DAVEY Resource Group

May 2020

STANDARD INVENTORY ANALYSIS AND MANAGEMENT PLAN

City of Warrenville, Illinois

Prepared for:

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ACKNOWLEDGMENTS

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

Warrenville also recognizes the support of its Mayor and City Council:

- David Brummel, Mayor
- Fred Bevier, Ward 1 Alderman
- Stuart Aschauer, Ward 1 Alderman
- Robert (Bob) Wilson, Ward 2 Alderman
- Bill Weidner, Ward 2 Alderman
- Jeff Krischel, Ward 3 Alderman
- Kathryn Davolos, Ward 3 Alderman
- Clare Barry, Ward 4 Alderman
- Leah Goodman, Ward 4 Alderman

Additional staff involved and integral to the success of this project include:

- John Coakley, City Administrator
- Phil Kuchler, Deputy Public Works Director
- Jamie Clark, Deputy Public Works Director

Recommended Maintenance Types

STANDARD INVENTORY ANALYSIS AND MANAGEMENT PLAN EXECUTIVE SUMMARY

The City of Warrenville *Standard Inventory Analysis and Management Plan*, written by Davey Resource Group, Inc. "DRG", focuses on quantifying the benefits provided by the inventoried tree resource and addressing its maintenance needs. DRG completed a tree inventory for the City of Warrenville in March 2020 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 Streets and recommended a prioritized management program for future tree care. Supporting and funding proactive maintenance of the public tree resource is a sound long-term investment that will reduce tree management costs over time.

The inventory recorded a total of 4,217 sites which included: 3,911 trees and 42 stumps. Additionally, 264 planting sites were collected, but only at the beginning of the project and concentrated in the northwestern portion of the city. An analysis of the inventory found the following:

- Of the species identified, silver maple (*Acer saccharinum)* is the most abundant species, representing 9% of the inventoried population.
- At the genus level, maple (*Acer*) dominate the population, representing 30% of the total population.
- Urban forests dominated by a few species/genera are vulnerable to attack by species- and genera-specific epidemics, which can lead to significant losses in a community's tree canopy. A recent example of this vulnerability is the impact that the emerald ash borer (EAB, *Agrilus planipennis* Fairmaire) had on ash trees and urban tree canopy in southeast Michigan communities over the last 15+ years.
- Spotted lanternfly (*Lycorma delicatula*) and Asian longhorned beetle (*Anoplophora glabripennis*) pose the greatest threats to the health of the inventoried population.
- The city's inventoried tree population trends towards the ideal size and age class distribution; however, young trees are overrepresented while established, maturing, and mature size classes lag behind the ideal.
- The overall condition of the inventoried tree population is rated **Average.**
- Deadwood and poor tree architecture were the most noted defects during the inventory.
- The functions of Warrenville's inventoried tree population provide benefits with an estimated total value of $328,085 annually.

Recommended Maintenance Types

Tree Removal and Hazards

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.

Hazard tree are those that need immediate attention due to the likelihood that the tree will result in injury to people or damage to property.

Tree Removals = 110 trees

Hazard Trees = 5 trees

Stumps = 42

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 = 63 trees

Cyclical Pruning

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

Total = 3,696 trees

Number of trees in cycle each year = approximately 740

New Tree Planting

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

Number of trees each year = at least 25

Tree Monitoring

Trees observed to be in a state of change. These factors could include visible onset of insect or pathogen which may change the maintenance recommendation in the coming year.

Total = 37 trees

Inspections and Inventory Updates

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

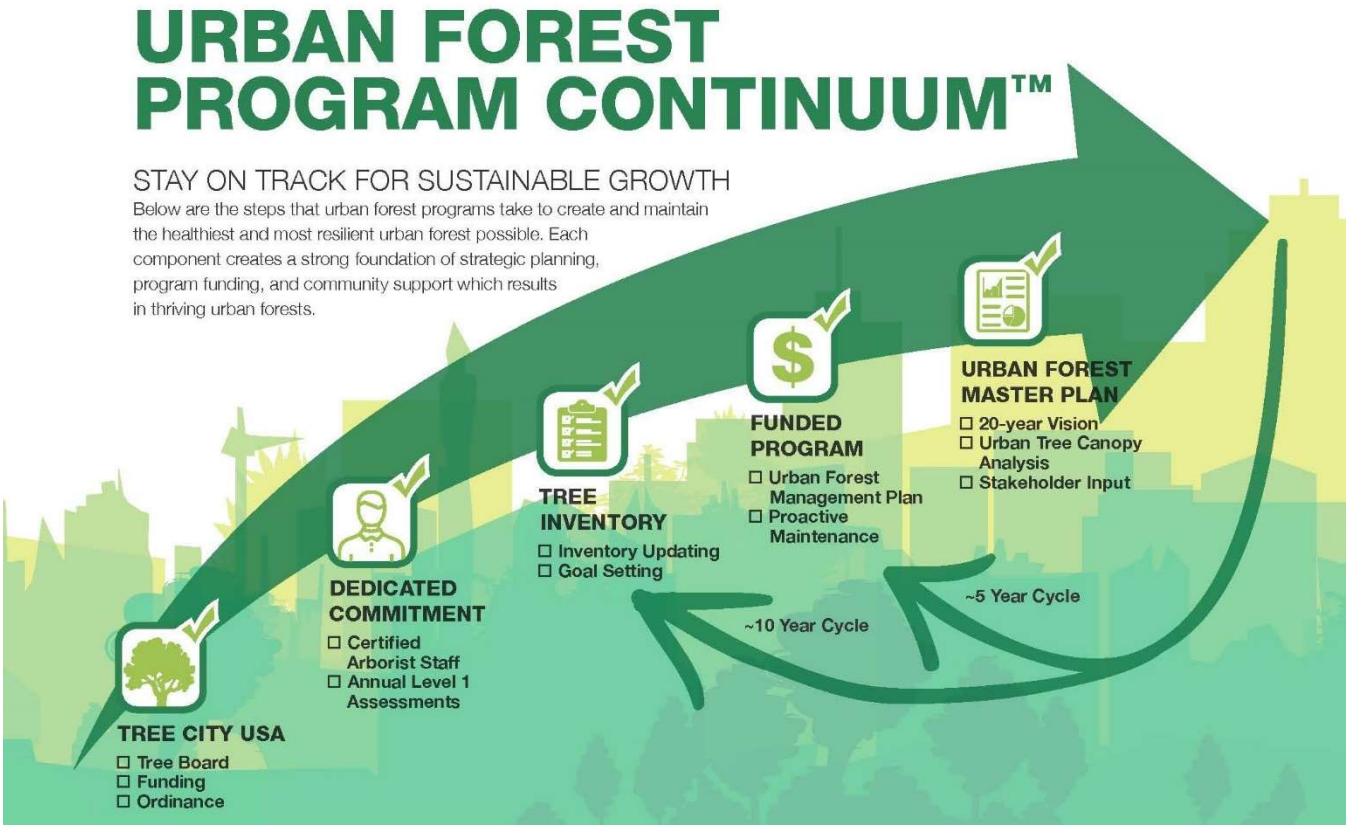
Ongoing and in concert with all other maintenance recommendations.

INTRODUCTION

The City of Warrenville is home to 13,140 residents (U.S. Census Bureau 2018, retrieved from: https://www.census.gov/quickfacts/fact/table/warrenvillecityillinois,US/PST045219) 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 throughout public parks. Urban forestry program budgets are funded by the City's General Fund. Warrenville celebrates Arbor Day and has been a Tree City USA community for 32 years.

Past Arbor Day celebrations have included an event hosted by the Environmental Advisory Commission (EAC). Festivities included a tree dedication ceremony and an environmental fair. In addition, visitors could receive a choice of several native trees or shrubs to take home and plant in their yard to enjoy for years and years to come.

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.

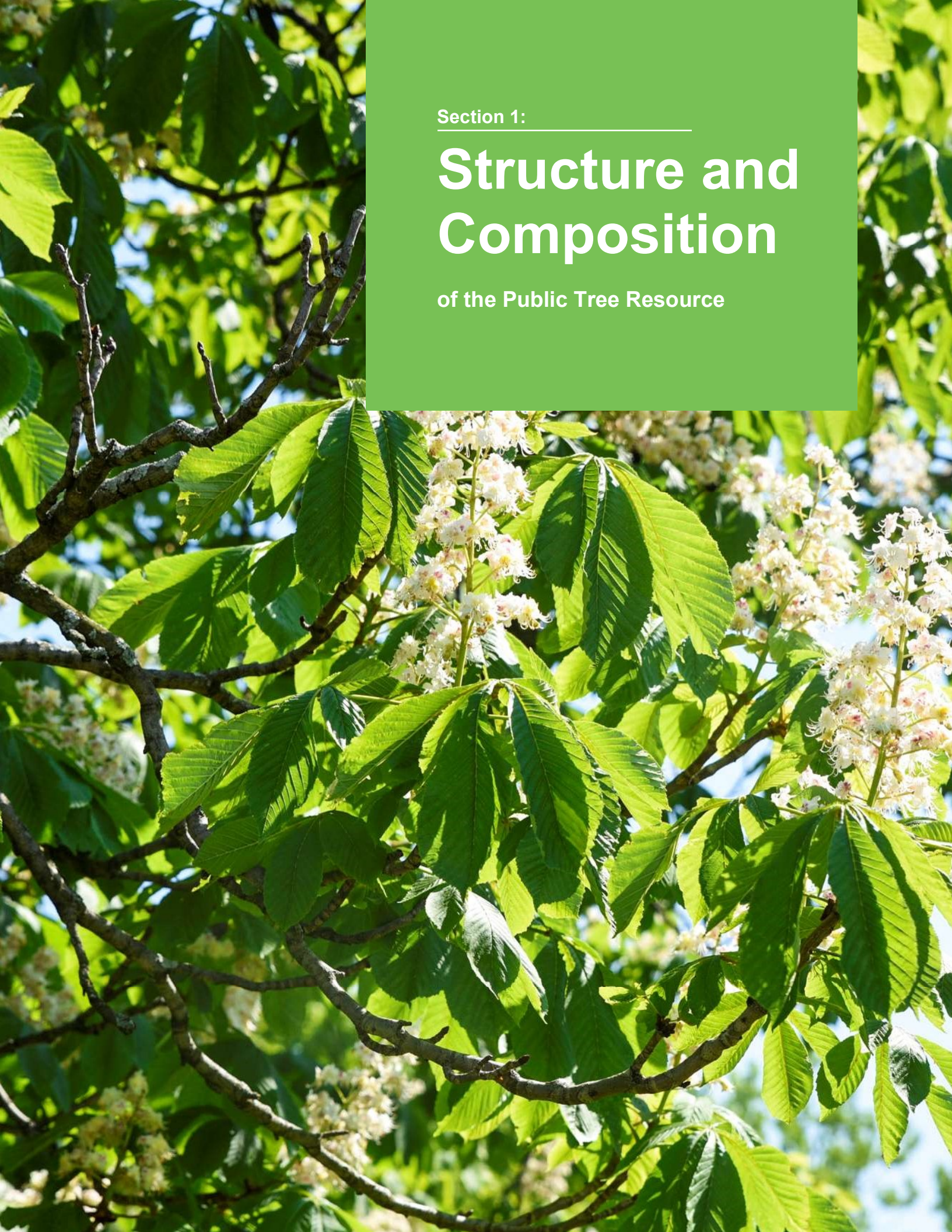


RECOMMENDED APPROACH TO TREE MANAGEMENT

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 March 2020, Warrenville worked with DRG to inventory its public trees and develop this management plan. Consisting of three sections, this plan considers the diversity, distribution, and condition of the inventoried tree population and provides a prioritized system for managing the 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 1:

Structure and Composition

of the Public Tree Resource

SECTION 1: STRUCTURE AND COMPOSITION OF THE PUBLIC TREE RESOURCE

In March 2020, DRG arborists collected site data on trees and stumps along the street ROW and on trees on public properties for a tree inventory contracted by the City of Warrenville. Inventoried public properties include:

- Cerny Park
- Leone Schmidt Heritage Park
- Warrenville City Hall
- Warrenville Police Department
- Four community water towers
  - Country Ridge Drive
  - Warrenville Road and Lorraine Avenue
  - River Road
  - West Street
- Three well sites
  - Batavia Road and Cherice Drive
  - Timber Drive and Grove Lane
  - Rogers Avenue

Of the total 4,217 sites inventoried, 93% were trees, 6% were stumps, and the remaining 1% were vacant planting sites. Note that planting sites were only collected at the beginning of the project and concentrated in the northwestern portion of the city. Figure 1 breaks down the total sites inventoried by type (tree, stump, or planting site). See Appendix A for details about DRG's methodology for collecting site data.

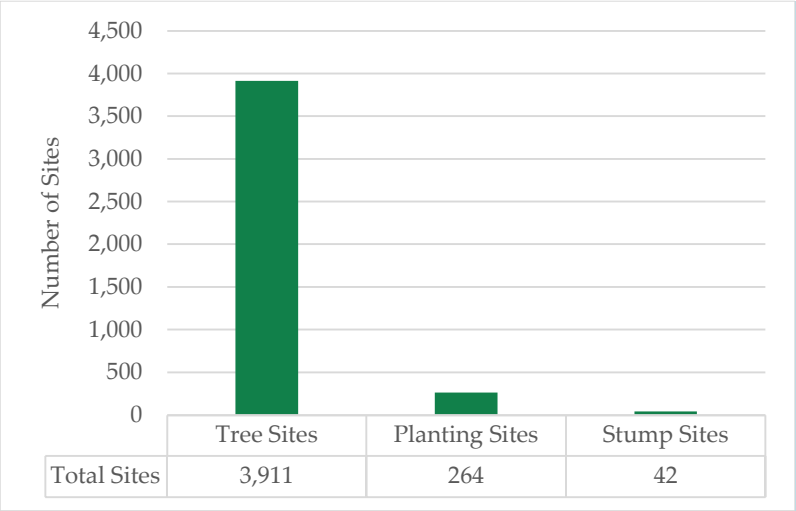
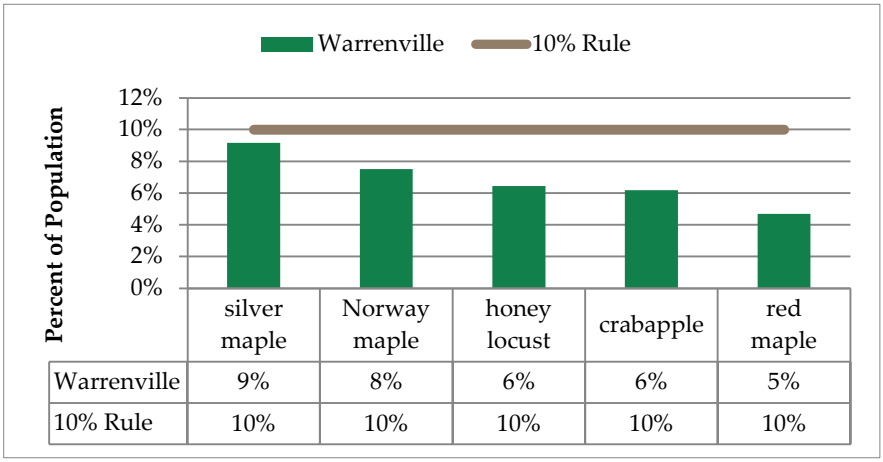


Figure 1. Number of inventoried sites by location and type.

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 2 shows Warrenville's distribution of the most abundant tree species inventoried compared to the 10% threshold. Silver maple (*Acer saccharinum)* is the most abundant species, and while 9% of the population is close to the 10% threshold, it is not immediately concerning from this data alone.



	silver maple	Norway maple	honey locust	crabapple	red maple
Warrenville	9%	8%	6%	6%	5%
10% Rule	10%	10%	10%	10%	10%

Figure 2. Inventoried tree population distribution of most abundant species.

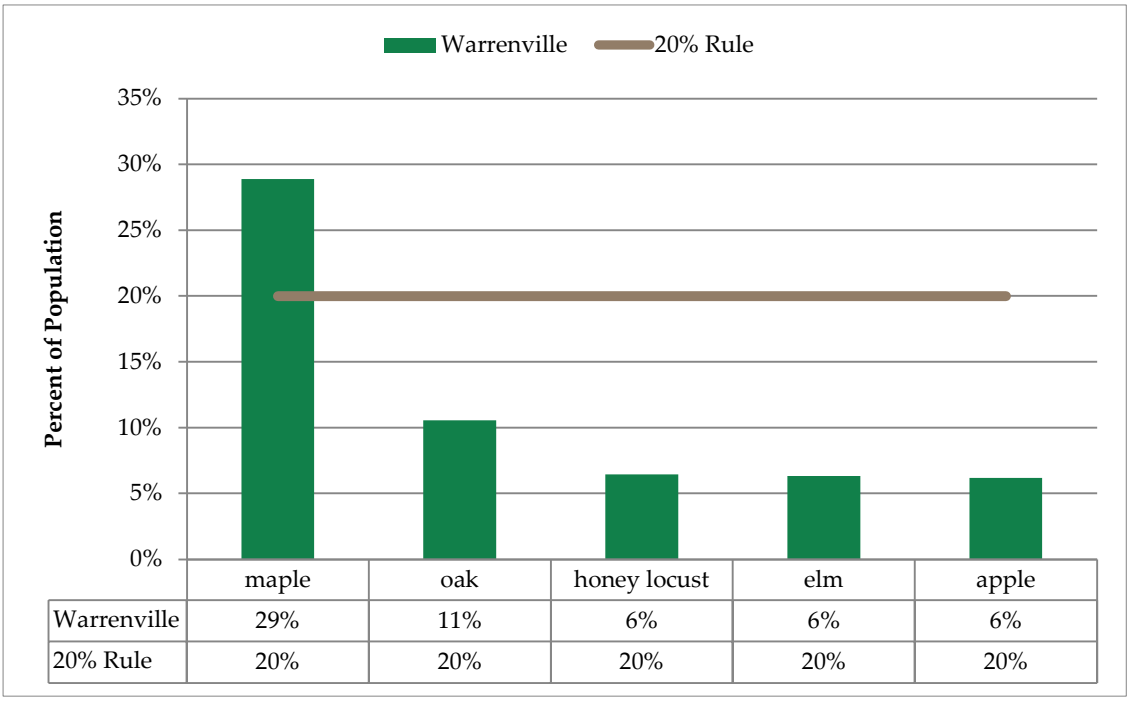
However, Figure 3 shows the city's distribution of the most abundant tree genera inventoried, and maple (*Acer*) is significantly higher than the 20% threshold. This means that silver maple is concerning after all, because maple compose 29% of the inventoried population. For this reason, the City of Warrenville should not plant silver maple or any other maple species until this distribution becomes more ideal.

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 communities. In the aftermath, ash trees became popular replacements and were heavily planted along city streets. History repeated itself in 2002 with the introduction of the emerald ash borer into America. This invasive beetle devastated ash tree populations across the Midwest. Other invasive pests spreading across the country threaten urban forests, so it is vital that we learn from history and plant a wider variety of tree genera to develop a resilient public tree resource.

Ash trees in an urban forest killed by emerald ash borer have become a gap in the canopy.

USDA Forest Service (2017)



	maple	oak	honey locust	elm	apple
Warrenville	29%	11%	6%	6%	6%
20% Rule	20%	20%	20%	20%	20%

Figure 3. Inventoried tree population distribution of most abundant genera.

PEST SUSCEPTIBLITY

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

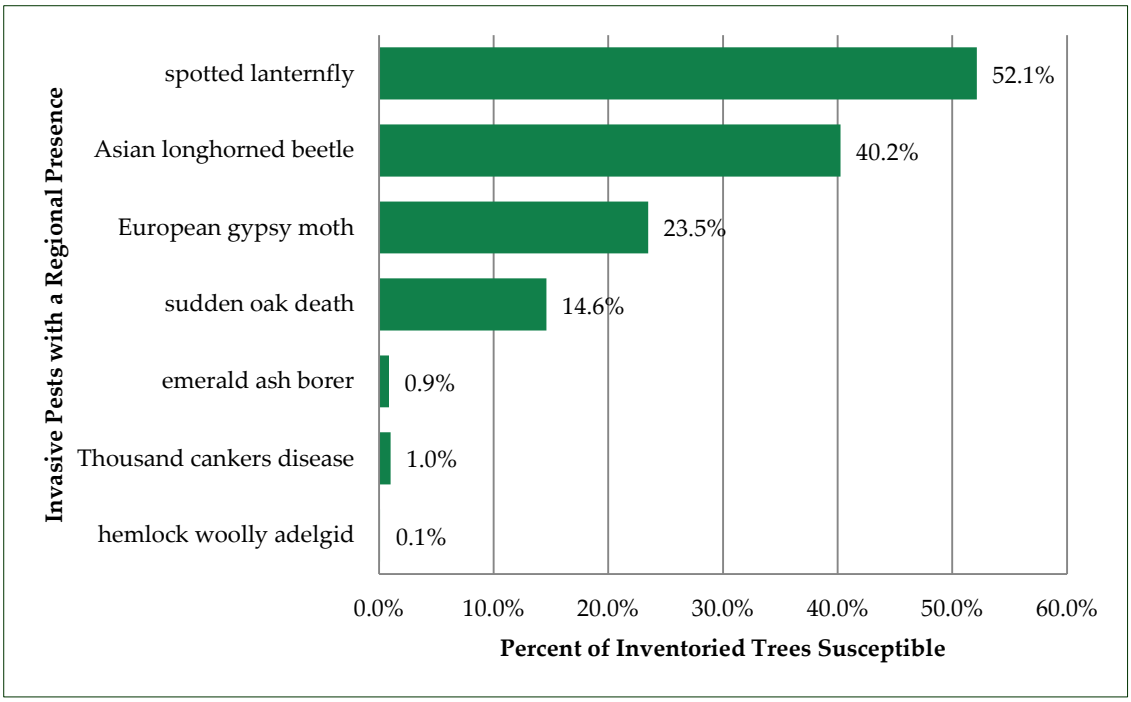


Figure 4. Public tree resource susceptibility to pests with a regional presence.

Figure 4 shows the percent of inventoried trees susceptible to some of the known pests in and around Illinois. It is important to remember that this figure only represents data collected during the inventory. Many more trees throughout Warrenville, especially those on private property, may be susceptible to hosting these invasive pests. Spotted lantern fly (SLF, *Lycorma delicatula*) and Asian longhorned beetle (ALB, *Anoplophora glabripennis*) are known threats to a large percentage of the inventoried tree resource, 52.1% and 40.2%, respectively.

Pest Susceptibility Recommendations

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

While it might be prudent for the city to limit planting maple species to prevent it from approaching the 20% threshold, efforts to improve diversity at species level are a better use of short-term resources until more research is done on genus diversity as a mechanism for promoting system resilience. For this reason, Warrenville should use its resources to inspect trees in the *Acer* genus for signs of infestation on a routine basis, so affected trees can be quarantined to contain the pest before an outbreak starts.

CONDITION

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

Figure 5 shows most of the inventoried trees were recorded in Average or Very Good condition, 68% and 16%, respectively. Based on these data, the general health of the inventoried tree population is rated as Average. Warrenville has a low percentage of trees in Poor and Very Poor condition, 9% of the total population.

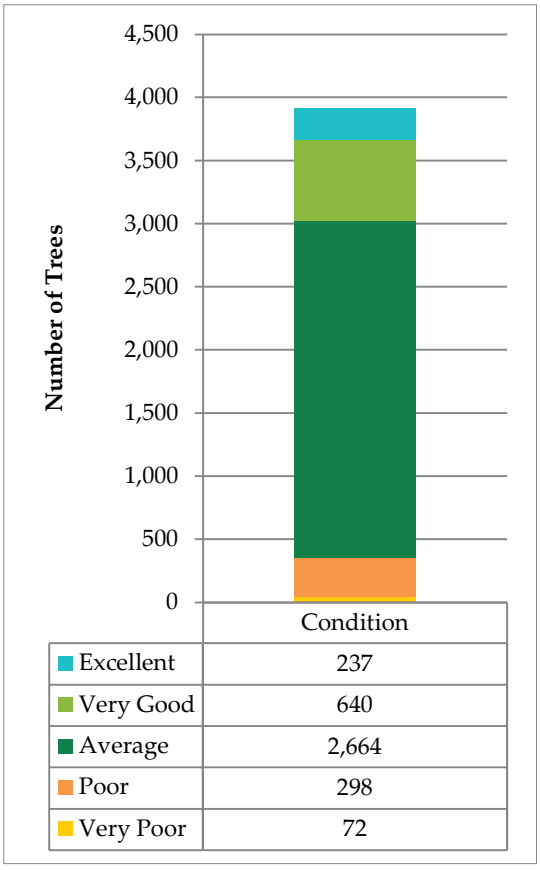


Figure 5. Condition of inventoried trees.

Condition Recommendations

- Trees in Poor and Very Poor condition (including dead trees) should be removed as soon as possible, because the health of these trees is unlikely to recover even with increased care and present a risk.
- Younger trees rated in Average or Poor condition may benefit from structural pruning to improve their health over time. Pruning should follow *ANSI A300 (Part 1)* guidelines.
- Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will likely require corrective pruning and intensive plant health care to improve their vigor and should be monitored for worsening conditions.

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 Warrenville'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.

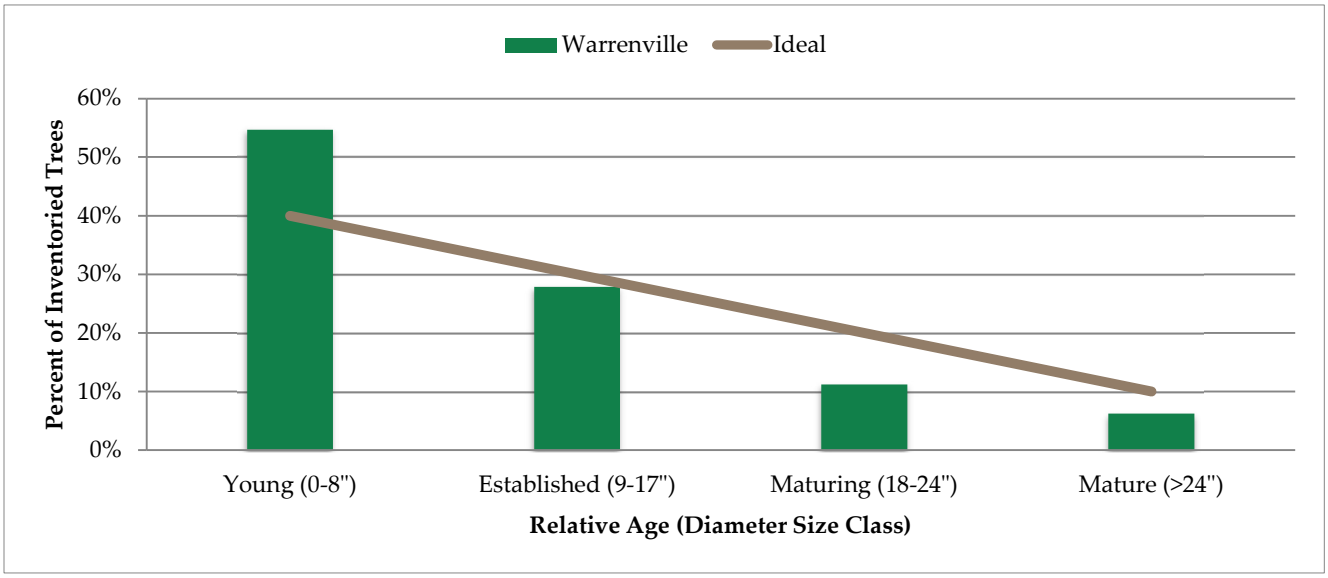


Figure 6. Relative age distribution of the inventoried trees.

Figure 6 compares Warrenville'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 exceed the ideal by 15%, while established, maturing, and mature trees fall short by 2%, 9%, and 4%, respectively.

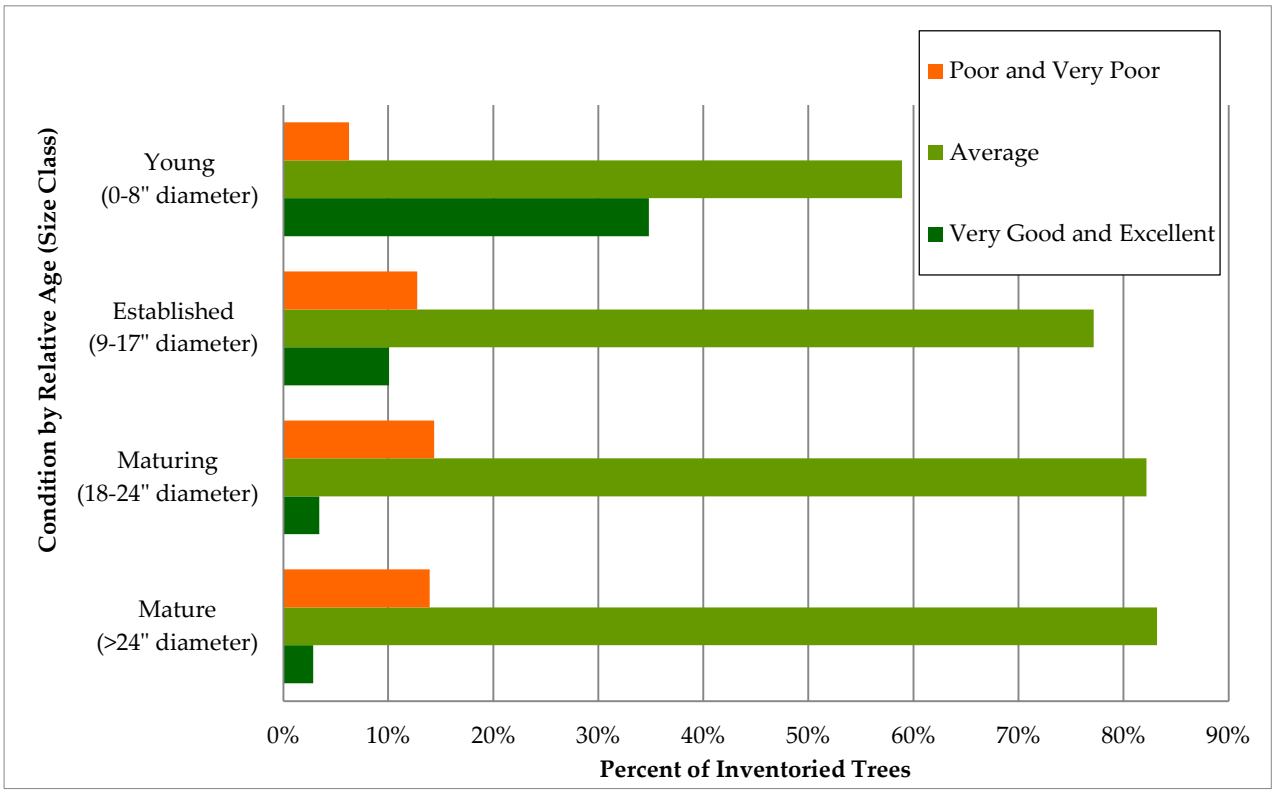


Figure 7. Condition of inventoried trees by relative age (size class).

Figure 7 cross analyzes the condition of the inventoried tree resource with its relative age distribution, providing insight into the inventoried population's stability. 86% of both mature and maturing trees are rated in Average condition or better, which matters because these larger trees would have a more damaging impact in the event of failure. 87% of established trees and 94% of young trees are rated in Average 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 and Very Poor condition.

Relative Age Recommendations

While Warrenville has an excess of young trees and a shortage of older age (size class) trees, the city overall 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 Warrenville 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 relevant comments. Defects were limited to the following categories:

- Broken/Hanging Branches – No or Yes
- Deadwood – None, Moderate, or Severe
- Poor Tree Architecture – No or Yes
- Roots – Normal, Girdling, or Exposed
- Rot – None, Basal, Trunk, or Widespread
- Wounds – None, Moderate, or Severe

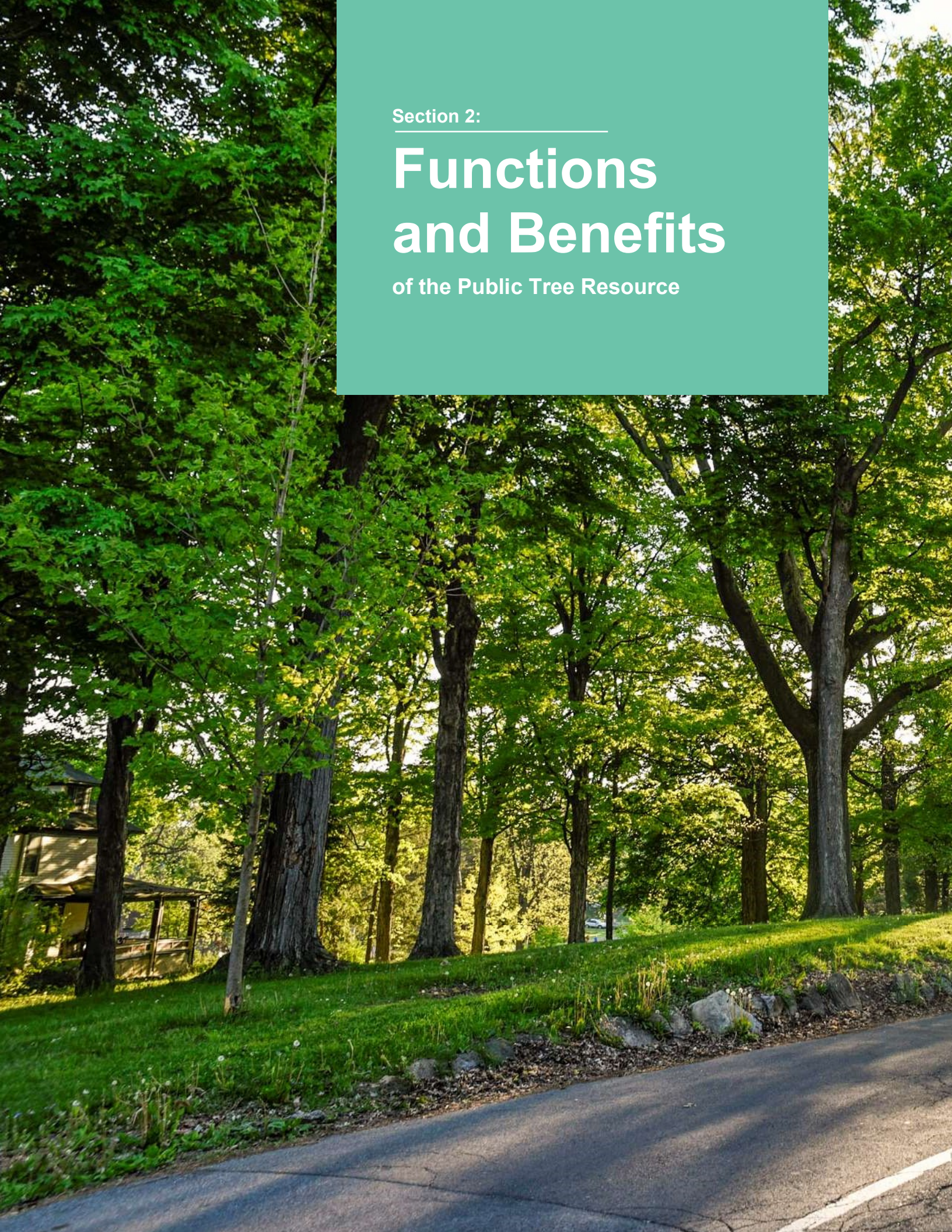
Table 1. Defect observations recorded during the tree inventory.

Observation		Number of Trees	Percent
Broken/Hanging Branches	No	3,772	96.4%
	Yes	139	3.6%
Deadwood	None	3,360	85.9%
	Moderate	351	9.0%
	Severe	200	5.1%
Poor Tree Architecture	No	3,391	86.7%
	Yes	520	13.3%
Roots	Normal	3,823	97.7%
	Girdling	69	1.8%
	Exposed	19	0.5%
Rot	None	3,786	96.8%
	Basal	15	0.4%
	Trunk	103	2.6%
	Widespread	7	0.2%
Wounds	None	3,767	96.3%
	Moderate	99	2.5%
	Severe	45	1.2%
Total Trees		**3,911**	**100.0%**

The two most frequently recorded defect categories of the inventoried trees were Deadwood (cumulative 14.1% recorded as Moderate and Severe) and Poor Tree Architecture (13.3% recorded as Yes) (Table 1).

Defect Observation Recommendations

When considering the defect recorded for each tree it is important to keep in mind that the categories are broadly inclusive. For example, the Deadwood 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.



Section 2:

Functions and Benefits

of the Public Tree Resource

SECTION 2: FUNCTIONS AND BENEFITS OF THE PUBLIC TREE RESOURCE

Trees occupy a vital role in the urban environment by providing of a wide array of economic, environmental, and social benefits far exceeding the investments in planting, maintaining, and removing them. Trees reduce air pollution, improve public health outcomes, reduce stormwater runoff, sequester and store carbon, reduce energy use, and increase property value. Using advanced analytics, such as i-Tree Streets 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.
- 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).

TREE BENEFIT ANALYSIS

i-Tree Streets

To quantify the dollar value of tree benefits provided and returned to the community, the City of Warrenville's street tree inventory data were formatted for use in the i-Tree Streets benefit-cost assessment tool.

i-Tree Streets, a component of the USDA Forest Service's i-Tree software tools, analyzes a city's inventoried tree population to estimate its costs and benefits. The assessment tool creates an annual benefit report that demonstrates the value street trees provide to the community.

The reports and tree benefits provided through the i-Tree Streets analysis are described below.

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

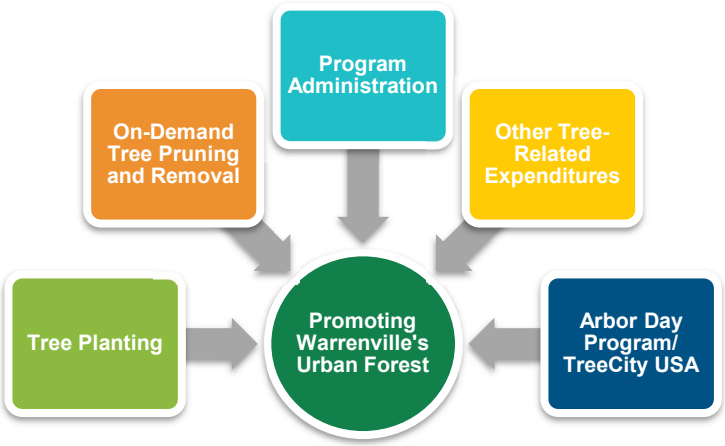
i-Tree Tools

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

THE BENEFITS OF WARRENVILLE'S URBAN FOREST

i-Tree Streets Inputs

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



Warrenville's Inputs

Since specific local economic data for Warrenville's urban forestry program were not available at the time of this plan, economic data from Minneapolis, MN were used to help calculate the inputs of Warrenville's community, as the cities are in the same climate zone (Midwest).

Because unadjusted program economic defaults were used, the reporting function of the i-Tree Streets model is based on estimates of tree benefits. Net Annual Benefits, Cost for Public Trees, and Benefit-Cost Ratio (BCR) will not be calculated.

Annual Benefits

The i-Tree Streets model estimated that the inventoried street trees provide a total annual benefit of $328,085. Essentially, due to the presence of Warrenville's public trees, $328,085 was saved to cool and heat buildings, manage stormwater, clean the air, increase property values, and improve community aesthetics. On average, a single Warrenville tree provides an annual benefit of $83.89.

The assessment found that the aesthetics and other tangible and intangible benefits from the city's trees offer the highest percentage (approximately 38%) with $124,568 provided in increases to property value. The energy conservation that trees provide was the next greatest value to the community, with approximately 29% of the total annual benefits deriving from these savings ($93,695). The city's trees intercept over 3.2 million gallons of rainfall each year, which equates to a savings of $87,100 in stormwater management costs, comprising approximately 27% of the annual benefits. Air quality improvements and CO_2 reductions are also important benefits, but account for lesser amounts of work performed by community trees. The urban forest positively impacted the air quality of the city with $12,893 saved annually in pollution reduction. This effect accounted for approximately 4% of the total benefits. Lastly, CO_2 reductions accounted for $9,829 or approximately 3% of the annual benefits in CO_2 avoidance and sequestration. Figure 8 summarizes the annual benefits and results for the inventoried street tree population.

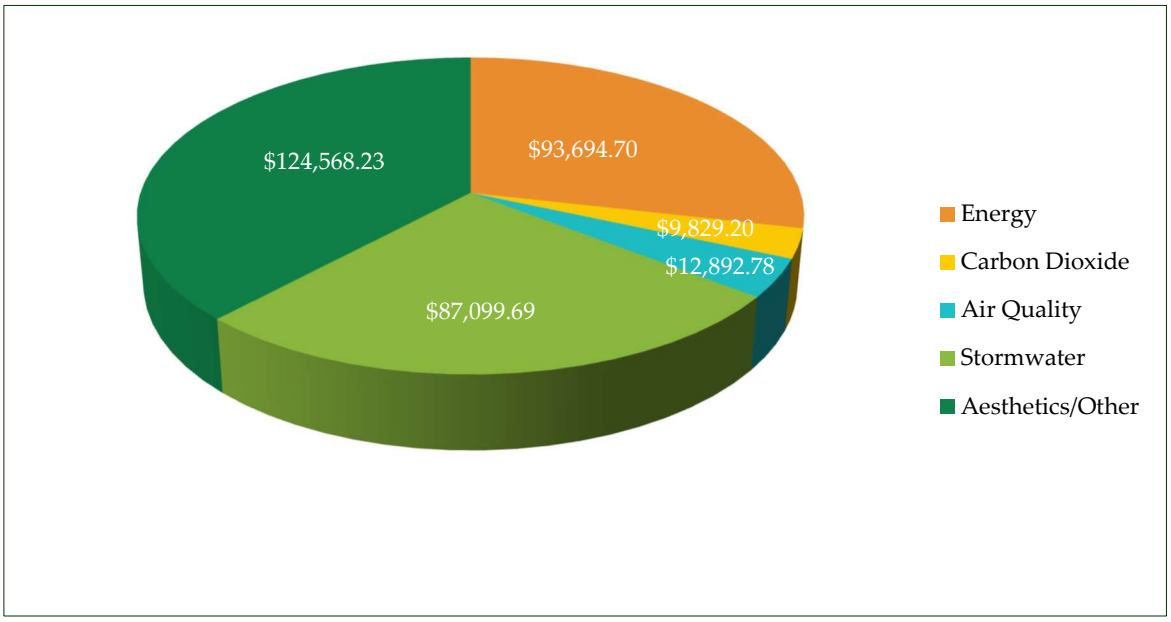


Figure 8. Breakdown of total annual benefits provided to Warrenville.

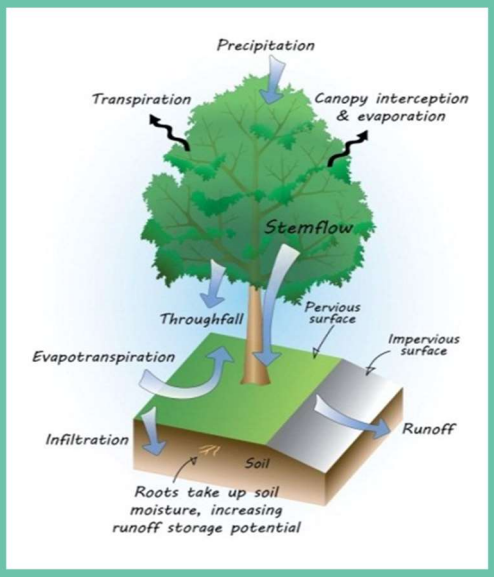
Aesthetic/Other Benefits

The total annual benefit associated with property value increases and other tangible and intangible benefits of street trees was $124,568. The average benefit per tree was $31.85 per year.

Energy Benefits

Warrenville's trees conserve energy by shading structures and surfaces, which reduces electricity use for air conditioning in the summer. In the winter, these same trees divert wind and reduce natural gas use. Based on the inventory data, the annual electric and natural gas savings are equivalent to approximately 446 megawatt-hours (MWh) of electricity and approximately 61,062 therms (thm) of natural gas, which accounts for an annual savings of $93,695 in energy consumption. On average, each tree provides $23.96 in energy benefits annually.

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.

Stormwater Benefits

Trees intercept rainfall, which helps lower costs to manage stormwater runoff. The inventoried trees in Warrenville intercept over 3.2 million gallons of rainfall each year, valued at $87,100 annually. On average, the estimated annual savings for the city in stormwater runoff management is $22.27 per tree.

Air Quality Improvements

The inventoried tree population annually removes approximately 4,109 pounds of air pollutants (including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter). The i-Tree Streets calculation considers the biogenic volatile organic compounds (BVOC's) that are released from trees in this calculation. While trees do a great deal to absorb air pollutants, they also contribute negatively to air pollution. Trees emit various BVOCs, such as isoprenes and monoterpenes, which can also contribute to formation of ozone, a harmful gas that pollutes the air and damages vegetation. The net total value of these benefits is estimated to be $12,893. The inventoried trees removed or avoided more pollutants than they emitted, resulting in a positive economic value. On average, each tree provides $3.30 in air quality improvement benefits.

i-Tree Tools

A common example of a natural BVOC is the gas emitted from pine trees, which creates the distinct smell of a pine forest.

Carbon Storage and Carbon Sequestration

Trees store some of the carbon dioxide (CO_2) they absorb, preventing it from reaching the upper atmosphere, where it can react with other compounds and form harmful gases like ozone, which adversely affects air quality. These trees also sequester some of the CO_2 during growth (Nowak et al. 2013).

The i-Tree Streets calculation considers the carbon emissions that are *not* released from power stations due to the heating and cooling effect of trees (i.e., conserved energy in buildings and homes). It also calculates emissions released during tree care and maintenance, such as driving to the site and operating equipment. The net carbon benefit is approximately $9,829 per year.

The city's trees store 382 tons of carbon (measured in CO_2 equivalents). This amount reflects the amount of carbon they have amassed during their lifetimes. An additional 295 tons of CO_2 per year are mitigated through avoidance. On average, each tree provides $2.51 in benefits through CO_2 storage and sequestration.

Discussion/Recommendations

The i-Tree Streets analysis found that Warrenville's trees provide environmental and economic benefits to the community by virtue of merely being present. Currently, the energy savings and aesthetic benefits provided by the city's trees were rated as having the greatest value to the community; however, their contributions to improving air quality, managing stormwater runoff, and storing CO_2 are also important.

To increase the benefits the urban forest provides, Warrenville should plant large-statured tree species (greater than 50 feet at maturity) that are low emitters of BVOCs where growth space size allows. Leafy large-stature trees consistently created the most environmental and economic benefits.

Section 3:

Recommended Management

of the Public Tree Resource

SECTION 3: RECOMMENDED MANAGEMENT OF THE PUBLIC TREE RESOURCE

During the inventory, a recommended maintenance activity was 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.

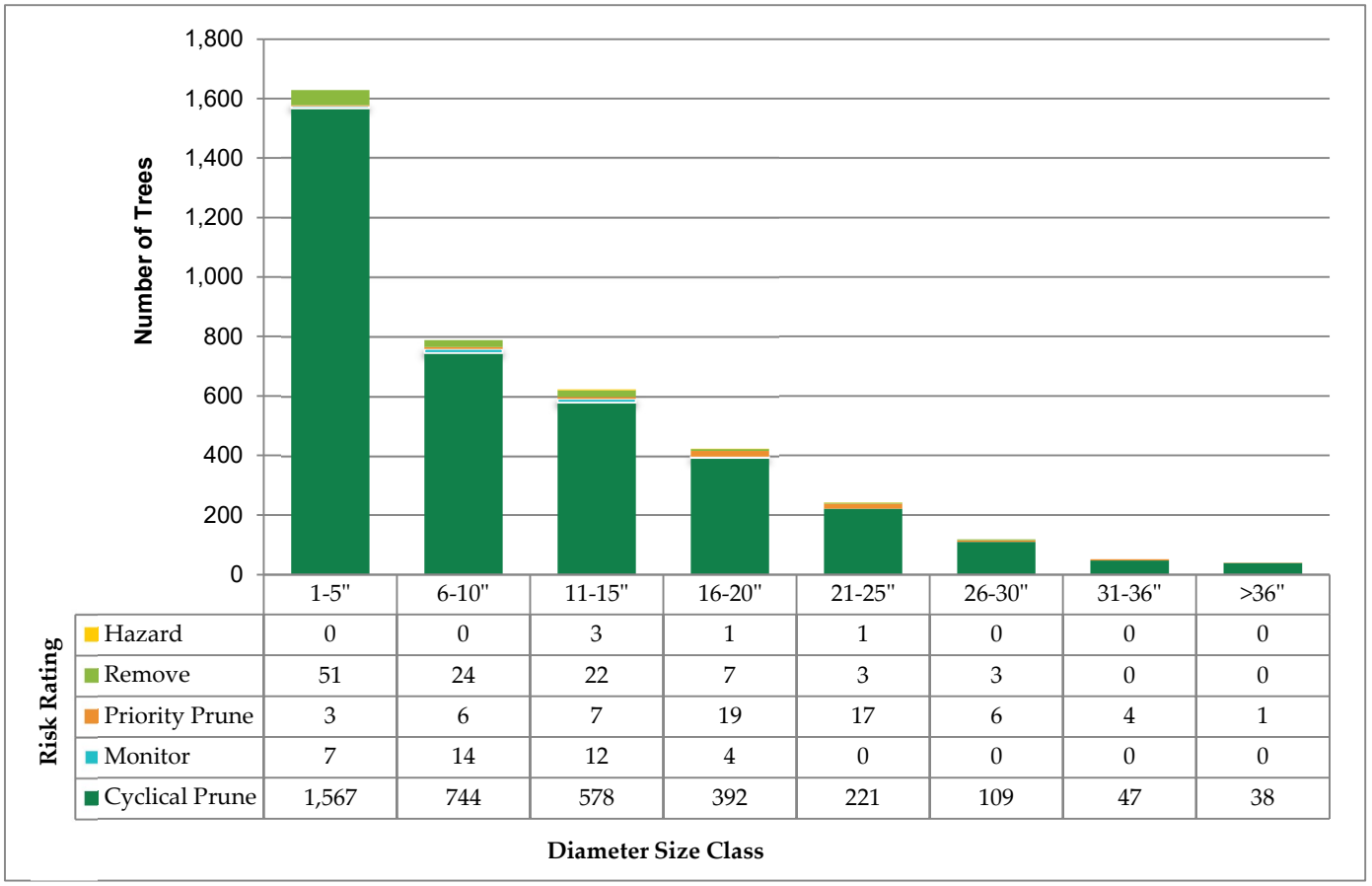
The following tree management program was developed with a focus on preserving and caring for Warrenville's urban forest. DRG recommends a maintenance cycle of five years, with the understanding that although exact costs and numbers may differ, this schedule addresses the maintenance needed as identified in the tree inventory in a reasonable timeframe. Utilizing data from the tree inventory, the proposed budget schedule was designed to prioritize tree removal and pruning and to improve tree health and structure through a proactive pruning cycle. Planting to replace removed trees and increase canopy cover, along with offering public outreach opportunities, are also included as parts of the program.

The recommended tree maintenance work was divided into either priority or proactive maintenance. Priority maintenance includes tree removals, trees designated for priority pruning, and trees recorded as potential hazards and requiring monitoring. The routine pruning cycle, tree planting, and stump removal are considered proactive maintenance.

While implementing a tree care program is an ongoing process, tree work must always be prioritized to reduce public safety risks. Since risk rating information was not collected during the inventory, DRG recommends completing the work identified based on the type of work and diameter size class. Higher diameter removals and pruning work should be considered before lower size classes. Maintenance pruning can occur after these priorities are addressed, again focusing on higher diameter trees first.

PRIORITY AND PROACTIVE MAINTENANCE

Figure 9 shows the breakdown of recommended work on the inventoried trees by budgetary diameter size classes.



Risk Rating	1-5"	6-10"	11-15"	16-20"	21-25"	26-30"	31-36"	>36"
Hazard	0	0	3	1	1	0	0	0
Remove	51	24	22	7	3	3	0	0
Priority Prune	3	6	7	19	17	6	4	1
Monitor	7	14	12	4	0	0	0	0
Cyclical Prune	1,567	744	578	392	221	109	47	38

Diameter Size Class

Figure 9. Breakdown of recommended work on the inventoried trees by budgetary diameter size classes.

Tree Removal and Hazard Trees

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

Findings

The inventory identified 110 trees, 3% of the inventoried population, for removal. The diameter size classes for trees with recommended for removal ranged between 1–5 inches DBH and 26–30 inches DBH.

Hazard trees identified during the inventory, 5 trees in total, should also be considered high priority removals.

Discussion/Recommendations

Even though higher short-term expenditures may be required, it is important to secure the funding needed to complete priority, higher diameter tree removals. The proposed budget reflects prioritizing the largest diameter removals within the first few years. Trees recorded as hazards are included in Year 1. Further accuracy and prioritization can be applied by examining the condition and comments associated with proposed removals. The budget allows for some flexibility regarding smaller diameter size classes, as these trees can sometimes be a lesser source of significant risk.

Unless already slated for removal, trees with poor condition or noted as having poor tree architecture, rot, wounds, or similar comments, should be inspected on a regular basis. Corrective action should be taken when warranted. If their condition worsens, tree removal may be required. Proactive tree maintenance that actively mitigates elevated-risk situations will promote public safety and potentially reduce storm damage.

Regularly maintaining and updating the tree inventory data can streamline workload management and lend insight into setting accurate budgets and staffing levels. Inventory updates should be implemented using the city's tree management software.

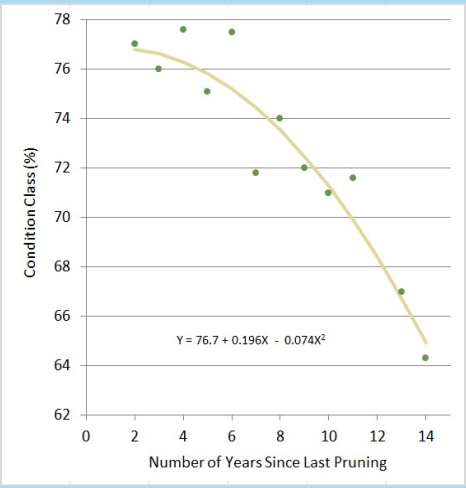
Monitoring

The monitoring primary maintenance recommendation indicates that tree's condition appears to be in a state of change, such as visible onset of an insect or pathogen which may change the maintenance recommendation in the coming year. Thirty-seven trees were identified for monitoring. These trees should be assessed by an ISA certified arborist as soon as possible and monitored over the next year. The longer serious defects are left unaddressed, the greater a risk that a tree becomes. Corrective action should be taken as soon as possible unless it will not adequately eliminate the defect, in which case tree removal is likely to be the safest and most cost-effective management.

Priority and Cyclical Tree Pruning

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

PROACTIVE PRUNING



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 high priority hazard, removal, and tree pruning maintenance has been completed.

For many communities, a proactive tree management program might present a considerable challenge, as an on-demand response to urgent situations is the norm. Research has shown that a proactive program that includes a routine pruning cycle will improve the overall health of a tree population (Miller and Sylvester 1981). In a proactive program, trees are regularly assessed and pruned, which helps detect and eliminate most defects before they impact the tree's structure and/or escalate to a hazardous situation. Other advantages of a proactive program include increased environmental and economic benefits from trees, more predictable budgets and projectable workloads, and reduced long-term tree maintenance costs.

Findings

Inventory pruning recommendations fell into two categories—Priority Prune and Cyclical Prune. Trees recorded for Priority Prune will need pruning or maintenance on a prompter schedule than a standard pruning cycle. Cyclical Prune denotes a tree that can be scheduled for standard maintenance on a regular pruning cycle.

63 trees, 3% of the inventoried population, were identified for priority pruning. The diameter size classes for trees with recommended for priority pruning ranged between 1–5 inches DBH and 26–30 inches DBH.

3,696 trees, 95% of the inventoried population, were identified for cyclical pruning. The diameter size classes for trees with recommended for cyclical pruning ran the entire range of budgetary size classes from 1–5 inches DBH to >36 inches DBH.

Discussion/Recommendations

Similar to the removal recommendations, higher diameter pruning work should be considered before lower size classes. Further accuracy and prioritization can be applied by examining the condition and comments associated with the proposed pruning work.

DRG recommends that Warrenville establish a Routine Pruning (RP) Cycle in which approximately one-fifth of the tree population is, at a minimum, pruned each year. The 3,696 trees identified for Cyclical Prune provide the basis of a routine pruning cycle. An average of 743 trees should be considered or inspected for pruning each year over the course of the cycle. Training pruning work should occur as part of this cycle when possible with an effort to improve the health and condition of young trees. If left unchecked, small defects can result in larger and more hazardous failures as trees age. The actual cost of this work may vary based on diameter class distribution in each yearly cycle, and whether any pruning work needs to take place. DRG recommends that the RP Cycle begin in Year 1, after all the priority hazard, removal, and pruning work for that year has been completed.

ROUTINE INSPECTIONS AND INVENTORY UPDATES

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

Routine Inspection Recommendations

All trees along the street ROW should be regularly inspected and attended to as needed. When trees require additional or new work, they should be added to the maintenance schedule. The budget should also be updated to reflect the additional work. Utilize computer management software 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. Warrenville has a large population of trees that are susceptible to pests and diseases, including ash, maple, and oak.

DRG recommends that Warrenville perform routine inspections of inventoried trees by windshield survey (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* annually and after all severe weather events, to identify defects with heightened risk, signs of pest activity, and symptoms of disease. Routine inspections can also occur in concert with pruning or removal work. When trees need additional maintenance, they should be added to the work schedule immediately using the city's asset management software to update inventory data and schedule work records.

TREE PLANTING AND STUMP REMOVAL

While the City of Warrenville receives value from the ecosystem services provided by the public tree resource, those benefits usually are not distributed evenly across the city. Focusing on planting trees in areas where there is sparse canopy, areas with poor canopy continuity, or those with gaps in existing canopy, can help maximize the benefits of those efforts.

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 utility lines and hardscape as it grows taller, wider, and deeper. If the tree at maturity will reach overhead lines, or conflict with sidewalks and curbs, it is best to choose another tree or a different location.

Tree Planting and Stump Removal Recommendations

Creating larger growing sites for trees in the municipal ROW can be the single most beneficial management practice to improve the survival rate of planted and developing trees. Increasing planting space can also reduce the amount of tree-related infrastructure conflicts, as the trees will be planted further from curbs and sidewalks. Depending on the site, there are several methods available to create and/or increase the growing space for newly planted trees:

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

The inventory identified 42 stumps recommended for removal, with a wide range of sizes from 2 inches to 38 inches in diameter. Stump removals should occur when convenient and be included in regular planting plans if the site would be feasible for planting after the stump is removed. For this reason, it is most convenient to remove all stumps in areas with scheduled tree planting work, so all feasible sites in an area are stocked at once. The proposed budget accounts for stump removal in Years 3 and 4 the program.

A list of suggested tree species is provided in Appendix C. These tree species are specifically selected for the climate of Warrenville. 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.

COMMUNITY OUTREACH

The data collected and analyzed to develop this plan not only provides important information to guide the development of a proactive management program, but it can also be utilized to educate the Warrenville community about the value of the urban forest and the tree management program. Tree inventory data can be shared with the community to:

- Educate the public on the importance of trees and generate a sense of pride in becoming stewards of their urban forest.
- Help explain and justify necessary priority and proactive tree maintenance activities, as well as tree planting and preservation initiatives.
- Guide tree species selection for planting projects with the goals of improving species diversity and limiting the introduction of invasive pests and diseases.
- Advise citizens about threats to their trees and the urban forest (such as spotted lanternfly and Asian longhorned beetle).

There are various approaches the city can use to educate and communicate information about the urban forest to the community, including:

- Creating and posting maps on the city website, in parks, or in business areas.
- Developing public service announcements and articles about the benefits of trees.
- Producing educational programs about trees, tree care, and the benefits trees provide.
- Creating signs to hang from public trees that highlight the contribution that trees make to the community.
- Holding a photo contest to highlight trees of Warrenville and increase awareness of the importance of trees.

MAINTENANCE SCHEDULE AND BUDGET

Utilizing 2020 City of Warrenville 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 Warrenville's five-year tree management program 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.

Ideally, Warrenville's budget should accomplish all priority and proactive maintenance. However, that might not be possible due to budget constraints. The proposed budget considered $96,059 each year for Cyclical Pruning. This would account for approximately one-fifth of the 3,696 trees identified for Cyclical Pruning with a DBH appropriate pruning activity. The numbers below are presented both including and excluding that proactive maintenance activity. To implement the proposed maintenance schedule, Warrenville's tree maintenance budget should consider:

- No less than $130,254 in total for the first year of implementation, or $34,195 without considering cyclical pruning.
- No less than $117,403 in total for the second year, or $21,334 without considering cyclical pruning.
- No less than $112,439 in total for the third year, or $16,380 without considering cyclical pruning.
- No less than $111,484 for the fourth year, or $15,425 without considering cyclical pruning.
- No less than $110,559 for the final year of the maintenance schedule, or $14,500 without considering cyclical pruning.

Annual budget funds are needed to ensure that higher diameter removals and priority pruning needs are remediated, as well as the trees recorded as Hazard and Monitor, and that crucial maintenance pruning cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

If routing efficiencies and/or contract specifications allow for the completion of more tree work, or if the schedule requires changes 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. Should conditions or maintenance needs change, budgets and equipment will need to be adjusted to meet the new demand.

Table 2. Estimated costs for five-year tree 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	
Hazards and Removals	1-5"	$50	21	$1,050	30	$1,500	0	$0	0	$0	0	$0	$2,550
	6-10"	$75	20	$1,500	4	$300	0	$0	0	$0	0	$0	$1,800
	11-15"	$100	20	$2,000	5	$500	0	$0	0	$0	0	$0	$2,500
	16-20"	$125	8	$1,000	0	$0	0	$0	0	$0	0	$0	$1,000
	21-25"	$375	4	$1,500	0	$0	0	$0	0	$0	0	$0	$1,500
	26-30"	$565	3	$1,695	0	$0	0	$0	0	$0	0	$0	$1,695
	31-36"	$800	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	>36"	$1,300	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			76	$8,745	39	$2,300	0	$0	0	$0	0	$0	$11,045
Monitoring		$50 per hour	37	$1,850	0	$0	0	$0	0	$0	0	$0	$1,850
Activity Total(s)				$1,850	0	$0	0	$0	0	$0	0	$0	$1,850
Stump Removals	1-5"	$25	0	$0	0	$0	0	$0	6	$150	0	$0	$150
	6-10"	$35	0	$0	0	$0	0	$0	3	$105	0	$0	$105
	11-15"	$50	0	$0	0	$0	6	$300	5	$250	0	$0	$550
	16-20"	$65	0	$0	0	$0	4	$260	4	$260	0	$0	$520
	21-25"	$80	0	$0	0	$0	4	$320	2	$160	0	$0	$480
	26-30"	$100	0	$0	0	$0	7	$700	0	$0	0	$0	$700
	31-35"	$150	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	>36"	$300	0	$0	0	$0	1	$300	0	$0	0	$0	$300
Activity Total(s)			0	$0	0	$0	22	$1,880	20	$925	0	$0	$2,805
Priority Pruning	1-5"	$58	2	$116	1	$58	0	$0	0	$0	0	$0	$174
	6-10"	$113	3	$339	3	$339	0	$0	0	$0	0	$0	$678
	11-15"	$183	4	$732	3	$549	0	$0	0	$0	0	$0	$1,281
	16-20"	$203	10	$2,030	9	$1,827	0	$0	0	$0	0	$0	$3,857
	21-25"	$253	10	$2,530	7	$1,771	0	$0	0	$0	0	$0	$4,301
	26-30"	$283	6	$1,698	0	$0	0	$0	0	$0	0	$0	$1,698
	31-36"	$323	4	$1,292	0	$0	0	$0	0	$0	0	$0	$1,292
	>36"	$363	1	$363	0	$0	0	$0	0	$0	0	$0	$363
Activity Total(s)			40	$9,100	23	$4,544	0	$0	0	$0	0	$0	$13,644
Cyclical Pruning	1-5"	$58	314	$18,212	314	$18,212	314	$18,212	314	$18,212	314	$18,212	$91,060
	6-10"	$113	149	$16,837	149	$16,837	149	$16,837	149	$16,837	149	$16,837	$84,185
	11-15"	$183	116	$21,228	116	$21,228	116	$21,228	116	$21,228	116	$21,228	$106,140
	16-20"	$203	79	$16,037	79	$16,037	79	$16,037	79	$16,037	79	$16,037	$80,185
	21-25"	$253	45	$11,385	45	$11,385	45	$11,385	45	$11,385	45	$11,385	$56,925
	26-30"	$283	22	$6,226	22	$6,226	22	$6,226	22	$6,226	22	$6,226	$31,130
	31-36"	$323	10	$3,230	10	$3,230	10	$3,230	10	$3,230	10	$3,230	$16,150
	>36"	$363	8	$2,904	8	$2,904	8	$2,904	8	$2,904	8	$2,904	$14,520
Activity Total(s)			743	$96,059	743	$96,059	743	$96,059	743	$96,059	743	$96,059	$480,295
Tree Planting	Purchasing	$170	25	$4,250	25	$4,250	25	$4,250	25	$4,250	25	$4,250	$21,250
	Planting	$110	25	$2,750	25	$2,750	25	$2,750	25	$2,750	25	$2,750	$13,750
Activity Total(s)			50	$7,000	50	$7,000	50	$7,000	50	$7,000	50	$7,000	$35,000
Admin, Legal, Outreach, Training				$2,000		$2,000		$2,000		$2,000		$2,000	$10,000
Inspections and Inventory Updates				$3,000		$3,000		$3,000		$3,000		$3,000	
Infrastructure Repair and Storm Response				$2,500		$2,500		$2,500		$2,500		$2,500	$12,500
Activity Total(s)				$7,500		$7,500		$7,500		$7,500		$7,500	$37,500
Activity Grand Total			909		855		815		813		793		
Cost without Cyclical Pruning				$34,195		$21,344		$16,380		$15,425		$14,500	$101,844
Cost Grand Total				$130,254		$117,403		$112,439		$111,484		$110,559	$582,139

CONCLUSION

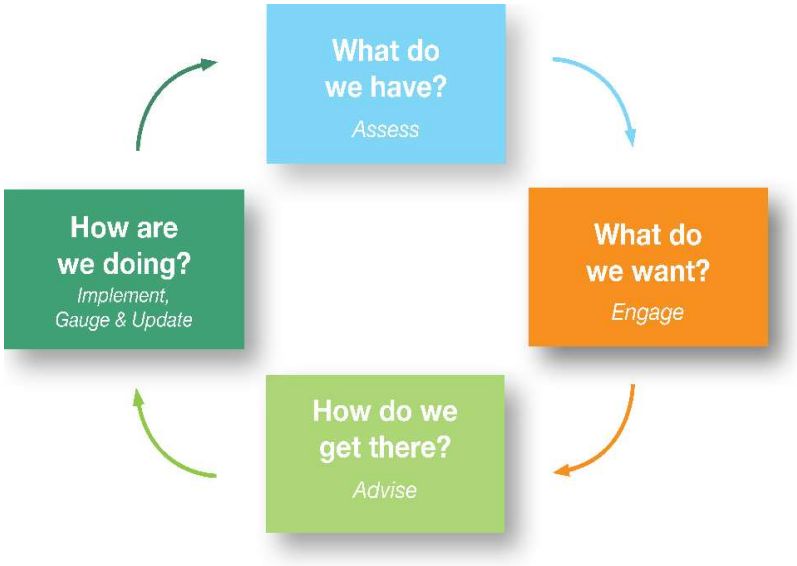
When properly maintained, the valuable benefits trees provide over their lifetime far exceed the time and money invested in planting, pruning, and inevitably removing them. The 3,911 public trees inventoried provide $328,085 in estimated annual benefits. When properly maintained, these trees will provide numerous environmental, economic, and social benefits that far exceed the time and money invested in their planting, pruning, protection, and removal. Successfully implementing the five-year program may increase Warrenville'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 Warrenville and its residents will increase as well. Inventoried trees are only a fraction of the total trees in Warrenville when including private property, which is why it is important to also incentivize private landowners to care for their trees and to plant new ones. The 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 asset management software as work is completed, so the software can provide updated species distribution and benefit estimates. This empowers Warrenville 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.

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APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

DATA COLLECTION METHODS

DRG collects tree inventory data using an internally developed computer-based system, Rover, loaded onto pen-based field computers equipped with geographic information system (GIS) and global positioning system (GPS) receivers.

Data analyzed in this management plan was accessed on the Warrenville TreeKeeper® 8 website on April 29, 2020. https://warrenvilleil.treekeepersoftware.com/

At each site, the following data fields were collected:

- condition
- defect observations*
- inventory date
- location**
- overhead utilities
- primary maintenance
- species
- tree size***

* recorded as relevant comments

** multiple data fields including address number, street name, side, and GPS coordinates.

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

Maintenance needs are based on *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture 2011). 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 used FZ-G1 Panasonic Toughpad® units equipped with internal GPS receivers. Geographic information system (GIS) map layers are loaded onto these units to help locate sites during the inventory. The table below lists these base map layers, along with each layer's source and format information.

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Warrenville, IL GIS Department	2019	NAD 1983 StatePlane Illinois East; Feet
Nearmap Inc 1 foot Resolution	April 2019	NAD 1983 StatePlane Illinois East; Feet

STREET ROW SITE LOCATION

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

Address Number and Street Name

Where there was no GIS parcel addressing data available for sites located by a vacant lot, or by an occupied lot without a posted address number on a building, the arborist used their best judgment to assign an address number based on opposite or adjacent addresses.

Sites in medians or islands were assigned an address number by Rover using parcel and streets geographical data. Each segment was numbered with an assigned address that was interpolated from addresses facing that median/island. If there were multiple median/islands between cross streets, each segment was assigned its own address. The *street name* assigned to a site was determined by street ROW parcel information and posted street name signage.

Side values for street ROW sites.

Side Value and Site Number

Each site was assigned a *side value*. Side values include *front*, *left*, *right*, or *back* based on the site's location in relation to the lot's street frontage. The *front* is the side facing the address street. *Left* and *right* are corresponding side of the lot that is between the front and back. *Median* indicates a median or island surrounded by pavement. The *back* is the side of the lot opposite of the address street.

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 'Yes.'

Location Example

Corner Lot A

Address/Street Name:	205 Hoover St.
Side:	Right / 1
On Street:	Taft St.
Address/Street Name:	205 Hoover St.
Side/Site Number:	Right / 2
On Street:	Taft St.
Address/Street Name:	205 Hoover St.
Side/Site Number:	Right / 3
On Street:	Taft St.
Address/Street Name:	205 Hoover St.
Side/Site Number:	Front / 1
On Street:	Hoover St.

Corner Lot B

Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Right / 1
On Street:	Davis St.
Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Front / 1
On Street:	E Mac Arthur St.
Address/Street Name:	226 E Mac Arthur St.
Side/Site Number:	Front / 2
On Street:	E Mac Arthur St.

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.

Photograph 1. *Pinned spotted lanternfly.*

Photograph courtesy of PA Dept of Agriculture

Photograph 2. *Pinned spotted lanternfly nymph with wingspan open.*

Photograph courtesy of USDA APHIS

ASIAN LONGHORNED BEETLE

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

Photograph 3. 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)*.

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.

Photograph 4. 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, poplar *(Populus)*; oak *(Quercus)*; and willow *(Salix)*.

SUDDEN OAK DEATH

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

Photograph 5. **Drooping tanoak shoot.**

Photograph courtesy of Indiana Department of Natural Resources (2012)

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

This pathogen is devastating to oak *(Quercus)* but also affects several other plant species.

EMERALD ASH BORER

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

Photograph 6. **Close-up of the emerald ash**

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 ash *(Fraxinus)*.

THOUSAND CANKERS DISEASE

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

Photograph 7. *Walnut twig beetle, side view.*

Photograph courtesy of USDA Forest Service (2011)

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

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.

Photograph 8. *Hemlock woolly adelgids on a branch.*

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

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APPENDIX C
SUGGESTED TREE SPECIES

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

DECIDUOUS TREES

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer rubrum	red maple	Red Sunset®
Acer nigrum	black maple	
Acer saccharum	sugar maple	'Legacy'
*Aesculus flava**	yellow buckeye	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
*Castanea mollissima**	Chinese chestnut	
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	(male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Juglans regia**	English walnut	'Hansen'
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	Cherokee™
Liriodendron tulipifera	tuliptree	'Fastigiatum'
Maclura pomifera	osage-orange	'White Shield','Witchita'
*Magnolia acuminata**	cucumbertree magnolia	(numerous exist)
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	black tupelo	
Platanus × acerifolia	London planetree	'Yarwood'
*Platanus occidentalis**	American sycamore	
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	

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

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

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus × carnea	red horsechestnut	
Cladrastis kentukea	American yellowwood	'Rosea'
Eucommia ulmoides	hardy rubbertree	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	eastern hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense	amur corktree	'Macho'
Prunus maackii	amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
Sorbus alnifolia	Korean mountainash	'Redbird'

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer buergerianum	trident maple	Streetwise®
Acer campestre	hedge maple	Queen Elizabeth™
Acer cappadocicum	coliseum maple	'Aureum'
Acer ginnala	amur maple	Red Rhapsody™
Acer griseum	paperbark maple	
*Acer pensylvanicum**	striped maple	
Acer truncatum	Shantung maple	
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	(numerous exist)
Amelanchier laevis	Allegheny serviceberry	
Carpinus caroliniana	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
Chionanthus virginicus	white fringetree	
Cornus kousa	Kousa dogwood	(numerous exist)
*Cornus mas**	corneliancherry dogwood	'Spring Sun'
Corylus avellana	European filbert	'Contorta'
*Cotinus coggygria**	common smoketree	'Flame'
*Cotinus obovata**	American smoketree	
Crataegus phaenopyrum	Washington hawthorn	Princeton Sentry™
Crataegus viridis	green hawthorn	'Winter King'
*Franklinia alatamaha**	Franklinia	
Halesia tetraptera	Carolina silverbell	'Arnold Pink'
*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'
Styrax japonicus	Japanese snowbell	'Emerald Pagoda'
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

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

CONIFEROUS AND EVERGREEN TREES

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Abies balsamea	balsam fir	
Abies concolor	white fir	'Violacea'
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
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	
Psedotsuga menziesii	Douglasfir	
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	
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.