



April 2021

STANDARD INVENTORY ANALYSIS AND MANAGEMENT PLAN

Town of Andover, Massachusetts

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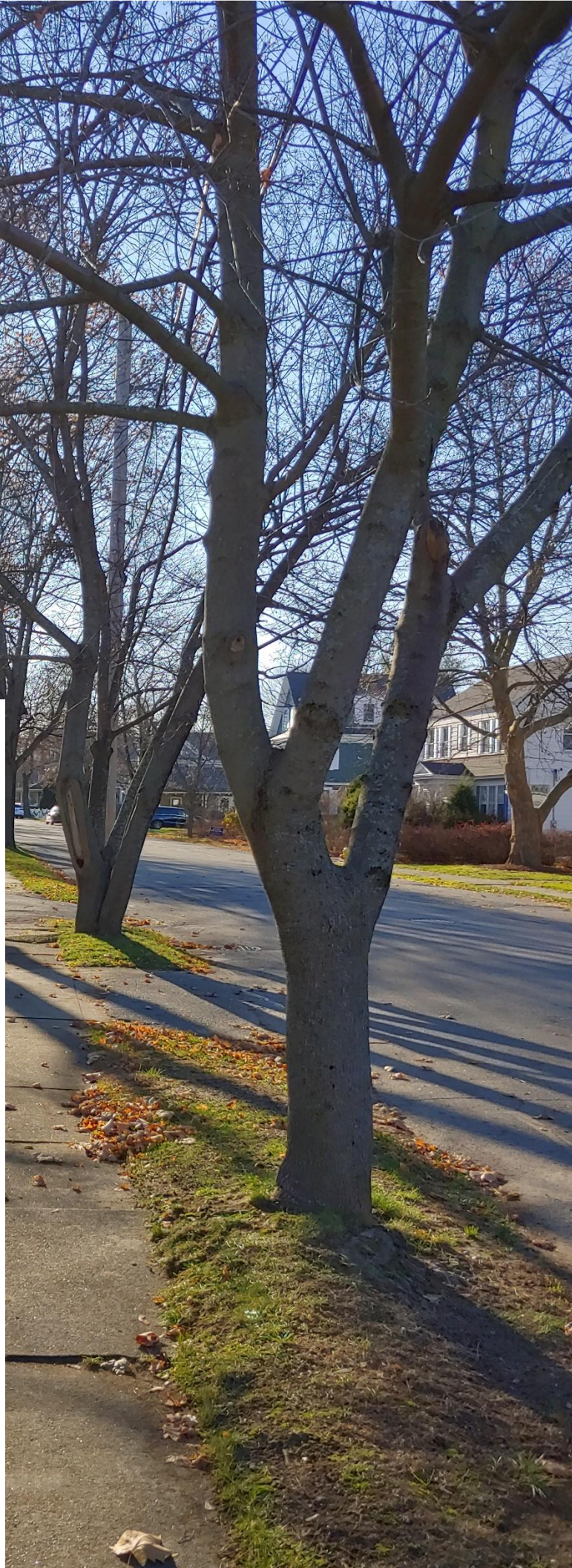


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ACKNOWLEDGMENTS

This project supports the Town of Andover’s vision to promote and enhance community well-being through public tree conservation and improved urban forestry management practices. This *Standard Inventory Analysis and Management Plan* offers expertise in preserving and expanding urban canopy so the environmental, economic, and social benefits it provides continue for generations.

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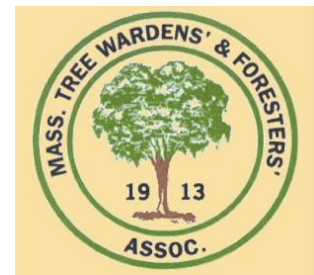
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MASSACHUSETTS DEPARTMENT OF
CONSERVATION AND RECREATION

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

Ten-Year Tree Resource Maintenance Schedule

EXECUTIVE SUMMARY

The Town of Andover *Standard Inventory Analysis and 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 Andover between November 2020 and March 2021 and analyzed the inventory data to understand the structure of the town’s inventoried tree resource, estimated the economic values of the various environmental benefits provided by this public tree resource using i-Tree Eco, and recommended a prioritized management program for future tree care.

The inventory included over 16,000 trees, stumps, and sites suitable for new tree planting, and 86% of the inventoried trees were rated in fair or better condition. However, the overabundance of maple in the inventory presents a concern for the town in the event of an outbreak of disease or insects which target maple trees. The town is heavily forested, providing incredible recreation opportunities as well as financial benefits to residents. The functions of Andover’s inventoried tree population provide benefits with an estimated total value of \$29,318 annually. The town’s annual tree maintenance budget is \$398,292, making Andover’s return on investment more than 7% annually. The functions of Andover’s inventoried tree population throughout its trees’ lifetimes are worth an estimated \$26,203,879. Supporting and funding proactive maintenance of the public tree resource is a sound long-term investment that will reduce tree management costs while increasing the benefits provided by trees over time.

High priority tree removal and pruning is costly, accounting for the larger budget in year one of the ten-year tree maintenance schedule, as shown in Figure 1. After high priority work has been completed, budgets are expected to decrease and stabilize as tree management transitions from reactive to proactive maintenance. Although the maintenance program described in this document is ambitious, it can serve as a useful tool to guide decision making and help advocate for increased funding for public tree care.

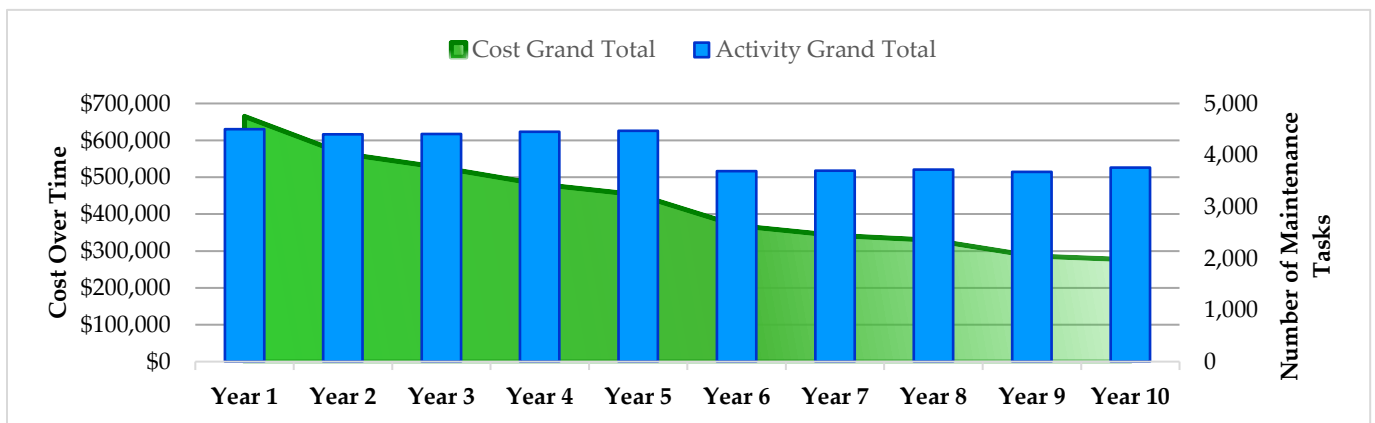


Figure 1. Estimated annual budget and activity totals for each year of the ten-year management program.

Recommended Maintenance Types



Tree Removal

Trees designated for removal have defects that cannot be cost-effectively or practically corrected. Most of the trees in this category have a large percentage of dead crown.

Total = 1,267 trees
High Priority = 0 trees
Moderate Priority = 78 trees
Low Priority = 1,189 trees
Stumps = 897



Priority Pruning

Priority pruning removes defects such as Dead and Dying Parts or Broken and/or Hanging Branches. Pruning the defected branch(es) can lower risk associated with the tree while promoting healthy growth.

Total = 505 trees
High Priority = 0 trees
Moderate Priority = 61 trees
Low Priority = 444 trees



Routine Pruning Cycle

Over time, routine pruning of Low and Moderate Risk trees can minimize reactive maintenance, limit instances of elevated risk, and provide the basis for a robust risk management program.

Total = 6,343 trees
Number in cycle each year = around 634 trees



Young Tree Training Cycle

Younger trees can have branch structures that lead to potential problems as the tree ages, requiring training to ensure healthy growth. Training is completed from the ground with a pole pruner or pruning shear.

Total = 2,168 trees
Number in cycle each year = around 723 trees



Tree Planting

Planting new trees in areas that have poor canopy continuity is important, as is planting trees where there is sparse canopy, to ensure that tree benefits are distributed evenly across the town.

Total recommended plantings = 3,607 trees
Annual planting goal = 50 trees



Routine Tree Inspection

Routine inspections are essential to uncovering potential problems with trees and should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees.

Total = 10,255 existing trees not recommended for removal
Number in assessment cycle each year (5-year schedule) = 2,051 trees

INTRODUCTION

The Town of Andover is home to over 35,000 residents (U.S. Census Bureau estimate, 2019) benefitting from public trees in their community. The town's urban forestry program manages all trees, stumps, and planting sites along the street rights-of-way (ROW) and throughout public parks and grounds. For more than a decade, Andover's staff in the Public Works Department's Divisions of Parks & Grounds and Forestry have shown continued commitment to developing a thriving public tree resource.

Urban forestry program budgets are funded by the town's General Fund. Andover has a tree ordinance, spends more than \$11 per capita on tree maintenance, celebrates Arbor Day, and has been a Tree City USA community for 21 years.

Past urban forestry projects have demonstrated Andover's dedication and commitment to sustaining the public tree resource with higher levels of tree care, and the town will soon be able to set goals and perform proactive maintenance using this *Standard Inventory Analysis and Management Plan*. The town's urban forestry program is well on its way to creating a sustainable and resilient public tree resource, and it is important to stay on track by consistently renewing program funding and routinely updating the tree inventory.

RECOMMENDED 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.

From November 2020 through March 2021, the Town of Andover 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 town's public tree resource.

- *Section 1: Structure and Composition of the Public Tree Resource* summarizes the inventory data with trends representing the current state of the tree resource.
- *Section 2: Functions and Benefits of the Public Tree Resource* summarizes the estimated value of benefits provided to the community by public trees' various functions.
- *Section 3: Recommended Management of the Public Tree Resource* details a prioritized management program and provides an estimated budget for recommended maintenance activities over a ten-year period.

Section 1:

Structure and Composition

of the Public Tree Resource



SECTION 1: STRUCTURE AND COMPOSITION OF THE PUBLIC TREE RESOURCE

Between November 2020 and March 2021, a DRG arborist collected site data on trees, stumps, and planting sites (also termed “vacant sites”) along the street ROW and on trees in public parks and grounds for a tree inventory contracted by the Town of Andover. Of the total 16,026 sites inventoried, 72% were trees, 22% were planting sites, and 6% were stumps. Figure 2 breaks down the total sites inventoried by type. See Appendix A for details about DRG’s methodology for collecting site data.

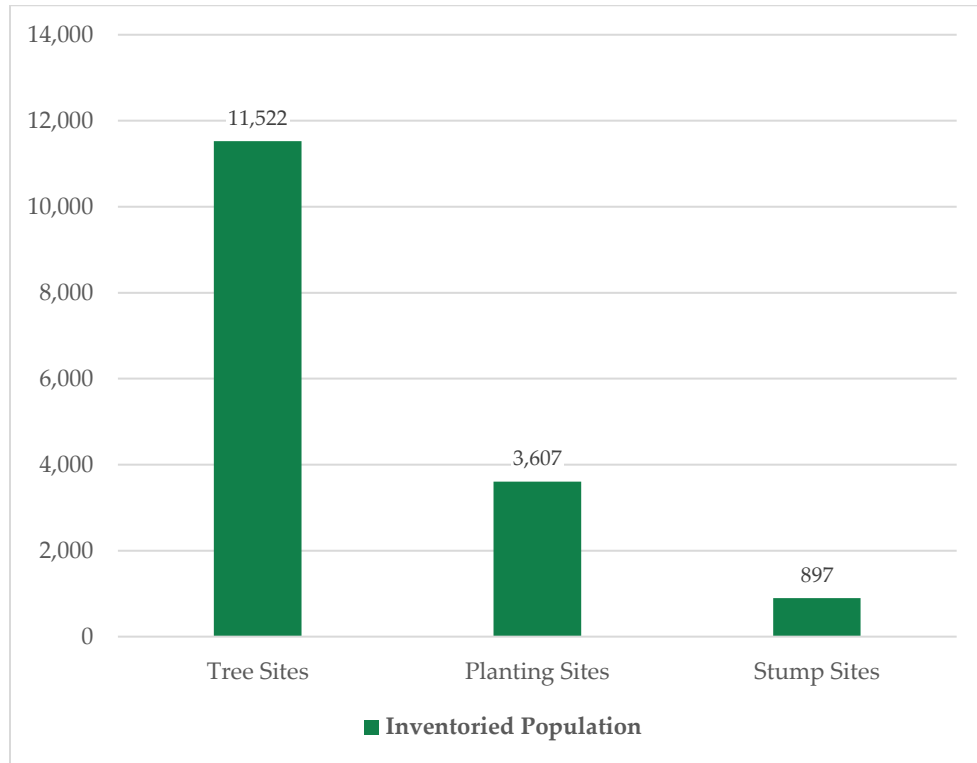


Figure 2. Number of inventoried sites by type.

The Town of Andover designated densely populated areas and primary roadways throughout the town as the project areas. In addition to these ROW, 33 public facilities and 23 publicly owned lots were inventoried (see Appendix B for a full list of these facilities, lots, and their locations).

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% (Santamour 1990). This rule was developed partially in response to tragedies such as the demise of vast swaths of American elm (*Ulmus americana*) after the introduction of Dutch elm disease to the United States (see side panel, “Resilience Through Diversity”). It provides a valuable guideline to help protect urban forests from both pests and diseases, as well as from the effects of extreme weather events and climate change.

Figure 3 shows Andover’s distribution of the most abundant tree species inventoried compared to the 10% rule. Two species, Norway maple (*Acer platanoides*, 16%) and eastern white pine (*Pinus strobus*, 11%), exceed the ideal 10% threshold. Red maple (*Acer rubrum*, 9%) and black oak (*Quercus velutina*, 9%) are also nearing the threshold.

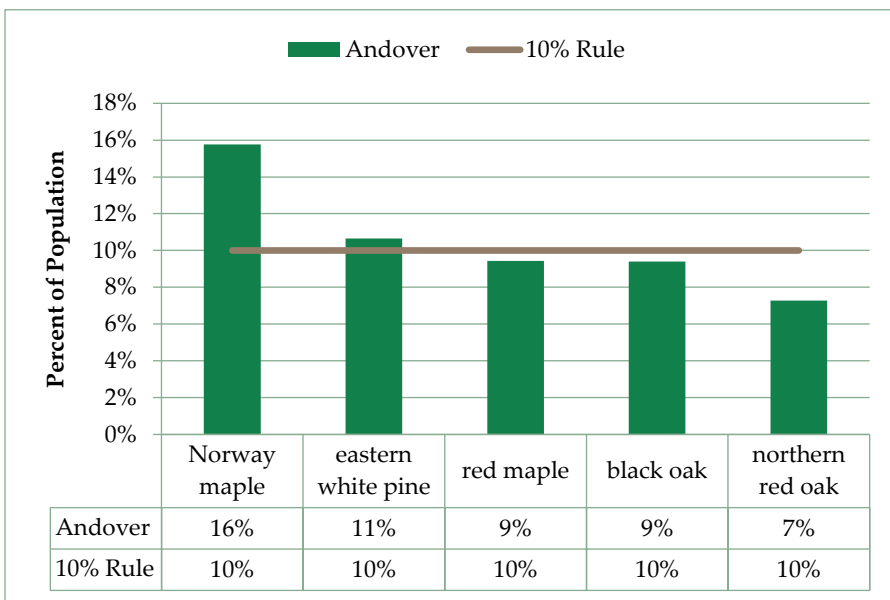


Figure 3. Species distribution of inventoried trees.

RESILIENCE THROUGH DIVERSITY

The Dutch elm disease epidemic of the 1930s provides a key historical lesson on the importance of diversity (Karnosky 1979). The disease killed millions of American elm trees, leaving behind enormous gaps in the urban canopy of many Midwestern and Northeastern 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 is vital that we learn from history and plant a wider variety of tree genera to develop a resistant and resilient public tree resource.



Ash trees in an urban forest killed by emerald ash borer.

USDA Forest Service (2017)

Figure 4 shows the town's distribution of the most abundant tree genera inventoried. Both maple (*Acer* spp.) and oak (*Quercus* spp.) exceed the ideal 20% threshold.

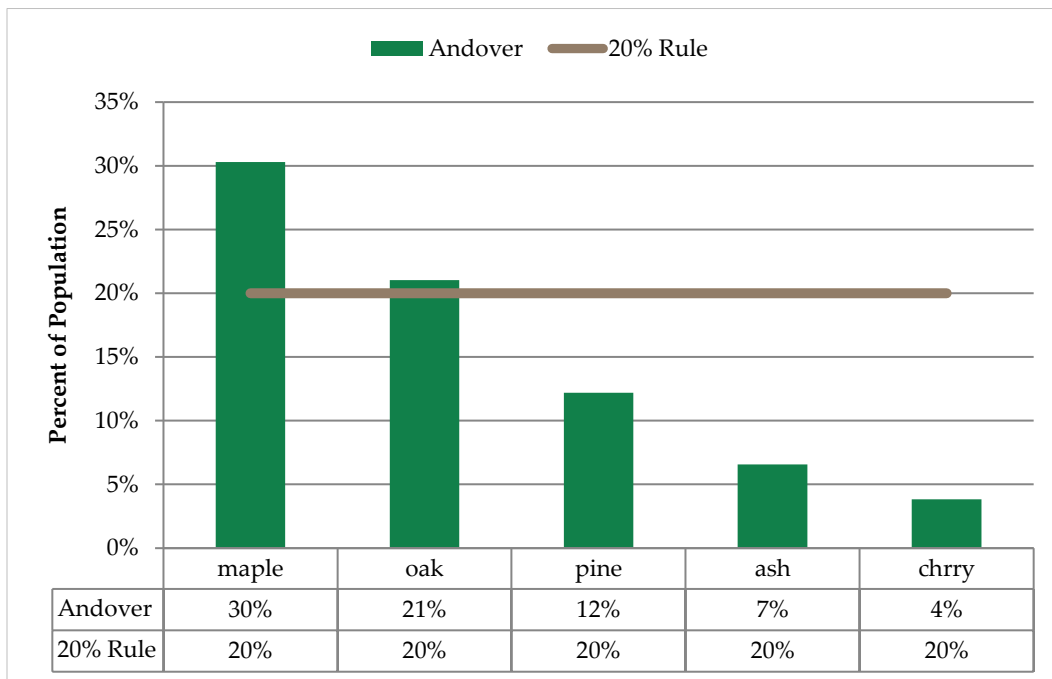


Figure 4. Genus distribution of inventoried trees.

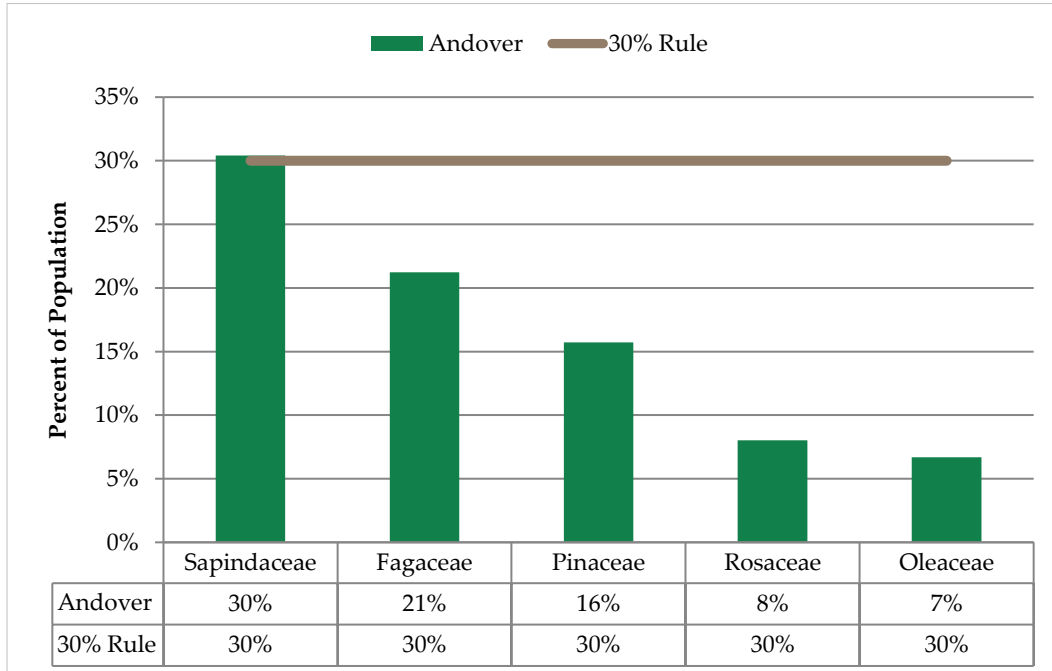


Figure 5. Family distribution of inventoried trees.

Figure 5 shows the town's distribution of the most abundant tree families inventoried compared to the 30% threshold. Sapindaceae, the family to which maple (*Acer* spp.) as well as horsechestnut and buckeye (*Aesculus* spp.) belong, has met the 30% threshold.

The species, genus, and family distribution of an urban tree population can be an important metric for gauging the ability of the urban forest to both resist disruption by pests, diseases, extreme weather, and climate change, as well as the forest’s resilience, or ability to recover from these disruptions (Ordóñez & Duinker 2014). For example, certain pests, like emerald ash borer (EAB, *Agrilus planipennis*), target a single genus (ash, *Fraxinus* spp.) as their host, and different species of tree have varying susceptibility to extreme weather events (Hauer et al. 2006, Duryea & Kampf 2007), which will become more common as the climate changes. Some pests also target a single family as their host, such as the bacterium *Erwinia amylovora*, commonly known as fireblight. Fireblight only affects plants in the rose family (*Rosaceae*), such as serviceberry, hawthorn, apple/crabapple, hawthorn, cherry/plum, and pear. An urban forest with low species, genera, or family diversity is more likely to be damaged by pest, disease, weather, and climate disruptions due to large populations of susceptible trees. It is also likely to be less resilient, or less capable of recovering from such disturbances, since large portions of the urban forest may be eliminated or damaged by said disturbances. Cultivating diversity on the species, genus, and family levels can help mitigate the effects of disturbances and ensure a thriving urban forest for generations to come.

PEST SUSCEPTIBILITY

Early diagnosis of disease and pest infestation is essential to ensuring the health and continuity of Andover’s public tree resource, particularly in the case of exotic pests and diseases. While most native threats to trees tend to not do lasting damage, introduced diseases and insects have the potential to seriously damage urban tree populations in the absence of natural predators and defenses.

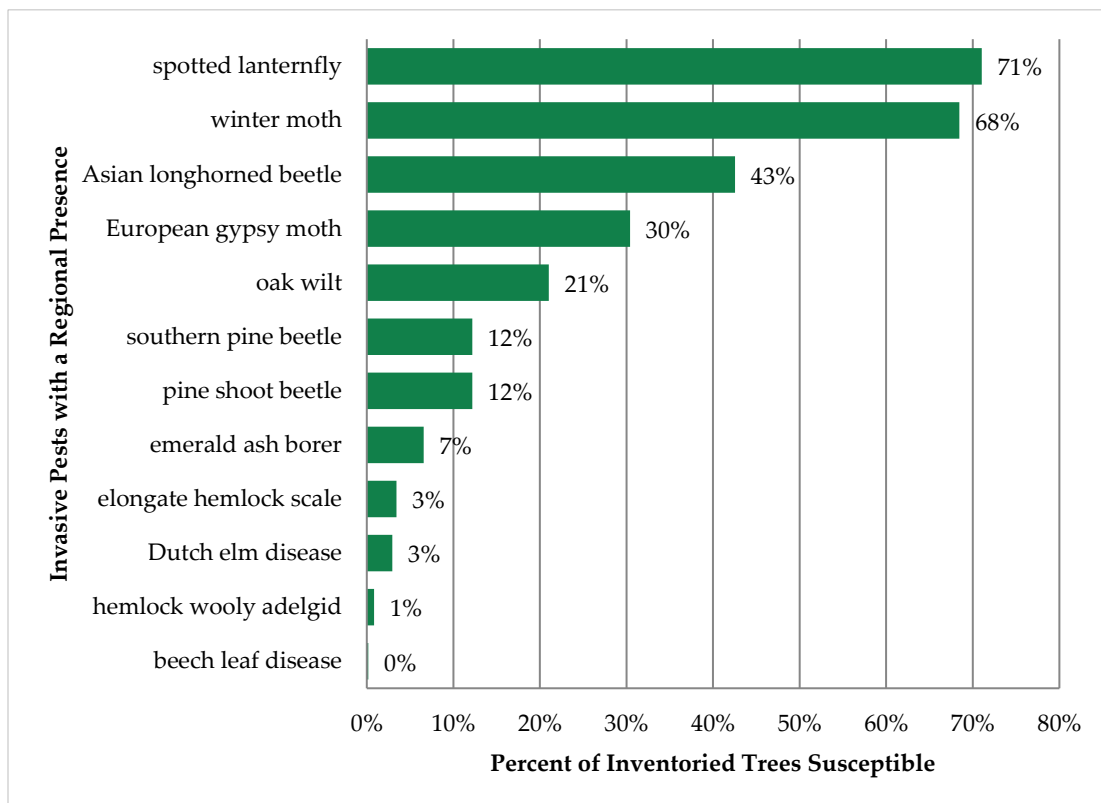


Figure 6. Tree resource susceptibility to invasive pests that have a regional presence.

Figure 6 shows the percent of inventoried trees susceptible to some of the known pests and diseases in and around Massachusetts. The introduced pests spotted lanternfly (SLF, *Lycroma delicatula*) and winter moth (*Operophtera brumata*) have the potential to affect the largest portion of the inventoried trees (71% and 68%, respectively). The ability of these two insect pests to subsist on a wide range of host species makes them potentially devastating invasive pests. While live SLF have not yet been found in Massachusetts, winter moth outbreaks have been observed on Cape Cod and along the coast of the state, and the insect has been found as far west as Athol (Elkinton et al. 2014, 2015). Since these pests, as well as Asian longhorned beetle (ALB, *Anaplophora glabripennis*) and European gypsy moth (EGM, *Lymantria dispar*), threats to 43% and 30% of Andover's inventoried tree population, respectively, can host on wide ranges of tree species, encouraging species, genera, and family diversity in the urban forest is unlikely to prevent the establishment of these pests. Instead, routine inspection of town trees for signs and symptoms of these and other pests and diseases should be conducted to catch and control infestations early before pests and diseases can become well established within the urban forest. It is also important to remember that Figure 6 only represents data collected during the inventory. Many more trees throughout Andover, including those on private property, may be susceptible to hosting these and other invasive pests. See Appendix C for information about the pests mentioned in Figure 6 and websites where additional information on the pests or diseases of most concern in Massachusetts can be found.

Pest Susceptibility Recommendations

Since overabundance of individual tree species and entire tree genera can reduce an urban forest's resistance and resilience to disruptions caused by insect pests, diseases, extreme weather events, and climate change (Safford et al. 2013), the Town of Andover may want to reduce or avoid new plantings of maple and oak, as well as white pine, until species and genera distribution across the town conform more closely to the 10% and 20% rules, respectively. Since the Sapindaceae family tree population in Andover is comprised almost entirely of maple (>99%), reducing new plantings of maple will also decrease the prevalence of the Sapindaceae family within the town. However, large portions of the inventoried trees within Andover were not intentional plantings and were often located in unmaintained, forested areas. It is unlikely that, given Andover's tree planting plans and large quantity of open, forested space, any action by the town will significantly change the species, genera, or family distributions within the urban forest. As such, the town may want to instead invest in increased monitoring for insect pests and diseases that could prove detrimental to the town's trees and begin planning for increased frequency of storm- and climate-related damage.

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 the arborist as either Good, Fair, Poor, Critical, or Dead. The definition of each of these condition ratings can be found in the glossary. The general health of the inventoried tree population was characterized by the most prevalent condition assigned during the inventory.

Figure 7 shows that most of the inventoried trees were recorded in Good or Fair condition, 33% and 53% of the inventoried trees, respectively. The general health of the inventoried tree population is rated as Fair. Andover had a fairly low percentage of trees in Poor, Critical, or Dead condition.

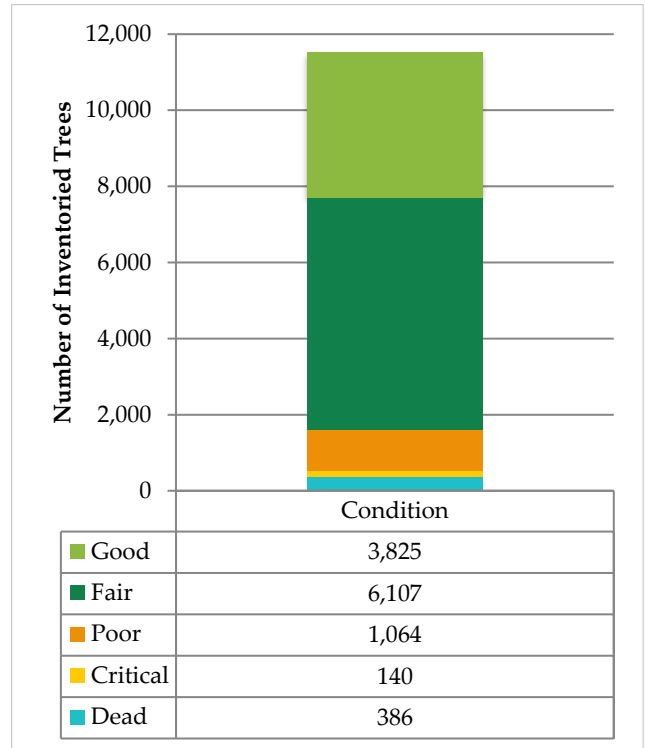


Figure 7. Condition of inventoried trees.

Condition Recommendations

Dead trees, critical trees, and most 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, and these trees may present an elevated risk to people or property. 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 worsening conditions. Trees in Fair condition may benefit from pruning to remove dead or defective limbs. These trees may return to Good condition with time and care.

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. Size is used as a proxy for age in this case because of the difficulty of accurately and rapidly measuring tree age in the field. 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 which can offer insight into the maintenance needs of Andover's tree resource. The inventoried trees were grouped into the following relative age classes:

- Young trees (0–8 inches diameter at breast height (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). This distribution helps ensure that there are sufficient young trees in a population to replace mature trees as they die back and are removed.

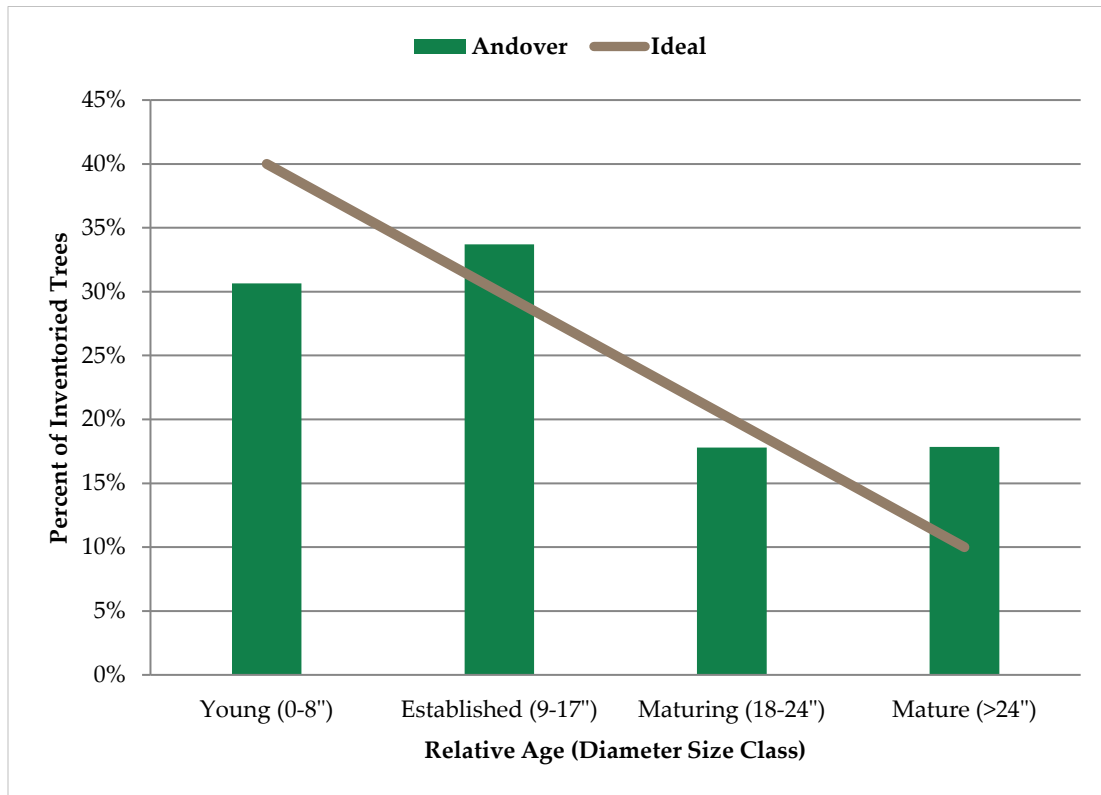


Figure 8. Relative age distribution of inventoried trees.

Figure 8 compares the relative age distribution of Andover’s inventoried tree population to the ideal. The town’s inventoried tree resource trends toward the ideal overall, with generally more young and established trees than mature and maturing trees. However, young trees are underrepresented in the inventory, with only 31% of the inventoried population falling in the smallest size category, much lower than the ideal 40%. Mature trees, on the other hand, are overrepresented in the inventoried population, comprising some 18% of the inventoried population as opposed to the ideal 10%. It is important to note that this skewed distribution may be an artifact of the data collection methods. In order to capture only the trees most likely to be maintained by the town, trees less than 10 inches DBH were not collected in unmaintained areas. Since Andover has large swaths of conservation land, many of the areas included in this inventory were unmaintained, likely leading to an underrepresentation of the number of young trees within the town.

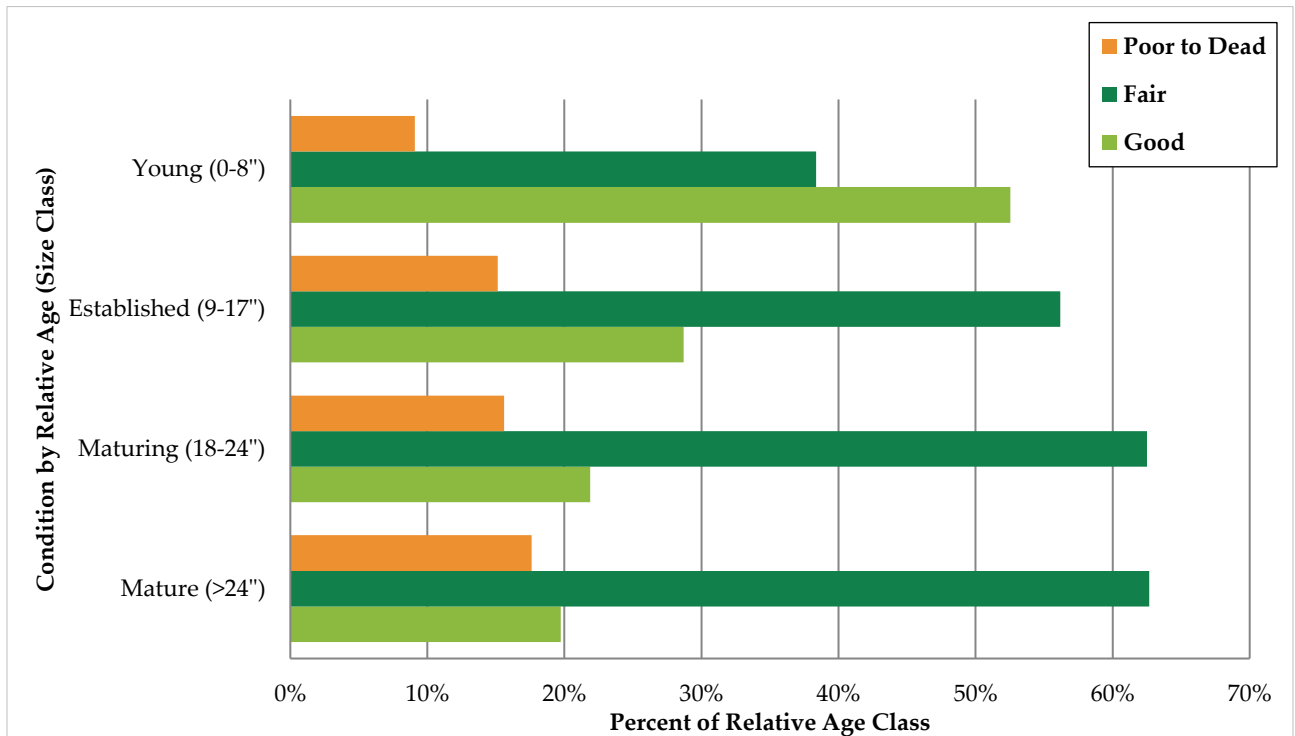


Figure 9. Condition of inventoried trees by relative age class.

Figure 9 cross analyzes the condition of the inventoried tree resource with its relative age distribution, providing insight into the inventoried population’s stability. Should one relative age class have a disproportionate number of trees in poor or worse condition, it could indicate an unstable age distribution that could change rapidly in the event of a forest disturbance or even as tree removals are undertaken to remove damaged and diseased specimens. Most of the inventoried trees in all age groups were in Fair or better condition (91% Young, 85% Established, 85% Maturing, 83% Mature), indicating that the age distribution of the inventoried population is likely to be relatively stable over time. Mature trees had the largest percentage of individuals in Poor condition or worse (18%), which is to be expected, as large trees nearing the end of their lifespan are included in this category. Young trees, on the other hand, had the highest percentage of trees in Good condition (53%). This is also to be expected, as recently established and recently planted trees have had less time to accrue damage or contract disease or pest infestations.

Relative Age Recommendations

While Andover may have a deficit of young trees and an excess of mature trees, the town has an overall low percentage of trees in Poor or worse condition, indicating that young trees have the potential of reaching maturity if they are well maintained. DRG recommends that Andover implement a robust young tree training program to conserve and improve the condition of young trees as they age so they may replace removed trees and fill canopy gaps in maturity. The town should also focus on tree preservation and proactive care, when possible, to protect mature and maturing trees from unnecessary removal and to prevent them from succumbing to treatable defects.

DEFECT OBSERVATIONS

A defect observation was only collected for trees which were either at an elevated risk level due to the defect in question or which required further inspection. As a result, only 8% of the inventoried trees had a defect recorded during the 2020–21 inventory, although any tree with a condition rating other than Good likely has at least a minor defect. Dead trees also did not have any defect recorded, since it can be assumed that these trees are hazardous due to dead parts or decayed wood. Recorded 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,
- and Other (pests & diseases).

Table 1. Tree defect categories recorded during the inventory.

Defects	Number of Trees	Percent
Missing or Decayed Wood	506	4%
Dead and Dying Parts	169	1%
Other (Pests & Diseases)	81	1%
Root Problems	47	0%
Broken and/or Hanging Branches	45	0%
Weakly Attached Branches and Codominant Stems	23	0%
Cracks	15	0%
Tree Architecture	3	0%
None	10,633	92%
Total	11,522	100%

The most frequently recorded defect was missing or decayed wood (4% of inventoried trees), followed by dead and dying parts (1%) and other (1%). Due to the methodological restrictions on the collection of defect data, this indicates that these three defects are the most likely to result in an elevated level of risk associated with trees with these defects. Of the trees recorded with a defect, nearly half (46%) were recommended for removal, and a further 39% were recommended for further inspection.

Trees recommended for further inspection fell into one of three categories: 1) those which need a Level 3 inspection, usually due to defects located in areas inaccessible or not visible during a Level 2 assessment, 2) those which need ongoing insect or disease monitoring to confirm whether a pest or disease is present and to assess the severity of the infestation or infection, or 3) those which need ongoing annual or semi-annual monitoring to assess whether a potential hazardous defect is improving or degrading over time.

Defect Observation Recommendations

Trees recorded with a defect and recommended for removal should be removed as soon as possible to eliminate the risk associated with a tree with defective parts, or, in the case of trees with pests or diseases present, to reduce the chances of further spread of the pests or diseases. Trees recorded with a defect and recommended for further inspection should be assessed by qualified personnel equipped with suitable tools and knowledge to determine the next steps needed to mitigate risk or salvage the tree. Trees recorded with a defect but not recommended for further monitoring or removal should be inspected as part of a routine assessment program designed to identify potentially hazardous trees and emerging disease or pest outbreaks. It is important to remember that most trees which were not considered to have a recordable defect by the data collection protocols used in this inventory may still have minor defects that could worsen over time if not corrected. Routine assessments by qualified arborists or other qualified town personnel can aid in identifying potentially hazardous tree defects before they become significant dangers to people or property.

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, planting site, or stump was noted. It is important to consider these data when planning pruning activities and selecting tree species for planting. For the purposes of this inventory, all overhead utilities, including primary and secondary electric distribution lines, telecommunication lines, and service drops, were considered when determining whether a site had overhead utilities present.

Table 2. Tree conflicts with overhead utilities recorded during the inventory.

Infrastructure	Presence	Number of Sites	Percent
Overhead Utilities	Present	7,341	46%
	Not Present	8,685	54%
Total		16,026	100%

Table 2 shows the total number of sites, including trees, stumps, and planting sites recorded with overhead utilities present. 46% of the sites collected during the inventory had overhead utilities present. Of those, 7% were stumps, 29% were vacant sites, and the remaining 63% were trees.

Infrastructure Recommendations

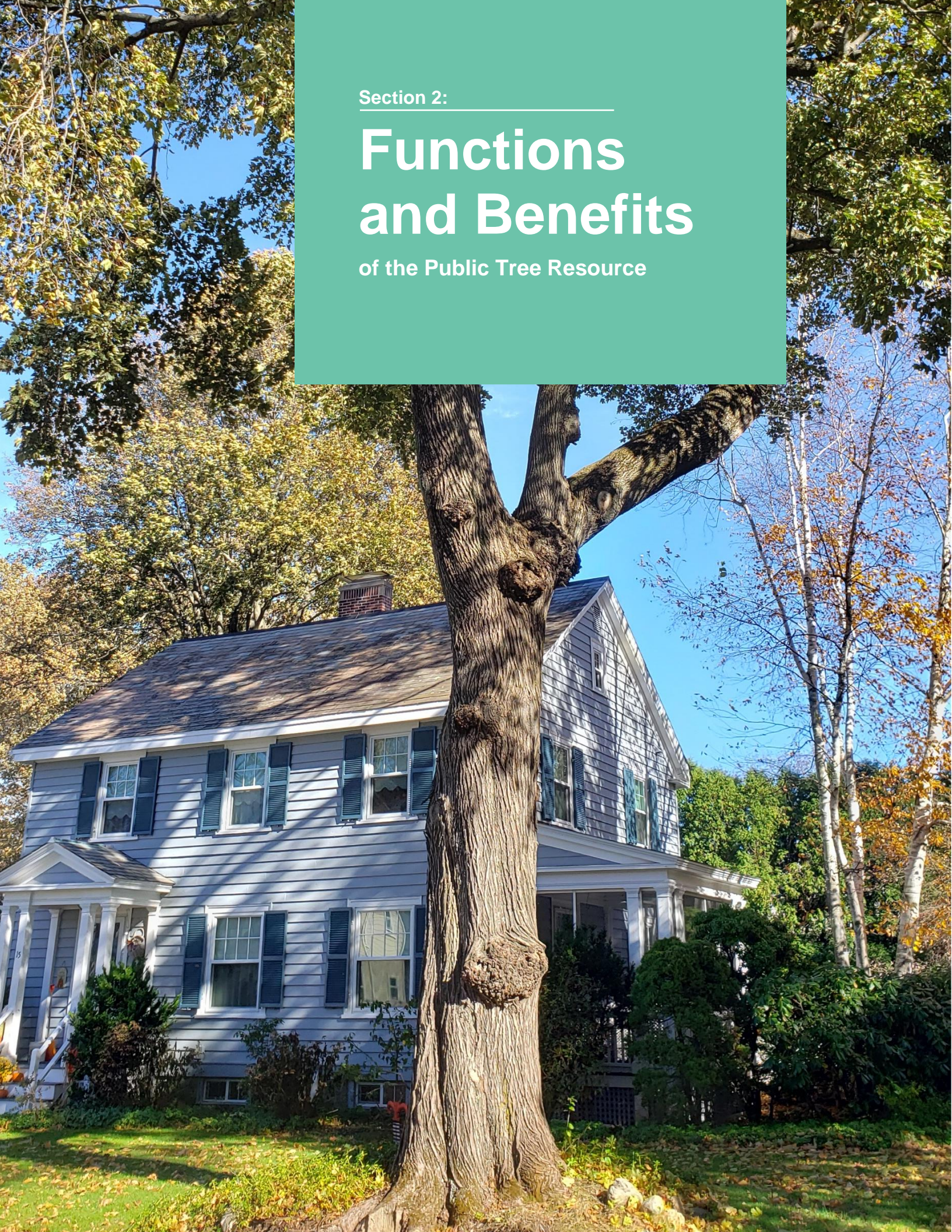
Data about the presence of overhead utilities should be used to determine whether specialized workers or equipment are needed to perform tree maintenance. Data about the presence of overhead utilities above stumps and vacant sites should be used to determine appropriate tree species for future plantings. 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.

Although conflicts with hardscape were not recorded during the 2020–21 Andover tree inventory, 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.

Section 2:

Functions and Benefits

of the Public Tree Resource



SECTION 2: FUNCTIONS AND BENEFITS OF THE PUBLIC TREE RESOURCE

Trees occupy a vital role in the urban environment by providing of a wide array of economic, environmental, and social benefits which far exceed the investments made in planting, maintaining, and removing them. Trees reduce air pollution, improve public health outcomes, reduce stormwater runoff, sequester and store carbon, reduce energy use, and increase property value. Using advanced analytics such as i-Tree Eco and other models in the i-Tree software suite to provide monetary estimates of these services can help improve public understanding of the importance of trees to a community.

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 2003).
- 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 et al. (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 (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 et al. 1991).

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, as 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.

ANNUAL RETURN ON INVESTMENT FROM THE PUBLIC TREE RESOURCE

The i-Tree Eco analysis of the Town of Andover's inventoried trees quantified the functional benefits of three critical ecosystem services that they provide: air pollution removal, carbon sequestration, and avoided surface runoff. The town's annual tree maintenance budget is around \$398,292, making Andover's return on investment more than 7% annually.

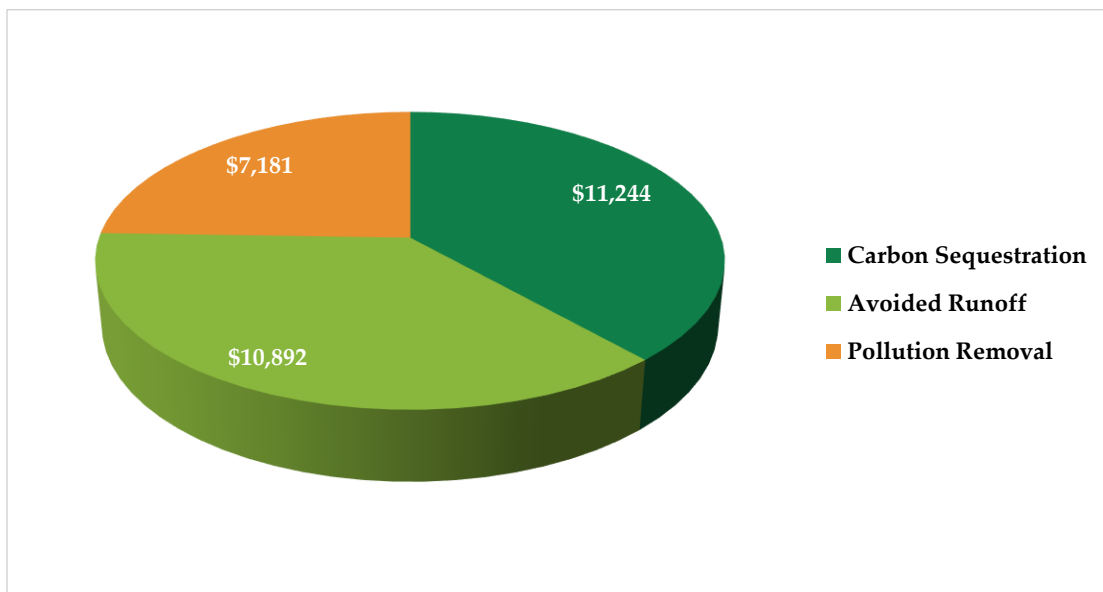


Figure 10. Estimated value of the annual benefits provided by inventoried trees.

Urban environments have unique challenges that make the estimated annual \$29,318 of functional benefits provided by Andover's inventoried tree population an essential asset to the town (Figure 10). Compared to rural landscapes, urban landscapes are characterized by high pollutant emissions in a relatively small area, causing the value of the 4,760 lbs. of airborne pollutants removed by Andover's inventoried tree resource annually to be estimated at \$7,181. Avoiding stormwater runoff reduces the risk of flooding and combined sewer overflow, both of which impact people, property, and the environment, valuing the 1,218,837 gals. of runoff avoided by Andover's tree resource at an estimated \$10,892 per year. Carbon dioxide (CO₂) also impacts people, property, and the environment as the primary greenhouse gas driving climate change, valuing the 131,800 lbs. of CO₂ sequestered by Andover's inventoried tree resource annually at an estimated \$11,244.

The replacement value of the town's inventoried tree population is estimated to be \$24,541,597. In Andover, five species account for more than half of the inventoried public tree resource and around 60% of the functional benefits it provides. If any of these species were lost to invasive pests, disease, or other threats, its loss would have significant costs. It is critical to routinely inspect Andover's public trees for signs of emergent disease, insect, or other problems and take steps to prevent wide-spread loss of valuable tree species. Planting large-statured broadleaf tree species wherever possible will help to maximize potential environmental and economic benefits. See Appendix D for a tree species planting list recommended by DRG.

SEQUESTERING AND STORING CARBON

Trees are carbon sinks - the opposite of carbon sources. While carbon is emitted from cars and smokestacks, it is absorbed into trees during photosynthesis and stored in their tissue as they grow. The i-Tree Eco model estimates both the carbon sequestered each year and total carbon stored by the inventoried tree resource. Andover's inventoried trees have stored an estimated 19,493,040 lbs. of carbon valued at \$1,662,281. The single weeping willow (*Salix babylonica*) collected in the inventory stores and sequesters the most carbon individually (16,540 lbs. total stored carbon and 40 lbs. carbon sequestered per year), likely due to its large DBH (44 inches). Among species with larger inventoried populations, silver maple (*Acer saccharinum*) and horsechestnut (*Aesculus hippocastanum*) stored the most carbon on average; 6,750 lbs. per tree and 5,353 lbs. per tree, respectively. Cottonwood (*Populus deltoides*) and honeylocust (*Gleditsia triacanthos*) sequester the most carbon annually; 40 lbs. per year per tree. However, much like the single weeping willow in the inventory, the populations of these species were not large and may not accurately reflect the carbon sequestration potential of the species. The species which were more numerous and have the highest annual carbon sequestration rates were American sycamore (*Populus occidentalis*) and silver maple (*Acer saccharinum*) which sequester around 35 lbs. of carbon per tree per year. Table 3 provides a summary of the benefits provided by the most common species in the 2020–21 Andover tree inventory.

Table 3. Summary of benefits provided by inventoried trees ranked by species prevalence.

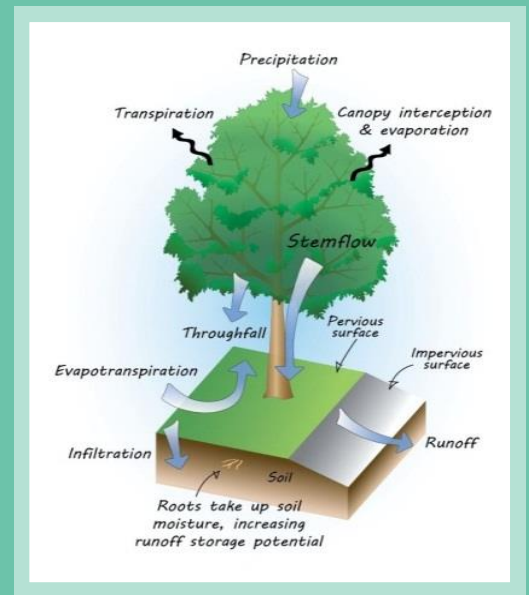
Most Common Trees Collected During Inventory		Number of Trees	Percent of Total Trees	Avoided Runoff	CO ₂ Sequestered	CO ₂ Stored	Air Pollution Removed
Common Name	Botanical Name						
Norway maple	<i>Acer platanoides</i>	1,741	15.6%	214,451.7	18,660	2,781,300	860
eastern white pine	<i>Pinus strobus</i>	1,184	10.6%	129,552.3	15,340	1,048,880	520
red maple	<i>Acer rubrum</i>	1,058	9.5%	124,821.3	10,840	1,541,120	500
black oak	<i>Quercus velutina</i>	1,025	9.2%	143,162.7	21,140	4,481,180	580
northern red oak	<i>Quercus rubra</i>	782	7.0%	131,456.4	12,540	2,732,180	520
white ash	<i>Fraxinus americana</i>	631	5.7%	56,498.2	9,260	1,165,480	220
sugar maple	<i>Acer saccharum</i>	470	4.2%	49,589.7	5,900	854,620	200
white oak	<i>Quercus alba</i>	349	3.1%	80,571.5	6,040	1,447,760	320
American elm	<i>Ulmus americana</i>	326	2.9%	17,180.9	3,360	202,160	60
black cherry	<i>Prunus serotina</i>	259	2.3%	8,084.2	3,240	186,440	40
crabapple	<i>Malus spp.</i>	256	2.3%	3,926.3	1,900	94,640	20
Callery pear	<i>Pyrus calleryana</i>	196	1.8%	7,906.1	2,360	120,340	40
northern white cedar	<i>Thuja occidentalis</i>	190	1.7%	770.3	420	25,080	0
cherry	<i>Prunus spp.</i>	161	1.4%	4,947.7	220	101,280	20
pignut hickory	<i>Carya glabra</i>	139	1.2%	23,406.0	700	175,760	100
littleleaf linden	<i>Tilia cordata</i>	136	1.2%	22,105.7	3,140	286,940	80
blue spruce	<i>Picea pungens</i>	130	1.2%	4,300.6	620	51,940	20
pitch pine	<i>Pinus rigida</i>	124	1.1%	8,935.9	1,400	79,980	40
green ash	<i>Fraxinus pennsylvanica</i>	100	0.9%	15,806.7	1,360	109,020	60
other trees	65 genera and ~111 species	1,880	16.9%	171,362.6	13,360	2,006,940	560
Total	66 genera and ~130 species	11,137	100%	1,218,836.5	131,800	19,493,040	4,760

CONTROLLING STORMWATER

Trees intercept rainfall with their leaves and branches, helping lower stormwater management costs by avoiding runoff. The inventoried trees in the Town of Andover avoid 1,218,837 gals. of runoff annually. Avoided runoff accounts for 37% of the annual functional benefits provided by Andover's inventoried public tree resource.

Of the species inventoried, American sycamore (*Platanus occidentalis*), silver maple (*Acer saccharinum*), and pin oak (*Quercus palustris*) contributed the most annual stormwater benefits; 601 gals. per tree per year, 432 gals. per tree per year, and 413 gals. per tree per year of runoff avoided, respectively. In contrast, the most abundant species in the inventoried tree population, Norway maple (*A. platanoides*), only avoided 123 gals. of runoff per tree per year. On a per-tree basis, large trees with leafy canopies provided the most functional benefits. Although relatively abundant in the inventory, the population of crabapple (*Malus* spp., 2.3% of the inventoried trees) only prevented a total of 3,926 gals. of runoff annually, compared to the much smaller population of green ash (*Fraxinus pennsylvanica*, 0.9% of the inventoried trees) which prevented 15,807 gals. of runoff annually – nearly four times the amount of runoff avoided by the crabapple population. This disparity illustrates the importance of large-stature, broadleaf trees in providing functional benefits to a community.

CANOPY FUNCTIONS



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

- Catching rainfall in their crown so it drips to the ground with less of an impact or flows down their trunk.
- 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 removes 4,760 lbs. of air pollutants annually, including sulfur dioxide (SO₂), carbon monoxide (CO), nitrogen dioxide (NO₂), ozone (O₃), and particulate matter (PM_{2.5}). The i-Tree Eco model estimated the value of this benefit at \$7,181 annually, which is 24% of the value of all annual benefits. As shown in Figure 11, a very small reduction in PM_{2.5} is more valuable than any of the other pollutants removed. The inventoried trees remove a great deal more O₃ than any other pollutant on an annual basis, resulting in the second highest dollar value of the pollutant removal benefit after PM_{2.5}. The trees that provided the highest annual air quality benefits were American sycamore (*Platanus occidentalis*), pin oak (*Quercus palustris*), and silver maple (*Acer saccharinum*), which removed 2.7 lbs. of pollutants per tree per year, 1.7 lbs. of pollutants per tree per year, and 1.5 lbs. of pollutants per tree per year, respectively.

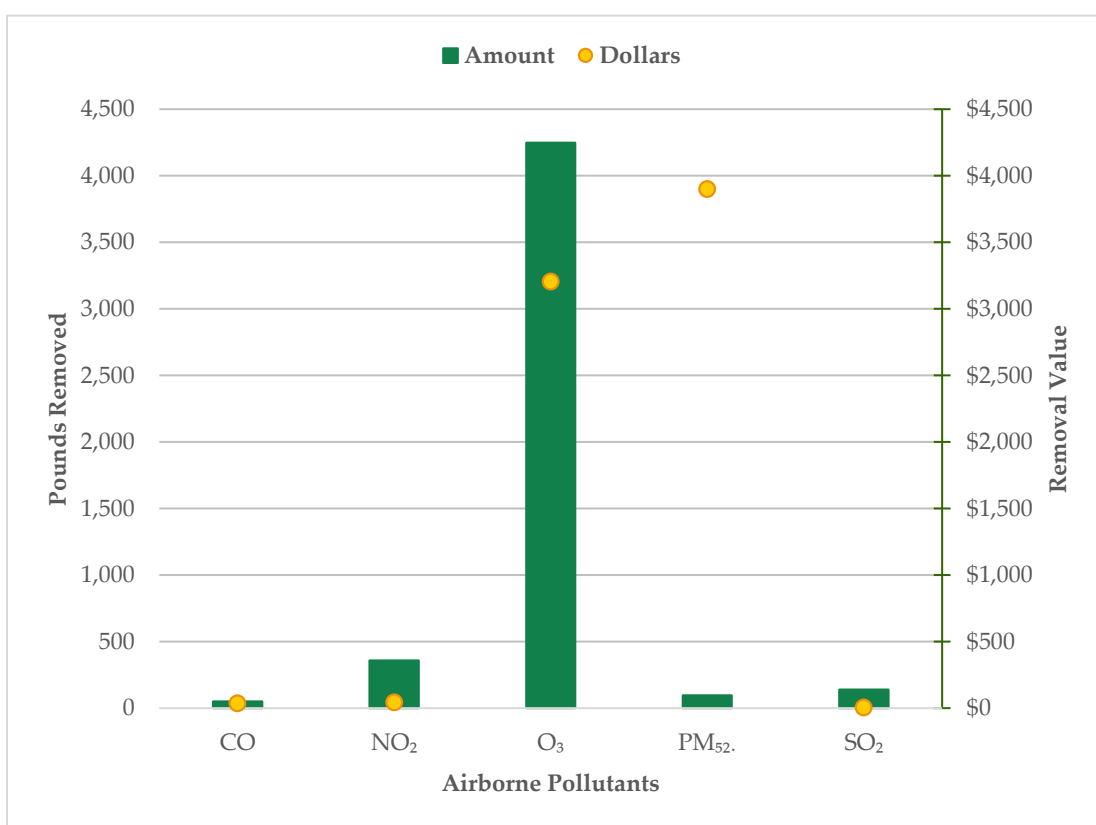


Figure 11. Estimated value of removing airborne pollutants by weight and type.

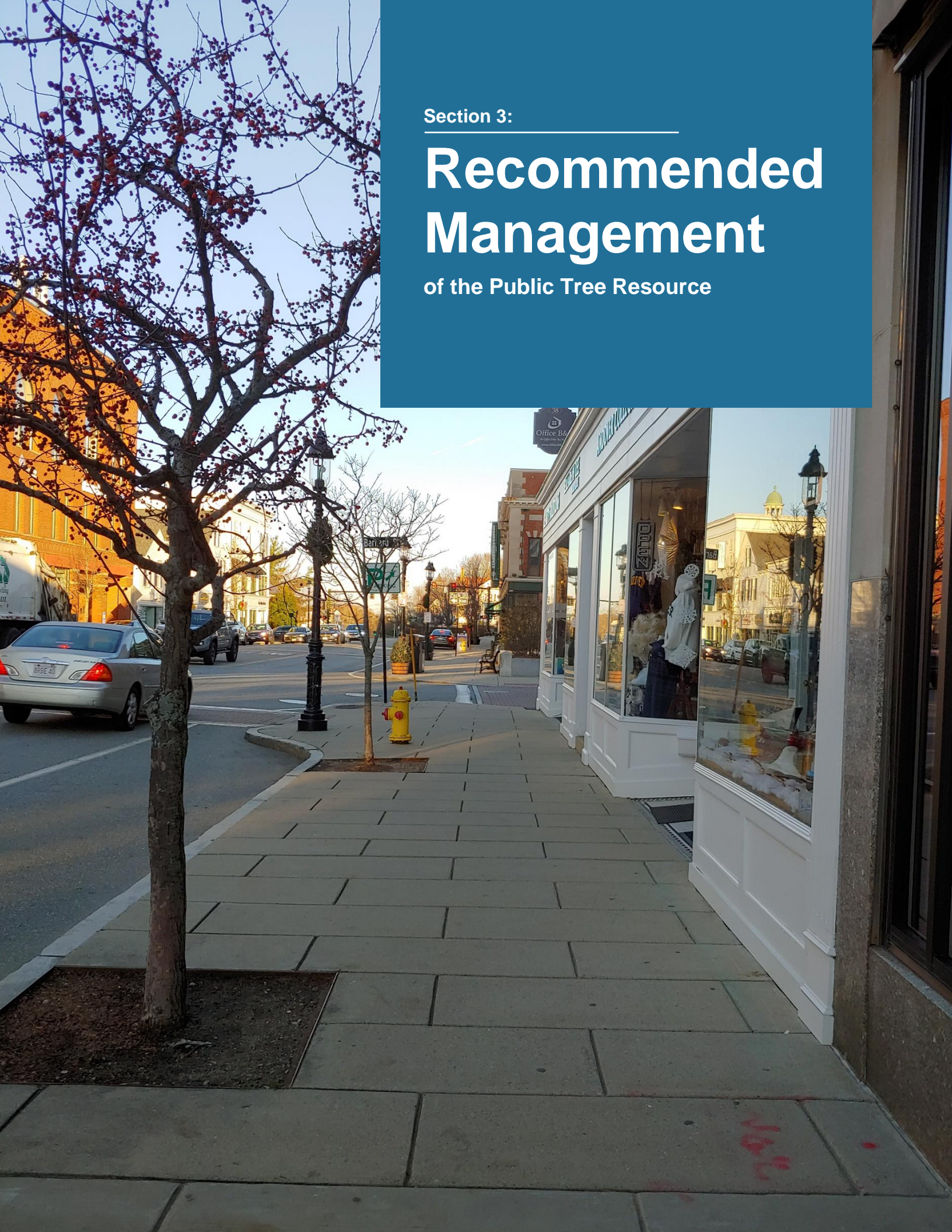
CONCLUSIONS

Overall, large-stature, broadleaf trees provide the most functional benefits to a community. Therefore, planting programs should prioritize planting species with these characteristics whenever and wherever possible to maximize the benefits provided by the urban forest. It is also important to consider that in Andover, only five species, including Norway maple (*Acer platanoides*), eastern white pine (*Pinus strobus*), red maple (*A. rubrum*), black oak (*Quercus velutina*), and northern red oak (*Q. rubra*), account for more than half of the inventoried trees and contribute around 60% of the total functional benefits provided by the inventoried tree population (see Table 3). Should any of these species be lost or severely damaged due to insects, diseases, or climate change, the impact to pollutant removal, carbon storage and sequestration, storm water management, and many other ecosystem services provided by trees could be significant. As such, it is essential that Andover implement a routine inspection program for the town's trees, to catch signs of disease, pests, or other disruption to the urban forest early. Early detection of a pest, disease, or other disturbance allows urban forestry professionals essential time to control pest or disease outbreaks before they become widespread, and reduces costs involved with mitigating significant forest disturbances.

Section 3:

Recommended Management

of the Public Tree Resource



SECTION 3: RECOMMENDED MANAGEMENT OF THE PUBLIC TREE RESOURCE

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. This ten-year tree management program takes a multi-faceted and proactive approach to tree resource management.



RISK MANAGEMENT AND RECOMMENDED MAINTENANCE

Although tree removal is usually considered a last resort and may 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 mitigate risk or when correcting problems would be cost-prohibitive. Trees that cause obstructions or interfere with power lines or other infrastructure should be removed when their defects cannot be corrected through pruning or other maintenance practices. Diseased and nuisance trees also warrant removal. 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.

EXTREME AND HIGH PRIORITY RECOMMENDED MAINTENANCE

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. Figures 12 and 13 present tree pruning and tree removals by risk rating and diameter size class.

Pruning or removing Extreme Risk and High 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 that pose the greatest risk. Once these are addressed, recommended tree maintenance activities should be completed for smaller diameter trees that pose the greatest risk. Addressing Extreme Risk and High Risk trees in a timely and proactive manner often requires significant resources to be secured and allocated. However, performing this work expediently will mitigate risk, improve public safety, and reduce long-term costs.

Extreme and High Priority Pruning Recommendations

Although no Extreme or High Risk trees were identified in Andover during the 2020–21 inventory, any Extreme and High Risk trees found in future surveys and recommended for pruning should be pruned immediately based on assigned risk rating, which generally requires removing defects such as dead and dying parts, broken and/or hanging branches, and missing or decayed wood that may be present in tree crowns, even when most of the tree is sound. In these cases, when pruning the defected branch(es) can correct the problem, risk associated with the tree is reduced while promoting healthy growth.

Extreme and High Priority Removal Recommendations

DRG recommends that trees be removed when pruning will not correct their defects, eliminate the risks that their defects cause, or when corrective pruning would be cost-prohibitive. While no Extreme or High Risk trees were found in the 2020–21 inventory, trees identified as Extreme or High Risk which require removal in the future should be removed immediately. Higher risk rating trees should be prioritized for pruning or removal over lower risk trees, and larger diameter trees should be given higher priority than smaller diameter trees in order to most effectively reduce risk as quickly as possible.

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, while the highest level is intended to provide in-depth information to make management decisions about an individual tree. These levels are:

- **Level 1:** 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:** 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. All trees in the 2020–2021 Andover tree inventory were assessed to this level, provided that 360-degree access around the tree could be gained.
- **Level 3:** 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 865 trees requiring one of three inspection types. Further inspections are beyond the scope of a standard tree inventory, and can be one of the following:

- a. Multi-year/Annual Inspection (e.g., a healthy tree that has been impacted by recent construction, weather, or other damage, or which has a defect that may require further monitoring to determine whether it is a hazard).
- b. Level 3 Risk Assessment (e.g., a tree with a defect requiring additional or specialized equipment for investigation).
- c. Insect/Disease Monitoring (e.g., a tree that appears to have an emerging insect or disease problem).
- d. No further inspection required.

A Level 3 inspection was recommended for trees in which a defect was observed during the inventory which warranted closer inspection by a tree risk assessment qualified (TRAQ) arborist. These trees may need inspection 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 serious defects 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.

Further Inspection Recommendations

The inventory found 77 trees recommended for an advanced Level 3 risk assessment, 225 trees recommended for annual/multi-year inspections, and 563 trees noted for insect and disease monitoring. The trees recommended for a Level 3 risk assessment should be assessed by a TRAQ arborist as soon as possible to determine whether these trees require removal, pruning, or other corrective action to reduce the risk associated with their observed defects. Level 3 assessments may require specialized or additional equipment, such as bucket trucks, to access and assess tree defects. Trees recommended for insect and disease monitoring were primarily ash trees (*Fraxinus* spp.) which showed symptoms of emerald ash borer (*Agrilus planipennis*) and hemlock (*Tsuga* spp.) which showed symptoms or signs of hemlock wooly adelgid (HWA, *Adelges tsugae*) and/or elongate hemlock scale (EHS, *Fiorinia externa*). These trees should be assessed when possible to confirm the presence of damaging insects or diseases and should either be removed or treated, if necessary, to reduce the pest species load in Andover. Trees recommended for multi-year/annual inspection should be assessed routinely to monitor their condition and look for signs of worsening defects that may merit intervention. Some of these trees will likely recover given time and will no longer need additional monitoring, while others may require removal if their defects worsen.

MODERATE AND LOW PRIORITY RECOMMENDED MAINTENANCE

Pruning or removing Moderate and Low Risk trees are generally the next priorities for maintenance activities. For efficiency, Moderate and Low Risk removals may also be addressed when removing adjacent higher risk trees. DRG recommends implementing proactive maintenance programs incrementally over time as the backlog of risk is reduced.

Moderate Risk Pruning Recommendations

Moderate Risk pruning should be performed after all Extreme and High Risk recommended maintenance is complete and may be performed concurrently with other Moderate Risk removals. Since there were no Extreme or High Risk trees identified during the inventory, Moderate Risk pruning and removals should take top priority in Andover to reduce tree-related risk in the community. The inventory identified 61 Moderate Risk trees recommended for pruning. The diameter size classes for these trees ranged between 9 inches DBH and 39 inches DBH. Most of the smaller diameter trees in Andover's inventory with Moderate Risk ratings were located on school grounds, especially around play areas which young children use frequently.

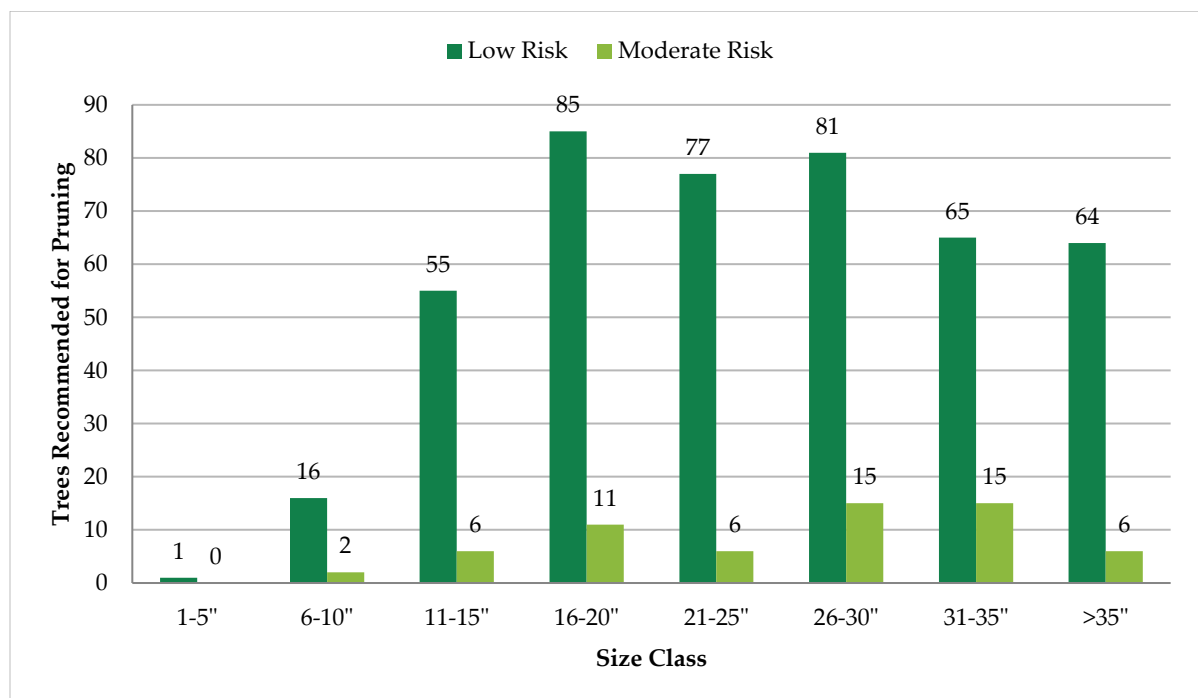


Figure 12. Recommended pruning by size class and risk rating.

Moderate Risk Removal Recommendations

DRG identified 78 Moderate Risk trees recommended for removal. The diameter size classes for these trees ranged from 9 inches DBH to 51 inches DBH. Again, smaller diameter Moderate Risk trees tended to be located on school grounds. These trees should be removed as soon as possible, with removal work generally starting with larger diameter trees and working down through the size classes to finish with smaller diameter trees. This ensures that the trees with the greatest potential to cause damage or injury are removed first, followed by those with less potential to cause severe consequences in the event of failure.

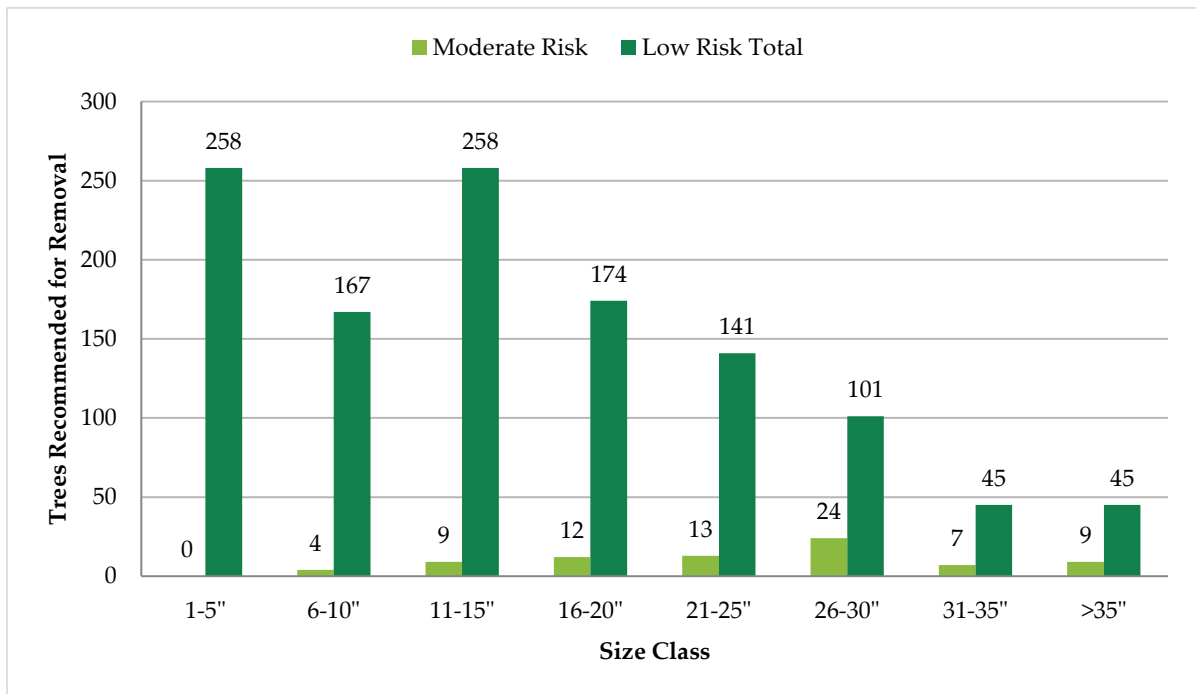


Figure 13. Trees recommended for removal by size class and risk rating.

Low Priority Pruning Recommendations

There were 444 Low Risk trees recommended for pruning. Low Risk trees should be tended to after all Moderate Risk trees have been pruned or removed. During the 2020–21 inventory, trees might be assigned a primary maintenance need of prune or routine prune, the difference being that trees with a maintenance need of “prune” needed more urgent attention than those with the maintenance need of “routine prune”. Low Risk pruning may take place concurrently with routine pruning.

Low Priority Removal Recommendations

DRG identified 1,189 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. If pruning cannot correct a tree’s defects and/or adequately mitigate risk, then the tree should be removed. All Low Risk trees should be removed when convenient after all higher risk pruning and removals have been completed and may be performed concurrently with routine pruning.

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 TRAQ credential.

Routine Inspection 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 trees with unidentified defects, inspections also present an opportunity to look for signs and symptoms of pests and diseases. Andover has a large population of trees that are susceptible to pests and diseases, including ash (*Fraxinus* spp.), maple (*Acer* spp.), and oak (*Quercus* spp.).

DRG recommends that Andover perform routine inspections of inventoried trees by windshield survey (inspections performed from a vehicle) or by foot in line with *ANSI A300 (Part 9)* annually and after all severe weather events, to identify trees with defects which cause heightened risk, signs of pest activity, and symptoms of disease. Ideally, every publicly-maintained tree should receive a Level 1 assessment once every five years. 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.

PROACTIVE PRUNING

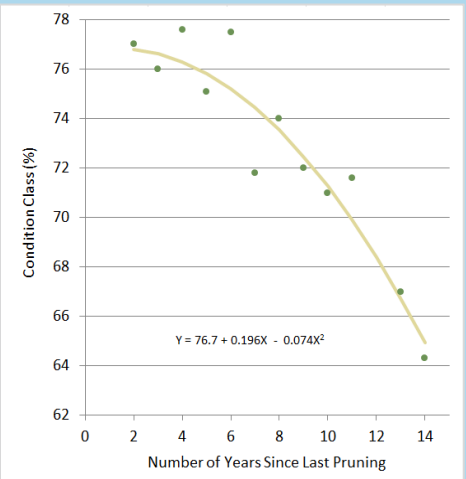
ROUTINE PRUNING CYCLE

The routine pruning cycle includes all Low Risk trees that received a “routine prune” primary maintenance recommendation. These trees pose some risk but have a smaller defect size and/or a lower probability of impacting a target. Over time, routine pruning can minimize reactive maintenance, limit instances of elevated risk, and provide the basis for a robust risk management program.

Based on Miller and Sylvester’s research, DRG recommends five-year routine pruning cycles to maintain the condition of the inventoried tree resource. However, not all municipalities are able to remain proactive with a five-year cycle based on budgetary constraints, the size of the public tree resource, or both. In these cases, extending the length of the Routine Pruning cycle is an option; however, it is in the municipality’s best interest to not exceed a 10-year pruning cycle. Tree condition has been shown to deteriorate significantly after 10 years without regular pruning as once-minor defects worsen, reducing tree health and potentially increasing risk (Miller and Sylvester 1981).

Routine Pruning Cycle Recommendations

Andover’s inventory had 6,343 trees that should be routinely pruned, and based on budgetary constraints, DRG recommends that the town establish a ten-year routine pruning cycle with approximately 634 trees pruned each year. DRG recommends that the routine pruning cycle begins in year one of the proposed ten-year management program after all elevated risk maintenance is complete.



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 reach higher risk levels. DRG recommends that pruning cycles begin after all Extreme and High 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 56% of the inventoried tree population would benefit from routine pruning. Figure 14 shows that a variety of size classes were recommended for routine pruning; however, most of the trees were smaller than 25 inches DBH.

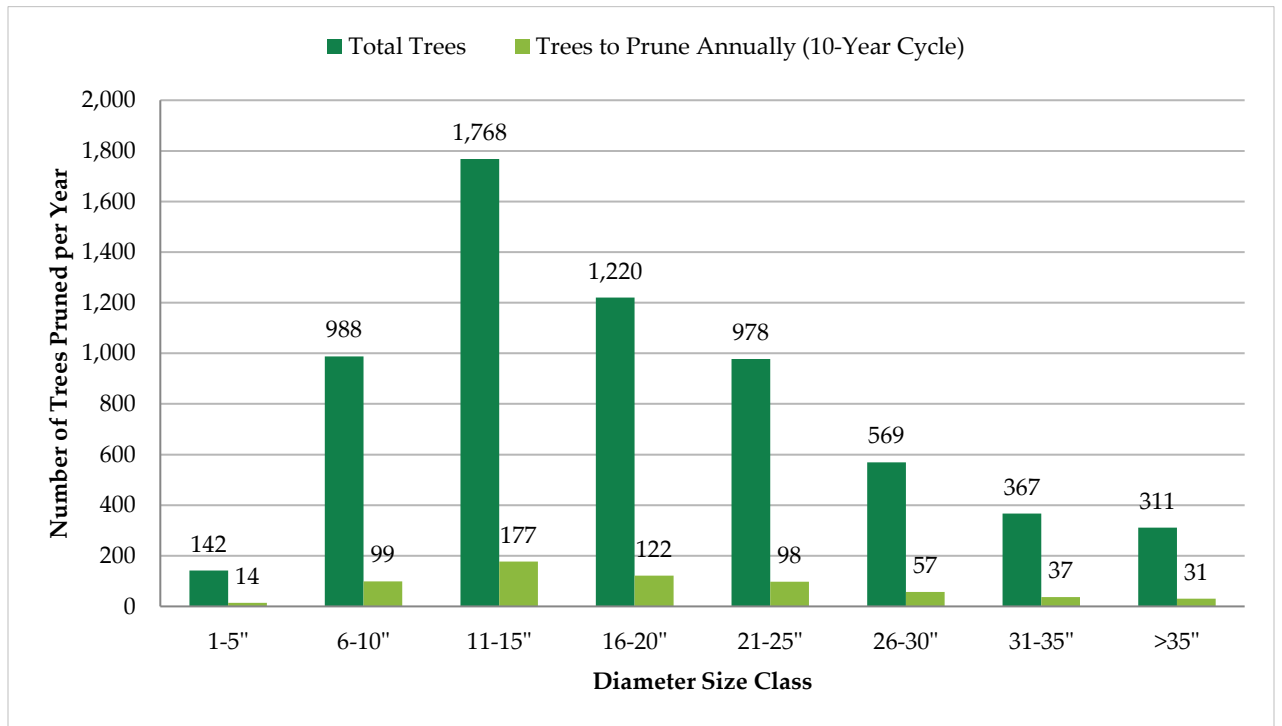


Figure 14. Ten-year routine pruning cycle by size class.

YOUNG TREE TRAINING CYCLE

Trees included in the Young Tree Training cycle are generally less than 8 inches DBH and can typically be pruned from the ground using pole saws. These younger trees may 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.

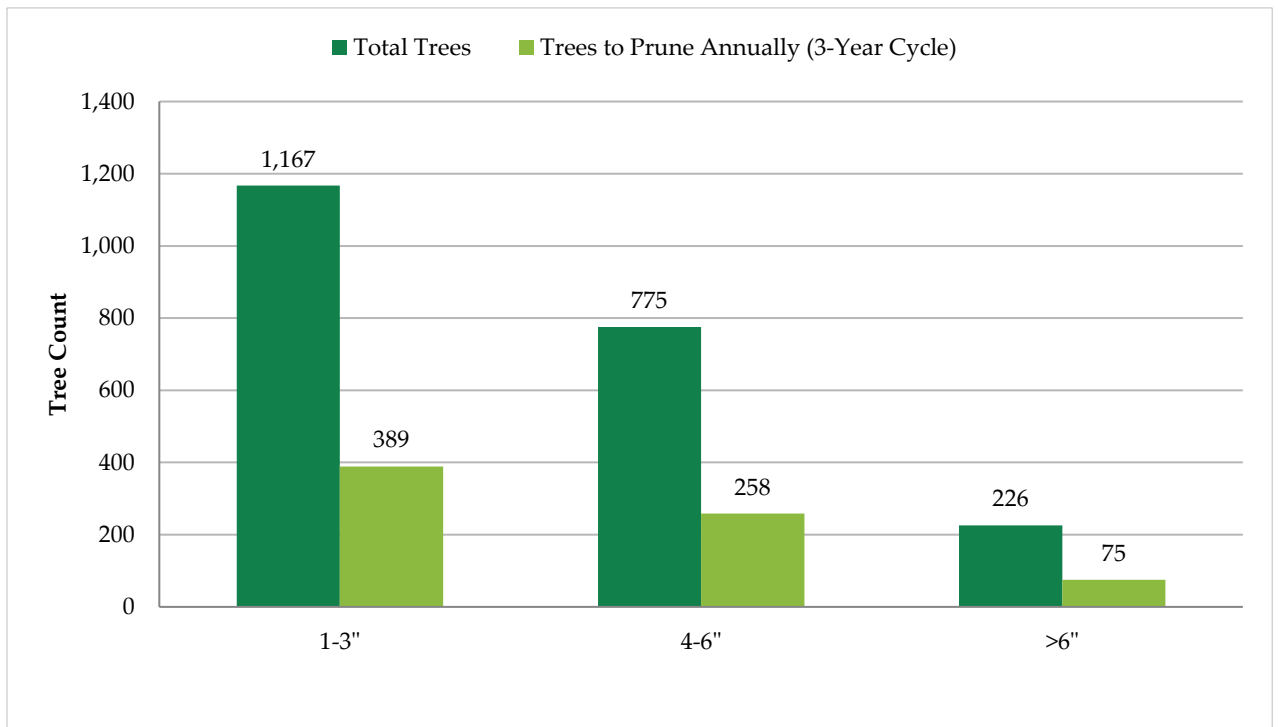


Figure 15. Three-year young tree training cycle by size class.

The recommended length of a young tree training cycle is three years because young trees tend to grow at faster rates than mature trees. 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 shear.

Young Tree Training Cycle Recommendations

DRG recommends that Andover implement a three-year young tree training cycle beginning after the completion of all elevated risk recommended maintenance activities. During the inventory, 2,168 trees were recommended for young tree training. DRG recommends that an average of 723 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

Planting new trees in areas where there is sparse canopy, poor canopy continuity, or gaps in existing canopy should be a priority for any municipality. While the Andover as a whole receives value from the ecosystem services provided by the public tree resource, those benefits are likely not distributed evenly across the town.

The “right tree in the right place” mantra for tree planting is 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. 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 shade may be a priority, but it is important to consider how a tree may impact existing utility lines and hardscape as it grows taller, wider, and deeper. If the tree at maturity will reach overhead lines, or conflict with sidewalks and curbs, it is best to choose another tree or a different location.

Tree Planting and Stump Removal Recommendations

Creating larger growing sites for trees in the municipal ROW can be the single most beneficial management practice to improve the survival rate of planted and developing trees. Increasing planting space can also reduce the amount of tree-related infrastructure conflicts. There are several methods available to create and/or increase the growing space for newly planted trees:

- Install or enlarge tree wells/pits in existing sidewalks of sufficient width. Ideally, the minimum growing space of a small-sized tree is 32 square feet. Where Andover has sidewalks of a sufficient width and length, the city could install tree pits with enough space remaining for the sidewalk to still comply with American Disability Act (ADA) standards.
- Planting trees 4 feet behind a curb without a sidewalk, or 4 feet behind an existing sidewalk, can be a low-cost alternative to more construction intensive methods. This can result in less damage to the sidewalk and give tree roots room to grow into the open soil.
- Re-routing the sidewalk around an area to create designated large tree sites is a relatively cost-effective method to increase growing spaces. This method can also be applied to existing large tree sites, where tree roots have already come in conflict with the sidewalk.
- A landscape bump-out/curb extension is a vegetative area that protrudes into the parking lane of a street, to provide a growing space for plants or trees. These spaces can be used quite effectively by municipalities to beautify a streetscape, provide greater storm water retention, along with the added benefit of slowing car speeds at the bump-out location.

The inventory identified 897 stumps recommended for removal, with a wide range of sizes from 1 to 72 inches in diameter. However, only 409 of those stumps were located in areas that would be suitable for a new planting if the stump were removed. Since Andover is unlikely to remove stumps located within the ROW on homeowner’s lawns without the intent of replanting a tree in that location, only these 409 stumps were included in the budget table at the end of this section of the management report. Stump removals should occur when convenient and be included in regular planting plans if the site would be feasible for planting after the stump is removed. For this reason, it is most convenient to remove all stumps in areas with scheduled tree planting work, so all feasible sites in an area are stocked at once.

A list of suggested tree species for new plantings is provided in Appendix D. These tree species are specifically selected for the climate of Andover. This list is not exhaustive but can be used as a guideline for species that meet community objectives and to enhance any existing list of approved species.

MAINTENANCE SCHEDULE AND BUDGET

Utilizing 2020–2021 Town of Andover tree inventory data, an annual maintenance schedule was developed detailing the recommended tasks to complete each year during a ten-year management timeframe. DRG made budget projections using industry knowledge, public bid tabulations, and information provided by the town. Following this schedule can help shift tree maintenance activities from being reactive to a more proactive tree care program. Figure 16 presents a summary of the ten-year budget needs for each maintenance task, excluding tasks with a constant annual cost, and combining some tasks to improve readability. A complete table of estimated costs for Andover’s ten-year tree management program follows.

Annual budget funds are needed to ensure that elevated 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 in a given 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 demand.

This management plan is ambitious and may be a challenge to complete during a ten-year timeframe. Even if annual budgets do not allow for all the work recommended in this plan to be completed, the budget suggestions put forth here can still help to guide decisions about how to prioritize maintenance tasks and allocate limited funds to best maintain, preserve, and grow Andover’s public tree resource. They can also serve as a useful tool when advocating for increased funding for public tree management at local and state levels.

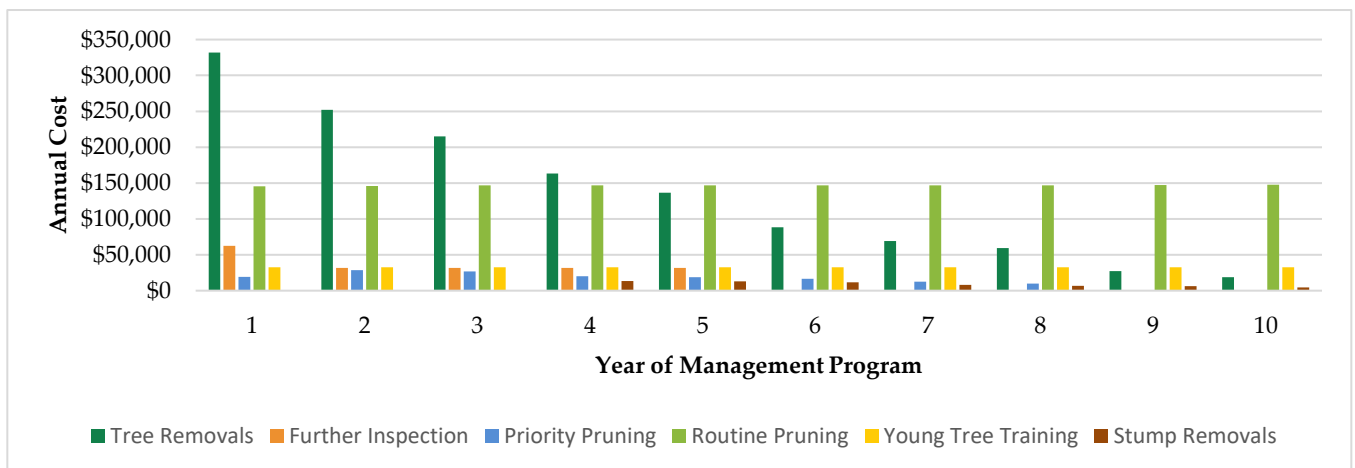


Figure 16. Estimated ten-year costs for individual maintenance tasks.

CONCLUSION

When properly maintained, the valuable benefits trees provide over their lifetime far exceed the time and money invested in planting, pruning, and inevitably removing them. The 10,522 public trees inventoried provide \$29,318 in estimated annual economic value, which is more than 7% of the town’s annual tree maintenance budget of \$398,292. Successfully implementing the ten-year management program may increase Andover’s return on investment (ROI) over time, or at least maintain it over the years.

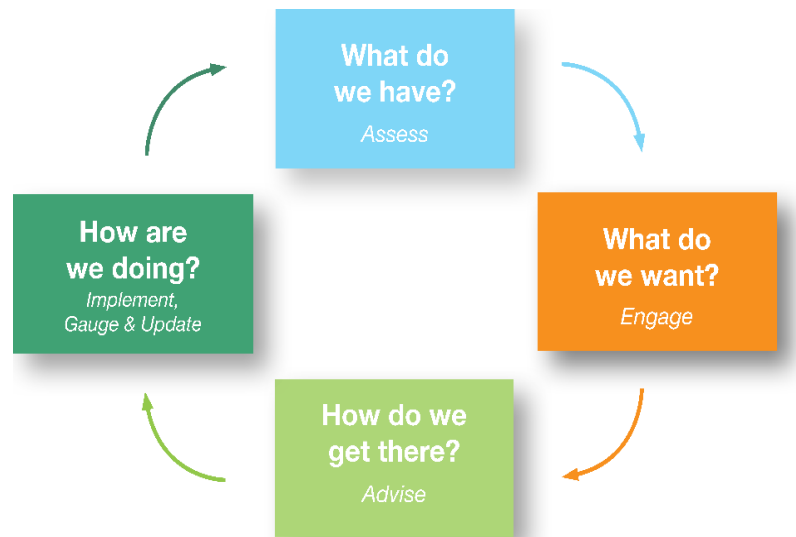
The maintenance program laid out in this document is ambitious and is a challenge to complete in ten years but becomes easier after all higher priority tree maintenance is completed. This *Standard Inventory Analysis and Management Plan* could potentially help the town advocate for an increased urban forestry budget to fund the recommended maintenance activities. Getting started is the most difficult part because of the expensive maintenance recommended in the first year, which represents the transition from reactive maintenance to a more proactive maintenance model. Significant investment early on can reduce tree maintenance costs over time.

As the urban forest grows, the benefits enjoyed by the Town of Andover and its residents will increase as well. Inventoried trees are only a fraction of the total trees in Andover when including private property, which is why it is important to also incentivize private landowners to care for their trees and to plant new ones. The town’s urban forestry program is well on its way to creating a sustainable and resilient public tree resource, and can stay on track by setting goals, updating inventory data to check progress, and setting more ambitious goals once they are reached.



EVALUATING AND UPDATING THIS PLAN

This *Standard Inventory Analysis and Management Plan* provides management priorities for the next ten years, and it is important to update the tree inventory using TreeKeeper® as work is completed so the software can provide updated species distribution and benefit estimates. This empowers Andover to self-assess the town's progress over time and set goals to strive toward by following the adaptive management cycle, depicted in the figure to the right. Below are some methods of implementing the steps of this cycle:



- Prepare planting plans well enough in advance to schedule and complete stump removal in the designated area, and to select species best suited to the available sites.
- Compare the number of trees planted to the number of trees removed and the number of vacant planting sites remaining annually, then adjusting future planting plans accordingly.
- Compare the species distribution of the inventoried tree resource with the previous year after completing planting plans to monitor recommended changes in abundance.
- Schedule and assign high-priority tree work so it can be completed as soon as possible instead of reactively addressing new lower priority work requests as they are received.
- Include data collection such as measuring DBH and assessing condition into the standard procedure for tree work and routine inspections, so changes over time can be monitored.

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GLOSSARY

address (data field): The address number was recorded based on parcel data within the GIS data collection program and confirmed with 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 “X”.

air pollution removal: In i-Tree Eco, air pollution removal refers to the removal of ozone (O₃), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), 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, Critical, or Dead.

critical (condition rating): The tree has a major structural problem that presents an unacceptable risk, has very little vigor, and/or has an insect or disease problem that is fatal.

cycle: Planned length of time between vegetation maintenance activities.

dead (condition rating): A dead tree shows no signs of life.

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.

fair (condition rating): A fair tree has minor problems that may be corrected with time or corrective action.

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.

good (condition rating): A tree in good condition shows no major problems.

grow space length (data field): Data field which records the size of the largest dimension of the growing space in which a site is located.

grow space width (data field): Data field which records the size of the smallest dimension of the growing space in which a site is located.

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

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

inventory: See **tree inventory**.

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, CO₂ 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.

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 coordinates (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.

Nitrogen Dioxide (NO₂): 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, or as a residual risk rating when a tree is recommended for removal.

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 (O₃): 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, cemetery, or other public property in which a site 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 utilities.

poor (condition rating): A tree in poor condition has major problems that are irrecoverable.

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.

replacement value: See **structural value**.

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.

resilience: The ability of a community to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks as prior to the disturbance.

resistance: The ability of a community to remain unchanged when challenged by a disturbance such as pests, severe weather, or climate change.

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

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

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

secondary maintenance need (data field): The type of pruning required to improve tree structure, tree health, or public access around the tree.

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.

site: Any point for which data was recorded during the inventory, including trees, vacant sites, and stumps.

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 (SO₂): 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 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 DATA COLLECTION AND SITE LOCATION METHODS

DATA COLLECTION METHODS

DRG collects tree inventory data using their proprietary GIS software, called Rover, loaded onto pen-based field computers. At each site, the following data fields were collected:

- address
- comments
- condition
- defect
- further inspection required
- growth space length
- growth space width
- inventory date
- multi-stem
- on street
- overhead utilities
- park name
- primary maintenance need
- residual risk
- risk assessment complete
- risk rating
- secondary maintenance need
- side
- size*
- species
- street
- suffix
- X and Y coordinate

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

The knowledge, experience, and professional judgment of DRG’s arborists ensure the high quality of inventory data. Further descriptions of these data fields can be found in the glossary.

SITE LOCATION METHODS

Equipment and Base Maps

Inventory arborists use FZ-G1 Panasonic Toughpad® units with internal GPS receivers. Geographic information system (GIS) map layers are loaded onto these units to help locate sites during the inventory. The table to the right lists these base map layers, along with each layer’s source and format information.

Data Source	Data Year	Projection
Town of Andover, MA GIS Department	2019-Most current	NAD 1983 StatePlane Massachusetts Mainland; Feet
6in Aerial Imagery NearMap Inc.	Spring, 2020	NAD 1983 StatePlane Massachusetts Mainland; Feet

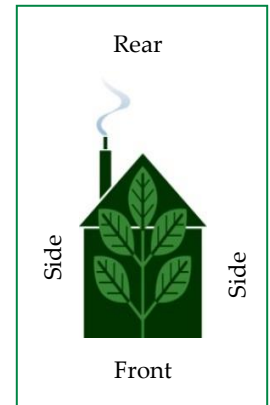
STREET ROW SITE LOCATION

Individual street ROW sites were located using a methodology that identifies sites by *address number, street name, side, and on street*. This methodology was used to help ensure consistent assignment of location.

Address Number and Street Name

Where there was no GIS parcel addressing data available for sites located adjacent to a vacant lot, or adjacent to an occupied lot without a posted address number, the arborist used their best judgment to assign an address number based on nearby addresses. An “X” was then added in the Suffix data field to indicate the estimated nature of the address.

Sites in medians were assigned an address number by the arborist in Rover using parcel and streets geographical data. Each site was numbered with an assigned address that was interpolated from addresses facing that median and addressed on that same street as the median. The *street name* assigned to a site was determined by street centerline information.



Side Value

Each site was assigned a *side value*, including *front, side, median, or rear* based on the site's location in relation to the lot's street frontage. The *front* is the side facing the address street. *Side* is either side of the lot that is between the front and rear. *Median* indicates a median or island surrounded by pavement. The *rear* is the side of the lot opposite of the address street.

← Street ROW

Median

Street ROW →

PARK AND PUBLIC SPACE SITE LOCATION

Park and/or public space site locations were collected using the same methodology as street ROW sites but have the Park Name field filled.

Site Location Example



Corner Lot A

Address/Street Name: 205 Hoover St.
 Side: Side
 On Street: Taft St.

Address/Street Name: 205 Hoover St.
 Side: Side
 On Street: Taft St.

Address/Street Name: 205 Hoover St.
 Side: Side
 On Street: Taft St.

Address/Street Name: 205 Hoover St.
 Side: Front
 On Street: Hoover St.

Corner Lot B

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

Address/Street Name: 226 E Mac Arthur St.
 Side: Front
 On Street: E Mac Arthur St.

Address/Street Name: 226 E Mac Arthur St.
 Side: Front
 On Street: E Mac Arthur St.

APPENDIX B PARKS/PLOTS AND ADDRESSES

A total of 33 assorted parks, grounds, and facilities were collected as part of the 2020–2021 Andover tree inventory. A further 23 publically owned and maintained plots were also inventoried. The chart below lists these parks, grounds, facilities, and plots and their addresses.

Park/Grounds/Facilities	Location
Andover High School grounds	80 Shawsheen Street
Andover Village lot	85 Main Street
Bald Hill Compost Site	288 High Plain Road
Ballardvale Common	between Center, Andover, and Church Streets
Ballardvale Fire Station	163 Andover Street
Ballardvale Playground	164 Andover Street
Bancroft School and grounds	15 Bancroft Road
Central Park and parking lot	36 Bartlet Street
Cuba Street Playground	between 21 and 29 Cuba Street
Deyermond Athletic Complex	between 1 and 23 Blanchard Street
Doherty Middle School and grounds	50 Bartlet Street
Elm Green	intersection of N Main, High, and Elm Streets
Elm Street Welcome Sign	between 196 and 200 Elm Street
High Plain & Wood Hill School and fields	333 High Plain Road
Iceland Road Park	between 17 and 25 Lowell Street
Lower Shawsheen Field	between 23 and 33 Balmoral Street
Memorial Hall Library and grounds	2 N Main Street
Middle Shawsheen Field and Playground	adjacent to 102 Burnham Road
Old Town Hall, Plaza, and lot	20 Main Street
Pomps Pond Complex	147 Abbot Street
Rec Park Complex	147 Abbot Street
Red Spring Road Maintenance Shop and grounds	across from 86 Red Spring Road
Sanborn School and grounds	90 Lovejoy Road
Shawsheen School and fields	18 Magnolia Avenue
South School and grounds	55 Woburn Street
The Bowling Green	2 Balmoral Street
The Public Safety Center	32 N Main Street
Town Offices and grounds	36 Bartlet Street
Upper Shawsheen Field and Playground	72 Burnham Road
West Elementary School and fields	58 Beacon Street
West Fire Station	200 Greenwood Road
West Middle School grounds	70 Shawsheen Road
Wood Memorial Park	corner of Lowell and N Main Streets

Plot	Location
Alderbrook plot	corner of Alderbrook Road and S Main Street
Argilla Road plot	corner of Argilla Road and Andover Street
Beacon Street plot	island at intersection of Beacon and Lowell Streets
Central Street plot	corner of School and Central Streets
Dascomb Road plots (2)	corner of Dascomb Road and Andover Street and in front of 69 Andover Street
Elm Street plot	in front of 147 Elm Street near corner of Elm Street and Farnsworth Road
Essex Street plot	island at intersection of Essex and School Streets
Haverhill Street plots (2)	corner of High and Haverhill Streets, both north side of the intersection
Hidden Road plot	corner of Hidden Road and Porter Road
High Street plot	island at intersection of High Street and Burnham Road
Lincoln Street plot	island across from 10-12 and 7-11 Lincoln Street
Lupine road plot	corner of Lupine Road and School Street
North Street plot	corner of North Street and River Road
Osgood at Raytheon plots (3)	corner of Osgood Street and Frontage Road
Osgood Street plot	corner of Osgood and Blanchard Streets
Poor Street plot	between 2 and 56 Poor Street, frontage on Hussey Pond
Porter Road plot	corner of Hidden Road and S Main Street
Rattlesnake Hill Road plot	island at intersection of Rattlesnake Hill Road and Woburn Street
Summer Street plot	corner of Upland and Stratford Roads and Summer Street

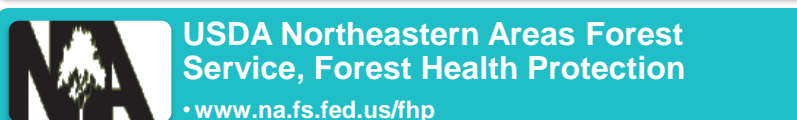
APPENDIX C INVASIVE PESTS AND DISEASES

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).

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 native species to extinction. The following appendix includes key pests and diseases that adversely affect trees in Massachusetts, or which are emergent threats for Massachusetts 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 so that you can be prepared to combat their attack. Updated pest range maps can be found at: <https://www.nrs.fs.fed.us/tools/afpe/maps/> and updated pest information can be found at: <https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/Pest-Tracker>.



ASIAN LONGHORNED BEETLE

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an exotic pest that threatens a wide variety of hardwood trees in North America. The beetle was introduced in Chicago, New Jersey, and New York City, and is believed to have been introduced in the United States from wood pallets and other wood-packing material accompanying cargo shipments from Asia. ALB is a serious threat to America's hardwood tree species.



Adult Asian longhorned beetle.

Photograph courtesy of New Bedford Guide (2011)

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

BEECH LEAF DISEASE

Beech leaf disease (BLD) was first identified in Ohio in 2012. Since then, it has been found in Pennsylvania, New York, Rhode Island, Connecticut, and most recently in Massachusetts. The first confirmed detection of this emergent disease in the state was made in Plymouth in 2020, but symptomatic trees have been observed in Worcester and Blandford as well. Although it does not yet appear to be widespread in Massachusetts, BLD is an emergent threat to forest health in the state.



Dark stripes between leaf veins are an early symptom of BLD.

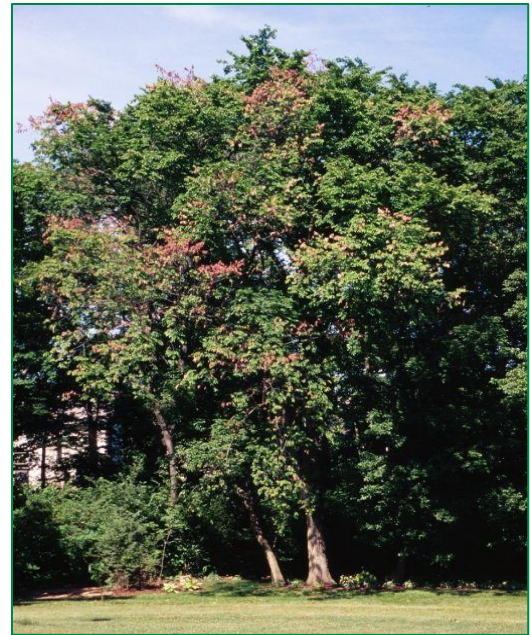
Photograph courtesy of Tom Macy, Ohio DNR Division of Forestry (2019)

The disease complex is associated with a nematode, *Litylenchas crenatae*, and impacts American beech (*Fagus grandifolia*), European beech (*F. sylvatica*), and Oriental beech (*F. orientalis*). Early signs of the disease include dark stripes between the veins of leaves, most noticeable when looking up through the canopy on sunny days. As the disease progresses, leaves become withered, curled, or develop a leathery texture and sections of canopy may die back. Infected trees often appear to have a thin canopy, and the disease can lead to tree mortality. Research into this disease is ongoing, and the method of spread and infection, as well as potential treatments, are not yet known. If you suspect a tree under your care to be infected, report it to the DCR Forest Health Program by emailing nicole.keleher@mass.gov or by calling (857) 337-5173.

DUTCH ELM DISEASE

Considered by many to be one of the most destructive invasive diseases of shade trees in the United States, Dutch elm disease (DED) was first found in Ohio in 1930. By 1933 the disease was present in several east coast cities and by 1959 it had killed thousands of elms. Today, DED is present in about two-thirds of the eastern United States and kills many of the remaining and newly planted elm annually. 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. The species most affected by DED is the *Ulmus americana* (American elm).

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



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)

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 Columbia. The insect is thought to have been spread widely on infested conifer products, including holiday wreaths and Christmas trees.



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 an 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.

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.

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).



Close-up of an emerald ash borer.

Photograph courtesy of USDA APHIS (2020)

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

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

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



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

Photograph courtesy of USDA APHIS (2019)

HEMLOCK WOOLLY ADELGID

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

In their native range, populations of HWA cause little damage to the hemlock trees, as they are preyed 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 eastern or Canadian hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliniana*), often damaging and killing them within a few years of becoming infested.

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



Hemlock woolly adelgids on a branch.

Photograph courtesy of Connecticut Agricultural Experiment Station, Bugwood.org (2011)

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 scarlet oak (*Quercus coccinea*), shingle oak (*Q. imbricaria*), pin oak (*Q. palustris*), willow oak (*Q. phellos*), and red oak (*Q. rubra*). It also attacks trees in the white oak subgenus, although it is not as prevalent and spreads at a much slower pace in these trees.

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



Oak wilt symptoms on red and white oak leaves.

Photograph courtesy of USDA Forest Service (2011a)

PINE SHOOT BEETLE

The pine shoot beetle (PSB, *Tomicus piniperda*), a native of Europe, is an introduced pest of pine (*Pinus* spp.) 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, including Connecticut, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin.

The beetle attacks new shoots of pine trees, stunting the growth of the trees. 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.

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

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



Mined shoots on a Scots pine.

*Photograph courtesy of USDA
Forest Service (1993)*

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 white pine including eastern white pine (*Pinus strobus*). Trees are killed when beetles construct winding, S-shaped egg galleries underneath the bark. These galleries effectively girdle the tree and destroy the conductive tissues that transport food throughout the tree. Furthermore, the beetles carry blue staining fungi on their bodies that clog the water conductive tissues which transport water within the tree. Signs of attack on the outside of the tree are pitch tubes and boring dust, known as frass, caused by beetles entering the tree.



Adult southern pine beetles.

Photograph courtesy of Forest Encyclopedia Network (2012)

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

SPOTTED LANTERNFLY

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



Pinned spotted lanternfly nymph.

Photograph courtesy of PA Dept of Agriculture

Symptoms of SLF include plants oozing or weeping with a fermented odor, buildup of a sticky fluid called honeydew on the plant or on the ground underneath them, and sooty mold growing on plants. The following trees are susceptible to SLF: almond, apricot, cherry, nectarine, peach, plum (*Prunus* spp.), apple (*Malus* spp.), maple (*Acer* spp.), oak (*Quercus* spp.), pine (*Pinus* spp.), poplar (*Populus* spp.), sycamore (*Platanus* spp.), walnut (*Juglans* spp.), and willow (*Salix* spp.), as well as grape vines and hop plants.

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 oak (*Quercus* spp.), maple (*Acer* spp.), elm (*Ulmus* spp.), ash (*Fraxinus* spp.), crabapple (*Malus* spp.), cherry (*Prunus* spp.), and blueberry (*Vaccinium* spp.), 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.

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.



Winter moth larva on an oak leaf.

Photograph courtesy of Milan Zubrik, Forest Research Institute – Slovakia, Bugwood.org

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APPENDIX D SUGGESTED TREE SPECIES FOR USDA HARDINESS ZONE 6

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 Zone 6 on the USDA Plant Hardiness Zone Map.

DECIDUOUS TREES

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
<i>Acer rubrum</i>	red maple	Red Sunset®
<i>Acer saccharum</i>	sugar maple	'Legacy'
<i>Aesculus flava*</i>	yellow buckeye	
<i>Betula alleghaniensis*</i>	yellow birch	
<i>Betula lenta*</i>	sweet birch	
<i>Betula nigra</i>	river birch	Heritage®
<i>Carpinus betulus</i>	European hornbeam	'Franz Fontaine'
<i>Carya illinoensis*</i>	pecan	
<i>Carya lacinata*</i>	shellbark hickory	
<i>Carya ovata*</i>	shagbark hickory	
<i>Castanea mollissima*</i>	Chinese chestnut	
<i>Celtis laevigata</i>	sugar hackberry	
<i>Celtis occidentalis</i>	common hackberry	'Prairie Pride'
<i>Cercidiphyllum japonicum</i>	katsuratree	'Aureum'
<i>Diospyros virginiana*</i>	common persimmon	
<i>Fagus grandifolia*</i>	American beech	
<i>Fagus sylvatica*</i>	European beech	(Numerous exist)
<i>Ginkgo biloba</i>	ginkgo	(Choose male trees only)
<i>Gleditsia triacanthos inermis</i>	thornless honeylocust	'Shademaster'
<i>Gymnocladus dioica</i>	Kentucky coffeetree	Prairie Titan®
<i>Juglans nigra*</i>	black walnut	
<i>Larix decidua*</i>	European larch	
<i>Liquidambar styraciflua</i>	American sweetgum	'Rotundiloba'
<i>Liriodendron tulipifera*</i>	tuliptree	'Fastigiatum'
<i>Magnolia acuminata*</i>	cucumbertree magnolia	(Numerous exist)
<i>Magnolia macrophylla*</i>	bignleaf magnolia	
<i>Metasequoia glyptostroboides</i>	dawn redwood	'Emerald Feathers'
<i>Nyssa sylvatica</i>	black tupelo	
<i>Platanus occidentalis*</i>	American sycamore	

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
<i>Acer buergerianum</i>	trident maple	Streetwise®
<i>Acer campestre</i>	hedge maple	Queen Elizabeth™
<i>Acer cappadocicum</i>	coliseum maple	'Aureum'
<i>Acer ginnala</i>	amur maple	Red Rhapsody™
<i>Acer griseum</i>	paperbark maple	
<i>Acer nigrum</i>	black maple	
<i>Acer pensylvanicum</i> *	striped maple	
<i>Acer triflorum</i>	three-flower maple	
<i>Aesculus pavia</i> *	red buckeye	
<i>Amelanchier arborea</i>	downy serviceberry	(Numerous exist)
<i>Amelanchier laevis</i>	Allegheny serviceberry	
<i>Carpinus caroliniana</i> *	American hornbeam	
<i>Cercis canadensis</i>	eastern redbud	'Forest Pansy'
<i>Chionanthus virginicus</i>	white fringetree	
<i>Cornus alternifolia</i>	pagoda dogwood	
<i>Cornus kousa</i>	Kousa dogwood	(Numerous exist)
<i>Cornus mas</i>	corneliancherry dogwood	'Spring Sun'
<i>Corylus avellana</i>	European filbert	'Contorta'
<i>Cotinus coggygria</i> *	common smoketree	'Flame'
<i>Cotinus obovata</i> *	American smoketree	
<i>Crataegus phaenopyrum</i> *	Washington hawthorn	Princeton Sentry™
<i>Crataegus viridis</i>	green hawthorn	'Winter King'
<i>Franklinia alatamaha</i> *	Franklinia	
<i>Halesia tetraptera</i> *	Carolina silverbell	'Arnold Pink'
<i>Laburnum × watereri</i>	goldenchain tree	
<i>Maackia amurensis</i>	amur maackia	
<i>Magnolia × soulangiana</i> *	saucer magnolia	'Alexandrina'
<i>Magnolia stellata</i> *	star magnolia	'Centennial'
<i>Magnolia tripetala</i> *	umbrella magnolia	
<i>Magnolia virginiana</i> *	sweetbay magnolia	Moonglow®
<i>Malus spp.</i>	flowering crabapple	(Disease resistant only)
<i>Oxydendrum arboreum</i>	sourwood	'Mt. Charm'
<i>Prunus subhirtella</i>	Higan cherry	'Pendula'
<i>Prunus virginiana</i>	common chokecherry	'Schubert'
<i>Staphylea trifolia</i> *	American bladdernut	
<i>Stewartia ovata</i>	mountain stewartia	
<i>Styrax japonicus</i> *	Japanese snowbell	'Emerald Pagoda'
<i>Syringa reticulata</i>	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
<i>Abies balsamea</i>	balsam fir	
<i>Abies concolor</i>	white fir	'Violacea'
<i>Cedrus libani</i>	cedar-of-Lebanon	
<i>Chamaecyparis nootkatensis</i>	Nootka falsecypress	'Pendula'
<i>Cryptomeria japonica</i>	Japanese cryptomeria	'Sekkan-sugi'
× <i>Cupressocyparis leylandii</i>	Leyland cypress	
<i>Ilex opaca</i>	American holly	
<i>Picea omorika</i>	Serbian spruce	
<i>Picea orientalis</i>	Oriental spruce	
<i>Pinus densiflora</i>	Japanese red pine	
<i>Pinus strobus</i>	eastern white pine	
<i>Pinus sylvestris</i>	Scotch pine	
<i>Pinus taeda</i>	loblolly pine	
<i>Pinus virginiana</i>	Virginia pine	
<i>Pseudotsuga menziesii</i>	Douglas-fir	
<i>Thuja plicata</i>	western arborvitae	(Numerous exist)
<i>Tsuga canadensis</i>	eastern hemlock	

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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