TREE MANAGEMENT PLAN

Town of Pendleton, Indiana

December 2016

Prepared for:
Town of Pendleton
100 West State Street
Pendleton, Indiana 46064

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ACKNOWLEDGMENTS

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

Pendleton is thankful for the grant funding it received from the Indiana Department of Natural Resources, Division of Forestry, Community and Urban Forestry program (IDNR CUF) in cooperation with U.S. Forest Service (USFS) through its Urban and Community Forestry (U&CF) Grant Program. The IDNR CUF grant program is designed to encourage communities to create and support long-term and sustained urban and community forestry programs throughout Indiana.

The town also recognizes the support of the following:

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EXECUTIVE SUMMARY

This plan was developed for the Town of Pendleton 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*. Also included in this plan are economic, environmental, and social benefits provided by the trees in Pendleton.

State of the Existing Urban Forest

The August 2015 inventory included trees and stumps along public street rights-of-way (ROW) and in parks and public properties. The parks and public properties selected for the inventory include: Grovelawn Cemetery, Falls Park, and Falls Park Golf Club. A total of 3,054 sites were recorded during the inventory: 3,014 trees and 40 stumps. Analysis of the tree inventory data found the following:

- One genus townwide, *Acer* (maple), was found in abundance (29%), which is a concern for the town's biodiversity.
- *Fraxinus americana* (white ash) dominates the street ROW (17%) and threatens biodiversity.
- *Acer saccharinum* (silver maple, 13%), *A. saccharum* (sugar maple, 12%), and *Cercis canadensis* (eastern redbud, 11%) exceed the ideal species distributions in the park tree population.
- 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 or better.
- Conflict with overhead utilities and trees occurs with 13% of the population.
- Lifted hardscape caused by trees occurs with 2% of the population.
- The majority of street trees are located in close proximity to single-family residential homes (73%) and grows in open/unrestricted areas (41%).
- Of potential threats from pests, looper complex [(*Erannis tiliaria*) and (*Phigalia titea*)], forest tent caterpillar (*Malacosoma disstria*), and Asian longhorned beetle (ALB or *Anoplophora glabripennis*) pose the biggest threats to the health of the inventoried population. None of these species were observed during the inventory; however, signs and symptoms of emerald ash borer (EAB, *Agrilus planipennis*) were observed during the inventory.
- Pendleton's trees have an estimated replacement value of $3,444,966.
- Trees provide approximately $364,084 in the following annual benefits:
  - *Aesthetic and other benefits*: valued at $91,926 per year.
  - *Air quality*: 6,971 pounds of pollutants removed, valued at $19,534 per year.
  - *Carbon sequestered*: 1,015 tons, valued at $15,230 per year.
  - *Energy*: 555 megawatt-hours (MWh) and 74,562 therms, valued at $80,166 per year.
  - *Stormwater:* 5,801,781 gallons, valued at $157,228 per year.
  - *Return on investment:* $1.45 in benefits for every $1 spent on municipal forestry program.

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 and Stump Removal (18%); Priority Prune (11%); Routine Prune (54%); and Young Tree Train (17%). Maintenance should be prioritized by addressing trees with the highest risk first. The inventory noted many Priority 1 and 2 trees (13% and 12% of trees assessed, respectively); these trees should be removed or pruned immediately to promote public safety. Priority 3 Removals and Routine Pruning should be addressed after all elevated risk tree maintenance has been completed. Young Tree Training should begin as soon as possible for the benefit of the population. Trees should be planted to mitigate removals and create canopy.

REMOVAL

- Total = 551 removals
- Priority 1 = 321 trees
- Priority 2 = 103 trees
- Priority 3= 87 trees
- Stumps = 40 stumps

HIGH RISK PRUNING

- **Total = 354 trees**
- **Priority 1 = 82 trees**
- **Priority 2 = 272 trees**

ROUTINE PRUNING CYCLE

- Total = 1,639 trees
- Number of trees in cycle each year = approximately 329 trees

YOUNG TREE TRAINING CYCLE

- Total = 510 trees
- Number of trees in cycle each year = approximately 170 trees

TREE PLANTING

- Number of trees year one = at least 73
- Number of trees year two = at least 156
- Number of trees year three = at least 270
- Number of trees years four and five = at least 100

Pendleton's urban forest will benefit greatly from a three-year young tree training cycle and a five-year routine pruning cycle. Proactive pruning cycles improve the overall health of the tree population and may eventually reduce program costs. In most cases, pruning cycles will correct defects in trees before they worsen, which will avoid costly problems. Based on inventory data, at least 170 young trees should be structurally pruned each year during the young tree training cycle, and approximately 329 trees should be cleaned each year during the routine pruning cycle.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind). Davey Resource Group recommends planting an average of 140 trees each year for the next five years and a variety of species each year to offset these losses, increase canopy, maximize benefits, and account for ash tree loss.

Townwide 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 maple should be limited until the species distribution normalizes. Due to the species distribution and impending threats from EAB, all *Fraxinus* spp. (ash) trees should be temporarily removed from planting lists.

Urban Forest Program Needs

Adequate funding will be needed for the town to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this five-year program is $169,195. This total will decrease to approximately $91,240 per year by year five of the program. High-priority removal and pruning is costly; since most of this work is scheduled during the first year of the program, the budget is higher for that year. After high-priority work has been completed, the urban forestry program will mostly involve proactive maintenance, which is generally less costly. Budgets for later years are thus projected to be lower.

Over the long term, supporting proactive management of trees through funding will reduce municipal tree care management costs and potentially minimize the costs to build, manage, and support certain town infrastructure.

Pendleton 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.

Year 1 - FY 2017 — $169,195

- 48 Priority 1 and 2 Removals
- 149 Priority 1 and 2 Prunes
- 88 Stump Removals
- YTT Cycle: 1/3 of Public Trees Trained
- 73 Trees Recommended for Planting and Follow-Up Care
- Approximately 25 Tree and Stump Removals (mortality 1%)

Year 2 - FY 2018 — $168,930

- 131 Priority 1 and 2 Removals
- 205 Priority 1 and 2 Prunes
- 131 Stump Removals
- YTT Cycle: 1/3 of Public Trees Trained
- 156 Trees Recommended for Planting and Follow-Up Care
- Approximately 25 Tree and Stump Removals (mortality 1%)

Year 3 - FY 2019 — $152,130

- 245 Priority 1 and 2 Removals
- 245 Stump Removals
- YTT Cycle: 1/3 of Public Trees Trained
- 270 Trees Recommended for Planting and Follow-Up Care
- Approximately 25 Tree and Stump Removals (mortality 1%)

Year 4 - FY 2020 — $146,495

- 87 Priority 3 Removal
- 87 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 1/3 of Public Trees Trained
- 100 Trees Recommended for Planting and Follow-Up Care
- Approximately 25 Tree and Stump Removals (mortality 1%)

Year 5 - FY 2021 — $91,240

- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 1/3 of Public Trees Trained
- 100 Trees Recommended for Planting and Follow-Up Care
- Approximately 25 Tree and Stump Removals (mortality 1%)

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INTRODUCTION

The Town of Pendleton is home to approximately 4,250 full-time residents who enjoy the beauty and benefits of their urban forest. The town's Public Works Department manages and maintains trees along street ROW and on public property. The town's Parks Department manages and maintains trees in Falls Park. For roughly five years, the Town of Pendleton has maintained staff committed to developing a strong urban forest. Most tree work is conducted by town staff. Less than 25 trees are removed annually and about 38 trees are planted annually.

Pendleton also has an Urban Forestry Committee, which is responsible for developing a comprehensive tree plan for the town, making recommendations to the town manager on planting and removal projects, and education and outreach to the community. The committee was re-established in 2015 and was awarded "Organization of the Year" by the Indiana Urban Forest Council in 2016.

Pendleton conducted an inventory of public trees sometime in the 1990s and again in 2016. The 1990s inventory was recorded on paper and tree maintenance recommendations were implemented. The 1990s inventory was not kept up-to-date so the use of it dissolved a few years later. The 2016 inventory was recorded in an ESRI® shapefile. The town plans to keep the inventory active through inventory management software.

Most funding for Pendleton's urban forestry program comes from the Town's Street Department's and Electric Department's budgets. The Town has a tree ordinance, maintains a budget of more than $2 per capita for tree-related expenses, celebrates Arbor Day, and has been a Tree City USA community for six years.

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 tree management plan) to set goals and measure progress. These tools can be utilized to establish tree care priorities, generate strategic planting plans, draft cost-effective budgets based on projected needs, and ultimately minimize the need for costly, reactive solutions to crises or urgent hazards.

In July and August 2016, Pendleton 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 and stumps along the street ROW and in parks and public properties.
- Analysis of tree inventory data.
- Development of a plan that prioritizes the recommended tree maintenance.

This plan is divided into three sections:

- *Section 1: Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: Benefits of the Urban Forest* summarizes the economic, environmental, and social benefits that trees provide to the community. This section presents statistics of an i-Tree Streets benefits analysis conducted for Pendleton.
- *Section 3: Tree Management Program* utilizes the inventory data to develop a prioritized maintenance schedule and projected budget for the recommended tree maintenance over a five-year period.

SECTION 1: TREE INVENTORY ANALYSIS

In July and August 2016, Davey Resource Group arborists assessed and inventoried trees and stumps along the street ROW in parks and public properties. A total of 3,054 sites were collected during the inventory: 3,014 trees and 40 stumps. Of the 3,054 sites collected, 45% were collected along the street ROW and 55% were collected in parks. Table 1 provides a detailed breakdown of the number and type of sites inventoried along street ROW and in parks and public properties. Appendix A explains data collection and site location methods. Data collection data field definitions are located in the glossary.

Two project areas, the town's public street rights-of-way, along with three parks and public properties (further referred to as parks), were selected by Pendleton for the tree inventory. Inventoried parks included: Grovelawn Cemetery, Falls Park, and Falls Park Golf Club.

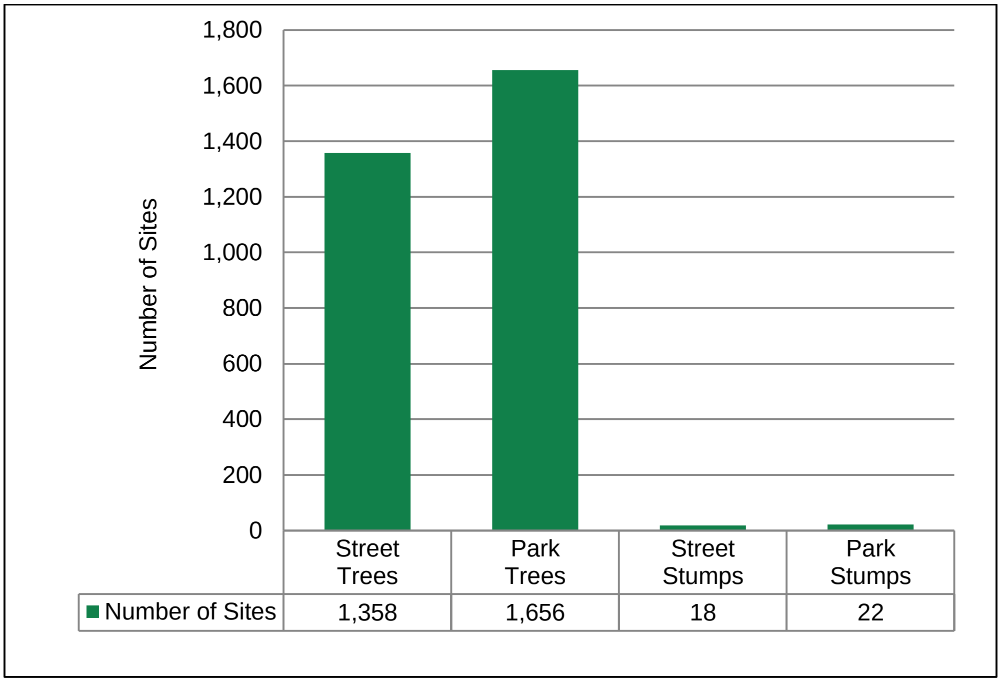


Figure 1. Sites collected during the 2016 inventory.

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. In this plan, the following criteria and indicators of the inventoried tree population were assessed:

- *Species Diversity*, the variety of species in a specific population, affects the population's ability to withstand threats from invasive pests and diseases. Species diversity also impacts tree maintenance needs and costs, tree planting goals, and canopy continuity.
- *Diameter Size Class Distribution*, 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 ROW trees compared to the total number of potential street ROW trees (number of inventoried trees plus the number of potential planting spaces); stocking level can help determine tree planting needs and budgets.
- *Other Observations* include inventory data analysis that provides insight into past maintenance practices and growing conditions; such observations may affect future management decisions.

Species Diversity

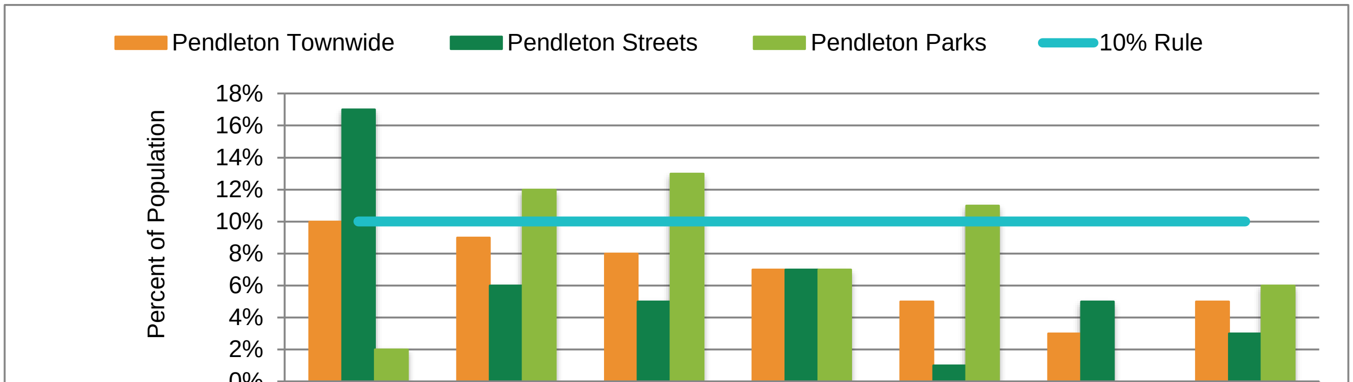
Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics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

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

Findings

Analysis of Pendleton's tree inventory data indicated that the street and park tree populations (townwide) were comprised of 44 genera and 96 species.

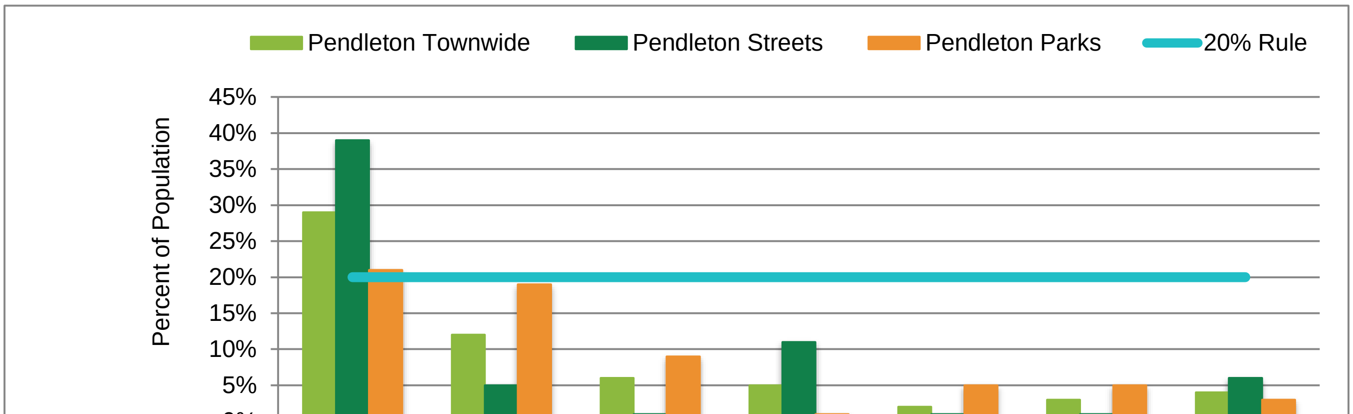
Figure 2 uses the 10% Rule to compare the percentages of the most common species townwide to the street and park tree species populations identified during the inventory. No species throughout the town exceeded the recommended 10% maximum for a single species in a population; however, *Fraxinus americana (white ash)* is at the 10% threshold, and *Acer saccharum* (sugar maple) is approaching the threshold. Within the street and park populations, some species exceed the recommended 10% maximum for a single species in a population. In the street population, *Fraxinus americana* (white ash) exceeds the threshold by 7%. In the parks population, *Acer saccharinum* (silver maple), sugar maple, and *Cercis canadensis* (eastern redbud) all exceed the threshold by 3%, 2%, and 1%, respectively.



	white ash	sugar maple	silver maple	red maple	eastern redbud	bur oak	northern hackberry
Pendleton Townwide	10%	9%	8%	7%	5%	3%	5%
Pendleton Streets	17%	6%	5%	7%	1%	5%	3%
Pendleton Parks	2%	12%	13%	7%	11%	0%	6%
10% Rule	10%	10%	10%	10%	10%	10%	10%

Figure 2. Most abundant species of the inventoried trees compared to the 10% Rule.

Figure 3 uses the 20% Rule to compare the percentages of the most common genera townwide to the street and park tree genera populations identified during the inventory. *Acer* (maple) exceeds the recommended 20% maximum for a single genus in all three populations (townwide, street, and parks), comprising 29%, 39%, and 21%, respectively, of the inventoried tree populations. *Fraxinus* (ash) in the park tree population is approaching the 20% threshold.



	maple	ash	oak	redbud	apple	elm	hackberry
Pendleton Townwide	29%	12%	6%	5%	2%	3%	4%
Pendleton Streets	39%	5%	1%	11%	1%	1%	6%
Pendleton Parks	21%	19%	9%	1%	5%	5%	3%
20% Rule	20%	20%	20%	20%	20%	20%	20%

Figure 3. Most abundant genera of the inventoried trees compared to the 20% Rule.

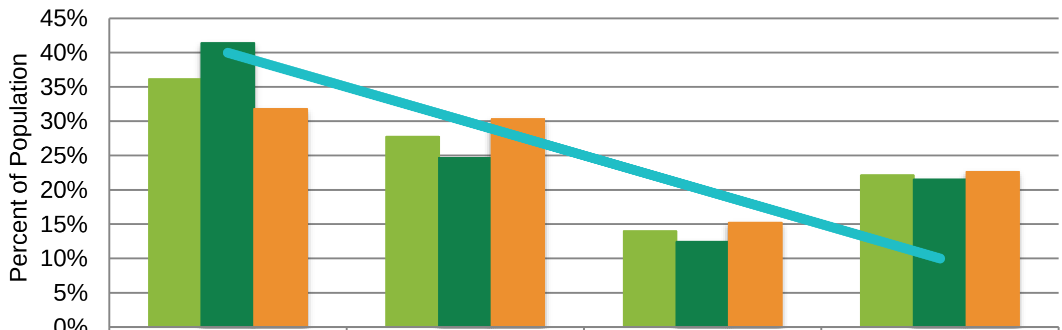
Discussion/Recommendations

Acer (maple) dominates the inventoried population. Its abundance presents concern within the park population due to the presence of silver maple and sugar maple. White ash dominates the street population. These are biodiversity concerns because their abundance in the landscape makes them limiting species. Continued diversity of tree species is an important objective that will ensure Pendleton's urban forest is sustainable and resilient to future invasive pest infestations. See Appendix B 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.



	0"–8" Young	9"–17" Established	18"–24" Maturing	>24" Mature
Pendleton Townwide	36%	28%	14%	22%
Pendleton Streets	41%	25%	12%	22%
Pendleton Parks	32%	30%	15%	23%
Ideal	40%	30%	20%	10%

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

Findings

Figure 4 compares Pendleton's diameter size class distribution of the inventoried tree populations to the ideal proposed by Richards (1983). Pendleton's distributions trend toward the ideal with the majority of trees being young; however, the young trees in the park population fall short of the ideal by 8%. Additionally, the overall, townwide young tree population falls short of the ideal by 4%. There are a large percentage of mature trees among all populations.

Discussion/Recommendations

Pendleton has healthy percentages of mature trees that provide many benefits to the town and citizens. Pendleton also has a healthy stock of young trees that will replace the mature trees as they need to be removed. One of Pendleton's objectives is to have an uneven-aged distribution of trees at the street, park, and townwide levels. Davey Resource Group recommends that Pendleton 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 still 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.

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.

Caring for trees is necessary to increase canopy cover and have healthy trees to reduce air and noise pollution, save energy with shade and windbreaks, mitigate stormwater costs, make habitat for wildlife, enhance aesthetics and property values, and contribute to community image, pride, and quality of life.

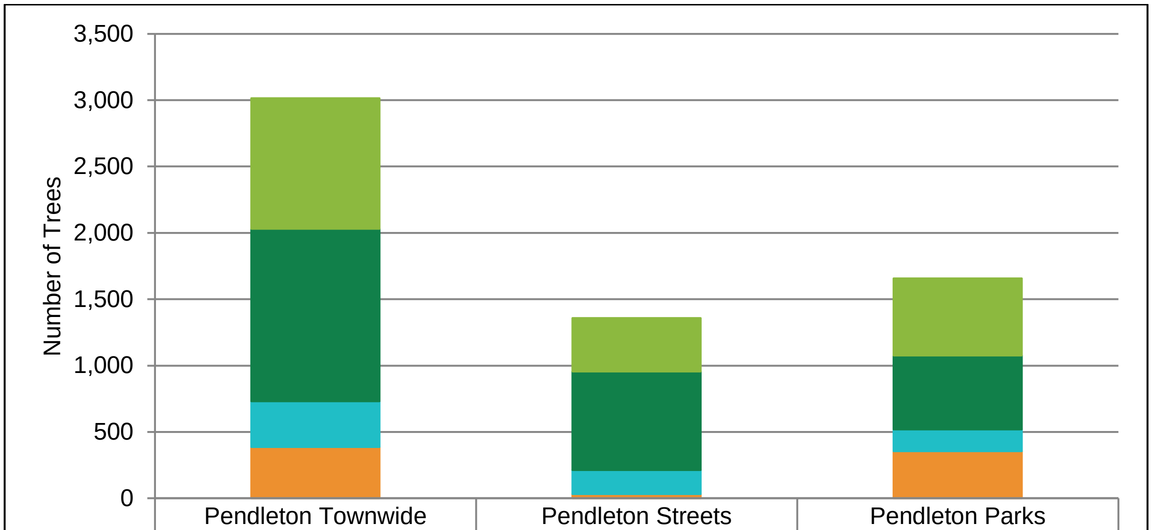
Condition

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

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

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

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



	Pendleton Townwide	Pendleton Streets	Pendleton Parks
Good	983	402	581
Fair	1,299	742	557
Poor	346	182	164
Dead	386	32	354

Figure 5. Conditions of inventoried trees.

Findings

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

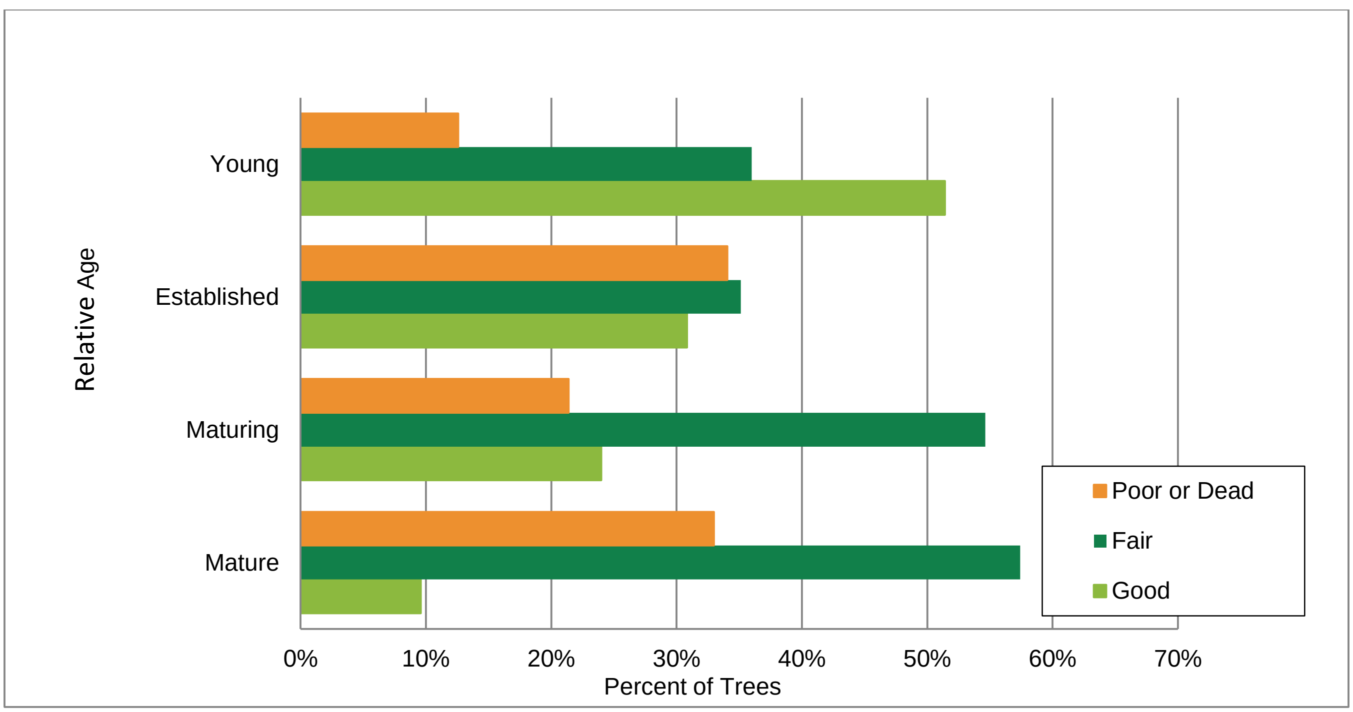


Figure 6. Tree condition by relative age during the 2016 inventory.

Discussion/Recommendations

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

- Dead trees and trees in Critical condition should be removed because of their failed health; these trees will likely not recover, even with increased care.
- Poor condition ratings of maturing and mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Young and established trees rated in Fair condition could benefit from improvements in structure that may improve their health over time. Pruning should follow *ANSI A300 (Part 1)* (ANSI 2008).
- 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 street tree population.

Replacement Value

Replacement value describes the historical investment in trees over time. Replacement value on a species level gives urban forest managers a glimpse into the landscape value of their species populations. Values will reflect species population, stature, and condition.

Findings

Pendleton's street and park trees are an important municipal asset valued at $3,444,966. Over time, this value could increase as trees mature and the number of trees increases, provided the trees are properly maintained. The average replacement value is approximately $114 per tree. Silver maple has the highest replacement value of all inventoried species at $583,359, or 17% of Pendleton's historical investment.

Discussion/Recommendations

A healthy, well-placed tree will become more valuable over time as it grows from a young tree to a mature tree. Davey Resource Group recommends that the town focus on tree care practices that will optimize species diversity, size distribution, and the health of the urban forest. Focusing on these components can provide a greater return on investment.

Street ROW Stocking Level

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

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

For an urban area, 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. However, street ROW stocking levels can be estimated using only the number of trees present and the number of street miles in the community.

To estimate stocking level based on total street ROW miles and the number of existing trees, it is assumed that any given street ROW should have room for 1 tree for every 50 feet along each side of the street. For example, 10 linear miles of street ROW with spaces for trees to grow at 50-foot intervals along each side of the street account for a potential 2,110 trees. If the inventory found that 1,055 trees were present, the stocking level would be 50%.

The potential stocking level for a community with 10 street miles is as follows:

> 5,280 feet/mile ÷ 50 feet = 106 trees/mile
>
> 106 trees/mile × 2 sides of the street = 212 trees/mile
>
> 212 trees per street mile × 10 miles = 2,120 potential sites for trees
>
> 1,055 inventoried trees ÷ 2,120 potential sites for trees = 50% stocked

When the estimated stocking level is determined using theoretical assumptions, the actual number of planting sites may be significantly less than estimated due to unknown growing space constraints, including inadequate growing space size, proximity of private trees, and utility conflicts.

Pendleton's inventory data set did not include planting sites. Since the data did not include planting sites, only the theoretical stocking level for the Town is presented.

Findings

Based on a theoretical stocking level, the Town has 39 linear miles of street ROW (Indiana Department of Transportation 2015) and 1,358 trees, which comes to an average of 35 trees per street mile. In theory, any given street should have growing space for 1 tree every 50 feet along each side of a street, or 211 trees per mile. This suggests that there is room for an additional 6,871 street trees in Pendleton to reach full stocking potential.

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 improving its street ROW population's stocking level of 17% and working towards achieving the ideal of 90% or better. Generally, this entails a planned program of planting, care, and maintenance for the Town's street ROW trees.

The Town of Pendleton estimates that it plants about 38 trees per year. With a theoretical estimate of 6,871 planting sites along the street ROW, it would take approximately 159 years for the town to reach the recommended stocking level of 90%. If budgets allow, Davey Resource Group recommends that Pendleton increase the number of trees planted to approximately 140 trees for the next 5 years. This will allow for a 1 to 1 ratio of trees removed and replaced, anticipated mortality, and a 2% replacement of potential planting sites. If possible, exceed this recommendation to better prepare for impending threats and to increase the benefits provided by the urban forest.

Stocking level can also be used to determine the number of trees per capita. 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.

Pendleton's ratio of street trees per capita is 0.32, which is below the mean ratio of 0.37 reported for 22 U.S. cities (McPherson and Rowntree 1989). According to the townwide study, there is 1 tree for every 3.1 residents. Pendleton's theoretical potential is 2 trees for every 1 resident.

Infrastructure Conflicts

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

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

Findings

There were 378 trees with utilities directly above, or passing through, the tree canopy. Of those trees, 83% were large- or medium-size trees.

Hardscape damage was minimal: only 2% of the tree population raised sidewalk slabs or curbs.

Table 1. Trees Noted to be Conflicting with Infrastructure

Conflict	Presence	Number of Trees	Percent
Overhead Utilities	Present and Conflicting	47	2%
	Present and Not Conflicting	331	11%
	Not Present	2,636	87%
Hardscape Damage	Present	66	2%
	Not Present	2,948	98%
Total		3,014	100%

Discussion/Recommendations

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

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

Growing Space

Information about the type and size of the growing space was recorded. Growing space types are categorized as follows:

- Island—surrounded by pavement or hardscape (for example, parking lot divider)
- Median—located between opposing lanes of traffic
- Natural Area—sites developed through natural growth instead if design or planning
- Open/Restricted—open sites with restricted growing space on two or three sides
- Open/Unrestricted—open sites with unrestricted growing space on at least three sides
- Tree Lawn/Parkway—located between the street curb and the public sidewalk
- Unmaintained/Natural Area—located in areas that do not appear to be regularly maintained
- Well/Pit—at grade level and completely surrounded by sidewalk

Findings

Most of the street and park tree populations are located in Open/Unrestricted areas that have unrestricted growth on at least three sides of a tree (Table 2).

Table 2. Trees Noted Growing Space Type

Grow Space	Number of Sites Street Trees	Percent	Number of Sites Park Trees	Percent
Island	9	<1%	29	2%
Median	130	10%	0	0%
Natural Area	7	<1%	287	17%
Open/Restricted	77	6%	30	2%
Open/Unrestricted	560	41%	1,228	74%
Tree Lawn/Parkway	491	36%	22	1%
Unmaintained/Natural Area	59	4%	59	4%
Well/Pit	25	2%	1	<1%
Total	1,358	100%	1,656	100%

Discussion/Recommendations

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

Land Use

Information about the type of land use was recorded. Land use types are categorized as follows:

- Industrial/large commercial
- Multi-family residential - duplex, apartments, condos
- Park/vacant/other - agricultural, riparian areas, greenbelts, park, etc.
- Small commercial - minimart, retail boutiques, etc.
- Single-family residential

Findings

Most (73%) of the street tree population is located adjacent to single-family residential properties (Table 3).

Table 3. Trees Noted by Land Use Type

Land Use	Number of Street Trees	Percent
Industrial/large commercial	178	13%
Multi-family residential	25	2%
Park/vacant/other	101	7%
Single-family residential	984	73%
Small commercial	70	5%
Total	1,358	100%

Discussion/Recommendations

Trees provide economic, environmental, and social benefits. Well-placed trees on single-family residential parcels generate greater tax revenue, slow vehicular traffic, increase community pride, clean the air of pollutants, improve public health, save energy, and reduce ambient air temperatures. Pendleton should define tree planting objectives based on potential benefits that may come from planting trees; efforts may produce results that greatly improve the quality of life in the town.

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 35 trees for further inspection.

Discussion/Recommendations

An ISA-Certified Arborist should perform additional inspections of the 35 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.

Ash and maple comprise 49% and 37%, respectively, of the trees with further inspection. The ash trees may need to be monitored for EAB because potential signs and symptoms were observed. The maples likely need a level 3 inspection due to observed cavity, decay, or poor structure.

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 C provides information about some of the current potential threats to Pendleton'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 Indiana (see Figure 7). It is important to note that the figure only presents data collected from the inventory. Many more trees throughout Pendleton, including those on public and private property, may be susceptible to these invasive pests.

Findings

Looper complex [(*Erannis tiliaria*) and (*Phigalia titea*)], forest tent caterpillar (*Malacosoma disstria*), and Asian longhorned beetle are known threats to a large percentage of the inventoried street trees. These pests were not detected in Pendleton, but if they were detected Pendleton could see severe losses in its tree population.

- Looper complex, linden looper (*Erannis tiliaria*), and spiny looper (*Phigalia titea*) feed on many species and cause widespread defoliation. These insects may not directly kill trees, but they can severely damage tree health. These insects threaten 57% of the street tree population. The potential loss equates to approximately $196,000 in replacement value.
- Forest tent caterpillar feeds on many species and causes widespread defoliation. These insects may not directly kill trees, but they can severely damage tree health. Forest tent caterpillar threatens 35% of the street tree population. The potential loss equates to approximately $122,000 million in replacement value.
- Asian longhorned beetle is an insect that bores into and kills a wide range of hardwood species. ALB poses a threat to 34% of the street tree population, which represents a potential loss of approximately $116,000 million in replacement value.

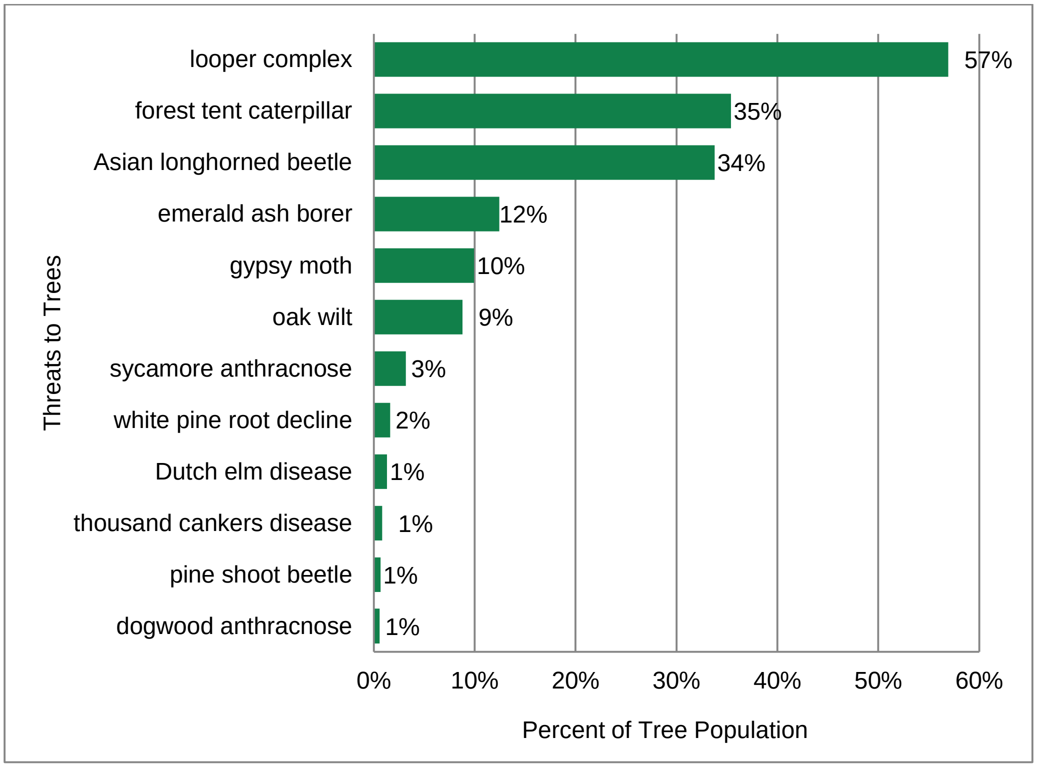


Figure 7. Potential impact of insect and disease threats noted during the 2016 inventory.

Discussion/Recommendations

There were 375 inventoried ash trees. EAB is an insect that bores into and kills most *Fraxinus* species. All other ash trees may need to be monitored for EAB because potential signs and symptoms were observed. EAB poses a threat to 12% of the street tree population, which represents a potential loss of $43,000 in replacement value. The Town has been reactively removing ash trees as they die.

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

SECTION 2: BENEFITS OF THE URBAN FOREST

The urban forest plays an important role in supporting and improving the quality of life in urban areas. A tree's shade and beauty contributes to a community's quality of life and softens the often hard appearance of urban landscapes and streetscapes. When properly maintained, trees provide communities abundant environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

Environmental Benefits

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

Economic Benefits

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

Social Benefits

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

The trees growing along the public streets and in parks constitute a valuable community resource. They provide numerous tangible and intangible benefits such as pollution control, energy reduction, stormwater management, property value increases, wildlife habitat, education, and aesthetics.

The services and benefits of trees in the urban and suburban setting were once considered to be unquantifiable. However, by using extensive scientific studies and practical research, these benefits can now be confidently calculated using tree inventory information. The results of applying a proven, defensible model and method that determines tree benefit values for the Town of Pendleton's tree inventory data are summarized in this report using the i-Tree's Streets application. The results of Pendleton's tree inventory provide insight into the overall health of the town's public trees and the management activities needed to maintain and increase the benefits of trees into the future.

Tree Benefit Analysis

i-Tree Streets

In order to identify the dollar value provided and returned to the community, the town's tree inventory data (townwide) were formatted for use in the i-Tree Streets benefit-cost assessment tool.

i-Tree Streets, a component of i-Tree Tools, analyzes an inventoried tree population's structure to estimate the costs and benefits of that tree population. The assessment tool creates an annual benefit report that demonstrates the value street trees provide to a community:

These quantified benefits and the reports generated are described below.

- **Aesthetic/Other Benefits:** Shows the tangible and intangible benefits of trees reflected by increases in property values (in dollars).
- **Stormwater:** Presents reductions in annual stormwater runoff due to rainfall interception by trees measured in gallons.
- **Energy:** Presents the contribution of the urban forest towards conserving energy in terms of reduced natural gas use in the winter (measured in therms [thm]) and reduced electricity use for air conditioning in the summer (measured in Megawatt-hours ([MWh]).
- **Carbon Sequestered:** Presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reductions in energy use measured in pounds. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.
- **Air Quality:** Quantifies the air pollutants (ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], particulate matter less than 10 micrometers in diameter [PM_{10}]) deposited on tree surfaces, and reduced emissions from power plants (NO_2, PM_{10}, volatile organic compounds [VOCs], SO_2) due to reduced electricity use in pounds. The potential negative effects of trees on air quality due to biogenic volatile organic compounds (BVOC) emissions is also reported.

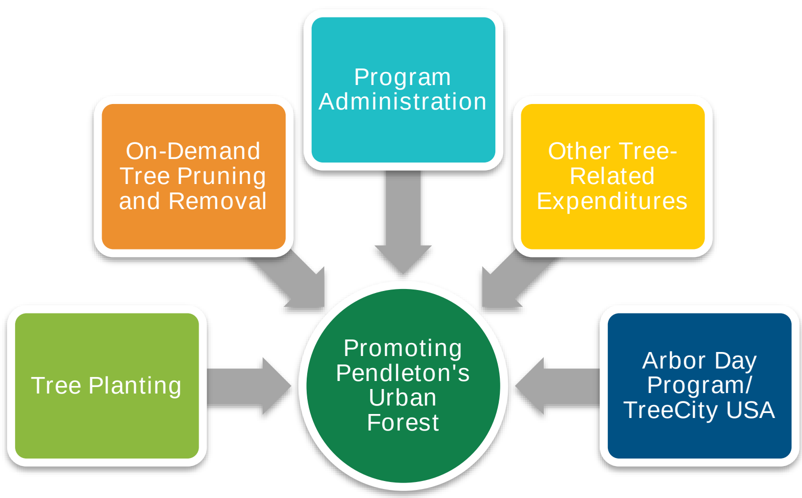
- **Importance Value (IV):** IVs are calculated for species that comprise more than 1% of the population. The Streets IV is the mean of three relative values (percentage of total trees, percentage of total leaf area, and percentage of canopy cover) and can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. IVs offer valuable information about a community's reliance on certain species to provide functional benefits. For example, a species might represent 10% of a population but have an IV of 25% due to its substantial benefits, indicating that the loss of those trees would be more significant than just their population percentage would suggest.

i-Tree Tools

i-Tree

i-Tree Tools software was developed by the U.S. Department of Agriculture, Forest Service (USDA FS) with the help of several industry partners, including The Davey Tree Expert Company. Learn more at www.itreetools.org.

i-Tree Streets Inputs



In addition to tree inventory data, i-Tree Streets requires cost-specific information to manage a community's tree management program—including administrative costs and costs for tree pruning, removal, and planting. Regional data, including energy prices, property values, and stormwater costs, are required inputs to generate the environmental and economic benefits trees provide. If community program costs or local economic data are not available, i-Tree Streets uses default economic inputs from a reference city selected by USDA FS for the climate zone in which your community is located. Any default value can be adjusted for local conditions.

Pendleton's Inputs

Local data were available at the time of this plan and were used to the greatest extent possible with i-Tree Streets to calculate the benefits Pendleton's trees provide its citizens. For Pendleton's benefit analysis, energy prices and property values were adjusted for local conditions, and air quality and stormwater costs were left as default regional values. The Town provided their urban forest management costs.

Annual Benefits

The i-Tree Streets model estimated that the inventoried street trees provide a total annual benefit of $364,084. Essentially, $364,084 was saved to cool buildings, manage stormwater, and clean the air. In addition, community aesthetics were improved and property values increased because of the presence of trees. Compared to the median values of five town benchmark communities used in the Sample Urban Statewide Inventory (Davey Resource Group 2009), Pendleton's benefit per tree of $120.80 is more than the benchmark of $52.31, and Pendleton's benefit per capita of $85.67 is more than the benchmark of $17.21.

The assessment found that stormwater management benefits provided by Pendleton's trees returned the greatest value to the community. Stormwater management comprises 43% of the annual benefits provided by the inventoried trees. The Town's public trees intercepted over 5.8 million gallons of rainfall, which equates to a savings of $157,228 in stormwater management costs. In addition to stormwater management savings, trees also play a major role in energy conservation and property value increases. The Town's trees mitigate the use of energy by $80,166, compromising 22% of the annual benefits. The Town's public trees improve economic growth through aesthetics by $91,926, compromising 25% of the annual benefits as well. Carbon and air quality contributions are also important and provide an annual benefit of $15,230 (10% of the total benefits).

Figure 8 summarizes the annual benefits and results for the inventoried public tree population. Table 4 presents results for individual tree species from the i-Tree Streets analysis.

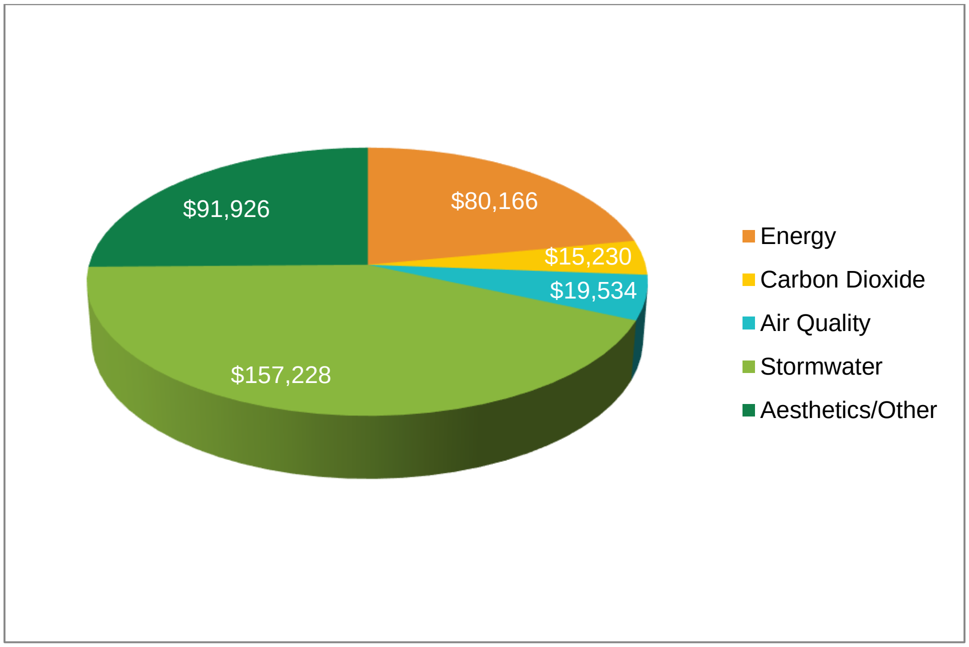


Figure 8. Breakdown of total annual benefits provided to Pendleton.

Table 4. Benefit Data for Common Street Trees by Species

Most Common Trees Collected During Inventory		Number Trees on the ROW	Percent of Total Trees	Canopy Cover	Benefit Provide By Street Trees					Importance Value (IV)
					Aesthetic/ Other	Stormwater	Energy	Carbon Sequestered	Air Quality	
Common Name	Botanical Name		(%)	(ft^2)	Average/$/Tree					0–100 (higher IV = more important species)
white ash	Fraxinus americana	309	10.25	366,271.86	45.97	62.95	34.96	6.61	9.06	11.67
sugar maple	Acer saccharum	264	8.76	369,941.11	48.99	85.24	39.81	7.72	9.20	12.88
silver maple	Acer saccharinum	252	8.36	500,085.58	83.20	135.27	48.03	14.26	12.88	15.94
red maple	Acer rubrum	209	6.93	124,381.51	18.51	27.11	19.47	2.80	4.84	4.88
eastern redbud	Cercis canadensis	162	5.37	20,165.37	1.76	2.82	4.52	0.69	1.01	2.09
northern hackberry	Celtis occidentalis	129	4.28	183,669.89	35.39	68.38	41.22	5.75	10.64	5.61
black walnut	Juglans nigra	97	3.22	75,434.01	28.61	44.40	24.64	4.83	6.01	2.89
bur oak	Quercus macrocarpa	82	2.72	80,094.75	12.81	58.94	31.00	4.03	6.35	2.90
apple	Malus spp.	73	2.42	19,255.05	4.06	6.37	9.60	1.47	2.21	1.10
black cherry	Prunus serotina	70	2.32	49,913.82	7.09	21.92	23.39	2.99	6.21	1.66
American sycamore	Platanus occidentalis	68	2.26	107,703.98	40.38	99.93	44.96	8.29	11.98	3.67
Norway maple	Acer platanoides	68	2.26	53,894.06	22.95	41.77	27.51	4.43	6.92	1.93
Norway spruce	Picea abies	67	2.22	23,738.18	18.59	40.20	12.62	1.76	1.16	1.67
callery pear	Pyrus calleryana	67	2.22	34,004.37	21.60	21.82	20.16	3.60	4.60	1.38
white mulberry	Morus alba	59	1.96	45,831.68	21.67	40.78	27.13	4.25	6.80	1.65
Siberian elm	Ulmus pumila	50	1.66	84,190.01	30.96	92.09	44.17	7.65	12.33	2.53
eastern white pine	Pinus strobus	49	1.63	18,923.70	17.77	45.06	14.14	1.93	1.15	1.33
pin oak	Quercus palustris	47	1.56	12,703.57	8.65	11.33	8.88	1.41	1.70	0.77
blue spruce	Picea pungens	46	1.53	18,213.36	21.60	42.14	14.84	2.05	1.79	1.15
American elm	Ulmus americana	40	1.33	12,751.59	13.49	12.76	12.40	1.84	2.68	0.68
tulip tree	Liriodendron tulipifera	39	1.29	35,908.40	30.81	52.92	29.42	5.58	7.29	1.32
honeylocust	Gleditsia triacanthos	38	1.26	19,811.02	27.67	22.56	16.35	2.74	3.75	0.85
green ash	Fraxinus pennsylvanica	38	1.26	22,694.75	26.50	30.43	20.53	4.03	4.72	0.92
freeman maple	Acer x freemanii	33	1.09	11,660.05	17.00	13.83	12.92	2.18	2.98	0.58
ginkgo	Ginkgo biloba	30	1.00	11,067.95	5.24	13.13	13.73	1.66	3.20	0.53
hawthorn	Crataegus spp.	30	1.00	4,958.88	2.83	3.87	5.82	0.95	1.31	0.41
other public trees	~70 species of varying species	598	19.84	404,539.24	2.80	4.99	2.59	0.48	0.60	17.00
ROW Total	~58 genera and ~96species on the ROW	3,014	100.00	2,711,807.76	30.50	52.17	26.60	5.05	6.48	100.00

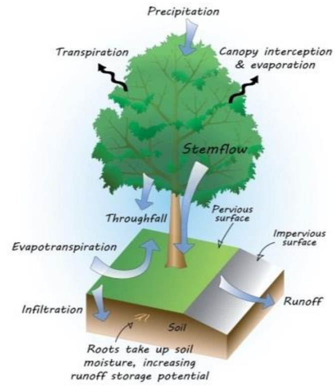
Aesthetic/Other Benefits

The total annual benefit associated with property value increases and other tangible and intangible benefits of street trees was $91,926. The average benefit per tree equaled $30.50 per year.

Stormwater Benefits

Trees intercept rainfall, which helps lower costs to manage stormwater runoff. The inventoried trees in Pendleton intercept 5,801,781 gallons of rainfall annually (Table 5). On average, the estimated annual savings for the town in stormwater runoff management is $157,228.

Of all species inventoried, *Acer saccharinum* (silver maple) contributed most of the annual stormwater benefits. The population of silver maples (8% of public trees) intercepted over 1.3 million gallons of rainfall. On a per-tree basis, large-statured trees with big canopies offer the greatest stormwater benefits. Northern hackberry (4% of the total population) absorbed 325,477 gallons of rainfall. In comparison, eastern redbud comprised approximately 5% of the total population, absorbing 16,877 gallons of rainfall.



- *Trees reduce stormwater runoff by capturing and storing rainfall in their canopy and releasing water into the atmosphere.*
- *Tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil.*
- *Trees help slow down and temporarily store runoff and reduce pollutants by absorbing nutrients and other pollutants from soils and water through their roots.*
- *Trees transform pollutants into less harmful substances.*

Air Quality Improvements

The inventoried tree population annually removes 1,570 pounds of air pollutants (including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter) through deposition. The population also avoids 5,897 pounds annually.

While trees do a great deal to absorb air pollutants, they also contribute negatively to air pollution. Trees emit various biogenic volatile organic compounds (BVOC's) such as isoprenes and monoterpenes, which can also contribute to formation of ozone, a harmful gas that pollutes the air and damages vegetation. These BVOC emissions are accounted for in the air quality net benefit.

The inventoried trees removed or avoided more pollutants than they emitted, resulting in a positive economic value. The net total value of these benefits is estimated to be $19,534. The trees that provided the most benefits based on an annual per-tree average value were *Populus alba* (white poplar) and *Catalpa speciosa* (northern catalpa) ($15.71 and $14.87, respectively). White poplar is an invasive tree species.

Table 5. Stormwater Benefits Provided by ROW Trees

Most Common Trees Collected During Inventory		Number of Trees on the ROW	Percent of Total Trees	Total Rainfall Interception
Common Name	Botanical Name		(%)	(gal.)
white ash	Fraxinus americana	309	10.25	717,732.07
sugar maple	Acer saccharum	264	8.76	830,382.30
silver maple	Acer saccharinum	252	8.36	1,257,870.10
red maple	Acer rubrum	209	6.93	209,106.18
eastern redbud	Cercis canadensis	162	5.37	16,876.74
northern hackberry	Celtis occidentalis	129	4.28	325,477.01
black walnut	Juglans nigra	97	3.22	158,925.57
bur oak	Quercus macrocarpa	82	2.72	178,347.72
apple	Malus spp.	73	2.42	17,162.25
black cherry	Prunus serotina	70	2.32	56,614.42
American sycamore	Platanus occidentalis	68	2.26	250,734.64
Norway maple	Acer platanoides	68	2.26	104,814.52
Norway spruce	Picea abies	67	2.22	99,395.01
callery pear	Pyrus calleryana	67	2.22	53,951.65
white mulberry	Morus alba	59	1.96	88,784.35
Siberian elm	Ulmus pumila	50	1.66	169,898.93
eastern white pine	Pinus strobus	49	1.63	81,472.69
pin oak	Quercus palustris	47	1.56	19,642.54
blue spruce	Picea pungens	46	1.53	71,522.99
American elm	Ulmus americana	40	1.33	18,840.28
tulip tree	Liriodendron tulipifera	39	1.29	76,158.13
honeylocust	Gleditsia triacanthos	38	1.26	31,635.50
green ash	Fraxinus pennsylvanica	38	1.26	42,663.71
freeman maple	Acer x freemanii	33	1.09	16,842.50
ginkgo	Ginkgo biloba	30	1.00	14,539.16
hawthorn	Crataegus spp.	30	1.00	4,278.90
other public trees	~70 species of varying species	598	19.84	888,111.37
ROW Total	~58 genera and ~96species on the ROW	3,014	100.00	5,801,781

Carbon Storage and Carbon Sequestration

Trees absorb CO_2 and sequester some during growth (Nowak et al. 2013). This prevents CO_2 from reaching the upper atmosphere, where it can react with other compounds and form harmful gases like ozone, which adversely affects air quality. i-Tree Streets calculates how much CO_2 sequestered annually.

The i-Tree Streets calculation also takes into account the carbon emissions that are *not* released from power stations due to the heating and cooling effect of trees (i.e., conserved energy in buildings and homes). It calculates emissions released during tree care and maintenance, such as driving to the site and operating equipment. The net CO_2 benefit was approximately $15,230 per year and $5.05 per tree.

The Town's public trees sequester 602 tons of CO_2 per year. Through sequestration and avoidance, 465 tons of CO_2 are removed each year. Silver maple provided the most CO_2 benefits, with each tree sequestering an annual average of $14.26 worth of carbon.

Energy Benefits

Public trees conserve energy by shading structures and surfaces, which reduces electricity use for air conditioning in the summer. Trees divert wind in the winter to reduce natural gas use. Based on the inventoried trees, the annual electric and natural gas savings are equivalent to 555 MWh of electricity and 74,562 therms of natural gas, which accounts for an annual savings of $80,166 in energy consumption.

Large leafy canopies are valuable because they provide shade, which reduces energy usage. White ash, silver maple, northern hackberry, and *Quercus macrocarpa* (bur oak) all have annual values per tree greater than $31. Smaller species such as eastern redbud, *Malus* spp. (crabapple spp.), *Pyrus calleryana* (callery pear), *Prunus* spp. (cherry spp.), *Cornus florida* (flowering dogwood), and *Syringa japonica* (Japanese tree lilac) all have annual per-tree values between $2.90 and $9.60 per tree.

Cercis canadensis (eastern redbud)	Fraxinus americana (white ash)	Acer saccharinum (silver maple)	Celtis occidentalis (northern hackberry)
5% of ROW	10**% of ROW**	8% of ROW	**4% of ROW**
5MWh ElectriXYZ	77MWh ElectriXYZ	84MWh ElectriXYZ	**37MWh ElectriXYZ**
798thm Natural Gas	9,174thm Natural Gas	**11,105thm** Natural **Gas**	5,082thm Natural Gas
$4.52 Average $/tree	$34.96 Average $/tree	**$48.03 Average $/**tree	**$41.22 Average $/tree**

Importance Value (IV)

Understanding the importance of a tree species to the community is based on its presence within the landscape, but also its ability to provide environmental and economic benefits to the community. The IV calculated by the street computer model takes into account the total number of trees of a species, its percentage in the population, and its total leaf area and canopy cover. The IV can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. If IV values are greater or less than the percentage of a species on the ROW, it indicates that the loss of that species may be more important or less important than its population percentage implies.

The i-Tree Streets assessment found that silver maple has the greatest IV in the ROW population at 15.94. This indicates that the loss of the silver maple in the population would be more economically detrimental than its percentage of the population leads us to believe. The second highest IV was for sugar maple (12.88), followed by white ash (11.67) and northern hackberry (5.61). The abundance of northern hackberry (4%) in the public tree population is not as high as eastern redbud (5%), but northern hackberry’s IV is greater. Because it is a large-growing species, the size and canopy of broadleaf species by nature provide more environmental benefits to the community, which all factor into assigning IV. The IV for eastern redbud is less than its percentage of the population, indicating that if eastern redbud was lost, its economic impact would not be as significant as its percentage of the population leads us to believe.

Benefit-Cost Ratio

According to the benefits presented in this section, trees make good sense, but are the collective benefits worth the costs of management? In other words, are trees a good investment for Pendleton? To answer that question, we must compare the benefit public trees provide to the cost of their management.

Applying a benefit-cost ratio (BCR) is another useful way to evaluate the investment in public trees. A BCR is an indicator used to summarize the overall value compared to the costs of a given project. Specifically, in this analysis, BCR is the ratio of the cumulative benefits provided by the town’s public trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms. When Pendleton’s annual expenditures of $251,000 are considered, the net annual benefit (benefits minus costs) returned by public trees to the town is $163,157. Pendleton receives $1.45 in benefits for every $1 spent on its municipal forestry program. Pendleton’s BCR is less than the Sample Urban Statewide Inventory town median benchmark of $1.74.

Discussion/Recommendations

The i-Tree Streets analysis found that public trees provide environmental and economic benefits to the community by virtue of their mere presence in the landscape. Currently, the stormwater benefits provided by public trees were rated as having the greatest value to the community. In addition to stormwater benefits, increase property values by improved aesthetic/other benefits, trees provide shade and windbreaks to reduce energy usage, remove pollutants from the air, and sequester CO_2. Even though these benefits were not found to be as great as the stormwater benefits, they are noteworthy.

i-Tree Streets analysis found that the silver maple is the most influential tree along Pendleton’s public trees. If this species was lost to ALB or other threats, its loss would be felt more than the community may realize.

To further increase the benefits public trees provide, Pendleton should plant young, large-growing tree species that are low emitters of BVOCs wherever possible. Leafy, large-growing trees consistently created the most environmental and economic benefits. The following list of tree species is used for improving air quality (ICLEI 2006):

- *Betula nigra* (river birch)
- *Celtis laevigata* (sugar hackberry)
- *Fagus grandifolia* (American beech)
- *Metasequoia glyptostroboides* (dawn redwood)
- *Tilia cordata* (littleleaf linden)
- *Tilia europea* (European linden)
- *Tilia tomentosa* (silver linden)
- *Ulmus americana* (American elm)
- *Ulmus procera* (English elm)

SECTION 3: TREE MANAGEMENT PROGRAM

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

While implementing a tree care program is an ongoing process, tree work must always be prioritized to reduce public safety risks. Davey Resource Group recommends completing the work identified during the inventory based on the assigned risk rating; however, it is also essential to routinely monitor the tree population to identify other high risk trees so that they may be systematically addressed. While regular pruning cycles and tree planting is important, priority work (especially for Priority 1 and 2 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 all tree and stump removals and Priority 1 and 2 Prunes. Proactive tree maintenance includes routinely pruning young and more mature trees. Tree planting, inspections, and community outreach are also considered proactive maintenance. Further explanation about priority and proactive maintenance can be found in Appendix E.

Tree and Stump Removal

Priority 1
- Perform tree maintenance immediately to reduce hazards
- Includes tree removal and pruning
- Trees pose high-liability risks
- Mostly high-use areas

Priority 2
- Perform tree maintenance immediately to reduce hazards
- Includes tree removal and pruning
- Trees pose minimal liabity then priority one category
- May be high or low-use areas

Priority 3
- Perform tree maintenance when convenient to improve aesthetics and eliminate nuisance trees
- Includes tree removal only
- Trees pose minimal liability risks
- May be high- or low-use areas

Stump Removal
- Preform tree maintenance when convenient to improve aesthetics

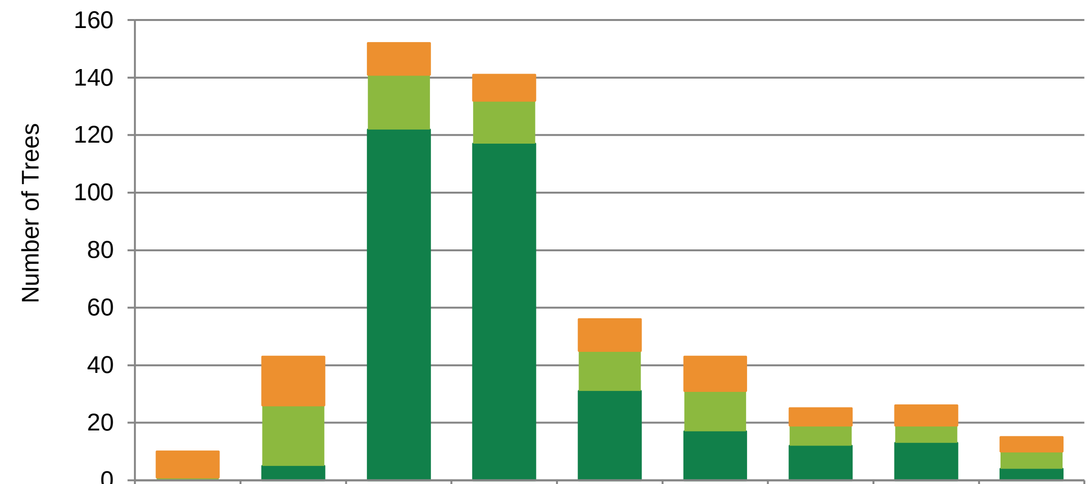
Routine Pruning
- Perform tree maintenance when convenient to improve aesthetics and tree health
- Perform corrective pruning to more mature trees to maintain structural integrity

Training Prune
- Perform corrective pruning to young trees to increase structural integrity and develop a strong architecture of branches before serious problems develop

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 9 presents tree removals by priority 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
Priority 3	9	17	11	9	11	12	6	7	5
Priority 2	1	21	19	15	14	14	7	6	6
Priority 1	0	5	122	117	31	17	12	13	4

Figure 9. Tree removals by risk rating and diameter size class.

Findings

The inventory identified 321 Priority 1 trees, 103 Priority 2 trees, and 87 Priority 3 that are recommended for removal.

The diameter size classes for Priority 1 trees range from 4 inches to greater than 43 inches in diameter at breast height (DBH). The majority of Priority 1 trees are between 7 and 12 inches DBH. These trees should be removed immediately based on their assigned risk. Priority 1 removals and pruning can be performed concurrently.

The diameter size classes for Priority 2 trees range from 1 inches to greater than 43 inches at breast height (DBH). The majority of Priority 2 trees are between 4 and 6 inches DBH. Priority 2 trees should be removed as soon as possible after Priority 1 removals have been completed.

Priority 3 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 Priority 3 trees should be removed when convenient and after Priority 1 and 2 removals have been completed.

The inventory identified 337 ash trees recommended for removal. This is 90% of the total ash population and 11% of the townwide inventoried population.

The inventory identified 40 stumps recommended for removal. The majority of these stumps were between 19 and 24 inches in diameter. Stump removals should occur when convenient.

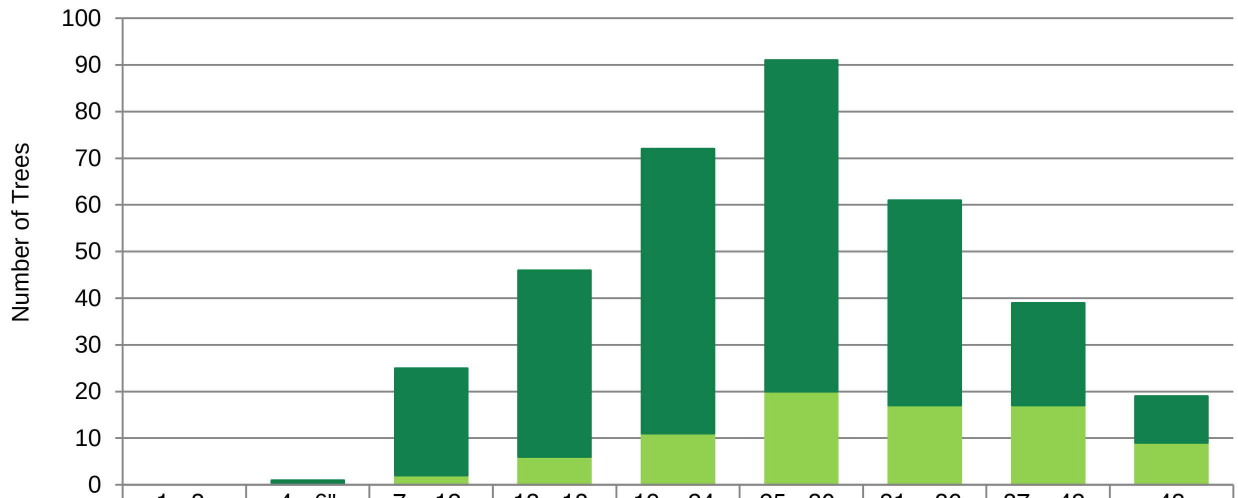
Discussion/Recommendations

Trees noted as needing further inspection should be inspected on a regular basis. Corrective action should be taken when warranted. If their condition worsens, tree removal may be required. Proactive tree maintenance that actively mitigates elevated-risk situations will promote public safety.

Tree Pruning

Priority 1 and 2 pruning generally require cleaning the canopy of both small and large trees to remove hazardous 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 10 presents the number of Priority 1 and 2 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
Priority 2	0	1	23	40	61	71	44	22	10
Priority 1	0	0	2	6	11	20	17	17	9

Figure 10. Priority pruning by diameter size class.

Findings

The inventory identified 82 Priority 1 and 272 Priority 2 trees recommended for pruning.

These high priority trees ranged in diameter size classes from 4 inches to greater than 43 inches DBH. This pruning should be performed immediately based on assigned risk and may be performed concurrently with other priority removals. Priority 1 trees should be pruned before Priority 2 trees.

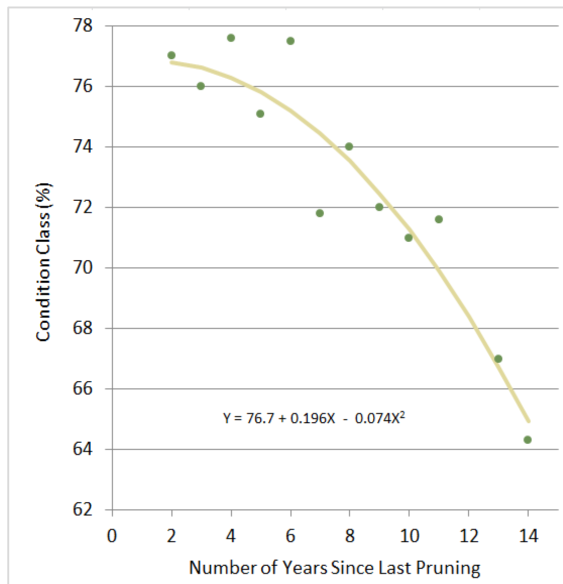


Figure 11. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

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 recommends that pruning cycles begin after all Priority 1 and 2 trees are corrected through removal or pruning. However, due to the long-term benefits of pruning cycles, Davey Resource Group recommends that the cycles be implemented as soon as possible. To ensure that all trees receive the type of pruning they need to mature with better structure and fewer hazards, two pruning cycles are recommended: the young tree training cycle (YTT Cycle) and the routine pruning cycle (RP Cycle). The cycles differ in the type of pruning, the general age of the target tree, and length.

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

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

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

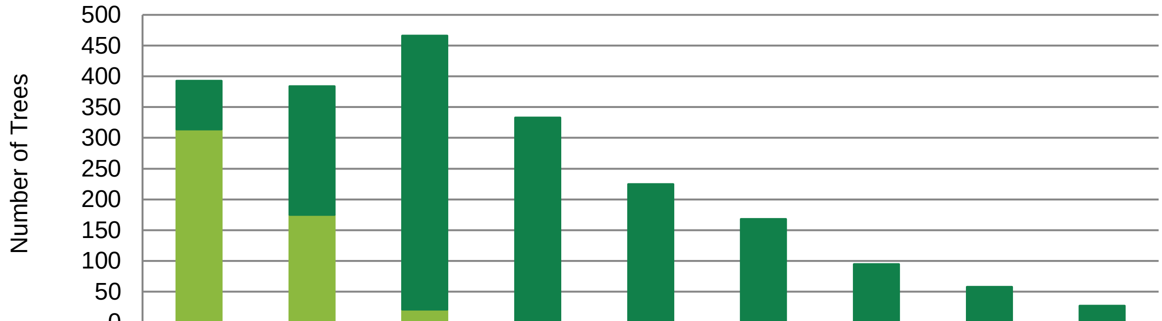
The YTT Cycle differs from the RP Cycle in that these trees generally can be pruned from the ground with a pole pruner or pruning shear. The objective is to increase structural integrity by pruning for one dominant leader. YTT Pruning is species-specific, since many trees such as *Betula nigra* (river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

Recommendations

The inventory found that 54% of trees need a routine prune and 17% need a training prune. Davey Resource Group recommends that Pendleton implement a three-year YTT Cycle to begin as soon as possible. The YTT Cycle will include existing young trees. During the inventory, 510 trees smaller than 12 inches DBH were inventoried and recommended for young tree training. Since the number of existing young trees is relatively large, and the benefit of beginning the YTT Cycle is substantial, Davey Resource Group recommends that an average of 170 trees be structurally pruned each year over three years, beginning in Year One of the management program.

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

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



	1″–3″	4″–6"	7″– 12″	13″–18″	19″– 24″	25″–30″	31″– 36″	37″– 42″	≥43″
Routine Prune	79	209	445	333	225	168	95	58	27
Young Tree Training	314	175	21	-	-	-	-	-	-

Diameter Size Class (inches)

Figure 12. Trees recommended for the RP Cycle and YTT Cycle by diameter size class.

Routine Pruning Cycle

The RP Cycle includes established, maturing, and mature trees (mostly greater than 8 inches DBH) that need cleaning, crown raising, and reducing to remove deadwood and improve structure. Over time, routine pruning generally improves health and reduces risk, as most problems can be corrected before they escalate into more costly priority tree work.

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

Recommendations

Davey Resource Group recommends that the Town establish a five-year RP Cycle in which approximately one-fifth of the tree population is to be pruned each year. The 2016 tree inventory identified approximately 1,639 trees that should be pruned over a five-year RP Cycle. An average of 328 trees should be pruned each year over the course of the cycle. Davey Resource Group recommends that the RP Cycle begin in year four of this five-year plan, after Priority 1 and 2 trees are pruned.

Figure 11 shows that a variety of tree sizes will require pruning; however, most of the trees that require routine pruning were between 7 and 24 inches DBH.

Maintenance Schedule

Utilizing data from the 2016 Town of Pendleton 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 using industry knowledge and public bid tabulations. Actual costs were not specified by Pendleton. A complete table of estimated costs for Pendleton's five-year tree management program is presented in Table 6.

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

To implement the maintenance schedule, the town's tree maintenance budget should be no less than $169,195 for the first year of implementation, no less than $168,930 for the second year, no less than $152,130 for the third year, no less than $146,495 for the fourth year, and no less than $91,240 for the fifth year of the maintenance schedule. After the fifth year, the annual budget should normalize. Annual budget funds are needed to ensure that hazard trees are remediated and that critical YTT and RP Cycles can begin. This budget does not account for the aging of the population. 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 6. Estimated Costs for Five-Year Urban Forestry Management Program

Estimated Costs for Each Activity			2017		2018		2019		2020		2021		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Priority 1 and 2 Removal	1-3"	$25	0	$0	0	$0	1	$25	0	$0	0	$0	$25
	4-6"	$105	0	$0	0	$0	26	$2,730	0	$0	0	$0	$2,730
	7-12"	$220	0	$0	0	$0	141	$31,020	0	$0	0	$0	$31,020
	13-18"	$355	0	$0	55	$19,525	77	$27,335	0	$0	0	$0	$46,860
	19-24"	$525	0	$0	45	$23,625	0	$0	0	$0	0	$0	$23,625
	25-30"	$845	0	$0	31	$26,195	0	$0	0	$0	0	$0	$26,195
	31-36"	$1,140	19	$21,660	0	$0	0	$0	0	$0	0	$0	$21,660
	37-42"	$1,470	19	$27,930	0	$0	0	$0	0	$0	0	$0	$27,930
	43"+	$1,850	10	$18,500	0	$0	0	$0	0	$0	0	$0	$18,500
Activity Total(s)			48	$68,090	131	$69,345	245	$61,110	0	$0	0	$0	$198,545
Priority 3 Removal	1-3"	$25	0	$0	0	$0	0	$0	9	$225	0	$0	$225
	4-6"	$105	0	$0	0	$0	0	$0	17	$1,785	0	$0	$1,785
	7-12"	$220	0	$0	0	$0	0	$0	11	$2,420	0	$0	$2,420
	13-18"	$355	0	$0	0	$0	0	$0	9	$3,195	0	$0	$3,195
	19-24"	$525	0	$0	0	$0	0	$0	11	$5,775	0	$0	$5,775
	25-30"	$845	0	$0	0	$0	0	$0	12	$10,140	0	$0	$10,140
	31-36"	$1,140	0	$0	0	$0	0	$0	6	$6,840	0	$0	$6,840
	37-42"	$1,470	0	$0	0	$0	0	$0	7	$10,290	0	$0	$10,290
	43"+	$1,850	0	$0	0	$0	0	$0	5	$9,250	0	$0	$9,250
Activity Total(s)			0	$0	0	$0	0	$0	87	$49,920	0	$0	$49,920
Stump Removal	1-3"	$25	0	$0	0	$0	1	$25	9	$225	0	$0	$250
	4-6"	$25	1	$25	0	$0	26	$650	17	$425	0	$0	$1,100
	7-12"	$25	4	$100	0	$0	141	$3,525	11	$275	0	$0	$3,900
	13-18"	$40	6	$240	55	$2,200	77	$3,080	9	$360	0	$0	$5,880
	19-24"	$60	12	$720	45	$2,700	0	$0	11	$660	0	$0	$4,080
	25-30"	$85	3	$255	31	$2,635	0	$0	12	$1,020	0	$0	$3,910
	31-36"	$110	25	$2,750	0	$0	0	$0	6	$660	0	$0	$3,410
	37-42"	$130	23	$2,990	0	$0	0	$0	7	$910	0	$0	$3,900
	43"+	$160	14	$2,240	0	$0	0	$0	5	$800	0	$0	$3,040
Activity Total(s)			88	$9,320	131	$7,535	245	$7,280	87	$5,335	0	$0	$29,470
Priority 1 and 2 Prune	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	1	$30	0	$0	0	$0	0	$0	$60
	7-12"	$75	0	$0	25	$1,875	0	$0	0	$0	0	$0	$2,550
	13-18"	$120	0	$0	46	$5,520	0	$0	0	$0	0	$0	$5,520
	19-24"	$170	0	$0	72	$12,240	0	$0	0	$0	0	$0	$12,240
	25-30"	$225	30	$6,750	61	$13,725	0	$0	0	$0	0	$0	$20,475
	31-36"	$305	61	$18,605	0	$0	0	$0	0	$0	0	$0	$18,605
	37-42"	$380	39	$14,820	0	$0	0	$0	0	$0	0	$0	$14,820
	43"+	$590	19	$11,210	0	$0	0	$0	0	$0	0	$0	$11,210
Activity Total(s)			149	$51,385	205	$33,390	0	$0	0	$0	0	$0	$85,480
Routine Pruning	1-3"	$20	0	$0	0	$0	0	$0	16	$320	16	$320	$640
	4-6"	$30	0	$0	0	$0	0	$0	42	$1,260	42	$1,260	$2,520
	7-12"	$75	0	$0	0	$0	0	$0	89	$6,675	89	$6,675	$13,350
	13-18"	$120	0	$0	0	$0	0	$0	67	$8,040	67	$8,040	$16,080
	19-24"	$170	0	$0	0	$0	0	$0	45	$7,650	45	$7,650	$15,300
	25-30"	$225	0	$0	0	$0	0	$0	34	$7,650	34	$7,650	$15,300
	31-36"	$305	0	$0	0	$0	0	$0	19	$5,795	19	$5,795	$11,590
	37-42"	$380	0	$0	0	$0	0	$0	12	$4,560	12	$4,560	$9,120
	43"+	$590	0	$0	0	$0	0	$0	5	$2,950	5	$2,950	$5,900
Activity Total(s)			0	$0	0	$0	0	$0	329	$44,900	329	$44,900	$89,800

Estimated Costs for Each Activity			2017		2018		2019		2020		2021		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Young Tree Training Pruning	1-3"	$20	105	$2,100	105	$2,100	105	$2,100	105	$2,100	105	$2,100	$10,500
	4-6"	$30	58	$1,740	58	$1,740	58	$1,740	58	$1,740	58	$1,740	$8,700
	7-12"	$75	7	$525	7	$525	7	$525	7	$525	7	$525	$2,625
Activity Total(s)			170	$4,365	170	$4,365	170	$4,365	170	$4,365	170	$4,365	$21,825
Tree Planting	Purchasing	$110	73	$8,030	156	$17,160	270	$29,700	100	$11,000	100	$11,000	$76,890
	Planting	$110	73	$8,030	156	$17,160	270	$29,700	100	$11,000	100	$11,000	$76,890
Activity Total(s)			146	$16,060	312	$34,320	540	$59,400	200	$22,000	200	$22,000	$153,780
Annual Mortality (1%) Removals	Average Tree	$726	25	$18,150	25	$18,150	25	$18,150	25	$18,150	25	$18,150	$90,750
Activity Total(s)			171	$18,150	337	$18,150	565	$18,150	225	$18,150	225	$18,150	$244,530
Annual Mortality (1%) Stump Removals	Average Tree	$73	25	$1,825	25	$1,825	25	$1,825	25	$1,825	25	$1,825	$9,125
Activity Total(s)			25	$1,825	25	$1,825	25	$1,825	25	$1,825	25	$1,825	$253,655
Activity Grand Total			797		1,311		1,790		1,123		949		5,980
Cost Grand Total				$169,195		$168,930		$152,130		$146,495		$91,240	$728,695

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 EAB, looper complex, forest tent caterpillar, and ALB).

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.

Pendleton’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.

Public trees 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. In addition to locating potential new hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. Pendleton has a large population of trees that are susceptible to pests and diseases, such as ash, maple, and oak.

Inventory and Plan Updates

Davey Resource Group recommends that the inventory and management plan be updated 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 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 as work is performed. Add new tree work to the schedule when work is identified through inspections or a citizen call process.
- Re-inventory the street ROW, and update all data fields in five years or a portion (1/5 the population/area) every year.
- Revise the *Tree Management Plan* after five years when the re-inventory has been completed.

CONCLUSIONS

Every hour of every day, public trees in Pendleton are supporting and improving the quality of life. The Town's trees provide a total annual benefit of $364,084. Pendleton's return on investment is $1.45 for every $1 spent on managing and maintaining the public trees. 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, Pendleton is well positioned to thrive. If the management program is successfully implemented, the health and safety of Pendleton's trees and citizens will be maintained for years to come.

GLOSSARY

aboveground utilities (data field): Shows the presence or absence of overhead utilities at the tree site.

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).

Aesthetic/Other Report: The i-Tree Streets Aesthetic/Other Report presents the tangible and intangible benefits of trees reflected by increases in property values in dollars ($).

Air Quality Report: The i-Tree Streets Air Quality Report quantifies the air pollutants (ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], coarse particulate matter less than 10 micrometers in diameter [PM_{10}]) deposited on tree surfaces and reduced emissions from power plants (NO_2, PM_{10}, Volatile Oxygen Compounds [VOCs], SO_2) due to reduced electricity use measured in pounds (lbs.). Also reported are the potential negative effects of trees on air quality due to Biogenic Volatile Organic Compounds (BVOC) emissions.

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.

Benefit-Cost Ratio (BCR): The i-Tree Streets (BCR) is the ratio of the cumulative benefits provided by the landscape trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms.

biogenic volatile organic compounds (BVOC): Gases emitted from trees, like pine trees, which create the distinct smell of a pine forest. When exposed to sunlight in the air, BVOCs react to form tropospheric ozone, a harmful gas that pollutes the air and damages vegetation.

block side (data field): Address information for a site that includes the *on street*, *from street*, and *to street*. The *on street* is the street on which the site is actually located. The *from street* is the cross street from which one moves away when heading in the direction of traffic flow. The *to street* is the cross street from which one moves towards when heading in the direction of traffic flow.

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

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

Carbon Dioxide Report: The i-Tree Streets Carbon Dioxide Report presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reduced energy use in pounds. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.

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**.

Energy Report: The i-Tree Streets Energy Report presents the contribution of the urban forest toward conserving energy in terms of reduced natural gas use in winter measured in therms (th) and reduced electricity use for air conditioning in summer measured in megawatt-hours (MWh).

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 type (data field): Best identifies the type of location where a tree is growing. During the inventory, grow space types were categorized as island, median, open/restricted, open/unrestricted, raised planter, tree lawn/parkway, unmaintained/natural area, or well/pit.

hardscape damage (data field): Indicates trees damaged by hardscape or hardscape damaged by trees (for example, damage to curbs, cracking, lifting of sidewalk pavement 1 inch or more).

importance value (IV): A calculation in i-Tree Streets displayed in table form for all species that make up more than 1% of the population. The i-Tree Streets IV is the mean of three relative values (percentage of total trees, percentage of total leaf area, and percentage of canopy cover) and can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. IVs offer valuable information about a community's reliance on certain species to provide functional benefits. For example, a species might represent 10% of a population, but have an IV of 25% because of its great size, indicating that the loss of those trees due to pests or disease would be more significant than their numbers suggest.

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

inventory: See **tree inventory**.

i-Tree Streets: i-Tree Streets is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase.

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

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

Land use (data fields): A description of the type of area where the tree is growing.

Management Costs: Used in i-Tree Streets, they are the expenditures associated with street tree management presented in total dollars, dollars per tree, and dollars per capita.

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

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

Net Annual Benefits: Specific data field for i-Tree Streets. Citywide benefits and costs are calculated according to category and summed. Net benefits are calculated as benefits minus costs.

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

notes (data field): Describes additional pertinent information.

ordinance: See **tree ordinance**.

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

Particulate Matter (PM_{10}): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

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

Priority 1 Removal (Primary Maintenance Need): Trees designated for removal have defects that cannot be cost-effectively or practically treated. The majority of the trees in this category have a large percentage of dead crown and pose an elevated level of risk for failure. Any hazards that could be seen as potential dangers to persons or property and seen as potential liabilities to the client would be in this category. Large dead and dying trees that are high-liability risks are included in this category. These trees are the first ones that should be removed.

Priority 2 Removal (Primary Maintenance Need): Trees that should be removed but do not pose a liability as great as the first priority will be identified here. This category would need attention as soon as "Priority One" trees are removed.

Priority 3 Removal (Primary Maintenance Need): Trees that should be removed, but that pose minimal liability to persons or property, will be identified in this category.

Priority 1 Prune (Primary Maintenance Need): Trees that require Priority One Pruning are recommended for trimming to remove hazardous deadwood, hangers, or broken branches. These trees have broken or hanging limbs, hazardous deadwood, and dead, dying, or diseased limbs or leaders greater than four inches in diameter.

Priority 2 Prune (Primary Maintenance Need): These trees have dead, dying, diseased, or weakened branches between two and four inches in diameter and are potential safety hazards.

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

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

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

Routine Pruning (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.

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.

Stored Carbon Report: While the i-Tree Streets Carbon Dioxide Report quantifies annual CO_2 reductions, the i-Tree Streets Stored Carbon Report tallies all of the Carbon (C) stored in the urban forest over the life of the trees as a result of sequestration measured in pounds as the CO_2 equivalent.

Stormwater Report: A report generated by i-Tree Streets that presents the reductions in annual stormwater runoff due to rainfall interception by trees measured in gallons (gals.).

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.

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

Summary Report: A report generated by i-Tree Streets that presents the annual total of energy, stormwater, air quality, carbon dioxide, and aesthetic/other benefits. Values are reflected in dollars per tree or total dollars.

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

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

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

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

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

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

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

urban tree canopy (UTC) assessment: A study performed of land cover classes to gain an understanding of the tree canopy coverage, particularly as it relates to the amount of tree canopy that currently exists and the amount of tree canopy that could exist. Typically performed using aerial photographs, GIS data, or Lidar.

Volatile Organic Compounds (VOCs): Hydrocarbon compounds that exist in the ambient air and are by-products of energy used to heat and cool buildings. Volatile organic compounds contribute to the formation of smog and/or are toxic. Examples of VOCs are gasoline, alcohol, and solvents used in paints.

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:

- aboveground utilities
- block side
- condition
- grow space type
- further inspection
- hardscape damage
- land use
- location
- primary maintenance needs
- mapping coordinates
- species
- tree size*

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

Maintenance needs are based on *ANSI A300 (Part 1)* (ANSI 2008). Risk assessments and risk ratings are based on *Urban Tree Risk Management* (Pokorny et al. 1992).

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

Site Location Methods

Equipment and Base Maps

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

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

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Indiana Map http://www.indianamap.org/	2014-2015	NAD 1983 UTM Zone 16N, Meters
USDA-FSA-APFO NAIP MrSID Mosaic https://gdg.sc.egov.usda.gov/	2014	NAD 1983 UTM Zone 16N, Meters

Street ROW Site Location

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

Address Number and Street Name

The *address number* was recorded based on visual observation by the arborist at the time of the inventory (the address number was posted on a building at the inventoried site). Where there was no posted address number on a building, or where the site was located by a vacant lot with no GIS parcel addressing data available, the arborist used his/her best judgment to assign an address number based on opposite or adjacent addresses.

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.

Block Side

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

- The *on street* is the street on which the site is located. The *on street* may not match the address street. A site may be physically located on a street that is different from its street address (i.e., a site located on a side street).

Park and/or Public Space Site Location

Park and/or public space site locations were collected using the same methodology as street ROW sites.

Site Location Examples

Figure 2. 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
On Street:	Davis 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.

Figure 3. Location information collected for inventoried trees at Corner Lots A and B.

Corner Lot A		**Corner Lot B**	
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
On Street:	Taft St.	On Street:	Davis St.
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
On Street:	Taft St.	On Street:	E Mac Arthur St.
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
On Street:	Taft St.	On Street:	E Mac Arthur St.
Address/Street Name:	205 Hoover St.		
On Street:	Hoover St.		

APPENDIX B
RECOMMENDED SPECIES FOR FUTURE PLANTINGS

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 C
INVASIVE PESTS AND DISEASES THAT AFFECT TREES

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

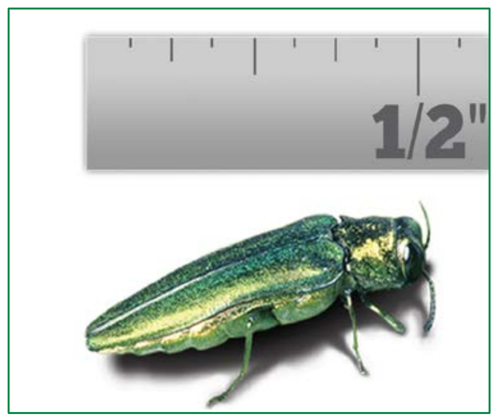
Adult Asian longhorned beetle

Photograph courtesy of New Bedford Guide 2011

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.

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).

Emerald Ash Borer



Close-up of the emerald ash borer

Photograph courtesy of APHIS (2011)

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

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

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

Forest Tent Caterpillar

Forest tent caterpillar (*Malacosoma disstria*) is possibly the most damaging tent caterpillar in the United States. It attacks ash, various fruit trees, poplar, willow, and many other deciduous trees. The name may be slightly misleading, as the larvae do not make a silken tent between the trunk and branches of trees as other tent caterpillars do. Instead, this larva makes a mat on the trunk. Masses of caterpillars rest on the mat. The larval caterpillar is distinctive in the bright blue coloration along its sides with a white, keyhole-shaped pattern running along its back.

Forest Tent Caterpillar larva with blue stripe and white "keyhole" pattern running down its back.

Photograph courtesy of Greg Hume CC-BY-SA-3.0 (2006).

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.

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).

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

Photograph courtesy of APHIS (2011b)

Oak Wilt

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

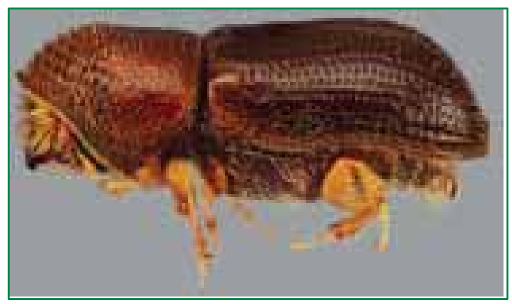
Oak wilt symptoms on red and white oak leaves

Photograph courtesy of USDA Forest Service (2011a)

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

Thousand Cankers Disease

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



Walnut twig beetle, side view

Photograph courtesy of USDA Forest Service (2011b)

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

The tree species preferred as hosts for TCD are walnuts.

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APPENDIX D
TREE PLANTING

Tree Planting

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

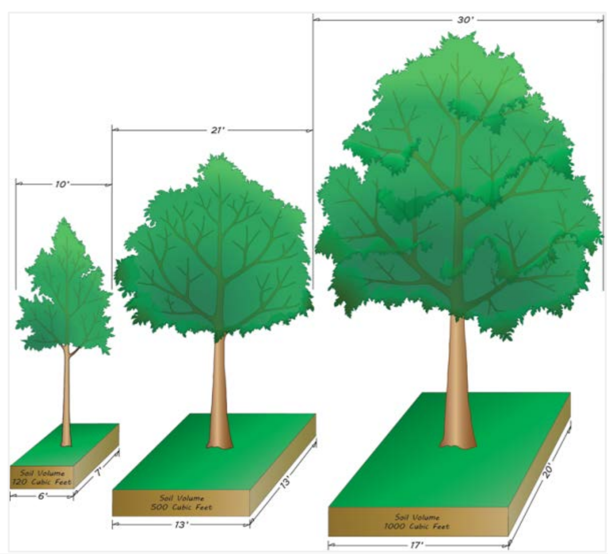
- Consider the specific purpose of the tree planting.
- Assess the site and know its limitations (i.e., confined spaces, overhead wires, and/or soil type).
- Select the species or cultivar best suited for the site conditions.
- Examine trees before buying them, and buy for quality.

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.

Pendleton 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 Pendleton 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.



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

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.

Tips for Planting Trees

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

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

Newly Planted and Young Tree Maintenance

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

Watering

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

Mulching

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

Lifelong Tree Care

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

The 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
PRIORITY AND PROACTIVE MAINTENANCE

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 priority tree removals and 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.