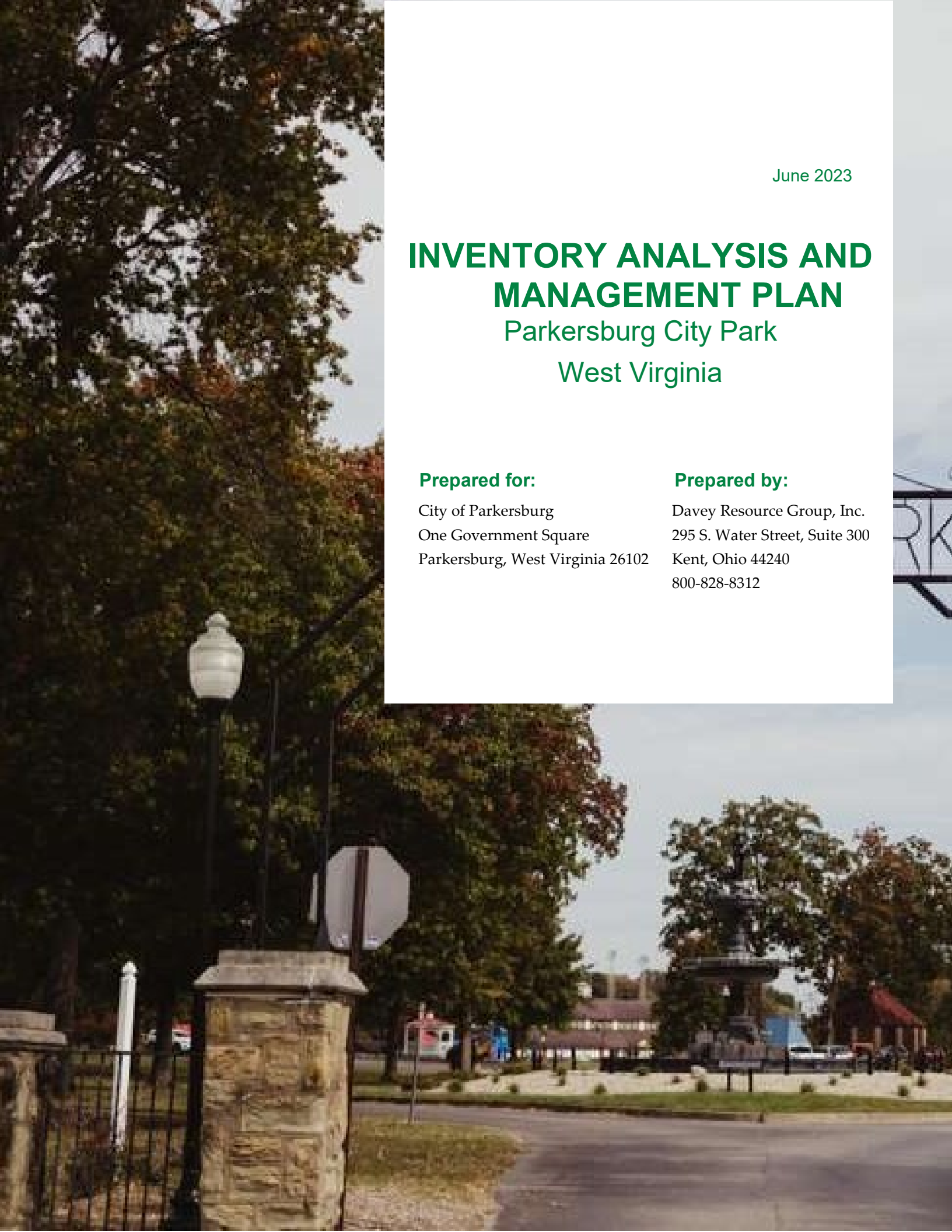


June 2023

INVENTORY ANALYSIS AND MANAGEMENT PLAN

Parkersburg City Park

West Virginia

Prepared for:

City of Parkersburg
One Government Square
Parkersburg, West Virginia 26102

Prepared by:

Davey Resource Group, Inc.
295 S. Water Street, Suite 300
Kent, Ohio 44240
800-828-8312

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ACKNOWLEDGMENTS

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

The City of Parkersburg is thankful for the grant funding it received from the West Virginia State Division of Forestry through *Demonstration City* Grant Program. The *Demonstration City* Grant Program funds urban forestry work such as tree planting, pruning, inventories, and other consulting work to cities in West Virginia, with priority to cities that have Tree City USA status.

City of Parkersburg also recognizes the support of its Mayor and City Officials:

Thomas T. Joyce, *Mayor of the City of Parkersburg*
Connie Shaffer, *City Clerk*
Ryan Barber, *Development Director*
Tammy Bunner, *Development Department*
Everett Shears, *Public Works Director*
Adam Stout, *City Engineer*

City of Parkersburg also recognizes the support of its City Council:

Jesse Cottrille, *District 1*
Sharon Kuhl, *District 2*
Bob Mercer, *District 3*
Wendy Tuck, *District 4*
JR Carpenter, *District 5*
Mike Reynolds, *District 6*
Chris Rexroad, *District 7*
Zach Stanley, *District 8*
Ray Eubanks, *District 9*

Finally, City of Parkersburg also recognizes the support of the Parkersburg Tree Commission:

Craig Minton, *Commission Chairman*
Betty Camp
Dan Hickman
Turner Sharp
Buck McCroskey, *City of Parkersburg Parks Supervisor*

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

EXECUTIVE SUMMARY

The City of Parkersburg City Park *Inventory Analysis and Management Plan*, written by Davey Resource Group, Inc. "DRG", focuses on quantifying the benefits provided by the inventoried tree resource and addressing its maintenance needs. DRG completed a tree inventory in City Park for Parkersburg in January 2023 and analyzed the inventory data to understand the structure of the city's inventoried tree resource. DRG also estimated the economic values of the various environmental benefits provided by this public tree resource by analyzing inventory data with i-Tree and recommended a prioritized management program for future tree care.

The functions of Parkersburg's inventoried park tree population provide benefits with an estimated total value of $3,927.39 annually. Supporting and funding proactive maintenance of the public tree resource is a sound long-term investment that will reduce tree management costs over time.

High priority tree removal and pruning is costly, accounting for the larger budget in Years 1 and 2 of the five-year schedule, as shown in Figure 1. After high priority work has been completed, budgets are expected to decrease and stabilize as tree management transitions from reactive to proactive maintenance. This also reduces the number of new elevated risk trees over time by preventing deteriorating conditions of trees with initial minor defects.

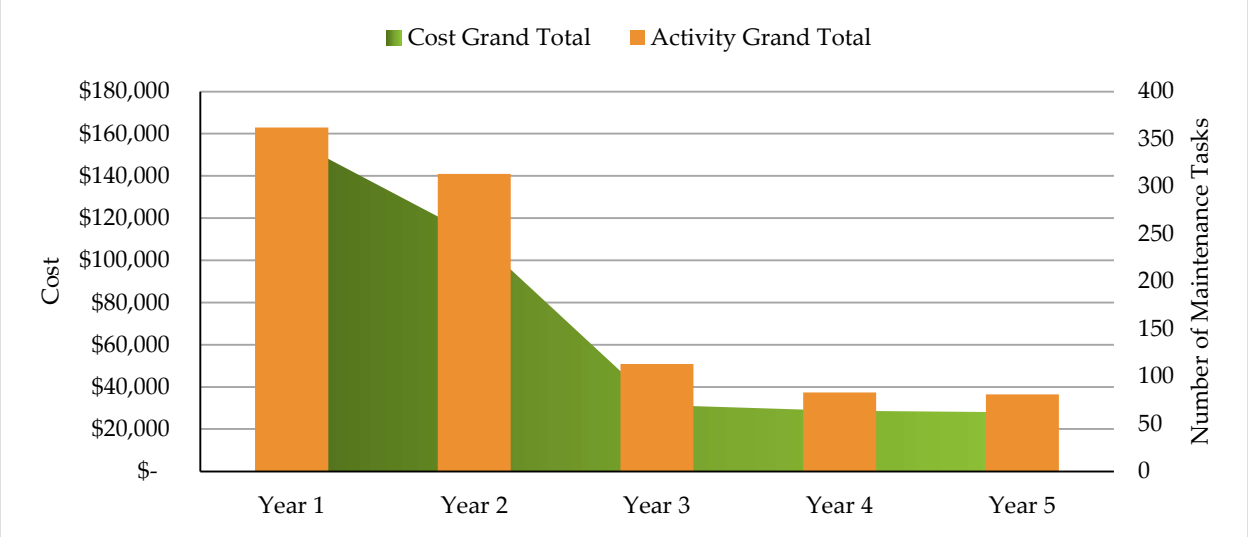


Figure 1. Number of inventoried sites by location and type.

Recommended Maintenance Types

Removal

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

Total = 75 trees
High Priority = 0 trees
Moderate Priority = 17 trees
Low Priority = 58 trees
Stumps = 9

Priority Pruning

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

Total = 83 trees
High Priority = 0 trees
Moderate Priority = 11 trees

Routine Pruning Cycle

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

Total = 227 trees
Yearly Cycle = at least 45 trees

Young Tree Training Cycle

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

Total =91 trees
Yearly Cycle = at least 30 trees

Planting

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

Total new plantings = 20 trees

INTRODUCTION

The City of Parkersburg, West Virginia is home to 29,403 residents (U.S. Census Bureau 2023, retrieved from: U.S. Census Bureau QuickFacts) benefitting from public trees in their community. The city's urban forestry program manages all trees, stumps, and planting sites along the street rights-of-way (ROW) and public spaces. For years, city staff in the Service Department have shown continued commitment to developing a thriving public tree resource.

Urban forestry program budgets are funded by the City's General Fund. Parkersburg has a tree committee, has a tree ordinance, spends more than $2 per capita on tree maintenance, celebrates Arbor Day, and has been a Tree City USA community for 24 years.

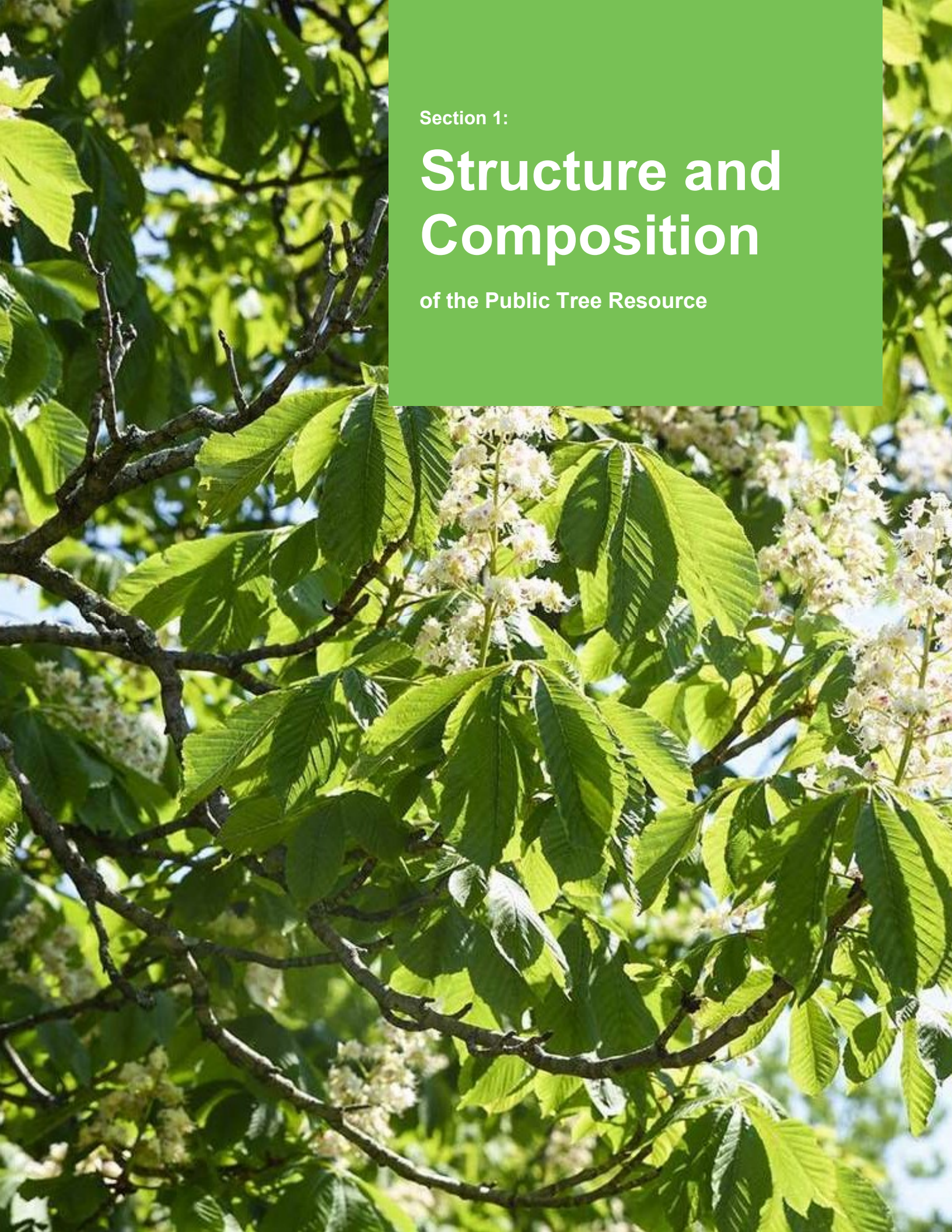
Past urban forestry projects have demonstrated Parkersburg's dedicated commitment to sustaining the public tree resource with higher levels of tree care. Parkersburg has been able to set goals and perform proactive maintenance using this *Inventory Analysis and Management Plan*. The city's urban forestry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

RECOMMENDED APPROACH TO TREE MANAGEMENT

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

In January 2023, Parkersburg worked with DRG to inventory public trees in City Park and develop this management plan. Consisting of three sections, this plan considers the diversity, distribution, and condition of the inventoried tree population and provides a prioritized system for managing the city's public tree resource.

- *Section 1: Structure and Composition of the Public Tree Resource* summarizes the inventory data with trends representing the current state of the tree resource.
- *Section 2: Functions and Benefits of the Public Tree Resource* summarizes the estimated value of benefits provided to the community by public trees' various functions.
- *Section 3: Recommended Management of the Public Tree Resource* details a prioritized management program and provides an estimated budget for recommended maintenance activities over a five-year period.
- *Section 4: Future Tree Planting* lays out a path for a planting effort in City Park and a budget that is in-line with the city's capacity.



Section 1:

Structure and Composition

of the Public Tree Resource

SECTION 1: STRUCTURE AND COMPOSITION OF THE PUBLIC TREE RESOURCE

In January 2023, DRG arborists collected site data on trees, stumps, and planting sites in City Park for a tree inventory contracted by the City of Parkersburg. Figure 2 breaks down the total sites inventoried by type within the park. See Appendix A for details about DRG's methodology for collecting site data.

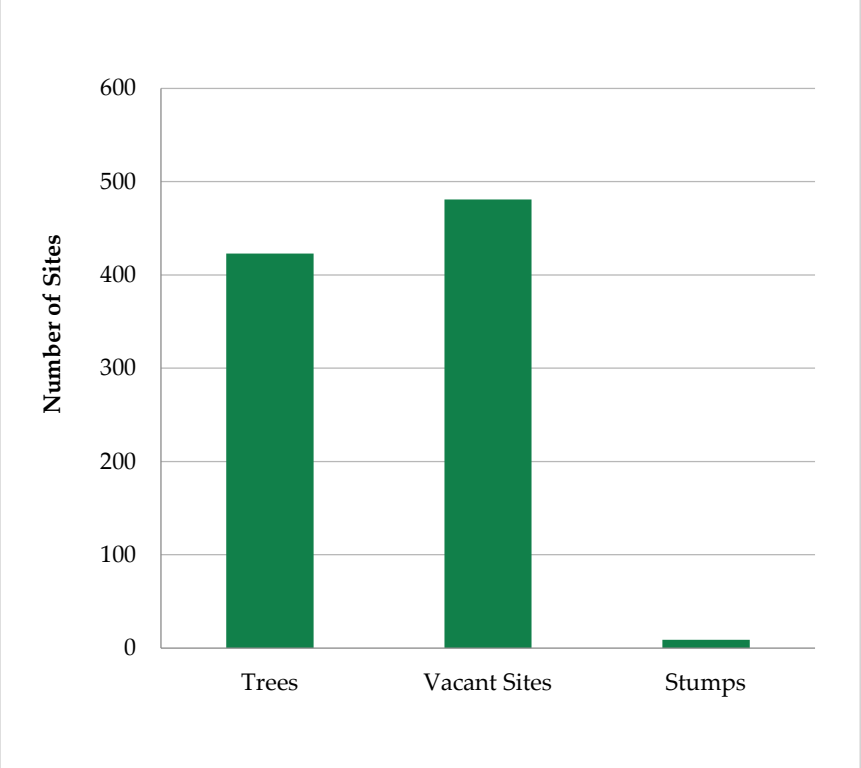


Figure 2. Number of inventoried sites by location and type.

The City of Parkersburg designated one project area for DRG to collect site data for the tree inventory, City Park, which is the city's largest public park asset. City Park is 46 acres and provides many avenues for passive and active recreation.

The city's goal for completing a tree inventory is to determine maintenance needs for larger, mature park trees and to identify planting sites for future park plantings that align with the current recreational use of the park.

RESILIENCE THROUGH DIVERSITY

The Dutch elm disease epidemic of the 1930s provides a key historical lesson on the importance of diversity (Karnosky 1979). The disease killed millions of American elm trees, leaving behind enormous gaps in the urban canopy of many Midwestern and Northeastern communities. In the aftermath, ash trees became popular replacements and were heavily planted along city streets. History repeated itself in 2002 with the introduction of the emerald ash borer into America. This invasive beetle devastated ash tree populations across the Midwest. Other invasive pests spreading across the country threaten urban forests, so it's vital that we learn from history and plant a wider variety of tree genera to develop a resilient public tree resource.

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

USDA Forest Service (2017)

SPECIES, GENUS, AND FAMILY DISTRIBUTION

The 10-20-30 rule is a common standard for tree population distribution, in which a single species should compose no more than 10% of the tree population, a single genus no more than 20%, and a single family no more than 30% (Santamour 1990).

Figure 3 shows City Park's distribution of the most abundant tree species inventoried compared to the 10% threshold. Pin oak (*Quercus palustris*) is the most abundant species, representing 13% of the park tree population. Although this does exceed the 10% threshold, decisions about park tree diversity requirements should consider the species diversity of the City's tree population as a whole.

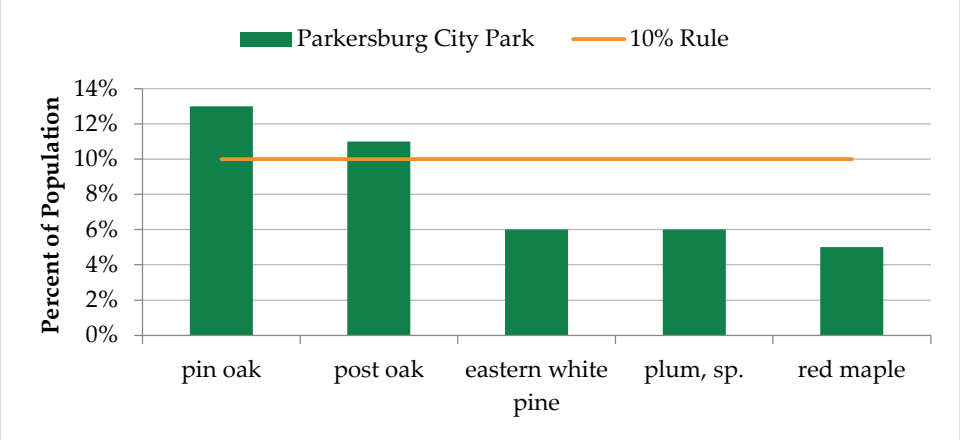


Figure 3. Species distribution of inventoried trees.

However, Figure 4 shows the Park's distribution of the most abundant tree genera inventoried, and oak (*Quercus*) is significantly higher than the 20% threshold at 35%. While this is significantly higher than the ideal threshold, the oak population in the park should be compared to the city-wide oak population before decisions about planting restrictions are finalized. Public parks are often the best places to plant ecologically valuable large trees, such as oak, because the growing space is not limited the way it can be in the public right-of-way.

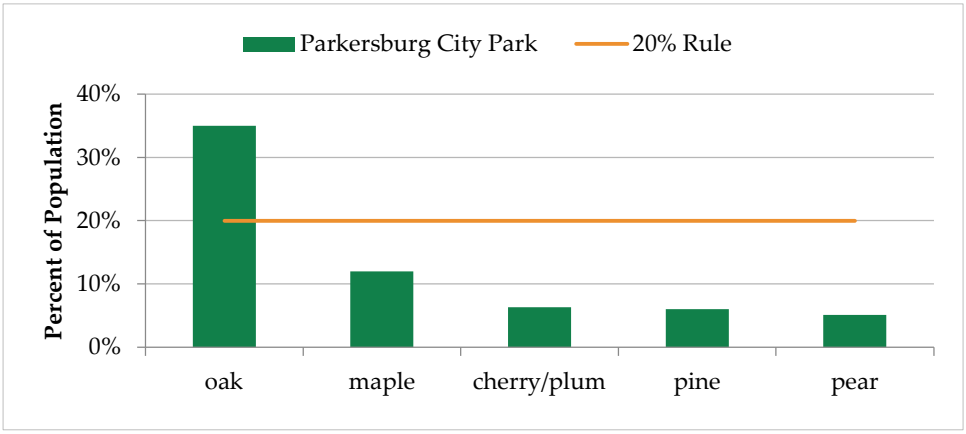


Figure 4. Genus distribution of inventoried trees.

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

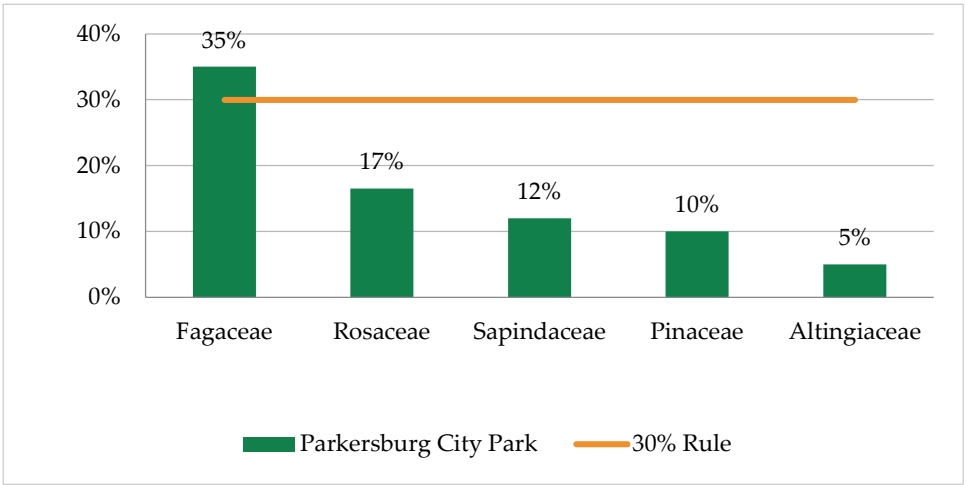


Figure 5. Family distribution of inventoried trees.

Figure 5 shows the park's distribution of the most abundant tree families inventoried compared to the 30% threshold. While Rosaceae (17%) is fairly far from the threshold, Fagaceae (35%) is the only family exceeding the ideal threshold.

PEST SUSCEPTIBILITY

Early diagnosis of disease and infestation is essential to ensuring the health and continuity of Parkersburg's public tree resource. See Appendix B for some information about the pests listed below and websites where additional information can be found.

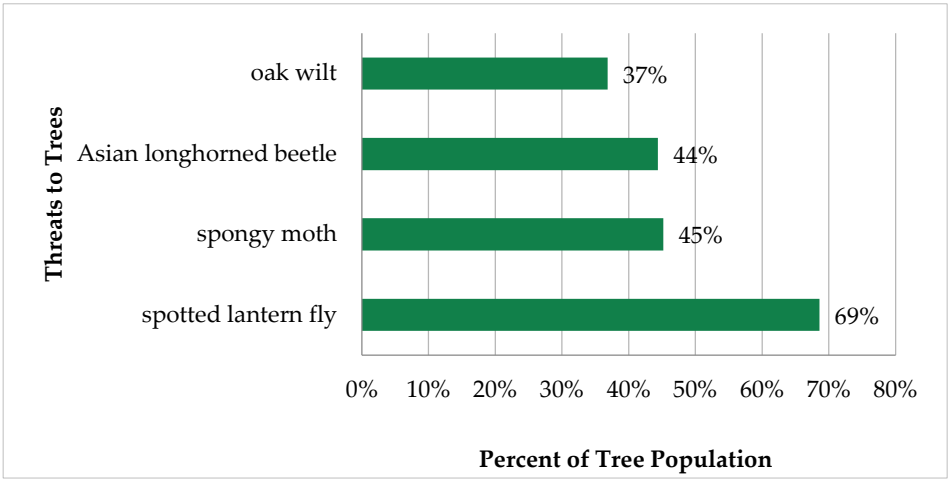


Figure 6. Tree resource susceptibility to invasive pests that have a regional presence.

Figure 6 shows the percent of inventoried trees susceptible to some of the known pests in and around West Virginia. It is important to remember that this figure only represents data collected during the inventory. Many more trees throughout Parkersburg, especially those on private property, may be susceptible to hosting these invasive pests. Spotted lantern fly (SLF, *Lycorma delicatula*), spongy moth (SM, *Lymantria dispar*), Asian longhorned beetle (ALB, *Anoplophora glabripennis*), and oak wilt (OW, *Ceratocystis fagacearum)* are known threats to a large percentage of the inventoried tree resource, threatening 69%, 45%, 44%, and 37%, respectively.

Pest Susceptibility Recommendations

The overabundance of oak in Parkersburg's park tree resource is a potential management concern because it creates unnecessary risk in the event of an invasive pest outbreak. This abundance is not only more tree resource to lose but is also more habitat for the pests it is susceptible to, such as SM and OW, making it easier for them to spread. Increasing species diversity is a critical goal that will help Parkersburg's tree resource be resilient in the event of future pest invasions.

While it might be prudent for the city to limit planting species in the *Quercus* genus, and particularly species from the red oak group, efforts to improve diversity at the genus and species level are a better use of short-term resources until more research is done on family diversity as a mechanism for promoting system resilience. For this reason, Parkersburg should use its resources to inspect trees in the *Quercus* genus for symptoms of oak wilt on a routine basis, so affected trees can be removed to contain the pest before an outbreak starts.

CONDITION

Several factors affecting condition were considered for each tree, including root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition of each inventoried tree was rated by an arborist as Good, Fair, Poor, or Dead. The general health of the inventoried tree population was characterized by the most prevalent condition assigned during the inventory.

Figure 7 shows most of the inventoried trees were recorded in Good or Fair condition, 35% and 48%, respectively. Based on these data, the general health of the inventoried tree population is rated as Fair. City Park has a low percentage of Dead trees (1%) and trees in Poor condition (17%), so the general health of the City Park's tree resource is approaching Good.

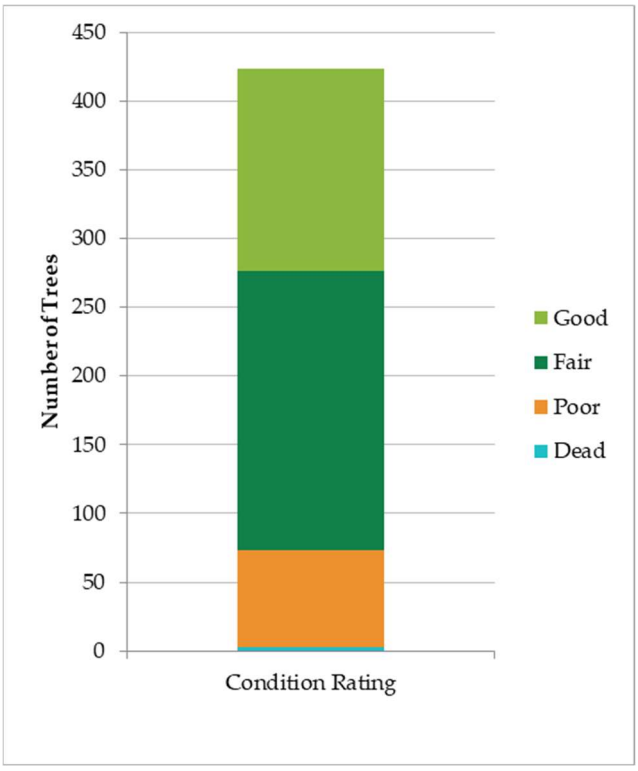


Figure 7. Condition of inventoried trees.

Condition Recommendations

- Dead trees should be removed because standing dead trees pose a risk to park users.
- Trees in Poor condition should be retained and monitored. If their condition worsens, they should be removed.
- Younger trees rated in Fair or Poor condition may benefit from structural pruning to improve their health over time. Pruning should follow *ANSI A300 (Part 1)* guidelines.

RELATIVE AGE DISTRIBUTION

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

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

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

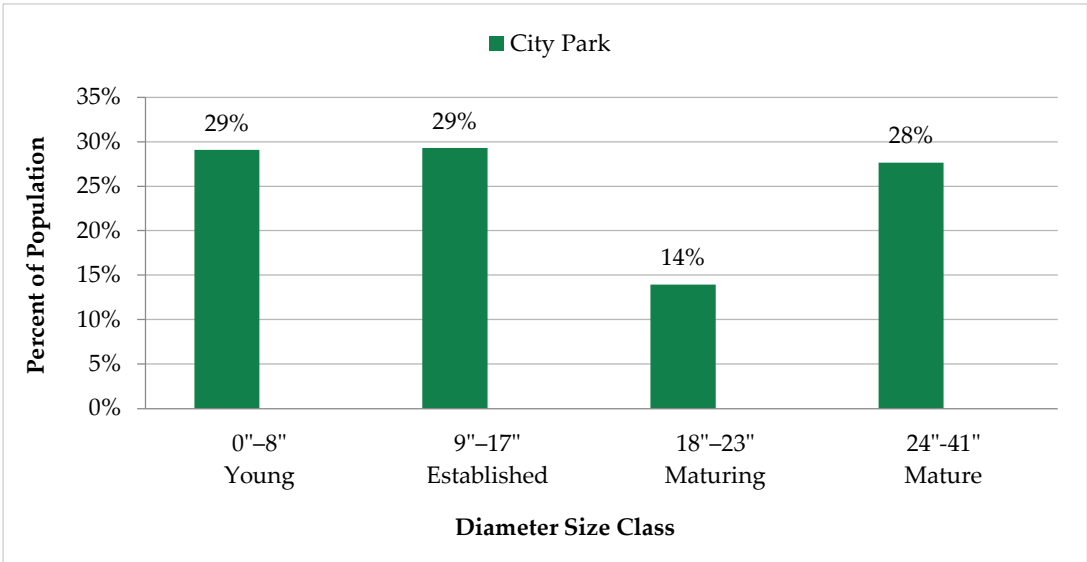


Figure 8. Relative age distribution of inventoried trees.

Figure 8 compares City Park's relative age distribution of the inventoried tree population to the ideal. The city's inventoried tree resource is starting to trend towards the ideal; however, young trees are below the ideal threshold by 11% while mature trees exceed the threshold by 18%. Established trees are at 29%, which is just below the ideal threshold of 30%, and maturing trees are 6% below the ideal threshold of 20%. Trees in the young age class should be monitored and maintained to ensure that they are able to age into the established and maturing class, so that succession of the urban forest is continuous. Continued planting efforts as well as addressing trees recommended for removal will also begin to balance out the age structure of the inventoried tree resource.

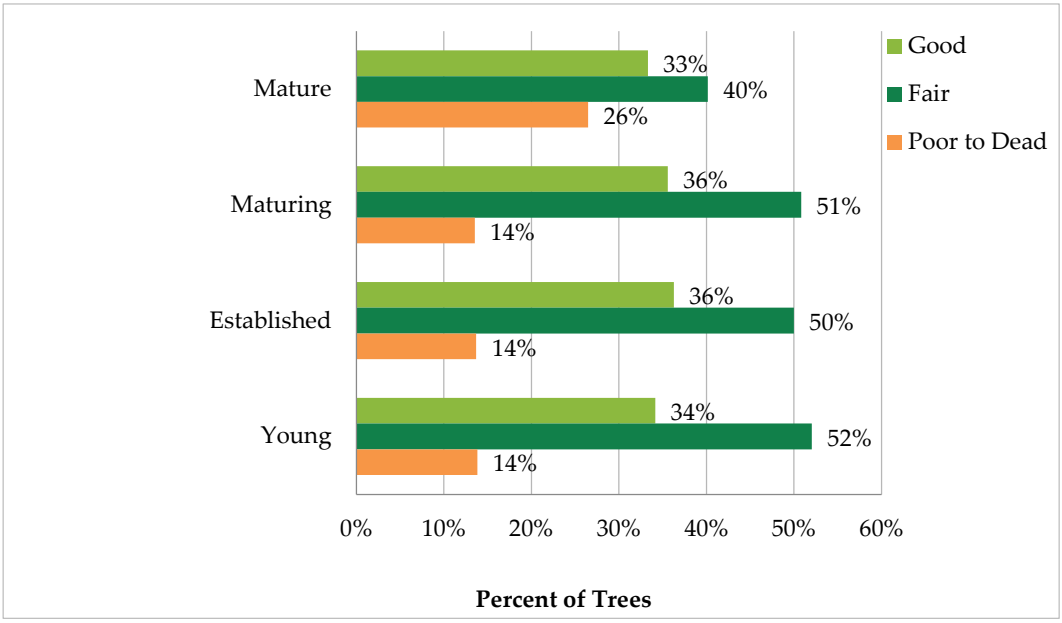


Figure 9. Condition of inventoried trees by relative age class.

Figure 9 cross analyzes the condition of the inventoried tree resource with its relative age distribution, providing insight into the inventoried population's stability. 73% of mature trees and 87% of maturing trees are rated in Fair condition or better, which matters because these larger trees would have a more damaging impact in the event of failure. 86% of established trees and young trees are rated in Fair condition or better, so it is important to provide the maintenance they need to remain healthy as they age and grow, to reduce the proportion of mature and maturing trees in Poor condition or worse.

Relative Age Recommendations

While Parkersburg has an excess of mature trees and a shortage of young trees in City Park, the city has a low percentage of trees in Poor condition, indicating that young trees have the potential of reaching maturity if they are well maintained.

DRG recommends that Parkersburg implement a robust maintenance program, to conserve the condition of young trees as they age so they replace removed trees and fill canopy gaps in maturity. The city should also focus on tree preservation and proactive care, to protect mature and maturing trees from unnecessary removal and to prevent them from succumbing to treatable defects. Prioritizing proactive maintenance above tree planting will shift the relative age distribution towards the ideal over time.

DEFECT OBSERVATIONS

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

- Dead and dying parts
- Weakly attached branches and codominant stems
- Decay or cavity
- Tree architecture
- Root problems
- Broken and/or hanging branches
- Trunk condition
- Missing or decayed wood
- Cracks
- Other

Table 1. Tree defect categories recorded during the inventory

Defect	Number of Trees	Percent
Dead and Dying Parts	116	27.42%
Weakly Attached Branches and Codominant Stems	107	25.30%
Decay or Cavity	68	16.08%
Tree Architecture	41	9.69%
Root Problems	27	6.38%
Broken and/or Hanging Branches	26	6.15%
Trunk Condition	15	3.55%
Missing or Decayed Wood	11	2.60%
None	11	2.60%
Cracks	1	0.24%
Total	**423**	**100%**

The two most frequently recorded defect categories were Dead & Dying Parts and Weakly Attached Branches/Codominant Stems at 27% and 25% of inventoried trees, respectively (Table 1). Of the 116 trees with Dead & Dying Parts trees with Dead & Dying Parts, 14 were recommended for removal.

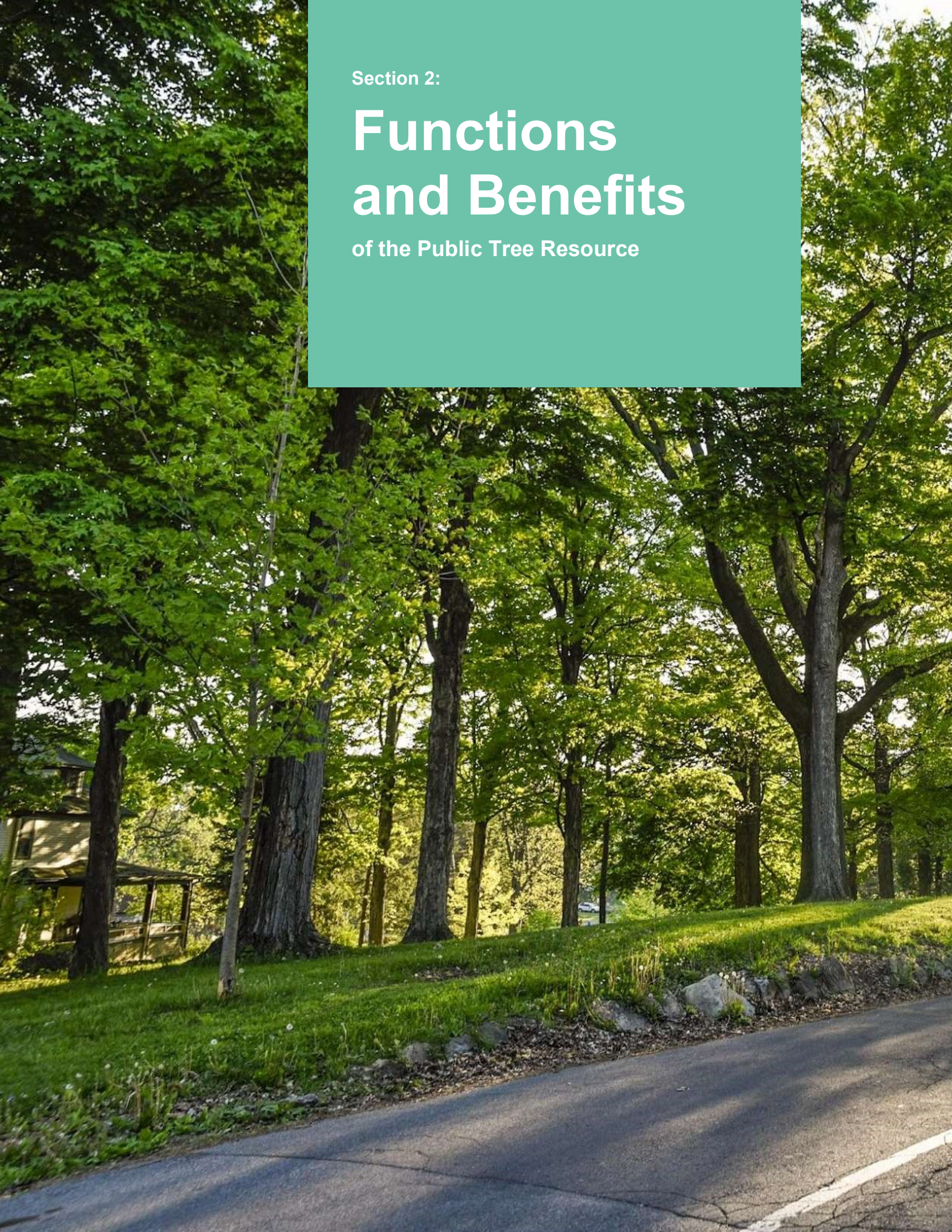
Defect Observation Recommendations

When considering the defect recorded for each tree, there are two important qualifiers to keep in mind. First, the categories are broadly inclusive. For example, the "Dead and Dying Parts" category can include trees with just one or two smaller diameter dead limbs as well as trees found with large-diameter dead limbs or entire sections of dead canopy. Therefore, inferences on overall tree condition or risk rating cannot be derived solely from the presence or absence of a defect recorded during the inventory. Second, an inventoried tree may have multiple defects; the 2023 City Park inventory recorded only the most significant defect observed for each tree. These two qualifiers are important to keep in mind when considering urban forest management planning and the prioritization of maintenance or monitoring activities.

Section 2:

Functions and Benefits

of the Public Tree Resource



SECTION 2: FUNCTION AND BENEFITS

VALUE OF CITY PARK'S TREES

Trees occupy a vital role in the urban environment. They are critical to public health and contribute significantly to community well-being by providing a wide array of economic, environmental, and social benefits that far exceed the investment cost of planting, maintaining, and removing trees. Trees reduce air pollution, improve air and water quality, improve public health outcomes, reduce stormwater runoff, sequester carbon, and improve property values. Using advanced analytics such as i-Tree Eco and other models in the i-Tree software suite, understanding the importance of trees to a community continues to expand by providing tools to estimate monetary values of the various benefits provided by a public tree resource.

Environmental Benefits

- Trees decrease energy consumption and moderate local climates by providing shade and acting as windbreaks. (Heisler, 1986)
- 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 423 park trees inventoried in Parkersburg are valued at over $2 million (Table 2). This value only reflects the environmental benefits that can be quantified by this analysis. Trees also boost neighborhood livability, lower crime rates, provide cooling effects, and help create more successful business district. Investment in protecting, maintaining and expanding these environmental and social benefits corresponds to the goals set for Parkersburg in the PKB 2030 vision plan adopted by the city in 2020.

Table 2. Benefits provided by park trees

Most Common Trees Inventoried		Count	Percent of Total	Benefits Provided by Park Trees				
				CO_2 Stored	CO_2 Sequestered	Avoided Runoff	Air Pollution Removed	Replacement Value
Common Name	Botanical Name		%	tons	tons/year	gal/year	lbs/year	Dollars
pin oak	*Quercus palustris*	53	13%	59.92	1.00	49,983.67	132.28	$378,053.53
post oak	*Quercus stellata*	47	11%	145.28	0.93	50,500.27	132.28	$130,173.04
eastern white pine	*Pinus strobus*	25	6%	15.50	0.27	12,620.41	22.05	$130,173.04
plum spp.	*Prunus spp.*	24	6%	9.98	0.17	4,008.12	0	$30,599.69
red maple	*Acer rubrum*	21	5%	1.63	0.08	1,022.35	0	$11,895.78
sweetgum	*Liquidambar styraciflua*	21	5%	17.40	0.29	11,834.36	22.05	$141,392.66
sugar maple	*Acer saccharum*	20	5%	6.70	0.05	1,302.61	0	$20,860.94
northern red oak	*Quercus rubra*	20	5%	32.62	0.24	6,469.35	22.05	$134,200.16
All Other Trees Inventoried		192	44%	129.56	1.86	52,928.08	154.31	$1,050,544.91
Total		**423**	**100%**	**418.59**	**4.89**	**190,669.22**	**485**	**2,027,893.75**

i-Tree Eco Analysis

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

Annual Return on Investment from the Public Tree Resource

The i-Tree eco analysis of the community's inventoried trees quantified the functional benefits of three critical ecosystem services that they provide: air pollution removal, carbon sequestration, and avoided surface runoff (Figure 10).

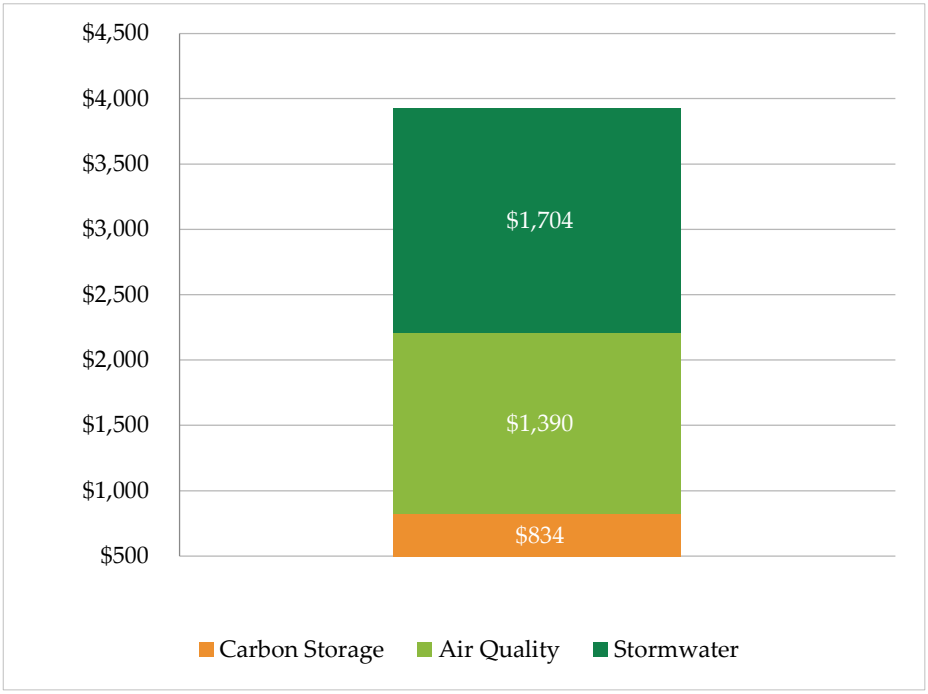


Figure 10. Estimated annual value of the inventoried tree resource functional benefits.

Urban environments have unique challenges that make the estimated $3,927 of functional benefits provided by City Park's inventoried tree population an essential asset to the community (Figure 10). Compared to rural landscapes, urban landscapes are characterized by high emissions in a relatively small area, valuing the 485 lbs. of air pollutants removed by the park trees at $1,390 per year. Avoiding stormwater runoff reduces the risk of flooding and combined sewer overflow, both of which impact people, property, and the environment, valuing the 190,669.22 gals. avoided with Parkersburg's park tree resource at an estimated $1,704. Carbon dioxide ($CO_2$) also impacts people, property, and the environment as the primary greenhouse gas driving climate change, valuing the 9,780 lbs. stored annually by City Park's trees at $834.

The replacement value of the community's inventoried tree resource in City Park is estimated to be over $2 million. Five species of tree make up 40% of the inventoried tree population and provide more than half of the functional benefits provided by the park trees. If any of these species were lost to invasive pests, disease, or other threats, the loss would have significant costs. It is critical to promote species diversity with future plantings to minimize susceptibility to potential threats, and to plant large-statured broadleaf tree species wherever possible to maximize potential environmental and economic benefits. See Appendix D for a list of tree species recommended by DRG.

Sequestering and Storing Carbon

Trees are carbon sinks, the opposite of carbon sources. While carbon is emitted from motor vehicles and urban industry, carbon is absorbed into trees during photosynthesis and stored in their tissue as they grow. The i-Tree eco model estimates both the carbon sequestered each year and total carbon stored. Throughout their life, the 421 inventoried trees in City Park have amassed 837,200 lbs. of carbon. This is valued at $71,393. Willow oak (*Quercus phellos*) and post oak (*Q. stellata*) store the most carbon at 9,118.86 lbs. and 6,808.45 lbs. per tree, respectively. The park's willow tree (*Willow* spp.) and spruce trees (*Picea* spp.) sequester the most carbon annually at 110.2 lbs. per year and 79.36 lbs. per year, respectively.

Controlling Stormwater

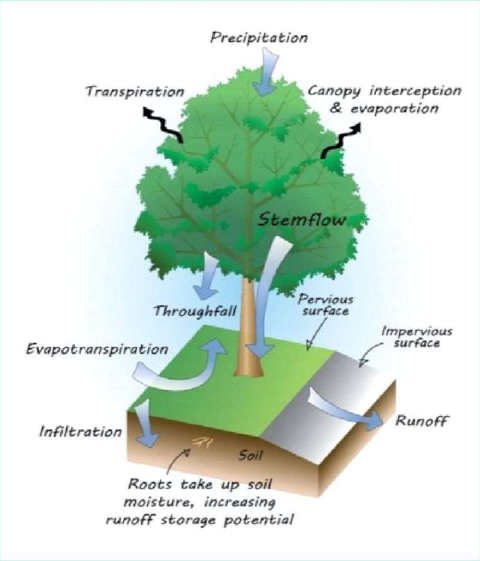
Trees help intercept rainfall with their leaves and branches, helping lower stormwater management costs by avoiding runoff. The inventoried trees in the overall community avoid 190,669 gals. of runoff annually. Avoided runoff accounts for 43% of the annual functional benefits provided by the public tree resource in City Park.

Of all the species inventoried, post oak and tulip tree (*Liriodendron tulipifera*) contribute the most stormwater benefits. Post oak and tulip tree (13% of the inventoried population) avoided 59,262.98 gals. of stormwater, which is 31% of the total avoided runoff. On a per-tree basis, large trees with leafy canopies provided the most functional benefits. Eastern redbud (*Cercis canadensis*) and willow oak make up 3% and 0.5% of the inventoried tree resource, respectively. Willow oak avoids 1,465.88 gals. of stormwater, 1.7 times as much as eastern redbud, despite only having about a sixth of its population size. This illustrates how large-statured trees with wide canopies provide significantly greater benefits.

Improving Air Quality

The inventoried tree population in City Park annually removes 485.02 lbs. of air pollutants, including sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and particulate matter (PM_{25}). The i-Tree Eco model estimated the value of this benefit at $1,390 annually, which is 35% of the value of all annual benefits. The trees that provided the highest annual air quality benefits are post oak and pin oak, removing approximately 4.5 lbs, of pollutants annually per tree.

CANOPY FUNCTIONS



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

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

Section 3:

Recommended Management

of the Public Tree Resource

SECTION 3: RECOMMENDED MANAGEMENT OF THE PUBLIC TREE RESOURCE

During the inventory, both a risk rating and a recommended maintenance activity were assigned to each tree. DRG recommends prioritizing and completing each tree's recommended maintenance activity based on the assigned risk rating. This five-year tree management program takes a multi-faceted and proactive approach to tree resource management.

High Priority

- All High Priority tree removals and pruning should be completed as soon as possible, because these trees have significant defects that will become severe over time.

Moderate Priority

- Moderate Priority tree removals and pruning should only start after most High Priority tree maintenance has been completed, and be performed concurrently.

Low Priority

- Low Priority tree maintenance should be performed after all High and Moderate Priority maintenance has been completed.

Stump Removal

- Stump removals should be performed either when a tree is removed or before a planting season begins, so planting sites become vacant for replacement trees.

Routine Inspection

- Routine Inspection from a drive-by perspective is important for detecting major defects before they worsen, and a walk-by perspective is important for updating inventory data.

Young Tree Training

- Young Tree Training Cycles improve tree structure so defects do not worsen and become more costly to correct as they grow, and should begin as soon as possible.

Routine Pruning

- Routine Pruning Cycles correct defects before they worsen, which is crucial for maintaining the overall condition of the inventoried tree resource over the long-term.

Replace Trees

- Removed trees should be replaced so there is no net loss of the tree resource, which should enter the Young Tree Training Cycle immediately.

Planting

- Planting new trees is important for increasing population size and urban canopy, but can wait until higher priority maintenance is complete or at least in progress.

RISK MANAGEMENT AND RECOMMENDED MAINTENANCE

Although tree removal is usually considered a last resort, and may sometimes create a reaction from the community, there are circumstances in which removal is necessary. Trees fail from natural causes such as diseases, insects, and weather conditions, and from physical injury due to vehicles, vandalism, and root disturbances. DRG recommends that trees be removed when corrective pruning will not adequately mitigate risk or when correcting problems would be cost-prohibitive. DRG recommends that tree maintenance activities are prioritized and completed based on the risk rating that was assigned to each tree during the inventory. The following section describes recommended maintenance for each risk rating category.

Trees that cause obstructions or interfere with power lines, buildings, 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 11 presents tree removals by risk rating and diameter size class. The following sections briefly summarize the recommended removals and pruning priorities identified during the inventory.

Figure 11. Recommended removals by size class and risk rating.

EXTREME AND HIGH PRIORITY RECOMMENDED MAINTENANCE

Pruning or removing the highest risk trees is strongly recommended to be prioritized and completed as soon as possible. In general, maintenance activities should be completed first for the largest diameter trees (>25″) that pose the greatest risk. Once addressed, recommended tree maintenance activities should be completed for smaller diameter trees (<25″) that pose the greatest risk. Addressing High Risk trees in a timely and proactive manner often requires significant resources to be secured and allocated. However, performing this work expediently will mitigate risk, improve public safety, and reduce long-term costs. A categorization of trees by diameter size class and risk rating is illustrated in Figure 12.

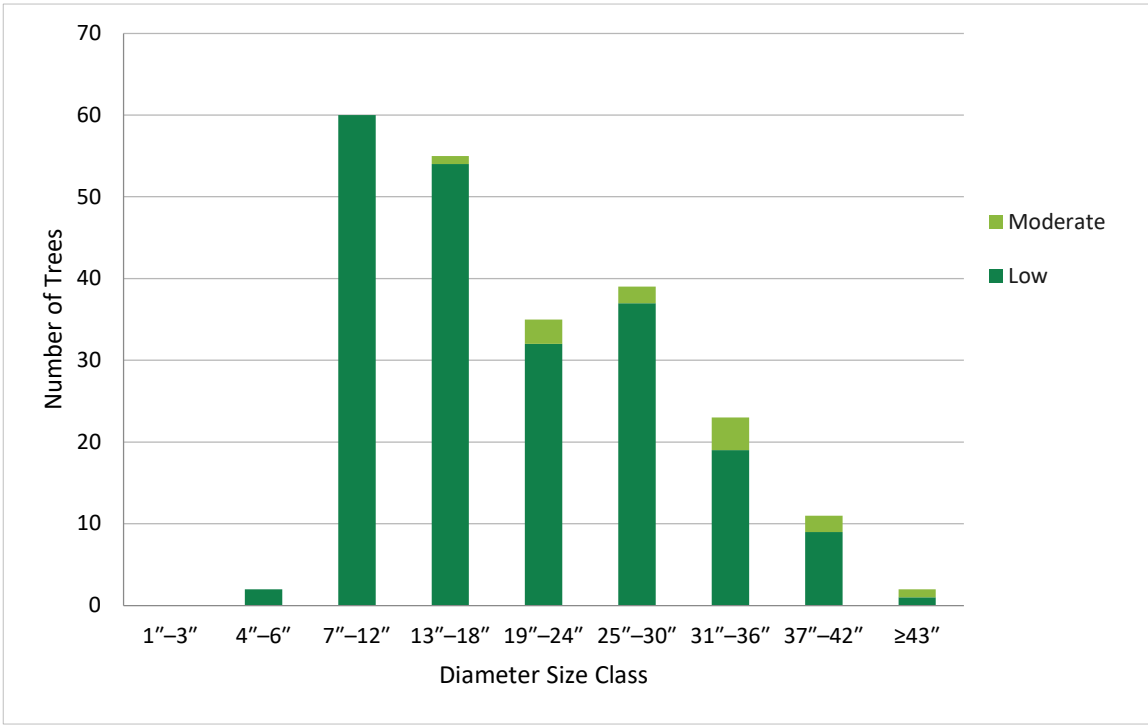


Figure 12. Recommended pruning by size class and risk rating.

High Priority Pruning Recommendations

High Risk trees should be pruned immediately based on assigned risk rating, which generally requires removing defects such as dead and dying parts, broken and/or hanging branches, and missing or decayed wood that may be present in tree crowns, even when most of the tree is sound. In these cases, when pruning the defected branch(es) can correct the problem, risk associated with the tree is reduced while promoting healthy growth.

The inventory did not identify any Extreme or High Risk trees. All trees were either Low or Moderate Risk. This is good news because it allows flexibility for the City of Parkersburg to set a proactive maintenance schedule. The risk rating of trees can change as the conditions of the tree changes, and trees identified as Low or Moderate Risk should still be inspected routinely to ensure that they are getting the needed maintenance to maintain their condition and to keep park users safe.

High Priority Removal Recommendations

DRG did not identify any Extreme or High Risk trees recommended for removal. All trees recommended for removal, even the large dead ones, were identified to be Moderate or Low risk. (Figure 11).

MODERATE AND LOW PRIORITY RECOMMENDED MAINTENANCE

Pruning or removing Moderate and Low Risk trees are generally the next priorities for maintenance activities. Most trees recommended for pruning with these risk levels can be maintained during proactive, routine pruning cycles. DRG recommends implementing proactive maintenance programs incrementally over time as the backlog of risk is reduced.

Moderate Risk Pruning Recommendations

Moderate Risk pruning should be performed after all Extreme and High Risk recommended maintenance is complete and may be performed concurrently with other Moderate Risk removals. The inventory identified 13 Moderate Risk trees recommended for pruning. The diameter size classes for Moderate Risk trees ranged between 13 inches DBH and 42 inches DBH.

Moderate Risk Removal Recommendations

DRG identified 17 Moderate Risk trees recommended for removal. The Moderate Risk trees recommended for removal were between 12 and 42 inches DBH. If corrective pruning cannot correct a tree's defects and/or adequately mitigate risk, then the tree should be removed. A total of 7 Moderate Risk trees larger than 31 inches DBH were recommended for removal. These trees should be the first priority maintenance trees to be removed.

Low Priority Pruning Recommendations

There were 214 Low Risk trees recommended for pruning. Low Risk trees with the assigned maintenance of either "Prune", "Discretionary Prune", 'Routine Prune", or "None" should be included in a proactive Routine Pruning cycle after all the higher risk trees are addressed.

Low Priority Removal Recommendations

DRG identified 58 Low Risk trees recommended for removal. Low Risk removals pose little threat; these trees are generally small, dead, invasive, or poorly formed trees that need to be removed. Eliminating these trees will reduce breeding site locations for insects and diseases and will increase the aesthetic value of the area. Healthy trees growing in poor locations or undesirable species are also included in this category. If pruning cannot correct a tree's defects and/or adequately mitigate risk, then the tree should be removed. All Low Risk trees should be removed when convenient after all higher risk pruning and removals have been completed and may be performed concurrently with routine pruning.

ROUTINE INSPECTIONS

Inspections are essential to uncovering potential problems with trees. They should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees. Arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care. Ideally, the arborist will be ISA Certified and also hold the ISA Tree Risk Assessment Qualification credential.

Routine Inspection Recommendations

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

DRG recommends that Parkersburg perform routine inspections of inventoried trees by a Level 1 visual assessment in line with *ANSI A300 (Part 9)* annually and after all severe weather events, to identify defects with heightened risk, signs of pest activity, and symptoms of disease. When trees need additional maintenance, they should be added to the work schedule immediately. Use asset management software such as TreeKeeper® to update inventory data and schedule work records.

ROUTINE PRUNING CYCLE

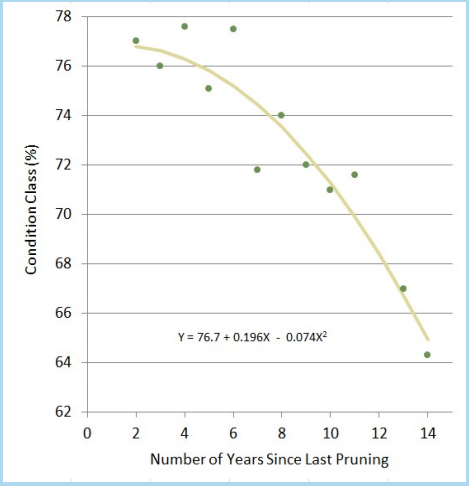
The Routine Pruning cycle includes all Low Risk trees that received a "Prune", "Discretionary Prune", or "None" maintenance recommendation. These trees pose some risk but have a smaller defect size and/or a lower probability of impacting a target. Over time, routine pruning can minimize reactive maintenance, limit instances of elevated risk, and provide the basis for a robust risk management program

Based on Miller and Sylvester's research, DRG recommends five-year Routine Pruning cycles to maintain the condition of the inventoried tree resource. However, not all municipalities are able to remain proactive with a five-year cycle based on budgetary constraints, the size of the public tree resource, or both. In these cases, extending the length of the Routine Pruning cycle is an option; however, it is in the municipality's best interest to not approach or exceed a 10-year pruning cycle. The reason is that this is around when tree condition deteriorates significantly without regular pruning, because their once-minor defects have worsened, reducing tree health and potentially increasing risk (Miller and Sylvester 1981).

Routine Pruning Cycle Recommendations

City Park's tree inventory has 227 trees that should be routinely pruned, and DRG recommends that the City establish a five-year Routine Pruning cycle with approximately 45 trees pruned each year. If this is not feasible for Parkersburg, a six-year Routine Pruning cycle with approximately 38 trees pruned each year, or a seven-year Routine Pruning cycle with approximately 32 trees pruned each year, is acceptable considering the inventoried tree population's size. DRG recommends that the Routine Pruning cycle begins in Year One of the proposed five-year program, after all priority removals and pruning of Moderate risk trees is complete.

Approximately 54% of the inventoried tree population would benefit from routine pruning. Figure 12 shows that a variety of size classes recommended for pruning; however, most of the trees are smaller than 24in DBH.



Relationship between tree condition and years since previous pruning.

(adapted from Miller and Sylvester 1981)

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

Routine pruning cycles help detect and correct most defects before they reach higher risk levels. DRG recommends that pruning cycles begin after all Extreme and High Risk tree maintenance has been completed.

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

YOUNG TREE TRAINING CYCLE

Trees included in the Young Tree Training 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 its risk rating and creating potential liability. The recommended length of a Young Tree Training cycle is three years because young trees tend to grow at faster rates than mature trees. A breakdown of trees and their diameter sizes can be seen in Figure 13.

Figure 13. Three-year Young Tree Training cycle by size class.

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

In an urban setting, space is limited both above and below ground. Trees in this environment may conflict with infrastructure, such as buildings, waking paths, parking spaces, utility wires, and underground utilities, which could pose risks to public safety. In parks, it is also important for young trees to coexist with recreational infrastructure. Young tree training helps to ensure the architecture of the tree is compatible with infrastructure as it matures.

Young Tree Training Cycle Recommendations

DRG recommends that Parkersburg implement a three-year Young Tree Training cycle beginning after the completion of all Extreme and High Risk Recommended Maintenance activities. During the inventory, 92 trees less than or equal to 8 inches DBH were inventoried and recommended for young tree training. Since City Park needs to see the maturation of young trees for the benefit of the tree resource's age structure, the Young Tree Training cycle is vital for the future condition of the inventoried tree population. DRG recommends that an average of 30 trees be trained with structural pruning each year over 3 years, beginning in Year One of the management program.

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

SECONDARY MAINTENANCE

In order to promote tree health, and canopy sustainability, DRG recommends incorporating recommended secondary maintenance into the care of the trees in City Park. These maintenance needs aim to improve growing conditions for trees, proactively protect trees against pest and disease, and ensure successful establishment. Secondary maintenance recommendations can be seen in Figure 14.

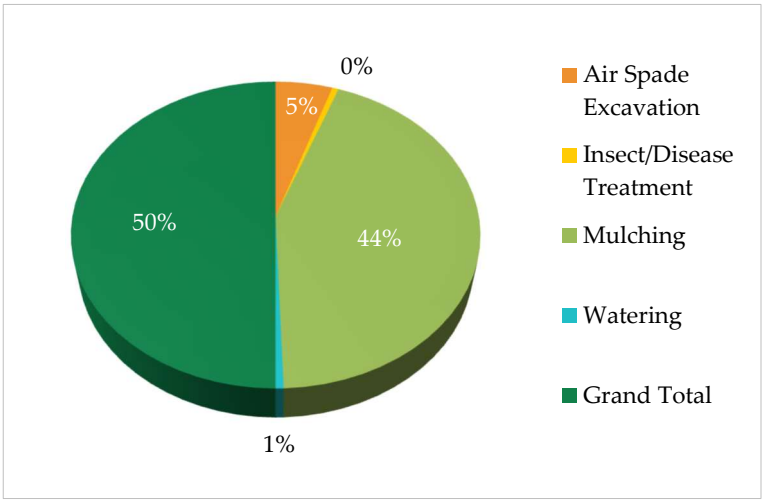


Figure 14. Secondary maintenance into the care of City Park's trees.

Air Spade Excavation

It is common in parks with high recreational traffic for soil to become compacted. Soil compaction occurs when consistent traffic from vehicles, machinery, and pedestrians condense soil particles and minimize soil pore space. Compacted soil limits tree growth because compacted soil has very little space for water flow and drainage and less oxygen available in the soil. This severely limits the nutrient and water uptake available to tree roots and can significantly restrict tree growth. Air space excavation uses a pneumatic hose to spray compressed air into the soil around tree roots. This loosens the compacted soil and creates more pore space in between soil particles, improving water drainage and making water and nutrient uptake easier for tree roots. Air spade excavation is recommended for 9 trees in City Park, ranging in size from 6 inches DBH to 40 inches DBH.

Mulching

Mulching is an important secondary maintenance activity that also supports soil health. Mulch facilitates nutrient cycling; as mulch breaks down, organic materials cycle into the soil around the tree roots. Mulch also regulates soil moisture levels by slowing down water infiltration around roots and slowing evaporation from soil. This also keeps soil temperatures regulated. Mulch also provides a buffer between tree trunks and mechanical equipment such as lawn mowers and string trimmers, both of which will damage tree trunks and surface roots.

It is recommended that 78 trees in City Park are mulched. Mulch can be sourced from tree removal or pruning work where tree limbs are woodchipped, and budgeting for mulching is based on sourcing material this way and utilizing park maintenance workers to conduct the work. Woodchips can then be recycled as mulch around the base of park trees. Mulch should never be piled up against the trunk of the tree; there should always be a few inches between mulch and the tree trunk. See Appendix E for more information.

TREE PLANTING AND STUMP REMOVAL

Planting new trees in areas where there is sparse canopy already is the most important. It is also important to plant more trees in areas with poor canopy continuity or gaps in existing canopy. While Parkersburg as a whole receives value from the ecosystem services provided by the public tree resource, those benefits usually are not distributed evenly across the city.

When it comes to knowing how many trees to plant, communities can benefit from setting goals and benchmarking. Evaluating how many trees are visible per household, overall canopy cover for a community, and distance to a greenspace are three metrics that can lend insight into the overall success of a community's urban forestry program as well as illustrate shortcomings. This is known as the 3-30-300 rule (Konijnendijk, C. 2021). Improving these factors will help combat climate change, improve the health and well-being of residents, and contribute to a sense of community.

- 3 trees from their home.
- 30% tree canopy cover in each neighborhood.
- 300 meters should be the maximum distance to the nearest high-quality public green space.

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. 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 buildings, hardscape, and other trees as it grows taller, wider, and deeper. If the tree at maturity will conflict with existing park infrastructure, it is best to choose another tree or a different location.

Tree Planting Recommendations

During the inventory and analysis of the data, DRG's inventory arborists made specific observations that require mention to Parkersburg. Planting specifications are also available in Appendix E.

Development of a Public Park Planting Plan: The Parkersburg Tree Commission is able to plant about 20 trees per year in City Park. DRG recommends that the Commission utilize inventory data and maintenance plans to draft specific planting plans for City Park and that those planting plans incorporate DRG's recommendations for species diversity (10% species and 20% genus rules). Most importantly, the Commission needs to keep in mind that choosing the proper tree species for the park will help provide the greatest return on the investment of planting and caring for new park trees.

Planting Stock: Trees in West Virginia are largely available as balled and burlapped (B&B) stock. It is important to inspect trees upon delivery to ensure that they are healthy and able to survive during the initial shock of planting. DRG insists that upon final inspection, trees with the following symptoms should be excluded: trees with circling or girdling roots; trees with an unhealthy appearance or weak, poorly formed, scarred, or cracked trunks or branches; trees with double leaders or with branches clustered together on the trunk; trees with leaves of abnormal size or with unwarranted yellowing, possibly signs of a health problem; and trees with insects, diseases, or mechanical damage.

Planting Stock: As trees are purchased through local nurseries, the key consideration should be species selection. This will aid in increasing species diversity in City Park. DRG feels that a good working relationship with a local nursery is very beneficial, but it is equally important that high-quality stock, good prices, and wide species availability be considered. It is recommended that Parkersburg continue to explore local and regional sources for trees and discuss the pricing and even contract growing with the current nursery source. Due to the requirement to work towards species diversity, it may be necessary to use several nurseries as sources for trees.

Planting Locations: Ensuring larger growing sites for trees in public spaces can be the single most beneficial management practice to improve the survival rate of planted and developing trees. Parks are an excellent place to plant and grow trees, because trees can grow unimpeded by curbs, sidewalks, and other pieces of urban infrastructure, and there is ample room to plant larger-maturing trees. Using the companion planting mapbook, DRG encourages the city to maximize planting of large and medium trees in City Park, as larger trees provide greater canopy benefits.

In parks, large-maturing trees should be planted out of the way of existing infrastructure and existing trees. This means planting trees 4 ft. behind paved paths to avoid conflict, at least 30 ft. away from buildings and structures, and at least 30 ft. from existing trees. This will allow newly planted large-maturing trees to have enough room to grow without conflict.

Site Preparation and Protection: Many of the vacant planting sites within City Park require site preparation to ensure the survival of future tree plantings. Some planting sites currently have compacted the soil, which is detrimental to the suitability of a site for a new tree. The soil here may need to be aerated, or new planting soil may need to be brought in.

Once appropriate trees have been selected for planting, the most important detail to ensure success is the preparation of the planting site. In general, the tree-planting hole should be relatively shallow (typically slightly less deep than the height of the root ball) and quite wide (three times the diameter of the root ball). Care should be taken that the root collar of the new tree is at the same level or slightly higher than the surrounding soil grade. In most situations, it is not recommended to add soil amendments to the planting hole as this can lead to severe differences between texture and structure of soils inside the planting hole and the surrounding soil. Such differences can lead to water being wicked away from or accumulating in the planting hole.

Staking of the tree should be done at the time of planting to keep the tree from leaning (if the site is windy) and to prevent damage from pedestrians and/or vandals. Stakes should only be attached to the tree with a loose, flexible material, and all staking materials should be removed within one growing season.

Mulch should be applied to the surface of the soil around each newly planted tree. Mulch should never be piled up around the root collar (mulch "volcanoes"), but rather should be pulled away from the root collar. Mulch that buries the root collar provides shelter for insects, fungi, and mammals that could damage the tree. Mulch should be applied to an area three times the diameter of the root ball to a depth of two to four inches. Mulch not only suppresses competition from grass and weeds, but also provides a zone where mowing is not needed, thereby keeping mowers and string trimmers safely away (thus preventing mechanical damage). Mulch also helps to hold moisture in the surface of the soil where most of the feeder roots are to be established.

Any fertilization process should not be thought of as "feeding" or "energizing" the plant; instead, arboricultural fertilizers should be understood as essentially replacing soil elements or minerals that are lacking or in short supply for a variety of reasons. Nutrients may be in adequate supply, but be unavailable for uptake by the tree because of extreme pH conditions. Application of fertilizer may not improve the situation until measures are taken to alter pH levels or to replace the plant with a species better suited for the existing soil conditions.

Fertilization may not be necessary for the first growing season unless specific nutrient deficiencies exist. At the beginning of the second growing season, fertilizers can be applied to the root zone. Nitrogen is usually the limiting nutrient for plant growth. Soil analysis, particularly when combined with a foliar analysis, can determine when other elements are in short supply. A light application of slow-release fertilizer applied a few months after planting will be delivered. Slow-release fertilizers applied in autumn will help root growth and will still be available the following spring.

Tree Establishment: Newly planted trees require at least two seasons of routine watering so that they establish and thrive. When trees are planted, they go through transplant shock that can last 3-5 years, depending on the size and species of the tree. While trees overcome transplant shock and establish in the park, they need to be watered routinely during the summer. Trees will require at least 5 gallons per caliper inch every other week. Watering young trees is an insurance policy on the investment of planting; trees that are not watered regularly will take longer to establish and may develop drought stress.

Young Tree Pruning*:* Assuming that the proper tree has been selected for the site, pruning a young tree to improve branch structure is the most cost-effective method of reducing maintenance costs as the tree matures. At the time of planting, the only pruning that should be done is the removal of broken or dead branches. In the second growing season, minor pruning can be done to remove branches with poor attachments. In subsequent years, selective pruning should be done to achieve proper spacing of branches.

Stump Removal Recommendations

The inventory identified 9 stumps recommended for removal, with a wide range of sizes from 10 inches to 41 inches in diameter. Stump removals should occur when convenient and be included regular planting plans if the site would be feasible for re-planting after the stump is removed. For this reason, it is most convenient to remove all stumps in areas with scheduled tree planting work, so all feasible sites in an area are stocked at once.

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

MAINTENANCE SCHEDULE AND BUDGET

Utilizing 2023 City Park tree inventory data, an annual maintenance schedule was developed detailing the recommended tasks to complete each year. DRG made budget projections using industry knowledge and public bid tabulations. A complete table of estimated costs for Parkersburg's 5-year tree management program for City Park follows.

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

To implement the maintenance schedule, Parkersburg's City Park tree maintenance budget should be:

- No less than $157,185 for the first year of implementation.
- No less than $143,065 for the second and third years.
- No less than $56,720 for the final two years of the maintenance schedule.

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

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

Table 3. Estimated budget for recommended five-year tree resource management program

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
High Risk Removals	1-3"	$40	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$70	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$240	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$385	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	19-24"	$460	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$825	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31-36"	$1,045	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$1,485	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$2,035	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$0**
Moderate and Low Risk Removals	1-3"	$40	33	$1,320	34	$1,360	0	$0	0	$0	0	$0	$2,680
	4-6"	$70	20	$1,400	17	$1,190	0	$0	0	$0	0	$0	$2,590
	7-12"	$240	46	$11,040	46	$11,040	0	$0	0	$0	0	$0	$22,080
	13-18"	$385	35	$13,475	33	$12,705	0	$0	0	$0	0	$0	$26,180
	19-24"	$460	29	$13,340	23	$10,580	0	$0	0	$0	0	$0	$23,920
	25-30"	$825	32	$26,400	26	$21,450	0	$0	0	$0	0	$0	$47,850
	31-36"	$1,045	19	$19,855	12	$12,540	0	$0	0	$0	0	$0	$32,395
	37-42"	$1,485	12	$17,820	6	$8,910	0	$0	0	$0	0	$0	$26,730
	43"+	$2,035	2	$4,070	0	$0	0	$0	0	$0	0	$0	$4,070
Activity Total(s)			**228**	**$108,720**	**197**	**$79,775**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$188,495**
Stump Removals	1-3"	$40	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$60	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$90	2	$180	0	$0	0	$0	0	$0	0	$0	$180
	13-18"	$150	2	$300	0	$0	0	$0	0	$0	0	$0	$300
	19-24"	$190	1	$190	0	$0	0	$0	0	$0	0	$0	$190
	25-30"	$220	2	$440	0	$0	0	$0	0	$0	0	$0	$440
	31-36"	$280	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$320	2	$640	0	$0	0	$0	0	$0	0	$0	$640
	43"+	$370	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**9**	**$1,750**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$1,750**
High Risk Pruning	1-3"	$50	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$80	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$190	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$300	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	19-24"	$430	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$570	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31-36"	$770	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$950	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$1,480	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$0**

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Air Spade Excavation	1-3"	$325	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$325	1	$325	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$455	2	$910	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$650	3	$1,950	0	$0	0	$0	0	$0	0	$0	$0
	19-24"	$975	1	$975	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$1,140	1	$1,140	0	$0	0	$0	0	$0	0	$0	$0
	31-36"	$1,340	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$1,570	1	$1,570	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$2,150	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**9**	**$6,870**									
Mulching	1-3"	$35	37	$1,295	0	$0	0	$0	0	$0	0	$0	$1,295
	4-6"	$50	29	$1,450	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	6	$450	0	$0	0	$0	0	$0	0	$0	$0
	13-18"	$85	2	$170	0	$0	0	$0	0	$0	0	$0	$0
	19-24"	$100	4	$400	0	$0	0	$0	0	$0	0	$0	$0
	25-30"	$110	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31-36"	$115	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37-42"	$120	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$125	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**78**	**$3,765**									
Routine Pruning (5-year cycle)	1-3"	$50	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$80	2	$160	0	$0	0	$0	0	$0	0	$0	$160
	7-12"	$190	13	$2,470	13	$2,470	13	$2,470	11	$2,090	10	$1,900	$11,400
	13-18"	$300	11	$3,300	11	$3,300	11	$3,300	11	$3,300	11	$3,300	$16,500
	19-24"	$430	7	$3,010	7	$3,010	7	$3,010	7	$3,010	7	$3,010	$15,050
	25-30"	$570	8	$4,560	8	$4,560	8	$4,560	8	$4,560	7	$3,990	$22,230
	31-36"	$770	5	$3,850	5	$3,850	5	$3,850	4	$3,080	4	$3,080	$17,710
	37-42"	$950	3	$2,850	2	$1,900	2	$1,900	2	$1,900	2	$1,900	$10,450
	43"+	$1,480	2	$2,960	0	$0	0	$0	0	$0	0	$0	$2,960
Activity Total(s)			**51**	**$23,160**	**46**	**$19,090**	**46**	**$19,090**	**43**	**$17,940**	**41**	**$17,180**	**$96,460**
Young Tree Training Pruning (3-year cycle)	1-3"	$50	20	$1,000	15	$750	20	$1,000	0	$0	0	$0	$2,750
	4-8"	$80	14	$1,120	15	$1,200	7	$560	0	$0	0	$0	$2,880
Activity Total(s)			**34**	**$2,120**	**30**	**$1,950**	**27**	**$1,560**	**0**	**$0**	**0**	**$0**	**$5,630**
Replacement Tree Planting	Purchasing	$170	20	$3,400	20	$3,400	20	$3,400	20	$3,400	20	$3,400	$17,000
	Planting	$170	20	$3,400	20	$3,400	20	$3,400	20	$3,400	20	$3,400	$17,000
Activity Total(s)			**40**	**$6,800**	**40**	**$6,800**	**40**	**$6,800**	**40**	**$6,800**	**40**	**$6,800**	**$34,000**
Replacement Young Tree Maintenance	Mulching	$100	20	$2,000	20	$2,000	20	$2,000	20	$2,000	20	$2,000	$10,000
	Watering	$100	20	$2,000	20	$2,000	20	$2,000	20	$2,000	20	$2,000	$10,000
Activity Total(s)			**40**	**$4,000**	**40**	**$4,000**	**40**	**$4,000**	**40**	**$4,000**	**40**	$4,000	**$20,000**
Activity Grand Total			**362**		**313**		**113**		**83**		**81**		
Cost Grand Total				**$157,185**		**$111,615**		**$31,450**		**$28,740**		**$27,980**	**$346,335**

Section 3:

Recommended Management

of the Public Tree Resource

CONCLUSION

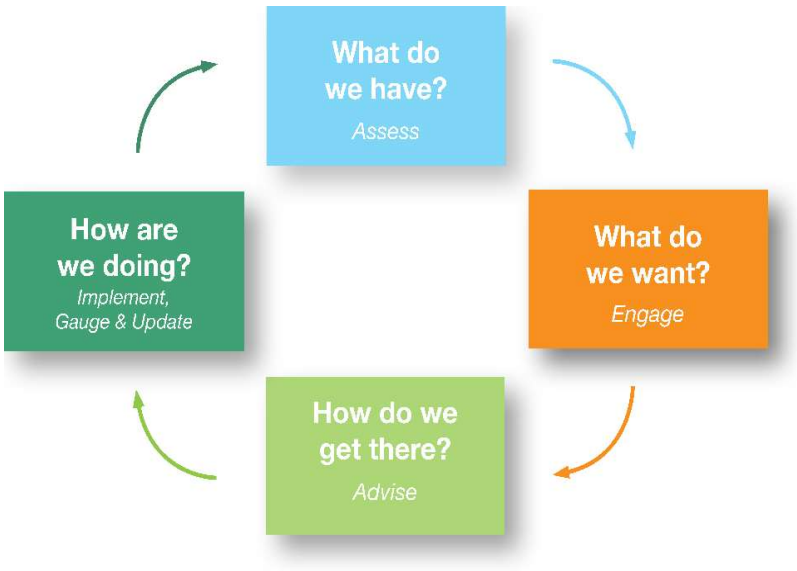
When properly maintained, the valuable benefits trees provide over their lifetime far exceed the time and money invested in planting, pruning, and inevitably removing them. The 423 public trees inventoried provide $3,900 in estimated annual economic value, which is almost 40% of the city's annual tree planting budget of $10,000. Successfully implementing the five-year program may increase Parkersburg's ROI over time, or at least maintain it over the years.

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

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

EVALUATING AND UPDATING THIS PLAN

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



- Prepare planting plans well enough in advance to schedule and complete stump removal in the designated area, and to select species best suited to the available sites.

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

REFERENCES

American National Standards Institute. 2017. *ANSI A300 (Part 1): Tree, Shrub, and Other Woody Plant Management—Standard Practices (Pruning)*. Tree Care Industry Association, Inc.

———. 2011. *ANSI A300 (Part 9): Tree, Shrub, and Other Woody Plant Management Standard Practices (Tree Risk Assessment a. Tree Failure).* Tree Care Industry Association, Inc.

Coder, K. D. 1996. Identified Benefits of Community Trees and Forests. University of Georgia Cooperative Extension Service: Forest Resources Unit. Publication FOR96-39. Retrieved from https://nfs.unl.edu/documents/communityforestry/coderbenefitsofcommtrees.pdf

Culley, T.M. & Hardiman, N.A. 2007. The Beginning of a New Invasive Plant: A History of the Ornamental Callery Pear in the United States. *BioScience*, 57(11): 956-964.

Evans, E. 2012. Americans are Planting Trees of Strength. North Carolina State University College of Agriculture & Life Sciences: Department of Horticultural Science. http://www.treesofstrength.org/benefits.htm

Heisler, G. M. 1986. Energy Savings with Trees. *Journal of Arboriculture* 12(5):113–125. Retrieved from https://www.nrs.fs.fed.us/pubs/jrnl/1986/nrs_1986_heisler_002.pdf

Karnosky, D. F. 1979. Dutch Elm Disease: A Review of the History, Environmental Implications, Control, and Research Needs. *Environmental Conservation* 6(4): 311–322.

Kuo, F. E., & Sullivan, W. C. 2001a. Environment and Crime in the Inner Village: Does Vegetation Reduce Crime? *Environment and Behavior* 33(3): 343–367. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.644.9399&rep=rep1&type=pdf

———. 2001b. Aggression and Violence in the Inner Village: Effects of Environment via Mental Fatigue. *Environment and Behavior* 33(4): 543–571. Retrieved from https://pdfs.semanticscholar.org/9ca8/a34eee31d42ac2235aa6d0b9b6e7a5f32386.pdf

Lovasi, G. S., Quinn, J. W., Neckerman, K. M., Perzanowski M., Rundle, A. 2008. Children living in areas with more street trees have lower prevalence of asthma. *Journal of Epidemiology and Community Health* 62(7): 647-649. Retrieved from https://www.researchgate.net/publication/5401459_Children_living_in_areas_with_more_trees_have_lower_prevalence_of_asthma

McPherson, E. G., Rowntree, R. A. 1989. Using Structural Measures to Compare Twenty-Two U.S. Street Tree Populations. *Landscape Journal* 8(1): 13–23. Retrieved from https://www.fs.fed.us/psw/topics/urban_forestry/products/1/psw_cufr745_structuralmeasures.pdf

Michigan Department of Natural Resources. 2020. Black Locust (*Robinia pseudoacacia*). Retrieved from https://www.michigan.gov/invasives/0,5664,7-324-68002_71240_73851-379779--,00.html

Miller, R. W., & Sylvester, W.A. 1981. An Economic Evaluation of the Pruning cycle. *Journal of Arboriculture* 7(4): 109–112. Retrieved from http://webcache.googleusercontent.com/search?q=cache:VENBQXq9EmcJ:joa.isa-arbor.com/request.asp%3FJournalID%3D1%26ArticleID%3D1724%26Type%3D2+&cd=2&hl=en&ct=clnk&gl=us

Nowak, D. J., Greenfield, E. J., Hoehn, R. E., & Lapoint, E. 2013. Carbon storage and sequestration by trees in urban and community areas of the United States. *Environmental Pollution* 178: 229-236. Retrieved from https://www.fs.fed.us/nrs/pubs/jrnl/2013/nrs_2013_nowak_001.pdf

Richards, N. A. 1983. Diversity and Stability in a Street Tree Population. *Urban Ecology* 7(2): 159–171.

Santamour, F.S. 1990. Trees for Urban Planting: Diversity Uniformity, and Common Sense. *U.S. National Arboretum: Agricultural Research Service*. Retrieved from https://pdfs.semanticscholar.org/26a2/4c5361ce6d6e618a9fa307c4a34a3169e309.pdf?_ga=2.266051527.959145428.1587418896-558533249.1587418896

Ulrich, R. 1984. View through Window May Influence Recovery from Surgery. *Science* 224: 420–422. Retrieved from https://pdfs.semanticscholar.org/43df/b42bc2f7b212eb288d2e7be289d251f15bfd.pdf

———. 1986. Human Responses to Vegetation and Landscapes. *Landscape and Urban Planning* 13: 29–44. Retrieved from https://www.researchgate.net/profile/Roger_Ulrich4/publication/254315158_Visual_Landscapes_and_Psychological_Well-Being/links/0c96053a3fe7796728000000/Visual-Landscapes-and-Psychological-Well-Being.pdf

Ulrich R.S., R.F. Simmons, B.D. Losito, E. Fiority, M.A. Miles and M. Zeison. 1991. Stress Recovery During Exposure to Natural and Urban Environments. *Journal of Environmental Psychology* 11(3): 201-230.

USDA Forest Service. 2003a. Benefits of Urban Trees—Urban and Community Forestry: Improving Our Quality of Life. *Southern Region Forestry Report* R8-FR 71. Retrieved from http://www.sci-links.com/files/Benefits_of_Urban_Trees.pdf

———. 2003b. Is all your rain going down the drain? Look to Bioretainment—trees are a solution. *Center for Urban Forest Research: Pacific Southwest Research Station*. Retrieved from https://www.fs.fed.us/psw/topics/urban_forestry/products/cufr_392_rain_down_the_drain.pdf

———. 2020. Forest Health Highlights. https://www.fs.fed.us/foresthealth/protecting-forest/forest-health-monitoring/monitoring-forest-highlights.shtml

USDA Animal and Plant Health Inspection Service. 2020. Pest Tracker. https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/Pest-Tracker

Wolf, K. L. 1998a. Urban Nature Benefits: Psycho-Social Dimensions of People and Plants. *University of Washington: College of Forest Resources* Human Dimensions of the Urban Forest Fact Sheet #1. Retrieved from https://www.naturewithin.info/UF/PsychBens-FS1.pdf

———. 1998b. Trees in Business Districts: Positive Effects on Consumer Behavior! *University of Washington: College of Forest Resources* Human Dimensions of the Urban Forest Fact Sheet #5. Retrieved from https://www.naturewithin.info/VillageBiz/Biz3Ps-FS5.pdf

———. 1999. Grow for the Gold: Trees in Business Districts. *Washington State DNR: Community Forestry Program* Number 14. Retrieved from https://www.naturewithin.info/VillageBiz/TreeLink.PDF

———. 2000. Community Image: Roadside Settings and Public Perceptions. *University of Washington: College of Forest Resources* Human Dimensions of the Urban Forest Factsheet #10. Retrieved from https://www.naturewithin.info/Roadside/Rsd-Community-FS10.pdf

———. 2003. Social Aspects of Urban Forestry: Public Response to the Urban Forest in Inner-Village Business Districts. *Journal of Arboriculture* 29(3): 117–126. Retrieved from https://www.naturewithin.info/VillageBiz/JofA_Biz.pdf

———. 2007. Village Trees and Property Values. *Arborist News* 16(4): 34-36. Retrieved from https://www.naturewithin.info/Policy/Hedonics.pdf

———. 2009. Trees & Urban Streets: Research on Traffic Safety & Livable Communities. *University of Washington, Seattle USDA Forest Service: Pacific Northwest Research Station*. Retrieved from http://www.naturewithin.info/urban.html

APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

DATA COLLECTION METHODS

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

- Address
- Comments
- Condition
- Date of Inventory
- Maintenance Recommendation
- Multi-stem Tree
- Notes
- Relative Location
- Size*
- Species and Identification Confidence Level
- Utility Interference
- X and Y Coordinates

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

The knowledge, experience, and professional judgment of DRG's arborists ensure the high quality of inventory data.

SITE LOCATION METHODS

Equipment and Base Maps

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

STREET ROW SITE LOCATION

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

PARK AND PUBLIC SPACE SITE LOCATION

Park and/or public space site locations were collected using the same methodology as street ROW sites, however nearly all of them have the "Assigned Address" field set to 'X' and have the "Park Name" data field filled.

APPENDIX B
INVASIVE PESTS AND DISEASES

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

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

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

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

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

SPOTTED LANTERNFLY

The spotted lanternfly (SLF, *Lycorma delicatula*) is native to China and was first detected in Pennsylvania in September 2014. SLF feeds on a wide range of fruit, ornamental, and woody trees, with tree-of-heaven being one of its preferred hosts. SLF is a hitchhiker and can be spread long distances by people who move infested material or items containing egg masses.

If allowed to spread in the United States, this pest could seriously impact the country's grape, orchard, and logging industries. Be sure to inspect for the pest. Egg masses, juveniles, and adults can be on trees and plants, as well as on bricks, stone, metal, and other smooth surfaces. Also thoroughly check vehicles, trailers, and even the clothes you are wearing to prevent accidently moving SLF.

Symptoms of SLF are plants oozing or weeping with a fermented odor, buildup of a sticky fluid called honeydew on the plant or on the ground underneath them, and sooty mold growing on plants. The following trees are susceptible to SLF: almond, apple, apricot, cherry, maple, nectarine, oak, peach, pine, plum, poplar, sycamore, walnut, and willow, as well as grape vines and hop plants.

Pinned spotted lanternfly.

Photograph courtesy of PA Dept of Agriculture

Pinned spotted lanternfly nymph with wingspan open.

Photograph courtesy of USDA APHIS

EASTERN TENT CATERPILLAR

Eastern tent caterpillar (*Malacosoma americanum*) was first observed in the United States in 1646. In spring, caterpillars make nests in the forks and crotches of tree branches. Caterpillars do not feed within the nest; they leave the nest to feed up to 3 feet from nest and return to rest and take shelter in wet weather. Large infestations may occur at 8- to 10-year intervals. Egg masses overwinter on twigs. Trees are rarely killed by eastern tent caterpillar, but health is compromised that year and aesthetic value is decreased.

Easter tent caterpillar have a wide range of hosts, including apple (*Malus*) and cherry (*Prunus*).

Eastern tent caterpillar nest.

Photograph courtesy of Prairie Haven (2008)

ASIAN LONGHORNED BEETLE

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

Adult Asian longhorned beetle.

Photograph courtesy of New Bedford Guide (2011)

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

EUROPEAN GYPSY MOTH

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

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

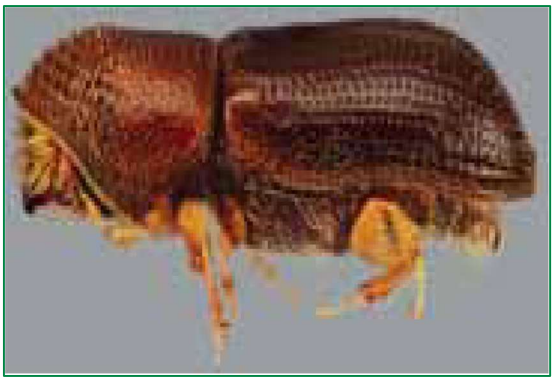
Photograph courtesy of USDA APHIS (2019)

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: birch (*Betula*); cedar (*Juniperus*); Larch (*Larix*); aspen,

cottonwood, polar (*Populus*); oak (*Quercus*); and willow (*Salix*).

THOUSAND CANKERS DISEASE



Walnut twig beetle, side view.

Photograph courtesy of USDA Forest Service (2011)

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.

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, walnut (*Juglans*) 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 black walnut (*J. nigra*) in the eastern United States may suffer severe decline and mortality.

The tree species preferred as hosts for TCD are walnut.

OAK WILT

Oak wilt symptoms on red and white oak leaves.

Photograph courtesy of USDA Forest Service (2011a)

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

Just as with DED, oak wilt disease is caused by a fungus that clogs the vascular system of oak and results in decline and death of the tree. The fungus is carried from tree to tree by several borers common to oak, but the disease

is more commonly spread through root grafts. Oak species within the same subgenus (red or white) will form root colonies with grafted roots that allow the disease to move readily from one tree to another.

HEMLOCK WOOLY ADELGID

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

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

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

Hemlock woolly adelgids on a branch.

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

EMERALD ASH BORER

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

Close-up of an emerald ash borer.

Photograph courtesy of USDA APHIS (2020)

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).

REFERENCES

Connecticut Agricultural Experiment Station, Bugwood.org. 2011. *Hemlock woolly adelgid* (*Adelges tsugae*). Retrieved from https://www.invasive.org/browse/detail.cfm?imgnum=3225077

Cranshaw, W. 2004. *Garden Insects of North America: The Ultimate Guide to Backyard Bugs* (pp. 114,118). Princeton University Press.

DiOrio, A. 2011. *Volunteers Needed for Asian Longhorned Beetle Survey.* New Bedford Guide. Retrieved from http://www.newbedfordguide.com/volunteers-needed-for-asian-longhorned-beetle-survey/2011/03/30

Indiana Department of Natural Resources. 2019. *Sudden Oak Death*. Entomology and PlantPathology. Retrieved from http://www.in.gov/dnr/entomolo/4532.htm

Miller, F. 2016. *2016 Illinois Forest Health Highlights*. The Morton Arboretum. Retrieved from http://www.mortonarb.org/files/2016-FHH-Final-Version-12-28-16-Submitted.pdf

University of Georgia. *Invasive Species*. Center for Invasive Species and Ecosystem Health. Retrieved from www.bugwood.org

USDA Animal and Plant Health Inspection Service. 2019. *Hungry Pests: Your Move Gypsy Moth Free.* Retrieved from https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/thethreat/gypsy-moth-free

USDA Animal and Plant Health Inspection Service. 2019. *Pest Alert: Spotted Lantern Fly* (*Lycorma delicatula*). Retrieved from https://www.aphis.usda.gov/publications/plant_health/alert-spotted-lanternfly.pdf

USDA Animal and Plant Health Inspection Service. 2020. *Plant Pests and Diseases: Emerald Ash Borer.* Retrieved from https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer/emerald-ash-borer

USDA Forest Service. 2013. *Pest Alert: Thousand Cankers Disease*. Northeastern Area State and Private Forestry, NA–PR–02–10. Retrieved from https://www.fs.usda.gov/naspf/sites/default/files/thousand_cankers_disease_print_res.pdf

APPENDIX C
i-TREE STREETS METHOLOGY

i-Tree Streets regionalizes the calculations of its output by incorporating detailed reference Village project information for 16 climate zones across the United States. Big Rapids falls within the Midwest Climate Zone. Sample inventory data from Minneapolis represent the basis for the Midwest Reference Village Project for the Midwest Community Tree Guidelines. The basis for the benefit modeling in this study compares the inventory data from Big Rapids to the results of Midwest Reference Village Project to obtain an estimation of the annual benefits provided by Big Rapids' tree resource.

Growth rate modeling information was used to perform computer-simulated growth of the existing tree population for one year and account for the associated annual benefits. This "snapshot" analysis assumed that no trees were added to or removed from the existing population. Calculations of carbon dioxide (CO_2) released due to decompositions of wood from removed trees did consider average annual mortality. This approach directly connects benefits with tree-size variables such as diameter at breast height (DBH) and leaf-surface area. Many benefits of trees are related to processes that involve

interactions between leaves and the atmosphere (e.g., interception, transpiration, photosynthesis); therefore, benefits increase as tree canopy cover and leaf surface area increase.

For each of the modeled benefits, an annual resource unit was determined on a per-tree basis. Resource units are measured as megawatt-hours of electricity saved per tree; therms of natural gas conserved per tree, pounds of atmospheric CO_2 reduced per tree; pounds of nitrogen dioxide (NO_2), particulate matter (PM_{10}), and volatile organic compounds (VOCs) reduced per tree; cubic feet of stormwater runoff reduced per tree; and square feet of leaf area added per tree to increase property values.

Prices were assigned to each resource unit using economic indicators of society's willingness to pay for the environmental benefits trees provide. Estimates of benefits are initial approximations as some benefits are difficult to quantify (e.g., impacts on psychological health, crime, and violence). In addition, limited knowledge about the physical processes at work and their interactions make estimates imprecise (e.g., fate of air pollutants trapped by trees and then washed to the ground by rainfall). Therefore, this method of quantification provides first-order approximations. It is meant to be a general accounting of the benefits produced by urban trees—an accounting with an accepted degree of uncertainty that can, nonetheless, provide science-based platform for decision-making.

A detailed description of how the default benefit prices are derived, refer to the *Village of Minneapolis, Minnesota Municipal Tree Resource Analysis* (McPherson *et al.* 2005) and the *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planning* (McPherson *et al.* 2009). i-Tree Streets' default values from the Midwest Climate Zone were used for air quality and stormwater benefit prices and local values were used for energy usage, aesthetics, and other benefits.

Benefit Prices Used by i-Tree Streets in the Analysis of Big Rapids' Tree Inventory

Benefits	Price	Unit	Source
Electricity	$0.00759	$/Kwh	Xcelenergy 2004
Natural Gas	$0.0098	$/Therm	Centerpoint Energy 2004
CO_2	$0.0075	$/lb	US EPA 2003
PM_{10}	$2.84	$/lb	US EPA 2003
NO_2	$3.34	$/lb	US EPA 2003
O_3	$3.34	$/lb	US EPA 2003
SO_2	$2.06	$/lb	US EPA 2003
VOCs	$3.75	$/lb	Ottinger and others 1990
Stormwater Interception	$0.0046	$/gallon	McPherson & Xiao 2004
Aesthetic Value	$218,000	Average Midwest Housing Price	TreeKeeper®

Using these prices, the magnitude of the benefits provided by the public tree resource was calculated based on the science of i-Tree Streets using DRG's TreeKeeper® inventory management software. For a detailed description of how the magnitudes of benefit prices are calculated, refer to the *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planning* (McPherson *et al.* 2009).

APPENDIX D
SUGGESTED TREE SPECIES FOR USDA HARDINESS ZONE 6

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout Zones 5 and 6 on the USDA Plant Hardiness Zone Map.

DECIDUOUS TREES

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

Scientific Name	Common Name	Cultivar
*Aesculus flava**	yellow buckeye	
*Betula lenta**	sweet birch	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Pyramidalis'
*Carya illinoensis**	pecan	
*Carya lacinata**	shellbark hickory	
*Carya ovata**	shagbark hickory	
*Castanea mollissima**	Chinese chestnut	
Catalpa speciosa	northern catalpa	
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	Espresso
*Juglans nigra**	black walnut	
*Juglans cinerea**	butternut	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
*Liriodendron tulipifera**	tuliptree	
*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 50 Feet in Height When Mature) (Continued)

Scientific Name	Common Name	Cultivar
Styphnolobium japonicum	Japanese pagodatree	'Regent'
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	
Tilia × euchlora	Crimean linden	
Tilia tomentosa	silver linden	'Sterling'
Ulmus ×	Hybrid Elm	'Pioneer', 'Princeton'
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	'Green Vase'

Medium Trees (31-45 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 pistachio	
Populus tremuloides	quaking aspen	
Prunus sargentii	Sargent cherry	
*Pterocarya fraxinifolia**	Caucasian wingnut	
*Salix babylonica**	weeping willow	
*Sassafras albidum**	sassafras	

Small Trees (15-30 Feet in Height at Maturity)

Scientific Name	Common Name	Cultivar
Acer palmatum	Japanese maple	(Numerous exist)
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	(Numerous exist)
Amelanchier laevis	Allegheny serviceberry	
Asimina triloba	pawpaw	
*Carpinus caroliniana**	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
Cornus alternifolia	pagoda dogwood	
Cornus florida	flowering dogwood	(Numerous exist)
Cornus kousa	Kousa dogwood	(Numerous exist)
*Cornus mas**	corneliancherry dogwood	'Spring Sun'
*Corylus avellane**	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	
Lagerstroemia spp.	crapemyrtle	(Numerous exist)
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'
*Salix caprea**	pussywillow	
*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 50 Feet in Height When Mature)

Scientific Name	Common Name	Cultivar
Abies balsamea	balsam fir	
Abies concolor	white fir	'Violacea'
Cedrus deodara	deodar cedar	
Cedrus libani	cedar-of-Lebanon	
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
× *Cupressocyparis leylandii*	Leyland cypress	
Cupressus arizonica	Arizona cypress	
Ilex opaca	American holly	
Picea abies	Norway spruce	
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Picea punges	Colorado blue spruce	
Pinus contorta	lodgepole pine	
Pinus densiflora	Japanese red pine	
Pinus nigra	Austrian pine	
*Pinus ponderosa**	ponderosa pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Pinus taeda	loblolly pine	
Pinus virginiana	Virginia pine	
Pseudotsuga menziesii	Douglas-fir	
*Sequoiadendron giganteum**	giant sequoia	
Thuja occidentalis	American arborvitae	(Numerous exist)
Thuja plicata	western arborvitae	(Numerous exist)
Tsuga canadensis	eastern hemlock	

Medium Trees (31 to 50 Feet in Height When Mature)

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 When Mature)

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

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

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

CONIFEROUS AND EVERGREEN TREES

Large Trees: Greater than 45 Feet in Height at Maturity

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

APPENDIX E
TREE PLANTING AND YOUNG TREE ESTABLISHMENT

TREE PLANTING

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

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

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

INVENTORIED PLANTING SPACE

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

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.

Parkersburg is located in USDA Hardiness Zone 6b, which is identified as a climatic region with average annual minimum temperatures between −5°F and 0°F. Tree species selected for planting in Parkersburg should be appropriate for this zone.

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

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

A major consideration for urban trees is the amount of litter dropped by mature trees. Trees such as silver maple (*Acer saccharinum*) have weak wood and typically drop many small branches during a growing season. Others, such as American sweetgum (*Liquidambar styraciflua*), drop high volumes of fruit. In certain species, such as ginkgo (*Ginkgo biloba*), female trees produce large odorous fruit; male ginkgo trees, however, do not produce fruit. Furthermore, a few species of trees, including hawthorn (*Crataegus* spp.) and honeylocust (*Gleditsia triacanthos*), 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 city 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 city'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 city'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 city's urban forestry program and encourage tree planting on private property. The city should encourage citizens to water trees on the ROW adjacent to their homes and to reach out to the city 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 F
TREE MAINTENANCE

Maintenance for trees in City Park, sorted by DBH and assigned maintenance.

Site ID	Species	DBH	Primary Maintenance Assigned
10199	Ash	1	Train
9461	Dogwood	1	Train
10076	Dogwood, Flowering	1	Train
9347	Ginkgo	1	Train
10066	Maple, Sugar	1	Train
10189	Oak, Northern Red	1	Train
9766	Oak, Scarlet	1	Train
10216	Pear	1	Train
9524	Redbud, Eastern	1	Train
10137	Redbud, Eastern	1	Train
9691	Oak, White	1	Remove
9338	Pear, Callery	1	Remove
9450	Unknown	1	Remove
10207	Ash	2	Train
10079	Dogwood, Flowering	2	Train
10087	Dogwood, Flowering	2	Train
9523	Dogwood, Flowering	2	Train
9331	Ginkgo	2	Train
9340	Ginkgo	2	Train
9354	Ginkgo	2	Train
10177	Holly	2	Train
9728	Lilac, Japanese Tree	2	Train
10175	Magnolia, Chinese; Saucer	2	Train
9618	Maple, Red	2	Train
9668	Maple, Red	2	Train
9586	Maple, Red	2	Train
9714	Maple, Red	2	Train
9759	Maple, Red	2	Train
9743	Maple, Sugar	2	Train
10073	Maple, Sugar	2	Train
9350	Maple, Sugar	2	Train
10222	Maple, Sugar	2	Train
9736	Maple, Sugar	2	Train
10083	Maple, Sugar	2	Train
9584	Maple, Sugar	2	Train
10068	Oak, Northern Red	2	Train
9887	Oak, Northern Red	2	Train
9700	Oak, Pin	2	Train

Site ID	Species	DBH	Primary Maintenance Assigned
9657	Oak, White	2	Train
9928	Oak, White	2	Train
9731	Oak, White	2	Train
10243	Oak, White	2	Train
10227	Plum	2	Train
9562	Plum	2	Train
9565	Redbud, Eastern	2	Train
9334	Ginkgo	2	Remove
9339	Ginkgo	2	Remove
9346	Ginkgo	2	Remove
9856	Maple, Sugar	2	Remove
9568	Pear	2	Remove
9333	Pear, Callery	2	Remove
9735	Redbud, Eastern	2	Remove
9903	Tree, Unknown	2	Remove
9452	Dogwood	3	Train
9492	Ginkgo	3	Train
9950	Maple, Hedge	3	Train
10154	Maple, Red	3	Train
9639	Maple, Sugar	3	Train
9811	Maple, Sugar	3	Train
10124	Maple, Sugar	3	Train
9833	Oak, Northern Red	3	Train
9958	Oak, Northern Red	3	Train
10105	Oak, Northern Red	3	Train
10106	Oak, Northern Red	3	Train
9875	Oak, Pin	3	Train
9613	Plum	3	Train
9669	Redbud, Eastern	3	Remove
9536	Crabapple, Common	4	Train
9367	Dogwood	4	Train
9469	Dogwood	4	Train
9505	Dogwood, Flowering	4	Train
9543	Maple, Red	4	Train
9713	Maple, Red	4	Train
9943	Maple, Red	4	Train
9968	Maple, Red	4	Train
10173	Maple, Red	4	Train
9881	Maple, Sugar	4	Train
10111	Maple, Sugar	4	Train
9813	Oak, Northern Red	4	Train
9828	Oak, Northern Red	4	Train

Site ID	Species	DBH	Primary Maintenance Assigned
10162	Oak, Northern Red	4	Train
9410	Oak, Swamp White	4	Train
9462	Plum	4	Train
9821	Plum	4	Train
9451	Apple	5	Train
10099	Crabapple, Common	5	Train
10170	Crabapple, Common	5	Train
10188	Crabapple, Common	5	Train
9790	Elm, Hybrid	5	Train
9360	Maple, Sugar	5	Train
10197	Plum	5	Train
10081	Plum	5	Train
10152	Mulberry, White	5	Prune
10117	Redbud, Eastern	5	Remove
9964	Crabapple, Common	6	Train
10135	Crabapple, Common	6	Train
10240	Crabapple, Common	6	Train
10270	Crabapple, Common	6	Train
9356	Maple, Red	6	Train
10251	Maple, Red	6	Train
10262	Maple, Red	6	Train
9379	Redbud, Eastern	6	Train
9517	Redbud, Eastern	6	Prune
9363	Maple, Red	6	Remove
9886	Maple, Norway	7	Train
9343	Maple, Red	7	Train
9898	Maple, Sugar	7	Train
10072	Maple, Red	7	Prune
10224	Maple	7	Remove
9600	Maple, Norway	7	Remove
10219	Oak, Pin	8	Train
9540	Birch	8	Prune
9494	Crabapple, Common	8	Prune
9457	Crabapple, Common	8	Prune
9620	Crabapple, Common	8	Prune
10179	Crabapple, Common	8	Prune
9677	Maple, Red	8	Prune
9595	Pear, Callery	8	Prune
9646	Pear, Callery	8	Prune
10148	Redbud, Eastern	8	Prune
10101	Pear, Callery	8	Remove
9698	Hickory, Shellbark	9	Prune

Site ID	Species	DBH	Primary Maintenance Assigned
9660	Maple, Freeman	9	Prune
9566	Maple, Red	9	Prune
9602	Oak, Northern Red	9	Prune
9630	Oak, Pin	9	Prune
9755	Oak, Pin	9	Prune
10228	Oak, Scarlet	9	Prune
9782	Oak, Shingle	9	Prune
9749	Pear, Callery	9	Prune
9370	Plum	9	Prune
9521	Plum	9	Prune
9342	Redbud, Eastern	9	Prune
9655	Crabapple, Common	9	Remove
10211	Redbud, Eastern	9	Remove
9535	Crabapple, Common	10	Prune
10241	Crabapple, Common	10	Prune
9617	Elm, Chinese	10	Prune
9594	Hickory, Shellbark	10	Prune
9576	Hickory, Shellbark	10	Prune
9786	Maple, Freeman	10	Prune
9573	Maple, Silver	10	Prune
9703	Maple, Sugar	10	Prune
9845	Oak, Pin	10	Prune
9542	Plum	10	Prune
9609	Plum	10	Prune
10139	Redbud, Eastern	10	Prune
9871	Sweetgum, Common	10	Prune
9510	Plum	10	Remove
10060	Ash, Green	10	Remove
9751	Cedar	10	Remove
10057	Stump	10	Stump Removal
9544	Crapemyrtle, Common	11	Prune
10235	Maple, Red	11	Prune
9859	Oak, Northern Red	11	Prune
10252	Oak, Shingle	11	Prune
9400	Pear, Callery	11	Prune
9545	Pear, Callery	11	Prune
9680	Pear, Callery	11	Prune
10067	Plum	11	Prune
10143	Plum	11	Prune
9604	Plum	11	Prune
9437	Redbud, Eastern	11	Prune
9878	Sweetgum, Common	11	Prune

Site ID	Species	DBH	Primary Maintenance Assigned
9699	Cedar	11	Remove
10184	Crabapple, Common	11	Remove
9355	Maple, Sugar	11	Remove
10164	Maple, Sugar	11	Remove
9665	Stump	11	Stump Removal
9622	Elm, Chinese	12	Prune
10194	Elm, Chinese	12	Prune
10069	Hickory, Shellbark	12	Prune
10092	Oak, Pin	12	Prune
10089	Oak, Shingle	12	Prune
9858	Oak, Swamp White	12	Prune
9399	Pear, Callery	12	Prune
9429	Pear, Callery	12	Prune
10150	Plum	12	Prune
10247	Plum	12	Prune
10255	Plum	12	Prune
9433	Plum	12	Prune
10172	Redbud, Eastern	12	Prune
9776	Catalpa, Southern	12	Remove
10250	Ginkgo	12	Remove
9884	Sweetgum, Common	12	Remove
10266	Birch	13	Prune
9649	Crabapple, Common	13	Prune
10029	Hickory, Shagbark	13	Prune
10232	Maple	13	Prune
10258	Maple, Freeman	13	Prune
9923	Oak, Pin	13	Prune
10075	Plum	13	Prune
9417	Tulip Tree	13	Prune
9847	Spruce, Blue	13	Remove
10212	Crabapple, Common	14	Prune
10231	Elm	14	Prune
10208	Elm, American	14	Prune
9742	Hickory, Bitternut	14	Prune
9891	Hickory, Shagbark	14	Prune
9674	Hickory, Shellbark	14	Prune
9919	Oak, Pin	14	Prune
9345	Oak, Scarlet	14	Prune
9579	Oak, Scarlet	14	Prune
9520	Oak, White	14	Prune
10118	Yew	14	Prune
9711	Plum	14	Remove

Site ID	Species	DBH	Primary Maintenance Assigned
9448	Birch	15	Prune
9911	Hickory, Shagbark	15	Prune
9621	Oak, Pin	15	Prune
9961	Oak, Pin	15	Prune
9978	Oak, Pin	15	Prune
9969	Oak, Pin	15	Prune
9729	Oak, Pin	15	Prune
9676	Pear, Callery	15	Prune
9443	Tulip Tree	15	Prune
10088	Maple, Red	15	Remove
10217	Honeylocust, Thornless	16	Prune
10220	Oak, Northern Red	16	Prune
9955	Oak, Pin	16	Prune
10210	Oak, Pin	16	Prune
9780	Oak, Swamp White	16	Prune
9515	Oak, Willow	16	Prune
10186	Plum	16	Prune
10203	Plum	16	Prune
9708	Cedar	16	Remove
9740	Cedar	16	Remove
9522	Stump	16	Stump Removal
9750	Stump	16	Stump Removal
10062	Hickory, Shellbark	17	Prune
10109	Oak, Pin	17	Prune
10195	Oak, Pin	17	Prune
9927	Oak, Pin	17	Prune
10269	Oak, Pin	17	Prune
9511	Sweetgum, Common	17	Prune
9773	Hickory, Shellbark	17	Remove
9528	Birch	18	Prune
9633	Crabapple, Common	18	Prune
10085	Hickory, Shagbark	18	Prune
9616	Oak, Pin	18	Prune
10169	Oak, Pin	18	Prune
9826	Oak, Pin	18	Prune
9357	Oak, Pin	18	Prune
9718	Oak, Post	18	Prune
9723	Oak, Sawtooth	18	Prune
9344	Pear, Callery	18	Prune
10187	Pear, Callery	18	Prune
9637	Pine, Eastern White	18	Prune
9850	Sweetgum, Common	18	Prune

Site ID	Species	DBH	Primary Maintenance Assigned
9827	Sweetgum, Common	18	Remove
9349	Oak, Scarlet	19	Routine Prune
9745	Pear, Callery	19	Prune
9877	Sweetgum, Common	19	Prune
9502	Pear, Callery	19	Remove
9351	Sweetgum, Common	19	Remove
9685	Hickory, Shellbark	20	Prune
9466	Maple, Silver	20	Prune
9627	Oak, Northern Red	20	Prune
9719	Oak, Pin	20	Prune
9737	Oak, Pin	20	Prune
9874	Oak, Pin	20	Prune
9623	Oak, Pin	20	Prune
9686	Oak, Pin	20	Prune
10260	Oak, Post	20	Prune
9504	Pear, Callery	20	Prune
9513	Sweetgum, Common	20	Prune
9456	Tulip Tree	20	Prune
9820	Stump	20	Stump Removal
9862	Oak, Pin	21	Prune
10077	Oak, Post	21	Prune
9787	Oak, Shingle	21	Prune
9831	Sweetgum, Common	21	Prune
9843	Sweetgum, Common	21	Prune
10221	Honeylocust, Thornless	22	Prune
10147	Oak, Pin	22	Prune
9560	Oak, Swamp White	22	Prune
9965	Catalpa, Southern	22	Remove
9541	Pear, Callery	22	Remove
9411	Oak, Pin	23	Prune
9337	Oak, Pin	23	Prune
9580	Oak, Pin	23	Prune
10248	Oak, Post	23	Prune
9518	Sweetgum, Common	23	Prune
9644	Sweetgum, Common	23	Prune
9440	Tulip Tree	23	Prune
9553	Tulip Tree	23	Prune
9908	Catalpa, Southern	23	Remove
9953	Catalpa, Southern	23	Remove
10001	Catalpa, Southern	23	Remove
10214	Katsura Tree	24	Prune
9336	Oak, Pin	24	Prune

Site ID	Species	DBH	Primary Maintenance Assigned
9587	Oak, Pin	24	Prune
9348	Oak, Pin	24	Routine Prune
10080	Oak, Post	24	Remove
9531	Pear, Callery	24	Remove
9537	Pear, Callery	24	Remove
9385	Tulip Tree	24	Remove
10086	Hickory, Shagbark	25	Prune
10006	Oak, Pin	25	Prune
9769	Oak, Pin	25	Prune
10120	Oak, Post	25	Prune
10261	Oak, Post	25	Prune
9799	Oak, Post	25	Prune
10242	Oak, Post	25	Prune
10031	Oak, Shingle	25	Prune
9760	Oak, Willow	25	Prune
9376	Pine, Eastern White	25	Prune
9591	Sweetgum, Common	25	Prune
9717	Oak, Post	25	Remove
9688	Oak, Post	25	Remove
9514	Sweetgum, Common	25	Remove
9661	Oak, Pin	26	Prune
9869	Oak, Pin	26	Prune
9872	Oak, Post	26	Prune
10193	Oak, Post	26	Prune
9403	Planetree, London	26	Prune
9554	Sweetgum, Common	26	Prune
9640	Tulip Tree	26	Prune
10097	Willow	26	Prune
10091	Hawthorn	26	Remove
9670	Oak, Pin	27	Prune
9715	Pine, Eastern White	27	Prune
9406	Plum	27	Prune
9381	Spruce	27	Prune
9384	Tulip Tree	27	Prune
9453	Catalpa, Northern	28	Prune
9975	Oak, Pin	28	Prune
10035	Oak, Pin	28	Prune
10183	Oak, Post	28	Prune
10129	Sweetgum, Common	28	Prune
9402	Cherry, Black	28	Remove
9447	Maple, Norway	28	Remove
9697	Oak, Post	28	Remove

Site ID	Species	DBH	Primary Maintenance Assigned
10144	Pine, Eastern White	28	Remove
10157	Oak, Northern Red	29	Prune
10153	Oak, Pin	29	Prune
10182	Oak, Post	29	Prune
10209	Birch	29	Remove
9332	Catalpa	29	Remove
10130	Sweetgum, Common	29	Remove
10115	Stump	29	Stump Removal
10136	Stump	29	Stump Removal
9730	Oak, Pin	30	Prune
9459	Oak, Pin	30	Prune
9707	Oak, Post	30	Prune
10200	Oak, Post	30	Prune
9631	Oak, Scarlet	30	Prune
9557	Sweetgum, Common	30	Prune
9422	Tulip Tree	30	Prune
9671	Oak, Post	30	Remove
9681	Oak, Post	30	Remove
10273	Oak, Post	30	Remove
9864	Pine, Eastern White	31	Prune
9442	Sweetgum, Common	31	Remove
10141	Oak, Pin	32	Prune
10191	Oak, Post	32	Prune
9645	Oak, Post	32	Prune
9800	Oak, Post	32	Prune
9899	Oak, Post	32	Prune
10094	Oak, Post	32	Prune
10100	Oak, Post	32	Prune
10163	Oak, Post	32	Prune
10161	Pine, Eastern White	32	Prune
9377	Pine, Eastern White	32	Prune
9767	Oak, Post	32	Remove
10198	Oak, Pin	33	Prune
10218	Oak, Post	33	Prune
9632	Oak, Post	33	Prune
10236	Oak, Post	33	Prune
10278	Oak, Post	33	Prune
10259	Oak, Post	33	Remove
9412	Oak, Pin	34	Prune
10201	Oak, Swamp White	34	Prune
10230	Oak, Post	34	Remove
9585	Oak, Shingle	35	Prune

Site ID	Species	DBH	Primary Maintenance Assigned
9781	Oak, Post	35	Remove
10239	Oak, Post	35	Remove
10225	Oak, Northern Red	36	Prune
9863	Oak, Post	36	Prune
10275	Oak, Post	36	Prune
10128	Oak, Post	36	Prune
9378	Pine, Eastern White	36	Remove
9802	Catalpa, Southern	37	Prune
9798	Oak, Post	37	Prune
10274	Oak, Post	37	Prune
9725	Oak, Pin	38	Prune
9879	Oak, Post	38	Prune
9352	Oak, Northern Red	38	Remove
9361	Oak, Northern Red	38	Remove
10171	Oak, Post	39	Remove
9921	Oak, Pin	40	Prune
9706	Oak, Pin	40	Prune
9596	Oak, Post	40	Prune
9656	Oak, Scarlet	40	Prune
9628	Sweetgum, Common	40	Prune
9588	Maple, Sugar	40	Remove
9783	Oak, Post	40	Remove
10071	Stump	40	Stump Removal
10104	Stump	41	Stump Removal
9905	Oak, Northern Red	42	Prune
9597	Oak, Post	42	Remove
10206	Oak, Northern Red	54	Prune
9577	Oak, White	60	Prune