (2011)

Adult female EHS are soft bodied, amber, legless, and wingless. They are encased in a 2mm long, brown, waxy scale covered under which they feed and lay around 20 lemon-colored eggs. Males are enclosed in white, 1.5mm scales. While they have wings, they are weak fliers and travel only to mate. They do not feed. Young instars are called crawlers and are yellow and legged. They emerge from May–September and mature to later instars which feed under scales. The scales are a visible sign that a tree is infested with EHS, and needle yellowing, especially on lower branches, premature needle drop, and branch dieback are all common symptoms of EHS infestation. While these insects can kill trees outright by siphoning away nutrients and water from the tree, more commonly they weaken hosts, leaving them susceptible to other pests or environmental conditions.

EHS's preferred host species include *Tsuga* (hemlock), *Abies* (fir), and *Picea* (spruce). Other, less preferred hosts include *Cedrus* (cedar), *Pseudotsuga menziesii* (douglas-fir), *Pinus* (pine), and *Taxus* (yew). EHS is frequently found on the same trees as *Adelges tsugae* (hemlock woolly adelgid).

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APPENDIX D: 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 the soil and climate conditions throughout Zones 5 and 6 on the USDA Plant Hardiness Zone Map. The Town of Maynard falls in the USDA Plant Hardiness Zone 6a: -10 to -5 (F).

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

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

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

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

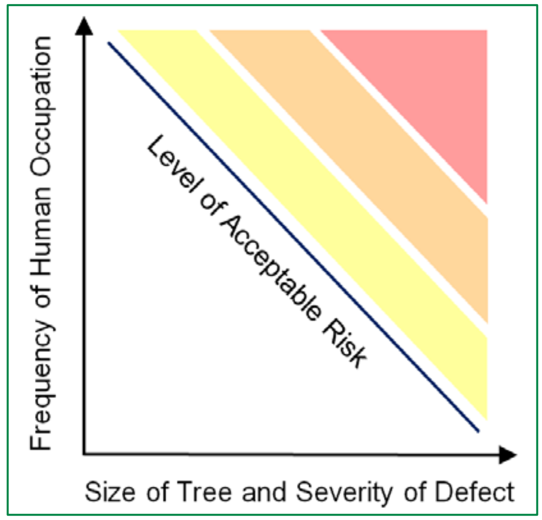
Scientific Name	Common Name	Cultivar
Ilex × attenuata	Foster's holly	
*Pinus aristata**	bristlecone pine	
*Pinus mugo**	mugo pine	

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

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

APPENDIX E: 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 was assigned during the inventory. The failure mode having the greatest risk served as the overall tree risk rating. The specified time period for the risk assessment was 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.
  - Imminent—Failure has started or is most likely to occur in the near future even if there is no significant wind or increased load. The imminent category overrides the stated time frame.
- **Likelihood of Impacting a Target**—The rate of occupancy of targets within the target zone and any factors that could affect the failed tree as it falls towards the target.
  - Very low—The chance of the failed tree or branch impacting the target is remote.
    - Rarely used sites
    - Examples include rarely used trails or trailheads
    - Instances where target areas provide protection
  - Low—It is not likely that the failed tree or branch will impact the target.
    - Occasionally used 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 very low monetary damage
    - Disruption of power to landscape lights
  - Minor—Consequences involve low to moderate property damage, small disruptions to traffic or communication utility, or very minor injury.
    - Small branch striking a house roof from a high height
    - Medium-sized branch striking a deck from a moderate height
    - Large tree part striking a structure, causing moderate monetary damage
    - Short-term disruption of power at service drop to house
    - Temporary disruption of traffic on neighborhood street
  - Significant—Consequences involve property damage of moderate to high value, considerable disruption, or personal injury.
    - Medium-sized part striking a vehicle from a moderate or high height
    - Large tree part striking a structure resulting in high monetary damage
    - Disruption of distribution of primary or secondary voltage power lines, including individual services and street-lighting circuits
    - Disruption of traffic on a secondary street
  - Severe—Consequences involve serious potential injury or death, damage to high-value property, or disruption of important activities.

- Injury to a person that may result in hospitalization
- Medium-sized part striking an occupied vehicle
- Large tree part striking an occupied house
- Serious disruption of high-voltage distribution and transmission power line
- Disruption of arterial traffic or motorways

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

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

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

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

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

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

Determination of acceptable risk ultimately lies with town managers. Since there are inherent risks associated with trees, the location of a tree is an important factor in the determination and acceptability of risk for any given tree. The level of risk associated with a tree increases as the frequency of human occupation increases in the vicinity of the tree. For example, a tree located next to a heavily traveled street will have a higher level of risk than a similar tree in an open field.

Priority Maintenance

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

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

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

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

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.