What We Learned About Our Trees: An Introduction to the Tree Inventory

Photograph by Richard Higgins

By Richard Higgins

Concord has a long history of caring for its trees, and for good reason. If they were the only measure, ours would still be one of the richest towns in Massachusetts. Their labors for us—cooling the air, blocking chill winds, filtering pollution, absorbing carbon, reducing erosion, improving water quality and enriching biodiversity—never cease, day or night. And that doesn't include their boundless beauty or the ways they improve our health. Trees are truly the common wealth of Concord.

To make sure we are caring for our public shade trees adequately, Concord this year hired a respected national tree care consultant to inventory and assess them. The results are encouraging. We have a good mix of trees in good health that will continue to provide solid benefits—if we maintain them. That will require allocating town resources to take proactive steps such as pruning the trees we have, planting new ones and fostering diversity, all of which will make our community forest more resilient.

The Davey Resources Group conducted the inventory between May and August. It considered only town-maintained trees, but those are the ones we are most likely to interact with—those lining our streets, parks, squares, libraries and cemeteries.

Davey counted all trees and stumps, as well as sites where trees could be planted, within the town's right-of-way (in most cases, 25 feet on either side from the center of a street) and certain town locations. The latter included six recreational fields (Emerson, Rideout, Ripley, Cousin's, South Meadow and Doug White), the three town cemeteries, the two public libraries, the waste water treatment plant on Bedford Street, town-owned buildings on Monument Square and Keyes Road and a few small parks.

In all, Davey identified 23,871 public trees—19,831 along streets and 3,950 at the parks and public areas—as well as 846 stumps and 2,135 planting sites. It collected data on the age, condition and distribution of the trees and analyzed that information to create a plan for managing them.

Its key findings were:

- The overall mix of younger and older, established trees, as measured by trunk diameter, is close to ideal. Although we need to keep planting, we have enough rising trees to replace those at the end of their lifespan.

- Our trees show "relatively good diversity," with 77 different families of trees and 184 individual species represented. However we have more of two familiar species, white pine and Norway maple, than is good for biodiversity. Together they comprise 30 percent of our trees—19 percent for white pine and 11 percent for Norway maple. It is only fitting that Henry David Thoreau's hometown should have a lot of white pine, a tree he loved, but, today, nearly one out of five is too many. Maple and oak are the most abundant tree families, each slightly exceeding the desirable maximum of 20 percent for any one genus.

- The vast majority of our trees, or 86 percent of the total, are in good or fair condition, with 7,605 trees rated as good and 12,832 as fair. Our ash trees, however, are doing very poorly. Half of them are dead or dying.

- Only 42 of the inventoried trees pose an extreme or high risk of failure and should be removed soon, Davey said. Another 511 trees have a moderate risk and 1496 more trees a minor risk of failure. Those trees might also need to be removed in the future, bringing the total number of trees given some chance of failure to 2,049. That may seem high at first, but many of them are in areas where they pose no public risk and thus won't be removed, while others may improve with pruning and fertilization. Even the high risk

trees may not fail, the report states, “based on different scenarios or what could happen to the tree after an arborist has looked at it.” We should also remember that trees are mortal. Death is a natural part of the lifecycle of the forest.

While all this is generally encouraging, it should not blind us to the challenges our urban forest faces from destructive pests, with oaks, maples and hemlocks being most susceptible, or the need for preventative action to keep it healthy. Davey urged vigilance in pruning young trees to catch structural problems before they worsen and in planting new trees to make up for losses and create canopy. It recommended that 558 young trees be pruned each year for the next three years and that the town plant 250 new trees each year.

In one respect, the inventory only reminds us of what we already know. Town officials stressed the importance of proper pruning 125 years ago.

“If there is anything about which the people of Concord feel a just pride,” the Concord Road Commission wrote in the 1892 town report, “it is the condition of the public grounds and the preservation of the beautiful shade trees which grow along the roadside, and which afford shade, shelter, and protection from the heat of the summer sun. But our love of trees should not be considered an excuse for neglecting to properly trim them. ...If shade trees were properly trimmed when young it would not be necessary in later years to mutilate and disfigure them by cutting off limbs three or four inches in diameter.”

The commissioners also urged that every public tree be protected from “the teeth of horses.” Today the threat is more likely from gypsy moth and hemlock woolly adelgid, the most prevalent pests Davey found in Concord, but the sentiment, a desire to aid our trees, is the same as ours today.

Now that we have good information about the state of our trees, it is important that we update it by inspecting them, both on a routine basis and after severe weather, and recording any changes in their condition using a special software program called Treekeeper, which will made be made available to the public on the town’s website. In addition to being a database, Treekeeper has tools to find, identify and check on our trees.

The management plan that follows will cost money. As the report notes, however, our trees offer a host of environmental, biological, social and economic dividends that, in the long view, far exceed the cost of pruning, planting and protecting them. In that sense, they are a worthwhile investment. Thoreau did not need any practical evidence to be persuaded of the value of Concord’s trees. He believed they had even “higher uses,” such

as stirring our awe and sense of beauty. We can enjoy all these benefits, tangible and intangible, by taking proper care of them.

Concord resident Richard Higgins is a writer, editor and photographer who is well acquainted with Concord's trees. A former longtime reporter for the *Boston Globe*, he is the author of *Thoreau and the Language of Trees* (University of California Press, 2017). His book about Thoreau's love of trees includes many of his photographs of trees right here in Concord.

TREE MANAGEMENT PLAN - DRAFT

Town of Concord, Massachusetts

October 2017

Prepared for:
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Highway and Grounds Division
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MISSION STATEMENT

It is the mission of Concord Public Works to enhance Concord's quality of life, and through sound management, innovation, teamwork, and vision, provide dependable, high-quality, responsive public works and utility services, consistent with community values and at reasonable costs to Concord's citizens, businesses, institutions, and visitors.

ACKNOWLEDGMENTS

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

The Town of Concord is thankful for the grant funding it received from the Massachusetts Department of Conservation and Recreation (DCR) through its Urban and Community Forestry Challenge Grant program. Urban and Community Forestry grant funds are provided by the USDA Forest Service and administered by DCR with guidance from the Massachusetts Tree Wardens' and Foresters' Association. The DCR Urban and Community Forestry Program assists communities and nonprofit groups in protecting, growing, and managing community trees and forest ecosystems. The program's ultimate goal is to improve the environment and develop better tree stewardship in Massachusetts communities of all sizes.

The town also recognizes the support of the following:

- Select Board: Jane Hotchkiss, Chair; Tom McKean, Clerk; Michael Lawson; Alice Kaufman; Steven Ng
- Public Works Commission: Andrew Boardman, Chair; KC Winslow, Vice Chair; Arthur Fulman; Peter W. Wallis
- Cemetery Committee: Paul Cooke, Chair; Gina Nasson, Vice Chair; Carol Harney; Whitney Kocher; Andrea Solomon
- Christopher Whelan, Town Manager
- Richard Reine, Public Works Director and Town Tree Warden
- Daniel Rowley, Highway and Grounds Superintendent and Deputy Tree Warden
- Keith Baldinger, Assistant Highway and Grounds Superintendent
- Dickinson Fowler (Retired), Highway and Grounds Superintendent
- Peter Flynn (Retired), Grounds Operations Supervisor and Tree Warden
- Massachusetts Department of Conservation and Recreation

Notice of Disclaimer: Inventory data provided by Davey Resource Group, a division of The Davey Tree Expert Company, 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. Davey Resource Group 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. Davey Resource Group 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 Davey Resource Group's recommendations or to seek additional advice. Important: know and understand that visual inspection is confined to the designated subject tree(s) and that the inspections for this project are performed in the interest of facts of the tree(s) without prejudice to or for any other service or any interested party.

EXECUTIVE SUMMARY

This plan was developed for the Town of Concord by Davey Resource Group with a focus on addressing short-term and long-term maintenance needs for inventoried public trees. Davey Resource Group completed a tree inventory to gain an understanding of the needs of the existing urban forest and to project a recommended maintenance schedule for tree care. Analysis of inventory data and information about the town's existing program and vision for the urban forest were utilized to develop this *Tree Management Plan*.

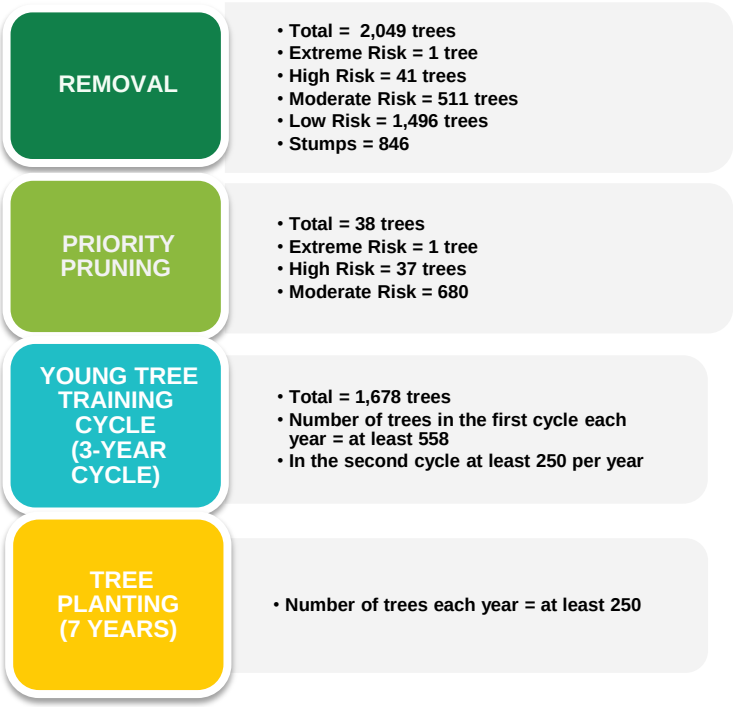
State of the Existing Urban Forest

The May–August 2017 inventory included trees, stumps, and planting sites along public street rights-of-way (ROW), and in specified parks and public facilities. The parks and public facilities selected for the inventory include Emerson Field (including the Hunt Gym); Rideout Field; Ripley Field; Cousin's Field; South Meadow Field; Doug White Field; Assessor's Building; Town House; Monument Square; Junction Park; Madriolli's Park; Fowler Library; Main Library; Harvey Wheeler Community Center; Waste Water Treatment Plant; and Keyes Road Public Works Complex. A total of 26,762 sites were recorded during the inventory: 23,781 trees, 846 stumps, and 2,135 planting sites. Analysis of the tree inventory data found the following:

- Two species, *Pinus strobus* (white pine) and *Acer platanoides* (Norway maple), comprise a large percentage of the inventoried tree population (19% and 11% respectively) and threaten biodiversity.
- The diameter size class distribution of the inventoried tree population trends towards the ideal, with a greater number of young trees than established, maturing, or mature trees.
- The overall condition of the inventoried tree population is rated fair.
- Overhead utilities were in close proximity to approximately 31% of the population.
- Approximately 46% of the inventoried white ash trees were determined to be either Dead or in Poor condition.
- Given the prevalence of host tree species for gypsy moth (*Lymantria dispar dispar*) and Asian longhorned beetle (*Anoplophora glabripennis*), these pests pose the largest potential threats to the health of the inventoried population.
- Hemlock woolly adelgid (*Adelges tsugae*) and gypsy moth were the most commonly identified pests active during this assessment.

Tree Maintenance and Planting Needs

Trees provide many environmental and economic benefits that justify the time and money invested in planting and maintenance. Recommended maintenance needs include Tree Removal (8%); Stump Removal (3%); Routine Pruning (75%); Young Tree Train (6%); and Plant Tree (8%). Maintenance should be prioritized by addressing trees with the highest risk first. Although not conclusive, the inventory noted some Extreme and High Risk trees (less than 1%); these trees should be prioritized for removal or pruning to promote public safety. Low Risk and Moderate Risk trees should be addressed after all elevated risk tree maintenance has been completed. Even though a tree has been identified as high risk, it may not fail in order of risk based on different scenarios on what could happen to the tree after an arborist has looked at it. Trees should be planted to mitigate removals and create canopy.



Concord's urban forest will benefit greatly from a three-year young tree training cycle for young and newly planted trees. Proactive pruning cycles improve the overall health of the tree population and may eventually reduce program costs. In most cases, pruning cycles will correct defects in trees before they worsen, which will avoid costly problems. Based on inventory data, at least 558 young trees should be structurally pruned each year during the young tree training cycle in the first 3 years. Then 250 every year to account for the newly planted trees. It is recognized that the ability to achieve this frequency may be limited based on available resources. However, efforts should be made toward this goal.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind). Davey Resource Group recommends planting at least 250 trees of a variety of species each year to offset these projected losses, increase canopy, maximize benefits, and account for ash tree loss. Losses are projected by recommended removals from the inventory and expected mortality over time. Currently the budget constraints do not allow for more than 250 trees planted per year. In time, the Town may want to consider increasing their planting budget to account for the rate of canopy loss if more than 250 removals are performed in that year.

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

Town-wide tree planting should focus on replacing tree canopy recommended for removal and establishing new canopy in areas that promote economic growth, such as business districts, recreational areas, trails, parking lots, areas near buildings with insufficient shade, and areas where there are gaps in the existing canopy. Various tree species should be planted; however, the planting of *Pinus strobus* (white pine) should be limited until the species distribution normalizes. The town's existing planting list offers smart choices for species selection. Due to the species distribution and impending threats from emerald ash borer (EAB, *Agrilus planipennis*), all *Fraxinus* spp. (ash) trees should be temporarily removed from the planting list.

Urban Forest Program Needs

The town has a strong forestry management program which includes skilled staff to complete tree maintenance work and should consider seeking additional funding to improve and maintain the condition of the urban forest. Adequate funding will be needed for the town to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this seven-year program is $259,597. The minimum investment needed for the program will decrease to approximately $200,000 per year by year five. High-priority removal and pruning is costly; since most of this work is scheduled during the first year of the program, the budget is higher for that year. After high-priority work has been completed, the urban forestry program will mostly involve proactive maintenance, which is generally less costly. Budgets for later years are thus projected to be lower. Recognizing that there are many other demands for funding town-wide, the value the urban forest provides to Concord is significant so it is recommended that the funding level in year one is maintained in future years and additional funds be invested in tree planting or pruning.

Over the long term, supporting proactive management of trees through funding will reduce municipal tree care management costs and potentially minimize the costs to build, manage, and support certain town infrastructure. Keeping the inventory up-to-date using *TreeKeeper® 8.0* or similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

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

FY 2018 $259,597

- 42 Extreme or High Risk Removals
- 38 Extreme or High Risk Prunes
- 115 Moderate Risk Removals
- 2,850 Moderate or Low Risk Prunes
- YTT Cycle: 560 Trees
- 304 Trees Recommended for Planting and Follow-Up Care
- Level 1 Assessment of Remaining Risk Trees and Pest Prone Areas
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2019 $230,888

- 250 Moderate Risk Removals
- YTT Cycle: 560 Trees
- 285 Stump Removals
- 250 Trees Recommended for Planting and Follow-Up Care
- Level 1 Assessment of Remaining Risk Trees and Pest Prone Areas
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2020 $244,933

- 146 Moderate Risk Removals
- 104 Low Risk Removals
- 282 Stump Removals
- YTT Cycle: 558 Trees
- 250 Trees Recommended for Planting and Follow-Up Care
- Level 1 Assessment of Remaining Risk Trees and Pest Prone Areas
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2021 $233,848

- 250 Low Risk Removals
- 279 Stump Removals
- 32 Moderate Risk Prunes
- YTT Cycle: 500 Trees
- 250 Trees Recommended for Planting and Follow-Up Care
- Level 1 Assessment of Remaining Risk Trees and Pest Prone Areas
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2022 $201,130

- 250 Low Risk Removals
- 218 Moderate Risk Prunes
- YTT Cycle: 500 Trees
- 304 Trees Recommended for Planting and Follow-Up Care
- Level 1 Assessment of Remaining Risk Trees and Pest Prone Areas
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2023 $200,600

- 250 Low Risk Removals
- 216 Moderate Risk Prunes
- YTT Cycle: 557
- 304 Trees Recommended for Planting and Follow-Up Care
- Level 1 Assessment of Remaining Risk Trees and Pest Prone Areas
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2024 $182,595

- 250 Low Risk Removals
- 214 Moderate Risk Prunes
- YTT Cycle: 559
- 304 Trees Recommended for Planting and Follow-Up Care
- Level 1 Assessment of Remaining Risk Trees and Pest Prone Areas
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

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INTRODUCTION

The Town of Concord is home to nearly 18,000 full-time residents who enjoy the beauty and benefits of their urban forest. Concord Public Works is responsible for the planting and care of the street, park, and other public trees in the community.

Funding for Concord's urban forestry program comes from the general fund budget.

Approach to Tree Management

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

From May–August 2017, Concord worked with Davey Resource Group to inventory trees and develop a management plan. This plan considers the diversity, distribution, and general condition of the inventoried trees, but also provides a prioritized system for managing public trees. The following tasks were completed:

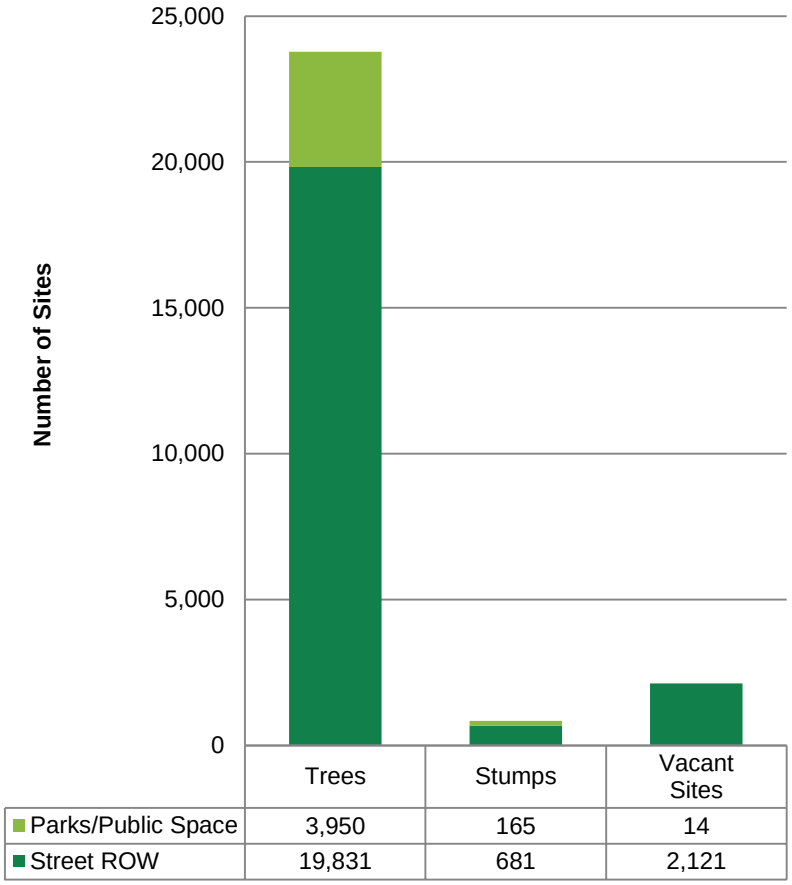
- Inventory of trees, stumps, and planting sites along the street ROW and within public parks and other town-owned property.
- Analysis of tree inventory data.
- Development of a plan that prioritizes the recommended tree maintenance.

This plan is divided into two sections:

- *Section 1: Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: Tree Management Program* utilizes the inventory data to develop a prioritized maintenance schedule and projected budget for the recommended tree maintenance over a seven-year period.

SECTION 1: TREE INVENTORY ANALYSIS

From May–August 2017, Davey Resource Group arborists assessed and inventoried trees, stumps, and planting sites along the public street ROW, specified parks, and public facilities. A total of 26,762 sites were collected during the inventory: 23,781 trees, 846 stumps, and 2,135 planting sites. Of the 26,762 sites collected, 85% were collected along the street ROW, and the remaining 15% were collected in specified parks and other public facilities. Figure 1 provides a detailed breakdown of the number and type of sites inventoried.



	Trees	Stumps	Vacant Sites
Parks/Public Space	3,950	165	14
Street ROW	19,831	681	2,121

Figure 1. Sites collected during the 2017 inventory.

Assessment of Tree Inventory Data

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

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

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

Species Diversity

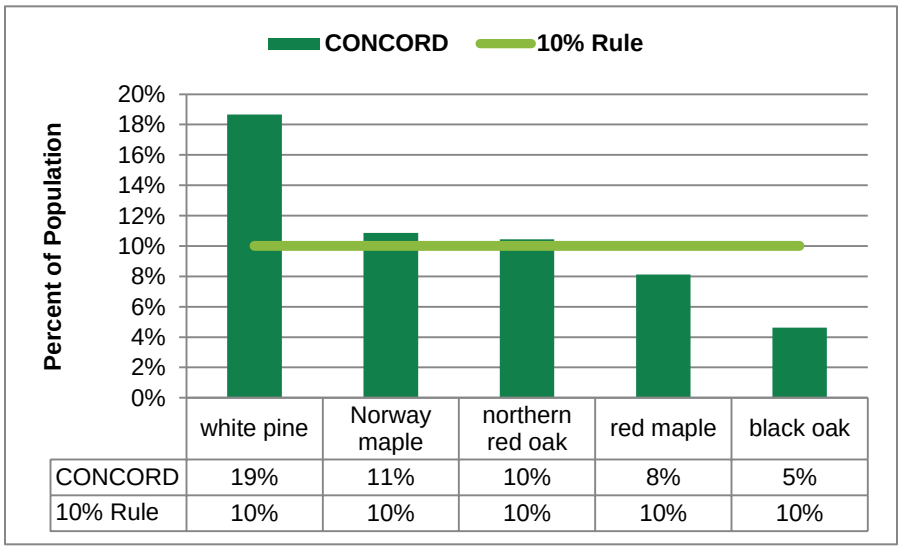
Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics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

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

Findings

Analysis of Concord's tree inventory data indicated that the tree population had relatively good diversity, with approximately 77 genera and approximately 184 species represented.

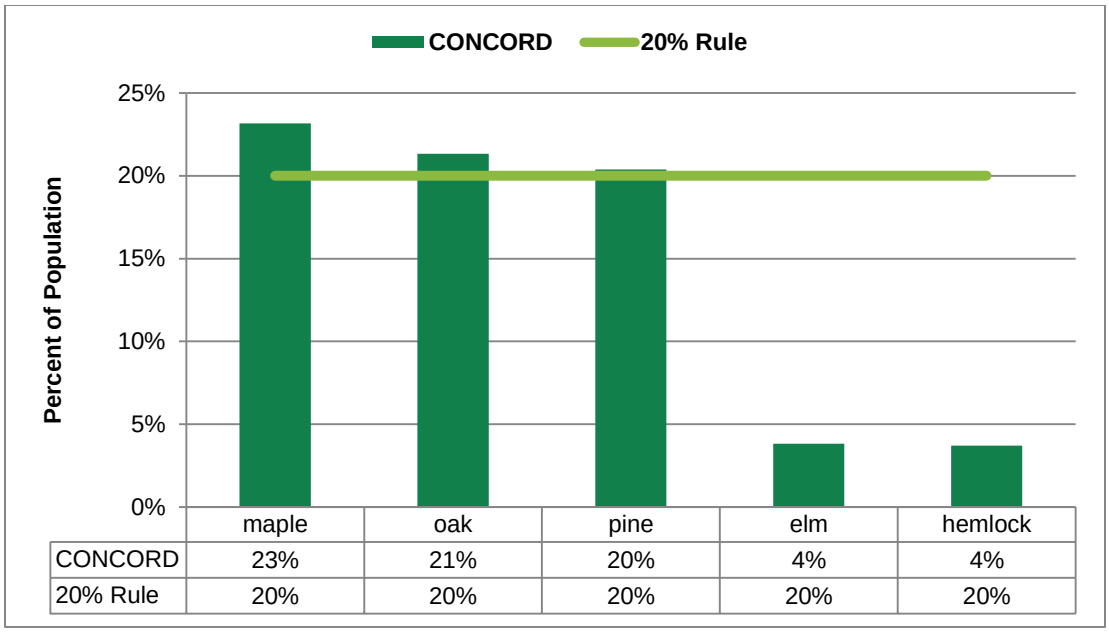
Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory to the park and street tree populations. *Pinus strobus* (white pine) far exceeds the recommended 10% maximum for a single species in a population, comprising 19% of the inventoried tree population. *Acer platanoides* (Norway maple) slightly exceeds the 10% maximum. *Quercus rubra* (northern red oak) meets the 10% threshold, and *Acer rubrum* (red maple) falls 2% short of the threshold.



	white pine	Norway maple	northern red oak	red maple	black oak
CONCORD	19%	11%	10%	8%	5%
10% Rule	10%	10%	10%	10%	10%

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

Figure 3 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory to the park and street tree populations. *Acer* (maple) and *Quercus* (oak) exceed the recommended 20% maximum for a single genus in a population, comprising 23% and 21% of the inventoried tree population, respectively. *Pinus* (pine) meets the 20% threshold.



	maple	oak	pine	elm	hemlock
CONCORD	23%	21%	20%	4%	4%
20% Rule	20%	20%	20%	20%	20%

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

Discussion/Recommendations

It is worth noting that a large number of woodlot grown trees was inventoried as part of this project. Therefore, the large percentage of white pine is not surprising given the natural distribution of this species throughout the New England forested landscape.

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

Considering the large quantity of Norway maple in the town's tree population, a known invasive species, and its susceptibility to Asian longhorned beetle (*Anoplophora glabripennis*), the planting of Norway maple should not be considered. See Appendix C for a recommended tree species list for planting.

Diameter Size Class Distribution

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

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

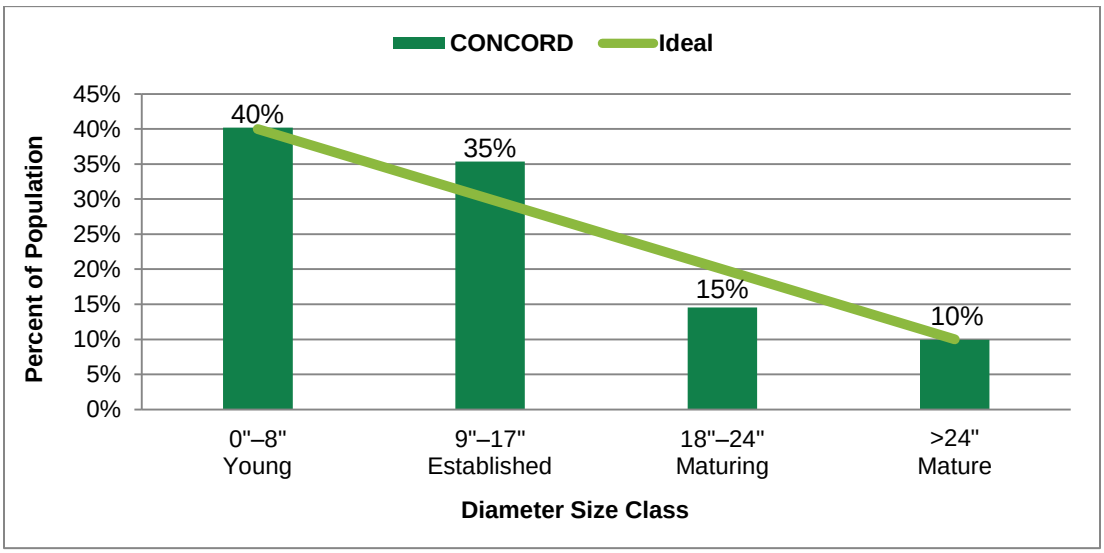


Figure 4. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Findings

Figure 4 compares Concord's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). Concord's distribution trends towards the ideal. Young trees comprise 40% of the inventoried tree population; established trees make up 5% more than the ideal for this size class; maturing trees fall short of the ideal by 5%; and mature trees meet the ideal distribution of 10%.

Discussion/Recommendations

In order to maintain this healthy diameter size class distribution, Davey Resource Group recommends that Concord continues to support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in tree canopy and replace older declining trees. The town must continue to promote tree preservation and proactive tree care to ensure the long-term survival of older trees. Tree planting and tree care will allow the distribution to normalize over time.

Appendix D provides more information on the value of tree planting, species selection, and tips for planting trees.

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

Condition

Davey Resource Group assessed the condition of individual trees based on methods defined by the International Society of Arboriculture (ISA). Several factors were considered for each tree, including root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition of each inventoried tree was rated as Good, Fair, Poor, or Dead.

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

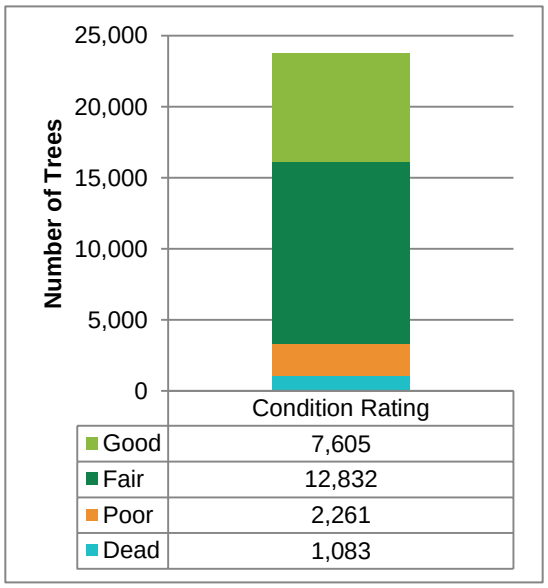


Figure 5. Conditions of inventoried trees.

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

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

Findings

Most of the inventoried trees were recorded to be in Fair or Good condition (54% and 32%, respectively) (Figure 5). Based on these data, the general health of the overall inventoried tree population is rated Fair. Figure 6 illustrates that most of the young, established, maturing, and mature trees were rated to be in Fair condition.

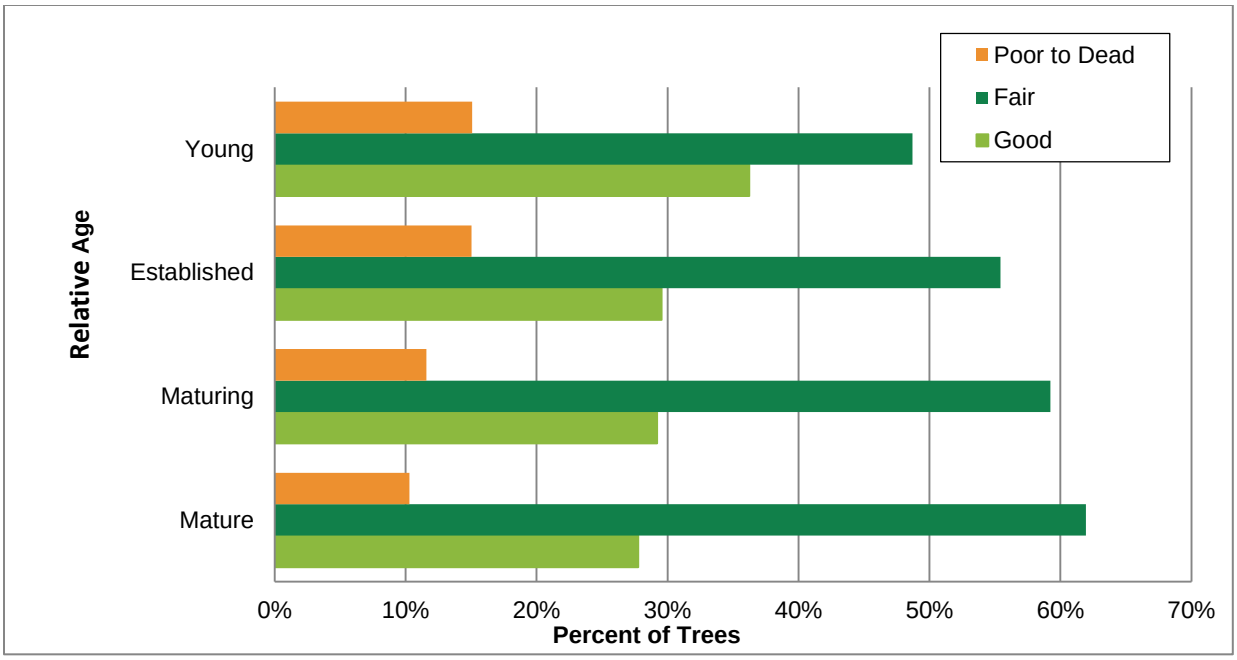


Figure 6. Tree condition by relative age during the 2017 inventory.

Discussion/Recommendations

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

- The similar trend in condition across street and park trees reveals that growing conditions and/or past management of trees were consistent.
- Dead trees should be removed because of their failed health; these trees will not recover, even with increased care.
- Younger trees rated in Fair or Poor condition may benefit from improvements in structure that may improve their health over time. Pruning should follow *ANSI A300 (Part 1)* (ANSI 2008).
- Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, crown dieback, or poor structure. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Proper tree care practices are needed for the long-term general health of the urban forest. Following guidelines developed by ISA and those recommended by *ANSI A300 (Part 6)* (ANSI 2012) will ensure that tree maintenance practices ultimately improve the health of the urban forest.

Street ROW Stocking Level

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

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

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

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

Findings

The inventory found 2,135 planting sites within the street ROW. Of the inventoried street ROW sites, 249 were potential planting sites for large-size trees (8-foot-wide and greater growing space size); 307 were potential sites for medium-size trees (6- to 7-foot-wide growing space sizes); and 1,579 were potential sites for small-size trees (4- to 5-foot-wide growing space sizes and/or presence of overhead utilities). Based on the data collected during this inventory, Concord's current street ROW tree stocking level is 91%.

Discussion/Recommendation

Fully stocking the street ROW with trees is an excellent goal. Inadequate tree planting and maintenance budgets, along with tree mortality, will result in lower stocking levels. Nevertheless, working to attain a fully stocked street ROW is important to promote canopy continuity and environmental sustainability. The town should consider adopting a plan that works to maintain a stocking level of at least 90%. Generally, this entails a planned program of planting, care, and maintenance for the town's street trees. If possible, exceed this recommendation to better prepare for impending threats and to increase the benefits provided by the urban forest.

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

Concord's ratio of street trees per capita is 1.12, which falls well above the mean ratio of 0.37 reported for 22 U.S. cities (McPherson and Rowntree 1989). According to the citywide study, there is 1 tree for every 3.3 residents. Concord's potential is 1 tree for every 0.81 residents.

Inventory Pest Evaluation and Detection (IPED)

Urban areas are frequently the first site of introduction for exotic pests, where they remain undetected until populations are well established and have had harmful impacts on the health of host trees. Many communities routinely complete and update tree inventories, but often overlook pest invasions because pest detection tools are not part of the inventory process. There are also no processes in place for aggregating pest inventory data into a standardized form, which would allow communities to analyze pest trends that are otherwise difficult to detect beyond geographic or political boundaries.

Benefits of Pest Detection

The goal of using IPED during Concord's inventory was to establish standard observations that can be used to compare the signs and symptoms of any emerging pest threats that may arise in the area. For example, emerging pest threats such as emerald ash borer, ash yellows (*Candidatus phytoplasma)*, and oak wilt (*Ceratocystis fagacearum)* may be more effectively managed by using this data. The benefits of pest detection are numerous and include the following:

- Increase and broaden efforts to detect exotic pests.
- Increase awareness of the need for routine tree health assessments.
- Provide a standardized method for integrating pest detection with urban forest management.
- Improve opportunities to control pests while invasions are still manageable.
- Reduce unchecked movement of pests across geographic and political boundaries.
- Reduce costs for long-term tree management, removal, and replacement.
- Provide a tool for integrating pest detection with more innovative, technologically advanced tree inventory and assessment tools.

Findings

Within the branches and bole of the inventoried trees, decay was the most common sign of disease, identified in approximately 5% of the entire inventoried tree population. Of the five most common genera inventoried, decay was most common in oak (7% of all oaks inventoried) and maple (5% of all maples inventoried). Carpenter ants were the most common insect found, identified in 125 trees (less than 1% of the inventoried tree population).

Within the foliage, minor to moderate defoliation (defoliation greater than 10% but not pervasive) was the most common pest indicator, occurring in roughly 6% of the inventoried tree population. Of the five most common genera inventoried, defoliation was most common in maple, with minor to moderate defoliation identified in approximately 16% of all maples inventoried. Mottling, spots, or blotches (any color) were identified in roughly 3% of inventoried trees. Of these 773 trees, 577 were *Acer platanoides* (Norway maple). The majority of the spotting observed on Norway maple was caused by giant tar spot.

Minor to moderate crown dieback was identified in 9% of trees inventoried. Pervasive dieback was identified in 4% of trees. Of the five most common genera inventoried, crown dieback was most commonly identified in *Tsuga* (hemlock). Approximately 15% of hemlocks inventoried were identified as having minor to moderate crown dieback, and roughly 9% of hemlocks had pervasive crown dieback. Although not one of the most common genera, pervasive crown dieback was notably identified in 15% of all *Fraxinus* (ash) trees inventoried.

Epicormic sprouts were identified in approximately 9% of inventoried trees.

Topping/poor pruning and wounding of woody tissue were the most common human-induced stressors identified in trees, with almost 3% of trees topped or poorly pruned and almost 3% of trees wounded. The primary causes of which are a result of line clearance activities and homeowner pruning.

Hemlock woolly adelgid (*Adelges tsugae*) and gypsy moth (*Lymantria dispar dispar*) were the most common pests positively identified (found in 133 and 47 trees, respectively).

Discussion/Recommendations

Wood decay is a common occurrence among trees. Decay can affect the roots, sapwood, or heartwood of a tree. Some trees may appear to be healthy yet have extensive decay. Trees with extensive decay are structurally weakened. Trees with decay should be monitored; if decay continues to spread, removal should be considered.

Defoliation is defined as wholly or partially eaten foliage. Many insects feed by eating only the softer parts of leaves, resulting in a skeletonizing effect. Certain caterpillars such as gypsy moth and winter moth have caused extensive damage to trees in New England. Most trees can withstand single defoliation events. However, if trees are defoliated over multiple consecutive seasons, the overall health of the tree may begin to decline. Outbreaks of gypsy moth and winter moth should be monitored; if defoliation of trees continues year after year, a plan should be adopted to manage these outbreaks. A level one assessment has been accounted for in the budget to monitor areas with high percentage of host trees each year.

Crown dieback is the dying back of branches and branch tips generally in the upper and outer portions of the tree crown. Dieback often occurs as a sign of stress but may be associated with a new pest or disease. Trees identified as displaying minor to moderate crown dieback should be monitored. Trees identified as displaying pervasive dieback should be considered for removal, as the tree may not be able to recover from its current condition due to a severe amount of stress.

Topping is a pruning practice that harms trees and should not be used. Topping, the pruning of large upright branches between nodes, is sometimes performed to reduce the height of a tree (especially for the purpose of utility line clearance). Topping results in epicormic sprouting (weakly attached branches) and contributes to branch death to the next lateral branch below. Poor pruning practices such as tipping, bark cutting, and flush cutting result in bark ripping and the dying back of branch stubs. Poor pruning also provides entry points for canker fungi that kill the cambium, and prevents or delays woundwood formation.

Potential Threats from Pests

Insects and diseases pose serious threats to tree health. Awareness and early diagnosis are essential to ensuring the health and continuity of street and park trees. Appendix E provides information about some of the current potential threats to Concord's trees and includes websites where more detailed information can be found.

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

Findings

Gypsy moth (*Lymantria dispar dispar*), winter moth (*Operophtera brumata*), and Asian longhorned beetle (ALB or *Anoplophora glabripennis*) are known threats to a large percentage of the inventoried street trees (52%, 51%, and 30%, respectively). Gypsy moth and winter moth have been detected in Concord. ALB has not been detected in Concord, but if it was detected the town could see severe losses in its tree population.

Although *Tsuga* spp. (hemlock) comprise only about 4% of the total inventoried tree population (881 trees), hemlock woolly adelgid (*Adelges tsugae*) was positively identified in 133 of these trees (15%). In the absence of these natural control elements in eastern North America, this introduced insect pest attacks both eastern (Canadian) and Carolina hemlock which are often damaged and killed within a few years of becoming infested.

While not identified positively during the inventory, emerald ash borer (EAB) is an imminent threat and poses risk to the health and condition of Concord's urban forest. EAB potentially affects 3% of the total inventoried population; effective management and monitoring of EAB is important.

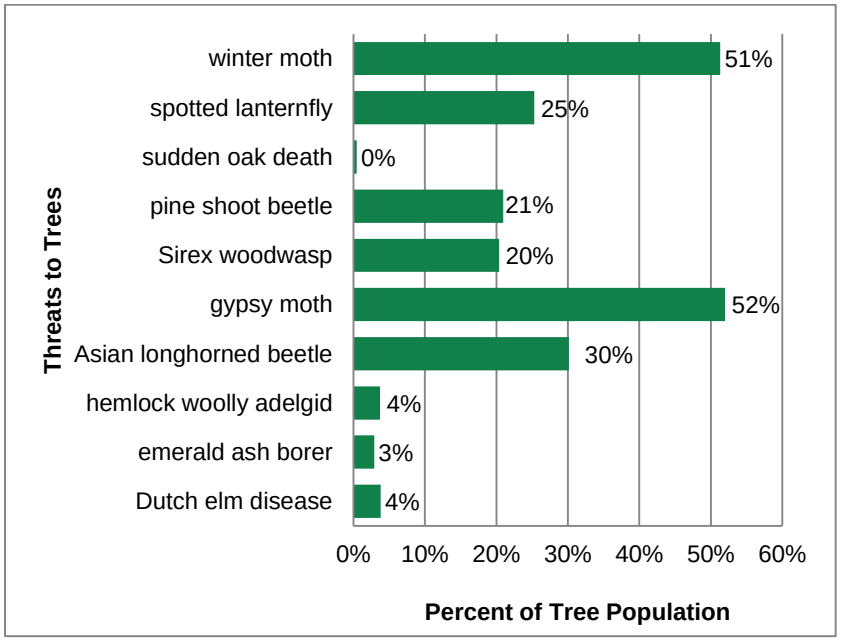


Figure 7. Potential impact of insect and disease threats noted during the 2017 inventory.

Discussion/Recommendations

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

Although emerald ash borer was not positively identified during this inventory, it is an impending threat to the area. A windsheld survey should be performed each year to monitor for this and other invasive pests.

Other Observations

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

Findings

Poor structure and cavity or decay were most frequently observed and recorded (6% and 3% of inventoried trees, respectively). Of these 2,121 trees, 222 were recommended for removal, and 21 were rated to be High or Extreme Risk trees.

Mechanical Damage was recorded for 682 trees.

Table 1. Observations Recorded During the Street Tree Inventory

Observation	Number of Trees	Percent
Poor Structure	1,375	5.79%
Cavity or Decay	747	3.13%
Mechanical Damage	682	2.88%
Improperly Pruned	658	2.78%
Serious Decline	501	2.10%
Poor Location	259	1.09%
Poor Root System	159	0.67%
Improperly Mulched	118	0.50%
Pest Problem	94	0.40%
Nutrient Deficiency	28	0.12%
Memorial Tree	11	0.05%
Improperly Installed	9	0.04%
Removed Hardware	7	0.03%
Grate or Guard	5	0.02%
None	19,128	80.40%
Total	**23,781**	**100%**

Discussion/Recommendations

Unless slated for removal, trees noted as having poor structure (1,375 trees) or cavity or decay (747 trees) should be regularly inspected. Corrective actions should be taken when warranted. If their condition worsens, removal may be required. Of the 747 trees noted for cavity or decay, 147 were recommended for removal. Of the 1,375 trees noted for poor structure, only 75 were recommended for removal.

Mechanical damage was most likely caused by impact from motor vehicles or landscaping equipment. Street trees noted as having mechanical damage should be assessed to ensure their location is not impeding traffic or causing a driving hazard. Of the 682 trees noted as having mechanical damage, 565 are within the ROW.

Further Inspection

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

Findings

Davey Resource Group recommended 423 trees for further inspection.

Discussion/Recommendations

An ISA or Massachusetts Certified Arborist should perform additional inspections of the trees. If it is determined that these trees exceed the threshold for acceptable risk, the defective part(s) of the trees should be corrected or removed, or the entire tree may need to be removed. It is recommended that these trees be inspected at least once per year as funding allows.

SECTION 2: TREE MANAGEMENT PROGRAM

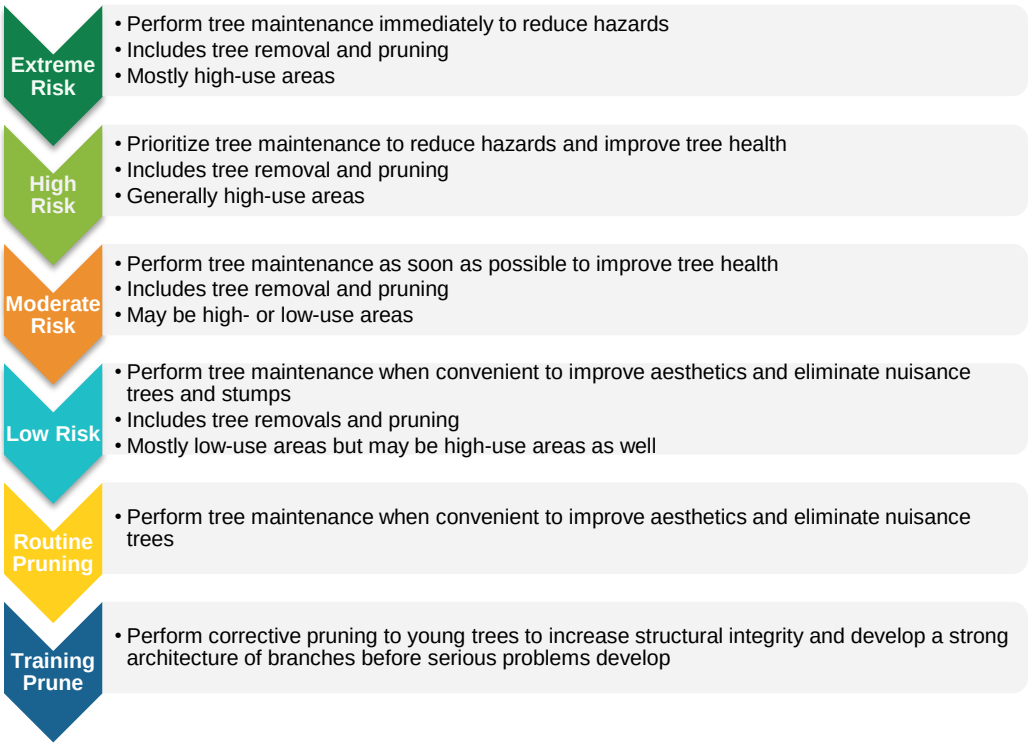
The recommendations of the tree management program were developed to uphold Concord's comprehensive vision for preserving its urban forest. This seven-year program is based on the tree inventory data; the program was designed to reduce risk through prioritized tree removal and pruning, and to improve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

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

Priority and Proactive Maintenance

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

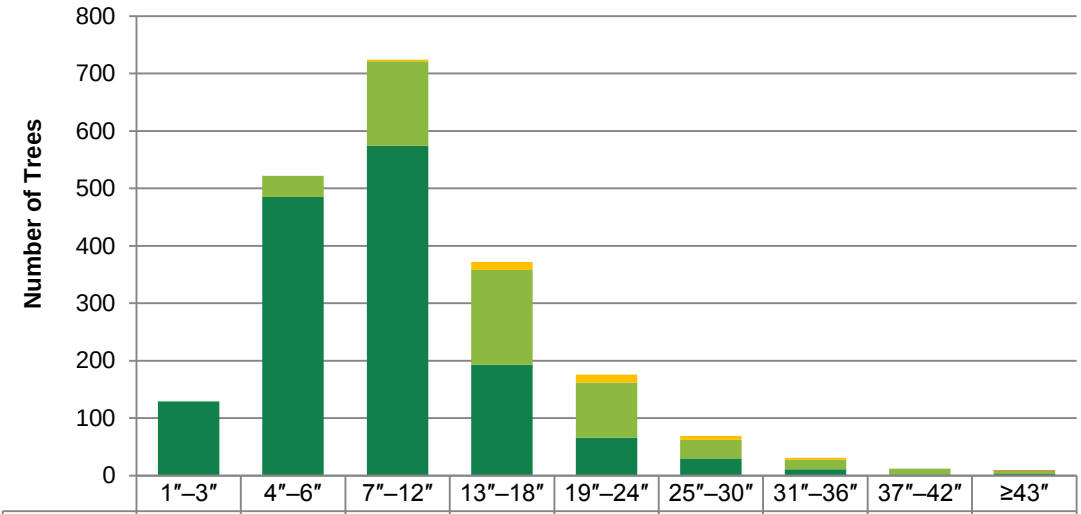
Tree and Stump Removal



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

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

Figure 8 presents tree removals by risk rating and diameter size class. The following sections briefly summarize the recommended removals identified during the inventory.



	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Extreme	0	0	0	0	0	0	0	0	1
High	0	0	3	14	14	7	3	0	0
Moderate	0	37	147	165	96	32	17	10	4
Low	129	485	574	193	66	30	11	2	4

Diameter Size Class

Figure 8. Tree removals by risk rating and diameter size class.

Findings

Although not conclusive, the inventory identified 1 Extreme Risk tree, 41 High Risk trees, 511 Moderate Risk trees, and 1,496 Low Risk trees that are recommended for removal.

The diameter size classes for High Risk trees ranged between 7–12 inches in diameter at breast height (DBH) and 31–36 inches DBH. These trees should be removed as resources allow based on their assigned risk. Extreme and High Risk removals and pruning can be performed concurrently.

Most Moderate Risk trees were smaller than 31 inches DBH. These trees should be removed as soon as possible after all Extreme and High Risk removals and pruning have been completed.

Low Risk removals pose little threat; these trees are generally small, dead, invasive, or poorly formed trees that need to be removed. Eliminating these trees will reduce breeding site locations for insects and diseases and will increase the aesthetic value of the area. Healthy trees growing in poor locations or undesirable species are also included in this category. All Low Risk trees should be removed when convenient and after all High and Moderate Risk removals and pruning have been completed. The town estimates it can effectively remove up to 250 per year based on current resources. This leaves out 329 trees marked for removal that were assigned a Low risk rating. These 329 trees are all 6 DBH or less.

The inventory identified 224 ash trees recommended for removal.

The inventory also identified 846 stumps recommended for removal. Almost all of these stumps were smaller than 31 inches in diameter. Stump removals should occur when convenient.

Discussion/Recommendations

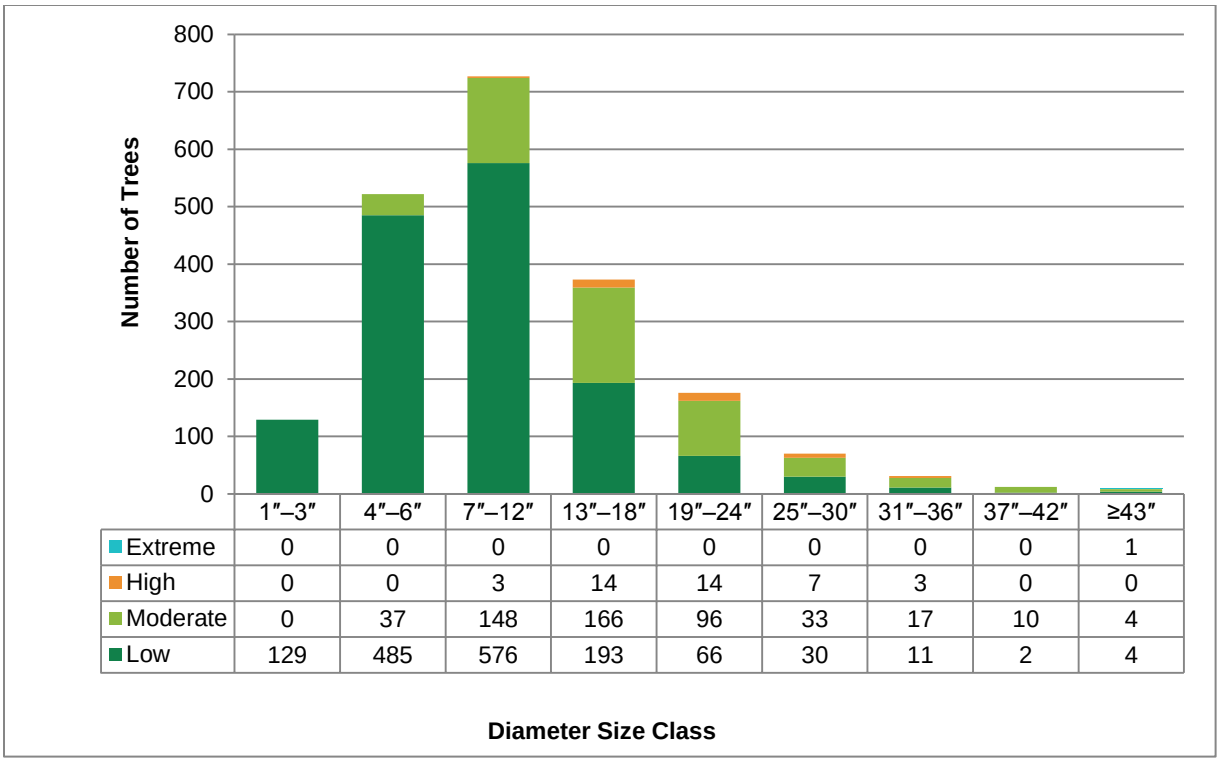
Unless already slated for removal, trees noted as having poor structure (1,375 trees) or cavity or decay (747 trees) should be inspected on a regular basis. This plan's budget includes funds earmarked to perform Level 1 assessments at these sites each year. Corrective action should be taken when warranted. If their condition worsens, tree removal may be required. Proactive tree maintenance that actively mitigates elevated-risk situations will promote public safety. See Appendix B for more information on risk assessment and priority maintenance.

Updating the tree inventory data can streamline workload management and lend insight into setting accurate budgets and staffing levels. Inventory updates should be made electronically and can be implemented using *TreeKeeper® 8.0* or similar computer software.

Tree Pruning

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

Figure 9 presents the number of High Risk trees recommended for pruning by size class. The following sections briefly summarize the recommended pruning maintenance identified during the inventory.



	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Extreme	0	0	0	0	0	0	0	0	1
High	0	0	3	14	14	7	3	0	0
Moderate	0	37	148	166	96	33	17	10	4
Low	129	485	576	193	66	30	11	2	4

Figure 9. Extreme and High Risk pruning by diameter size class.

Findings

The inventory identified 0 Extreme Risk trees, 38 High Risk trees, and 680 Moderate Risk trees recommended for pruning. High Risk trees ranged in diameter size classes from 7–12 inches DBH to greater than 43 inches DBH.

The inventory found that most trees on the street ROW were Low risk. Low risk trees can be effectively addressed if an annual windshield survey is completed to re-prioritize pruning needs Town-wide.

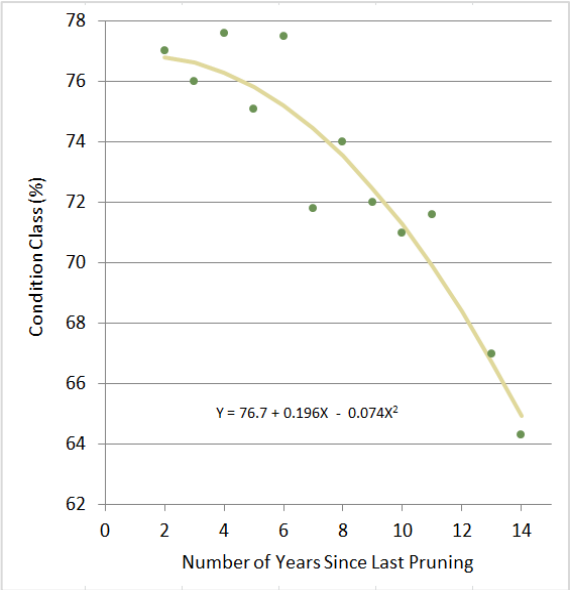


Figure 10. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

Discussion/Recommendations

Pruning should be performed based on assigned risk and may be accomplished concurrently with other Extreme and High Risk removals. Moderate Risk trees recommended for pruning are scheduled to begin in Year 4 and should be included in a proactive, routine pruning cycle after all of the higher risk trees are addressed. Level 1 inspections will observe Low Risk trees, and determine if further maintenance action is required.

Pruning Cycles

The goals of pruning cycles are to visit, assess, and prune trees on a regular schedule to improve health and reduce risk. Davey Resource Group and the town determined that proactive, young tree training is a priority for Concord's future urban forest health and structure.

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

Why Prune Trees on a Cycle?

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

Young Tree Training Cycle

Trees included in the YTT Cycle are generally no more than 8 inches DBH. These younger trees sometimes have branch structures that can lead to potential problems as the tree ages. Potential structural problems include codominant leaders, multiple limbs attaching at the same point on the trunk, or crossing/interfering limbs. If these problems are not corrected, they may worsen as the tree grows, increasing risk and creating potential liability.

YTT pruning is performed to improve tree form or structure; the recommended length of a YTT Cycle is three years because young trees tend to grow at faster rates (on average) than more mature trees. Trees in the YTT Cycle generally can be pruned from the ground with a pole pruner or pruning shear. The objective is to increase structural integrity by pruning for one dominant leader. YTT Pruning is species-specific, since many trees such as *Betula nigra* (river birch) may naturally have more than one leader. For such trees, YTT pruning is performed to develop a strong structural architecture of branches so that future growth will lead to a healthy, structurally sound tree.

Discussion/Recommendations

Davey Resource Group recommends that Concord implement a three-year YTT Cycle to begin after all Extreme and High Risk trees are removed or pruned. The YTT Cycle will include existing young trees. During the inventory, 1,675 trees smaller than 9 inches DBH were inventoried and recommended for young tree training (Figure 11). Since the number of existing young trees is relatively small, and the benefit of beginning the YTT Cycle is substantial, Davey Resource Group recommends that all 1,675 trees be structurally pruned at least once during the first three years of the overall management program, or approximately 558 trees per year.

As new trees are planted they will need to enter the YTT Cycle after establishment, typically a few years after planting. This was accounted for in Year 4 of the budget by including 250 trees per year throughout the remaining years in the overall program.

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

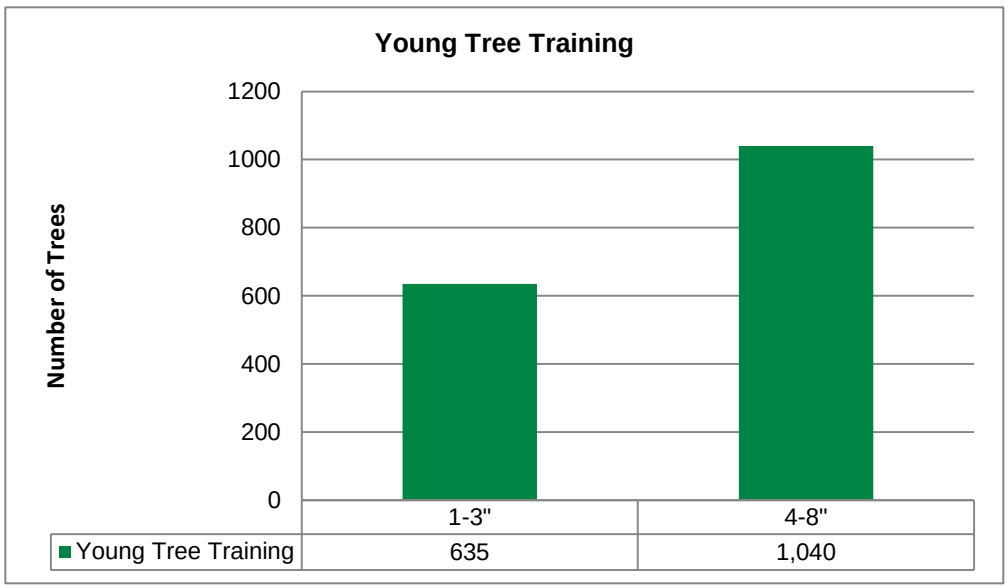


Figure 11. Trees recommended for the YTT Cycle by diameter size class.

Maintenance Schedule

Utilizing data from the 2017 Town of Concord tree inventory, an annual maintenance schedule was developed that details the number and type of tasks recommended for completion each year. Davey Resource Group made budget projections based on industry knowledge and estimated unit rates that are representative of the cost of using contractual services. CPW is fortunate to have a highly productive and skilled tree crew that can perform the majority of this work in-house. It is recommended to utilize the town's staff as much as possible for tree maintenance and planting work and to use contractors to supplement as needed. A complete table of estimated costs for Concord's seven-year tree management program is presented on the following page (Table 2).

To implement the maintenance schedule, the town's tree maintenance budget should be no less than $259,597 for the first year of implementation, no less than $230,888 for the second year, no less than $244,933 for the third year, no less than $233,848 for the fourth year, no less than $201,103 for the fifth year, no less than $200,600 for the sixth year, and no less than 182,595 for the seventh year of the maintenance schedule. Annual budget funds are needed to ensure that Extreme and High risk trees are remediated and that crucial YTT and RP Cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

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

Table 2. Estimated Costs for Seven-Year Urban Forestry Management Program

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Seven-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Extreme and High Risk Removals (Year 1)	1-3"	$28	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$58	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$138	3	$413	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$413
	13-18"	$314	14	$4,389	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$4,389
	19-24"	$605	14	$8,470	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$8,470
	25-30"	$825	7	$5,775	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$5,775
	31-36"	$1,045	3	$3,135	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$3,135
	37-42"	$1,485	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$2,035	1	$2,035	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$2,035
Activity Total(s)			**42**	**$24,217**	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	**$24,217**
Moderate Risk Removals (Years 1–3)	1-3"	$28	0	$0		$0		$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$58	0	$0	0	$0	37	$2,128	0	$0	0	$0	0	$0	0	$0	$2,128
	7-12"	$138	0	$0	39	$5,363	109	$14,988	0	$0	0	$0	0	$0	0	$0	$20,350
	13-18"	$314	0	$0	166	$52,041		$0	0	$0	0	$0	0	$0	0	$0	$52,041
	19-24"	$605	51	$30,855	45	$27,225	0	$0	0	$0	0	$0	0	$0	0	$0	$58,080
	25-30"	$825	33	$27,225		$0	0	$0	0	$0	0	$0	0	$0	0	$0	$27,225
	31-36"	$1,045	17	$17,765		$0	0	$0	0	$0	0	$0	0	$0	0	$0	$17,765
	37-42"	$1,485	10	$14,850		$0	0	$0	0	$0	0	$0	0	$0	0	$0	$14,850
	43"+	$2,035	4	$8,140		$0	0	$0	0	$0	0	$0	0	$0	0	$0	$8,140
Activity Total(s)			**115**	**$98,835**	**250**	**$84,629**	**146**	**$17,115**	0	$0	0	$0	0	$0	0	$0	**$200,579**
Low Risk Removals (Years 3-7)	1-3"	$28	0	$0		$0		$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$58	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	222	$12,765	$12,765
	7-12"	$138	0	$0	0	$0	0	$0	48	$6,600	250	$34,375	250	$34,375	28	$3,850	$79,200
	13-18"	$314	0	$0	0	$0		$0	193	$60,506	0	$0	0	$0	0	$0	$60,506
	19-24"	$605	0	$0	0	$0	57	$34,485	9	$5,445	0	$0	0	$0	0	$0	$39,930
	25-30"	$825	0	$0		$0	30	$24,750	0	$0	0	$0	0	$0	0	$0	$24,750
	31-36"	$1,045	0	$0		$0	11	$11,495	0	$0	0	$0	0	$0	0	$0	$11,495
	37-42"	$1,485	0	$0		$0	2	$2,970	0	$0	0	$0	0	$0	0	$0	$2,970
	43"+	$2,035	0	$0		$0	4	$8,140	0	$0	0	$0	0	$0	0	$0	$8,140
Activity Total(s)			0	$0	0	$0	**104**	**$81,840**	**250**	**$72,551**	**250**	**$34,375**	**250**	**$34,375**	**250**	**$16,615**	**$239,756**
Stump Removals (Years 2-4)	1-3"	$18	0	$0	15	$263	15	$263	15	$263	0	$0	0	$0	0	$0	$788
	4-6"	$28	0	$0	42	$1,155	41	$1,128	41	$1,128	0	$0	0	$0	0	$0	$3,410
	7-12"	$44	0	$0	77	$3,388	77	$3,388	77	$3,388	0	$0	0	$0	0	$0	$10,164
	13-18"	$72	0	$0	63	$4,505	63	$4,505	62	$4,433	0	$0	0	$0	0	$0	$13,442
	19-24"	$94	0	$0	43	$4,021	42	$3,927	42	$3,927	0	$0	0	$0	0	$0	$11,875
	25-30"	$110	0	$0	26	$2,860	25	$2,750	25	$2,750	0	$0	0	$0	0	$0	$8,360
	31-36"	$138	0	$0	10	$1,375	10	$1,375	9	$1,238	0	$0	0	$0	0	$0	$3,988
	37-42"	$160	0	$0	5	$798	5	$798	5	$798	0	$0	0	$0	0	$0	$2,393
	43"+	$182	0	$0	4	$726	4	$726	3	$545	0	$0	0	$0	0	$0	$1,997
Activity Total(s)			0	$0	**285**	**$19,089**	**282**	**$18,858**	**279**	**$18,468**	0	$0	0	$0	0	$0	**$56,415**
Extreme and High Risk Pruning (Year 1)	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	1	$75	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$75
	13-18"	$120	3	$360	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$360
	19-24"	$170	6	$1,020	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$1,020
	25-30"	$225	16	$3,600	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$3,600
	31-36"	$305	6	$1,830	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$1,830
	37-42"	$380	5	$1,900	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$1,900
	43"+	$590	1	$590	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$590
Activity Total(s)			**38**	**$9,375**	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	**$9,375**
Moderate Risk Pruning (Years 4-7)	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	1	$30	1	$30	1	$30	$90
	7-12"	$75	0	$0	0	$0	0	$0	0	$0	17	$1,275	17	$1,275	16	$1,200	$3,750
	13-18"	$120	0	$0	0	$0	0	$0	0	$0	48	$5,760	48	$5,760	48	$5,760	$17,280
	19-24"	$170	0	$0	0	$0	0	$0	0	$0	60	$10,200	60	$10,200	59	$10,030	$30,430
	25-30"	$225	0	$0	0	$0	0	$0	0	$0	54	$12,150	53	$11,925	53	$11,925	$36,000
	31-36"	$305	0	$0	0	$0	0	$0	0	$0	28	$8,540	27	$8,235	27	$8,235	$25,010
	37-42"	$380	0	$0	0	$0	0	$0	5	$1,900	10	$3,800	10	$3,800	10	$3,800	$13,300
	43"+	$590	0	$0	0	$0	0	$0	27	$15,930	0	$0	0	$0	0	$0	$15,930
Activity Total(s)			0	$0	0	$0	0	$0	**32**	**$17,830**	**218**	**$41,755**	**216**	**$41,225**	**214**	**$40,980**	**$141,790**
Young Tree Training Pruning (3-year cycle)	1-3"	$20	213	$4,260	213	$4,260	212	$4,240	250	$5,000	250	$5,000	250	$5,000	250	$5,000	$22,760
	4-8"	$30	347	$10,410	347	$10,410	346	$10,380	250	$7,500	250	$7,500	250	$7,500	250	$7,500	$46,200
Activity Total(s)			**560**	**$14,670**	**560**	**$14,670**	**558**	**$14,620**	**500**	**$12,500**	**500**	**$12,500**	**500**	**$12,500**	**500**	**$12,500**	**$93,960**
New Tree Planting	Purchasing	$100	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	$125,000
	Planting	$110	250	$27,500	250	$27,500	250	$27,500	250	$27,500	250	$27,500	250	$27,500	250	$27,500	$137,500
Activity Total(s)			**500**	**$52,500**	**500**	**$52,500**	**500**	**$52,500**	**500**	**$52,500**	**500**	**$52,500**	**500**	**$52,500**	**500**	**$52,500**	**$367,500**
New Tree Planting Maintenance	Mulching	$100	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	$125,000
	Watering	$100	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	250	$25,000	$125,000
Activity Total(s)			**500**	**$50,000**	**500**	**$50,000**	**500**	**$50,000**	**500**	**$50,000**	**500**	$50,000	**500**	$50,000	**500**	$50,000	**$350,000**
Contractor Inspections	Level 1 assessment	**$10,000**	1	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	**$70,000**
Activity Total(s)			**1**	**$10,000**	**1**	**$10,000**	**1**	**$10,000**	**1**	**$10,000**	**1**	**$10,000**	**1**	**$10,000**	**1**	**$10,000**	**$70,000**
Activity Grand Total			**1,756**		**2,096**		**2,091**		**2,062**		**1,969**		**1,967**		**1,965**		
Cost Grand Total				**$259,597**		**$230,888**		**$244,933**		**$233,848**		**$201,130**		**$200,600**		**$182,595**	**$1,553,590**

Community Outreach

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

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

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

Concord's data are instrumental in helping to provide tangible and meaningful outreach about the urban forest.

Inspections

Inspections are essential to uncovering potential problems with trees. They should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees. Arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care.

Trees along the street ROW should be regularly inspected and attended to as needed based on the inspection findings. When trees need additional or new work, they should be added to the maintenance schedule and budgeted as appropriate. Use appropriate computer management software such as *TreeKeeper® 8.0* to update inventory data and work records. In addition to locating potential new hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. Concord has a large population of trees that are susceptible to pests and diseases, such as oak, maple, ash, and hemlock.

A Level 1 inspection is included in this budget for trees that can't be addressed in Year 1 and following years to see if Risk has increased. It also includes areas with large host populations to be inspected for pests. A tree that was marked for further inspection in this inventory would need at least a Level 2 inspection, but could require a Level 3 (a bucket truck or resistograph may be required).

Inventory and Plan Updates

Davey Resource Group recommends that the inventory and management plan be updated using an appropriate computer software program so that the town can sustain its program and accurately project future program and budget needs:

- Conduct inspections of trees after all severe weather events. Record changes in tree condition, maintenance needs, and risk rating in the inventory database. Update the tree maintenance schedule and acquire the funds needed to promote public safety. Schedule and prioritize work based on risk.
- Perform routine inspections of public trees as needed. Windshield surveys (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* (ANSI 2011) will help the town staff stay apprised of changing conditions. Update the tree maintenance schedule and the budget as needed so that identified tree work may be efficiently performed. Schedule and prioritize work based on risk.
- If the recommended work cannot be completed as suggested in this plan, modify maintenance schedules and budgets accordingly.
- Update the inventory database using *TreeKeeper® 8.0* as work is performed. Add new tree work to the schedule when work is identified through inspections or a citizen call process.
- Re-inventory the street ROW, and update all data fields in seven years, or a portion of the population (1/7) every year over the course of seven years.
- Revise the *Tree Management Plan* after five to seven years when the re-inventory has been completed.

CONCLUSIONS

Every hour of every day, public trees in Concord are supporting and improving the quality of life. When properly maintained, trees provide numerous environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

Managing trees in urban areas is often complicated. Navigating the recommendations of experts, the needs of residents, the pressures of local economics and politics, concerns for public safety and liability, physical components of trees, forces of nature and severe weather events, and the expectation that these issues are resolved all at once is a considerable challenge.

The town must carefully consider these challenges to fully understand the needs of maintaining an urban forest. With the knowledge and wherewithal to address the needs of the town's trees, Concord is well positioned to thrive. If the management program is successfully

Photograph 3. *A street well stocked with trees provides economic, environmental, and social benefits, including temperature moderation, reduction of air pollutants, energy conservation, and increased property values.*

implemented, the health and safety of Concord's trees and citizens will be maintained for years to come.

GLOSSARY

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

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

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

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

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

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.

community forest: see **urban forest**.

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

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

diameter: See **tree size**.

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

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

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

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

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

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

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

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

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**.

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

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

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

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

Moderate Risk tree: The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are

"significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.

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

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

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

notes (data field): Describes additional pertinent information.

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

ordinance: See **tree ordinance**.

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

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

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

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

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

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

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

Restore (Secondary Maintenance Need): Signifies a maintenance need for a tree. Restoring is selective pruning to improve the structure, form, and appearance of trees that have been severely headed, vandalized, or damaged.

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

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

risk assessment (data fields): The risk assessment is a point-based assessment of each tree by an arborist using a protocol based on the U.S. Forest Service Community Tree Risk Rating System. In the field, the probability of tree or tree part failure is assigned 1–4 points (identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions), the size of the defective tree part is assigned 1–3 points

(rates the size of the part most likely to fail), the probability of target impact by the tree or tree part is assigned 1–3 points (rates the use and occupancy of the area that would be struck by the defective part), and other risk factors are assigned 0–2 points (used if professional judgment suggests the need to increase the risk rating). The data from the risk assessment is used to calculate the risk rating that is ultimately assigned to the tree.

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

Secondary Maintenance Need (data field): Recommended maintenance for a tree, which may be risk oriented, such as raising the crown for clearance, but generally was geared toward improving the structure of the tree and enhancing aesthetics.

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

site number (data field): All sites at an address are assigned a *site number*. Sites numbers are not unique; they are sequential to the side of the address only (the only unique number is the tree identification number assigned to each site). Site numbers are collected in the direction of vehicular traffic flow. The only exception is a one-way street. Site numbers along a one-way street are collected as if the street were actually a two-way street, so some site numbers will oppose traffic.

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

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

stems (data field): Identifies the number of stems or trunks splitting less than 1 foot above ground level.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

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

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

• Condition	• Primary maintenance needs
• Further inspection	• Risk assessment
• Grow space size	• Risk rating
• IPED	• Secondary maintenance needs
• Location	• Species
• Mapping coordinates	• Stems
• Notes	• Tree size*
• Observations	

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

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

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

Site Location Methods

Equipment and Base Maps

Inventory arborists use Panasonic Toughpad®.

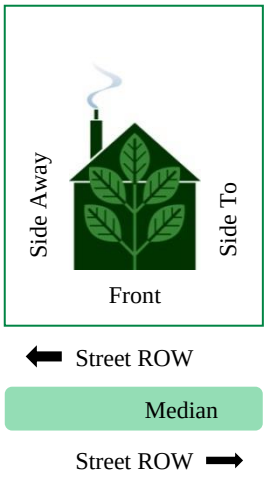
Base map layers were loaded onto these unit(s) to help locate sites during the inventory. The table below lists the base map layers, utilized along with source and format information for each layer.

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Basemap layers/Town of Concord, MA GIS Department	2016-2017	NAD 1983 StatePlane Massachusetts Mainland, Feet
3in Aerial Imagery/Town of Concord, MA GIS Department	2016	NAD 1983 StatePlane Massachusetts Mainland, Feet

Street ROW Site Location

Individual street ROW sites (trees, stumps, or planting sites) were located using a methodology that identifies sites by *address number*, *street name*, *side*, *site number*, or *block side*. This methodology was developed by Davey Resource Group to help ensure consistent assignment of location.



Side values for street ROW sites.

Address Number and Street Name

The *address number* was recorded based on visual observation by the arborist at the time of the inventory (the address number was posted on a building at the inventoried site). Where there was no posted address number on a building, or where the site was located by a vacant lot with no GIS parcel addressing data available, the arborist used his/her best judgment to assign an address number based on opposite or adjacent addresses. An "X" was then added to the number in the database to indicate that it was assigned (for example, "37X Choice Avenue").

Sites in medians or islands were assigned an address number using the address on the right side of the street in the direction of collection closest to the site. Each segment was numbered with an assigned address that was interpolated from addresses facing that median/island. If there were multiple median/islands between cross streets, each segment was assigned its own address.

The *street name* assigned to a site was determined by street ROW parcel information and posted street name signage.

Side Value and Site Number

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

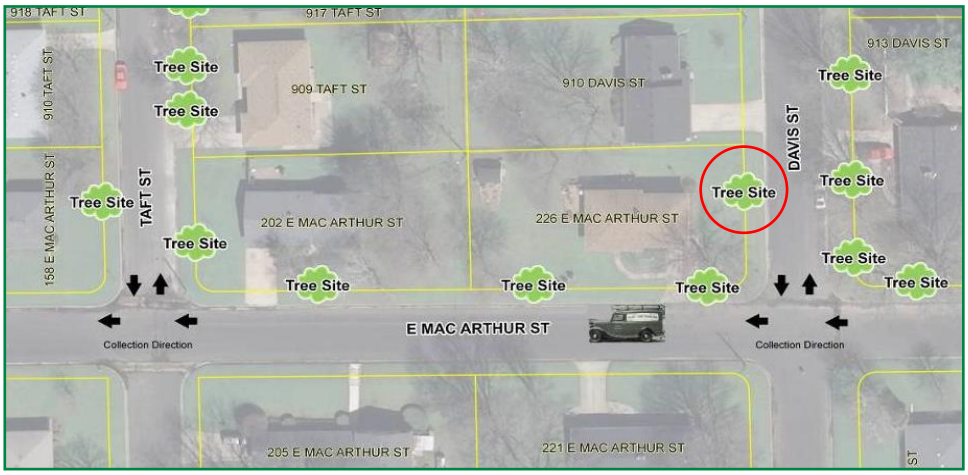
All sites at an address are assigned a *site number*. Site numbers are not unique; they are sequential to the side of the address only. The only unique number is the tree identification number assigned to each site. Site numbers are collected in the direction of vehicular traffic flow. The only exception is a one-way street. Site numbers along a one-way street are collected as if the street was a two-way street; therefore, some site numbers will oppose traffic.

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

Park and/or Public Space Site Location

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

Site Location Examples



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

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

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

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

Corner Lot A

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

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

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

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

Corner Lot B

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

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

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

205 Hoover St.

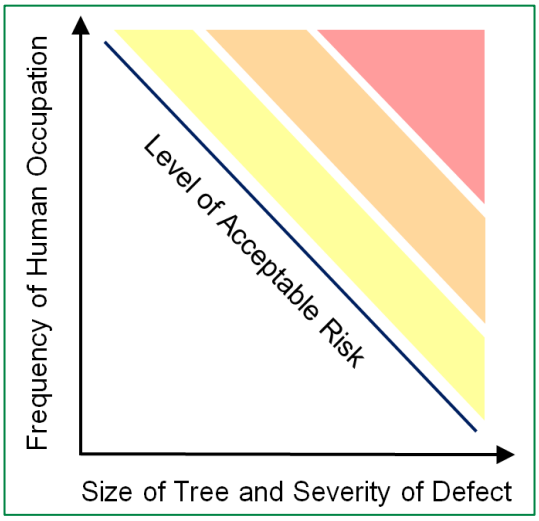
Address/Street Name: 226

Address/Street Name: 226

Address/Street Name: 226

APPENDIX B
RISK ASSESSMENT/PRIORITY AND PROACTIVE MAINTENANCE

Risk Assessment



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

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

- High—The failed tree or branch will most likely impact the target.
  - Fixed target is fully exposed to the tree or tree part

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

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

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

- Medium-sized part striking an occupied vehicle
- Large tree part striking an occupied house
- Serious disruption of high-voltage distribution and transmission power line disruption of arterial traffic or motorways

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

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

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

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

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

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

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

Priority Maintenance

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

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

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

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

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

Proactive Maintenance

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

APPENDIX C
RECOMMENDED SPECIES FOR FUTURE PLANTING

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout 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
Acer rubrum	red maple	Red Sunset®
Acer saccharum	sugar maple	'Legacy'
*Aesculus flava**	yellow buckeye	
*Betula alleghaniensis**	yellow birch	
*Betula lenta**	sweet birch	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
*Carya illinoensis**	pecan	
*Carya lacinata**	shellbark hickory	
*Carya ovata**	shagbark hickory	
*Castanea mollissima**	Chinese chestnut	
Celtis laevigata	sugar hackberry	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(Numerous exist)
Ginkgo biloba	ginkgo	(Choose male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Juglans nigra**	black walnut	
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
*Liriodendron tulipifera**	tuliptree	'Fastigiatum'
*Magnolia acuminata**	cucumbertree magnolia	(Numerous exist)
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	black tupelo	
*Platanus occidentalis**	American sycamore	
Platanus × acerifolia	London planetree	'Yarwood'
Quercus alba	white oak	

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

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

APPENDIX D
TREE PLANTING

Tree Planting

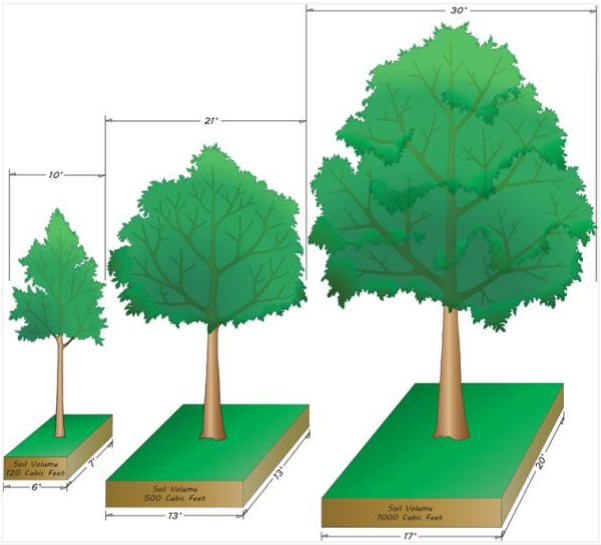
Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the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

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

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

Inventoried Street ROW Planting Space

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



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

Findings

The inventory found 2,128 planting sites, of which 74% are designated for small-sized mature trees, 14% for medium-sized trees, and 12% for large-sized trees. Plant small-sized trees where the growing space is either too small for a medium- or large-sized species or where overhead utilities are present.

Tree Species Selection

Selecting a limited number of species could simplify decision-making processes; however, careful deliberation and selection of a wide variety of species is more beneficial and can save money. Planting a variety of species can decrease the impact of species-specific pests and diseases by limiting the number of susceptible trees in a population. This reduces time and money spent to mitigate pest- or disease-related problems. A wide variety of tree species can help limit the impacts from physical events, as different tree species react differently to stress. Species diversity helps withstand drought, ice, flooding, strong storms, and wind.

Concord is located in USDA Hardiness Zone 6a, which is identified as a climatic region with average annual minimum temperatures between −10°F and −5°F. Tree species selected for planting in Concord should be appropriate for this zone.

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

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

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

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

Davey Resource Group recommends limiting the planting of *Pinus strobus* (white pine) and *Acer platanoides* (Norway maple) until the species distribution normalizes. Of the inventoried population, white pine and Norway maple already occupy 19% and 11%, both of which exceed the recommended 10% species maximum.

Tips for Planting Trees

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

- Handle trees with care. Trees are living organisms and are perishable. Protect trees from damage during transport and when loading and unloading. Use care not to break branches, and do not lift trees by the trunk.
- If trees are stored prior to planting, keep the roots moist.
- Dig the planting hole according to the climate. Generally, the planting hole is two to three times wider and not quite as deep as the root ball. The root flair is at or just above ground level.
- Fill the hole with native soil unless it is undesirable, in which case soil amendments should be added as appropriate for local conditions. Gently tamp and add water during filling to reduce large air pockets and ensure a consistent medium of soil, oxygen, and water.
- Stake the tree as necessary to prevent it from shifting too much in the wind.
- Add a thin layer (1–2 inches) of mulch to help prevent weeds and keep the soil moist around the tree. Do not allow mulch to touch the trunk.

Newly Planted and Young Tree Maintenance

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

Watering

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

Mulching

Mulch can be applied to the growspace around a newly planted tree (or even a more mature tree) to ensure that no weeds grow, that the tree is protected from mechanical damage, and that the growspace is moist. Mulch should be applied in a thin layer, generally 1 to 2 inches. The growing area should be covered. Mulch should not touch the tree trunk or be piled up around the tree.

Lifelong Tree Care

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

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

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

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

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

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

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

APPENDIX E
INVASIVE PESTS AND DISEASES

In today's worldwide marketplace, the volume of international trade brings increased potential for pests and diseases to invade our country. Many of these pests and diseases have seriously harmed rural and urban landscapes and have caused billions of dollars in lost revenue and millions of dollars in clean-up costs. Keeping these pests and diseases out of the country is the number one priority of the United States Department of Agriculture's (USDA) Animal and Plant Inspection Service (APHIS).

Although some invasive species naturally enter the United States via wind, ocean currents, and other means, most invasive species enter the country with some help from human activities. Their introduction to the U.S. is a byproduct of cultivation, commerce, tourism, and travel. Many species enter the United States each year in baggage, cargo, contaminants of commodities, or mail.

Once they arrive, hungry pests grow and spread rapidly because controls, such as native predators, are lacking. Invasive pests disrupt the landscape by pushing out native species, reducing biological diversity, killing trees, altering wildfire intensity and frequency, and damaging crops. Some pests may even push species to extinction. The following sections include key pests and diseases that adversely affect trees in America at the time of this plan's development. This list is not comprehensive and may not include all threats.

It is critical to the management of community trees to routinely check APHIS, USDA Forest Service, and other websites for updates about invasive species and diseases in your area and in our country so that you can be prepared to combat their attack.

APHIS, Plant Health, Plant Pest Program Information
- www.aphis.usda.gov/plant_health/plant_pest_info

The University of Georgia, Center for Invasive Species and Ecosystem Health
- www.bugwood.org

USDA National Agricultural Library
- www.invasivespeciesinfo.gov/microbes

USDA Northeastern Areas Forest Service, Forest Health Protection
- www.na.fs.fed.us/fhp

Asian Longhorned Beetle

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

Adult Asian longhorned beetle

Photograph courtesy of New Bedford Guide 2011

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

Dutch Elm Disease

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

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

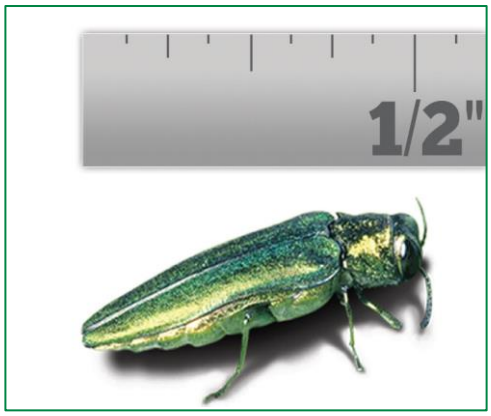
Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011)

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

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

Emerald Ash Borer

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



Close-up of the emerald ash borer

Photograph courtesy of APHIS (2011)

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

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

Gypsy Moth

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

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

Photograph courtesy of APHIS (2011b)

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

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

Hemlock Woolly Adelgid

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

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

The 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 USDA Forest Service (2011a)

Pine Shoot Beetle

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

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

Mined shoots on a Scotch pine

Photograph courtesy of USDA Forest Service (1993)

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

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

Sirex Woodwasp

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

Close-up of female Sirex Woodwasp

Photograph courtesy of USDA (2005)

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

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

Sudden Oak Death

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

Drooping tanoak shoot

Photograph courtesy of Indiana Department of Natural Resources (2012)

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

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