TREE INVENTORY ANALYSIS & MAINTENANCE STRATEGY PREPARED FOR

Village of Cass City, Michigan

July 2025

Prepared By:

Davey Resource Group, Inc.
Local Office
24301 Catherine Industrial Drive
Suite 124
Novi, Michigan 48375

DAVEY Resource Group

Table of Contents

Acknowledgments

Lives Built Here

This project supports Cass City's vision to promote and enhance community well-being through public tree conservation and improved forestry management practices. This Tree Inventory Analysis & Maintenance Strategy offers expert recommendations for preserving and expanding urban canopy so the environmental, economic, and social benefits it provides are maximized today and for future generations.

A grant was administered through the Michigan Department of Natural Resources Community Forestry Program with funding provided through the USDA Forest Service's Urban and Community Forestry Program. There was a 50/50 match provided by the Village of Cass City to cover the cost of the project.

Cass City is thankful for the grant funding it received from the Michigan Department of Natural Resources Community Forestry Program, in cooperation with USDA Forest Service's Urban and Community Forestry Program. This program is designed to encourage communities to create and support sustainable urban forestry programs throughout the United States.

Cass City recognizes the support of:

Debbie Powell, Village Manager

RJ Klaus, Director of DPW, Wastewater Treatment Plant

Melanie Radabaugh, Director of Economic Development, Parks and Recreation

Laken Chapin, CEDAM Fellow

Village of Cass City 2024-2025 Street Forestry Committee Members

Michigan Department of Natural Resources

Notice of Disclaimer: Inventory data provided by Davey Resource Group, Inc. (DRG) are based on visual recordings at the time of inspection (Level 2 assessments). 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 Cass City *Tree Inventory Analysis & Maintenance Strategy*, prepared by Davey Resource Group, Inc. (DRG), focuses on analyzing inventory data, quantifying the benefits provided by the community's inventoried trees, and identifying their maintenance needs.

DRG completed a street inventory for Cass City in May of 2025. The inventory data was then analyzed to understand the structure of the publicly managed urban forest and provide recommendations on both priority and routine tree maintenance and care programs. The data was also analyzed using i-Tree Eco to calculate the economic value of the publicly managed urban forest and its benefits to the community (i.e., stormwater, carbon, and air pollution).

The Village of Cass City's inventoried trees:

- **have an estimated replacement value of over $6.09 million.**
- **provide $26,380 annually in stormwater, air quality, and carbon benefits each year.**

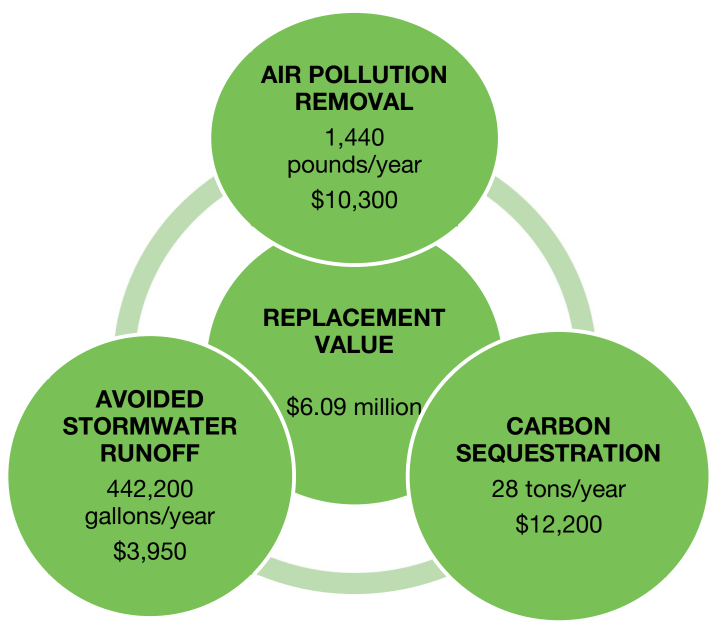
Supporting and funding proactive maintenance of Cass City's public trees is a sound long-term investment that will maximize tree benefits, reduce tree care costs over time, and increase the value of the urban forest. While other municipal infrastructure loses value over time (depreciates), the value of public trees increases (appreciates).

Calculating Tree Benefits

The benefits of Cass City's inventoried trees presented in this Plan are calculated using **i-Tree Eco**. i-Tree is the industry recognized suite of tools used to measure and quantify the ecosystem benefits that trees provide.

i-Tree is a partnership between the USDA Forest Service, The Davey Tree Expert Company, the Arbor Day Foundation, the International Society of Arboriculture, Society of Municipal Arborists, Casey Trees, and SUNY College of Environmental Science and Forestry. It was released in 2006, and its models are updated regularly based on the latest science and research.

Although high- and moderate-priority removal and pruning activities account for the bulk of first-year maintenance work and costs, they are essential investments. As Cass City accomplishes first-year maintenance, budgets will decrease and become more stable. We recommend this proactive approach to immediately increase tree benefits and prevent minor defects from becoming elevated-risk tree conditions.



Inventory Analysis Summary

Inventoried Sites

Trees = **1,755**
Planting Sites = **254**
Stumps = **58**
Total Sites = **2,067**

Stocking Level

Within the street right-of-way (ROW), "Stocking level" refers to the ratio of sites occupied by trees to the total amount of sites suitable for trees. **Cass City's current stocking level is 85%.** See calculation on page 44.

Annual Benefits

Avoided Stormwater Runoff = **$3,950**
Air Pollution Removal = **$10,300**
Carbon Sequestration = **$12,200**

Top 5 Inventoried Species

Species	% of Inventoried Population
Norway maple (*Acer platanoides*)	**27%***
Silver maple (*Acer saccharinum*)	**18%***
Sugar maple (*Acer saccharum*)	**14%***
Red maple (*Acer rubrum*)	**8.0%**
Colorado blue spruce (*Picea pungens*)	**3.7%**

* Exceeds industry guidelines of no more than 10% of one species in a tree population.

Top 5 Inventoried Genera

Genus	% of Inventoried Population
Maple (Acer)	71%*
Spruce (Picea)	7.5%
Pine (Pinus)	3.1%
Linden (Tilia)	1.9%
Elm (Ulmus)	1.8%

* Exceeds industry guidelines of no more than 20% of one genus in a tree population.

Relative Age Distribution

Arborists approximate age of trees using diameter at breast height (DBH). We measure DBH (in Inches) at a height of 4.5', or below scaffold branches. Of the 1755 inventoried trees:

- **15% were young (0-8")**, compared to the 40% industry guideline.
- **36% were established (9-17")**, compared to the 30% industry guideline.
- **22% were maturing (18-24")**, compared to the 20% industry guideline.
- **26% were mature (>24")**, compared to the 10% industry guideline.

Defect Observations

Of the 1755 inventoried trees:

- 24% had dead or dying parts.
- 10% had missing or decayed wood.
- 10% had weakly attached branches.
- 5% had tree architecture issues.
- 4% had broken and/or hanging branches.
- 3% had an issue with the trunk.
- <1% had cracks.
- <1% had root problems.

Pest Susceptibility

Cass City's inventoried trees are susceptible to one or more pests of concern in Michigan, including:

- **Spotted lanternfly**
- **Asian longhorned beetle**
- **Eastern tent caterpillar**

Condition

Of the 1,755 inventoried trees, there were:

- **21% in Good condition**
- **67% in Fair condition**
- **12% in Poor condition**
- **<1% Dead**

Infrastructure Conflicts/Overhead Utilities

Of the 1755 inventoried trees, there were:

- **411 trees situated below utilities**
- **175 trees NOT currently conflicting with utilities**
- **236 trees currently conflicting with utilities**

Recommended Maintenance

Tree Removal

Trees designated for removal have defects that are not cost-effective or practical to correct with pruning. Trees in this category often have more than 33% of dead crown.

Total = 126 trees
Extreme Risk = 0 trees
High Risk = 0 trees
Moderate Risk = 94 trees
Low Risk = 32 trees
Stumps = 58

Priority Pruning

Priority pruning removes defects such as dead, dying, diseased, broken and/or hanging branches. Pruning the defective part(s) can lower risk associated with the tree while promoting healthy growth.

Total = 282 trees
Extreme Risk = 0 trees
High Risk = 0 trees
Moderate Risk =203 trees
Low Risk = 79 trees

Routine Pruning Cycle

Regularly pruning low-risk trees can reduce reactive maintenance needs, instances of elevated risk, and provide the basis for a robust risk management program.

Total number of Low-risk trees = 1302 trees
Number of trees per routine pruning cycle = 260 (annually over 5 years)

New Tree Planting

Planting trees in areas with poor or sparse canopy coverage is important to distribute tree benefits evenly throughout the city.

Planting goal: 2:1 replacement to removal ratio

Young Tree Training (YTT) Cycle

Younger trees may have branch structure that can lead to potential problems as the tree ages, requiring training to ensure healthy growth. Arborists make training prunes from the ground with a pole pruner or pruning shear.

Total potential training prunes = 272
Actual number of YTTs prescribed = 104*
Number of trees per YTT cycle =
91 (Annually over 3 years)
*35 (Annually over 3 years)

*Excludes evergreen species and DBHs >6”

Routine Inspection & Inventory Updates

Routine inspections and inventory updates are essential to find potential problems with trees. DRG employs Tree Risk Assessment Qualified (TRAQ) Arborists trained in the art and science of planting, caring for, and maintaining individual trees.

Total tree count = 1629 trees (excluding removals)
Number of inspections per inventory update = 326 (Annually over 5 years)

Introduction

Cass City is home to nearly 2,500 residents benefiting from public trees in their community. Cass City Public Works manages all trees, stumps, and planting sites along the street right-of-way (ROW) and throughout public parks, and other public spaces.

Between May and June of 2025, DRG performed an inventory of Cass City's public trees and developed this Tree Inventory Analysis & Maintenance Strategy. 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 Cass City's public trees.

The sections of this plan are as follows:

- Section 1: Structure and Composition summarizes the inventory data with trends representing the current state of public trees.
- Section 2: Functions and Benefits summarizes the estimated value of benefits provided to the community by public trees' various functions.
- Section 3: Recommended Maintenance details a prioritized maintenance schedule and provides an estimated budget for recommended maintenance activities over a five-year period.

We have designed this *Tree Inventory Analysis & Maintenance Strategy* to help the community understand the current state of its public trees, set future goals and benchmarks, anticipate future program needs, and focus on initiative-taking maintenance.

The Urban Forest Program Continuum (shown on Page 2) outlines the steps to effectively and sustainably manage and care for Cass City's urban forest. The continuum includes other plans that can support Cass City's urban forest, including:

- Urban Forest Management Plan which establishes a detailed 3- to 5-year work plan to address risk and maintenance needs using current tree inventory data to streamline Cass City's urban forest management program.
- An Urban Forest Master Plan engages stakeholder and community members to provide a comprehensive vision for the future of the city's urban forest, with recommendations and a road map of action steps to reach Cass City's urban forestry goals.


URBAN FOREST PROGRAM CONTINUUM™
STAY ON TRACK FOR SUSTAINABLE GROWTH
Below are the steps that urban forest programs take to create and maintain the healthiest and most resilient urban forest possible. Each component creates a strong foundation of strategic planning, program funding, and community support which results in thriving urban forests.
TREE CITY USA
Tree Board
Funding
Ordinance
DEDICATED COMMITMENT
Certified Arborist Staff
Annual Level 1 Assessments
TREE INVENTORY
Inventory Updating
Goal Setting
FUNDED PROGRAM
Forest Management Plan
Proactive Maintenance
URBAN FOREST MASTER PLAN
20-year Vision
Urban Tree Canopy Analysis
Stakeholder Input

Section 1:

Structure and Composition

Section 1: Structure and Composition

In 2025, DRG's Arborists collected data on trees, stumps, and planting sites located on public spaces throughout Cass City. In all, we inventoried 2,067 sites along the street ROW and in parks (Figure 1). Trees currently occupy 85% (1755) of those 2,067 sites. See Appendix B for inventory data collection methodology.

Species & Genus Diversity

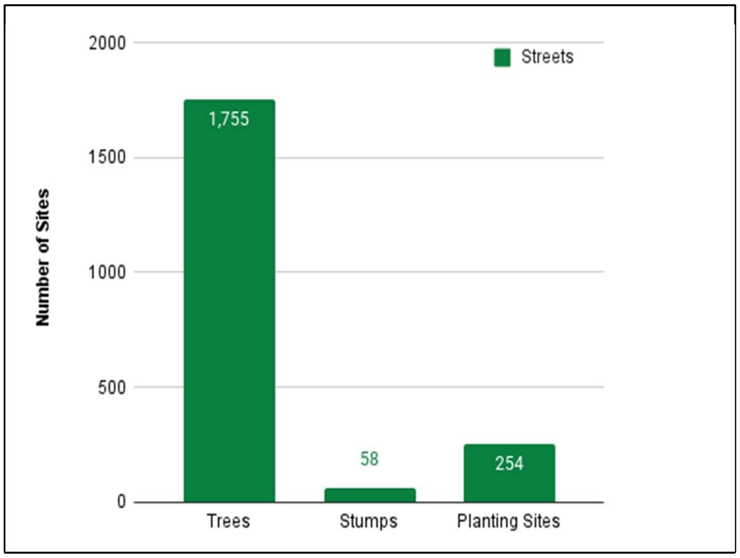


Figure 1 – Tree status of all sites collected during Cass City's inventory. This includes street and park trees in the public right of way (ROW).

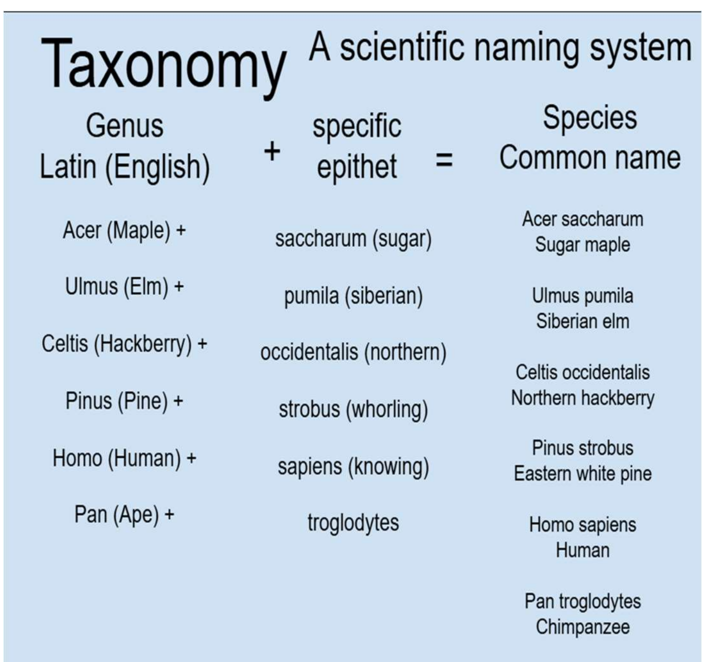
Taxonomy is a way of grouping organisms by shared characteristics. All organisms have a Latin name. Don't ever tell an Arborist that Latin is a "dead" language!

Taxonomic names have a format:
Genus (Capitalized)
specific epithet (not capitalized)

You may remember the classifications of organisms from school, but here is refresher.

All levels of taxonomy

Latin	English
Dominium	Domain
Regnum	Kingdom
Phylum	Phylum
Classis	Class
Ordo	Order
Familia	Family
Genus	Genus
Species	Species



Diversity within plant communities is important for increasing their resistance and resilience to disturbance (see side panel, "The Importance of Species Diversity"). The 10-20-30 rule is a common industry metric for tree species diversity in Urban Forestry. A single species should compose no more than 10% of the population, a single genus no more than 20%, and a single family no more than 30%. Some communities may be in the position to pursue more aggressive diversity goals, such as a 5-10-15 metric.

There are 65 species within this inventory. Figure 2 shows the species' diversity breakdown for Cass City's most common trees. Norway maple is the most common tree (27%), followed by Silver Maple (18%) and Sugar Maple (14%).

The City's inventoried trees represent 30 distinct genera. Figure 3 shows the genus diversity breakdown for Cass City's inventoried trees. Maple is the most common genus (71%), followed by spruce (7%), pine (2%), linden (2%), and elm (2%).

THE ROLE OF NON-NATIVE TREE SPECIES IN THE URBAN ENVIRONMENT

Certain non-native tree species that are especially tolerant of harsh urban conditions can be a practical choice to plant, especially when aiming to sustain high levels of species diversity. Non-native species of concern are those that are considered invasive, which should not be planted regardless of the site conditions.

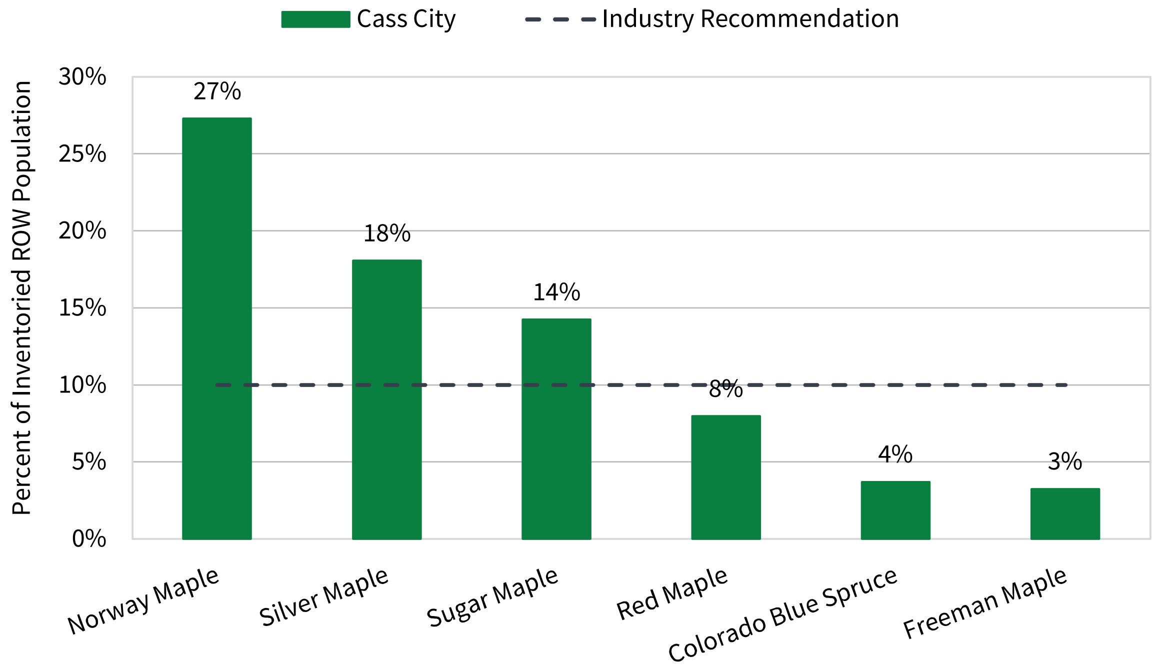


Figure 2. Species diversity of trees which make up at least 2% of the inventoried population.

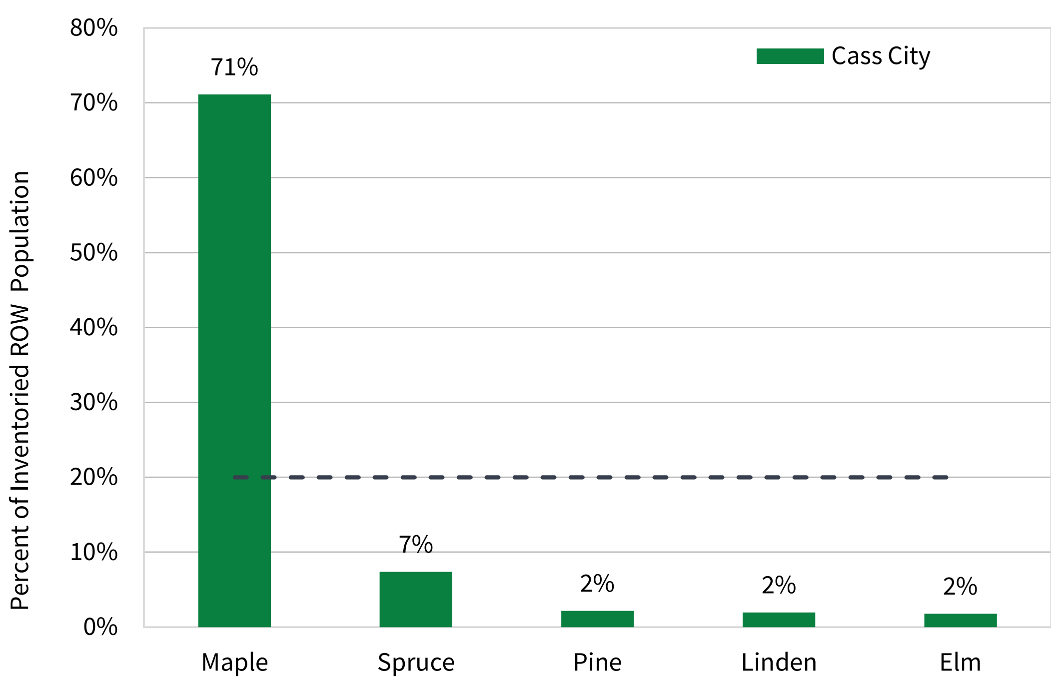


Figure 3. Genus diversity of trees which make up at least 2% of the inventoried population.

SPECIES & GENUS DIVERSITY RECOMMENDATIONS

- Avoid or limit planting of Norway, sugar, and silver maples and increase planting of other species until Norway, sugar, and silver maples make up less than 10% of public trees.
- Avoid or limit planting of the genus Acer (Maples) and increase planting of other genera until Acer makes up less than 20% of public trees.
- Remove volunteer trees that have invasive tendencies while they are small. These include species such as Norway maple and Callery/Bradford Pear.
- Increase planting of uncommon species and genera which are well suited to urban environments.

THE IMPORTANCE OF DIVERSITY

The Dutch elm disease epidemic of the 1930s provides a key historical lesson on the importance of diversity. The disease killed millions of American elm trees, leaving behind enormous gaps in the urban forest canopy of many 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 the US. This invasive beetle continues to devastate ash tree populations across the country.

Other invasive pests and diseases, severe weather events, and climate change threaten our urban forests today, so it is vital that we learn from history and plant a wider variety of tree species and genera to develop a resistant and resilient public tree resource.

Pest Susceptibility

An urban forest's vulnerability to pests and diseases depends on species and genus diversity since many pests favor certain hosts. Regular inspections can identify early infestations while they only affect a small tree population. This limits further spread and leads to more effective and cost-efficient management.

Figure 4 shows the percentage of inventoried trees which are susceptible to pests and diseases of concern in Michigan. Spotted lanternfly, Asian longhorned beetle, and eastern tent caterpillar present the greatest threat to Cass City's inventoried trees. These pests are less reliant on a single tree species than others and therefore present an outsized threat to Cass City's publicly managed urban forest.

It is important to remember that this figure only represents data collected during our inventory. Many more trees in Cass City, such as those on private property, are susceptible to these pests.

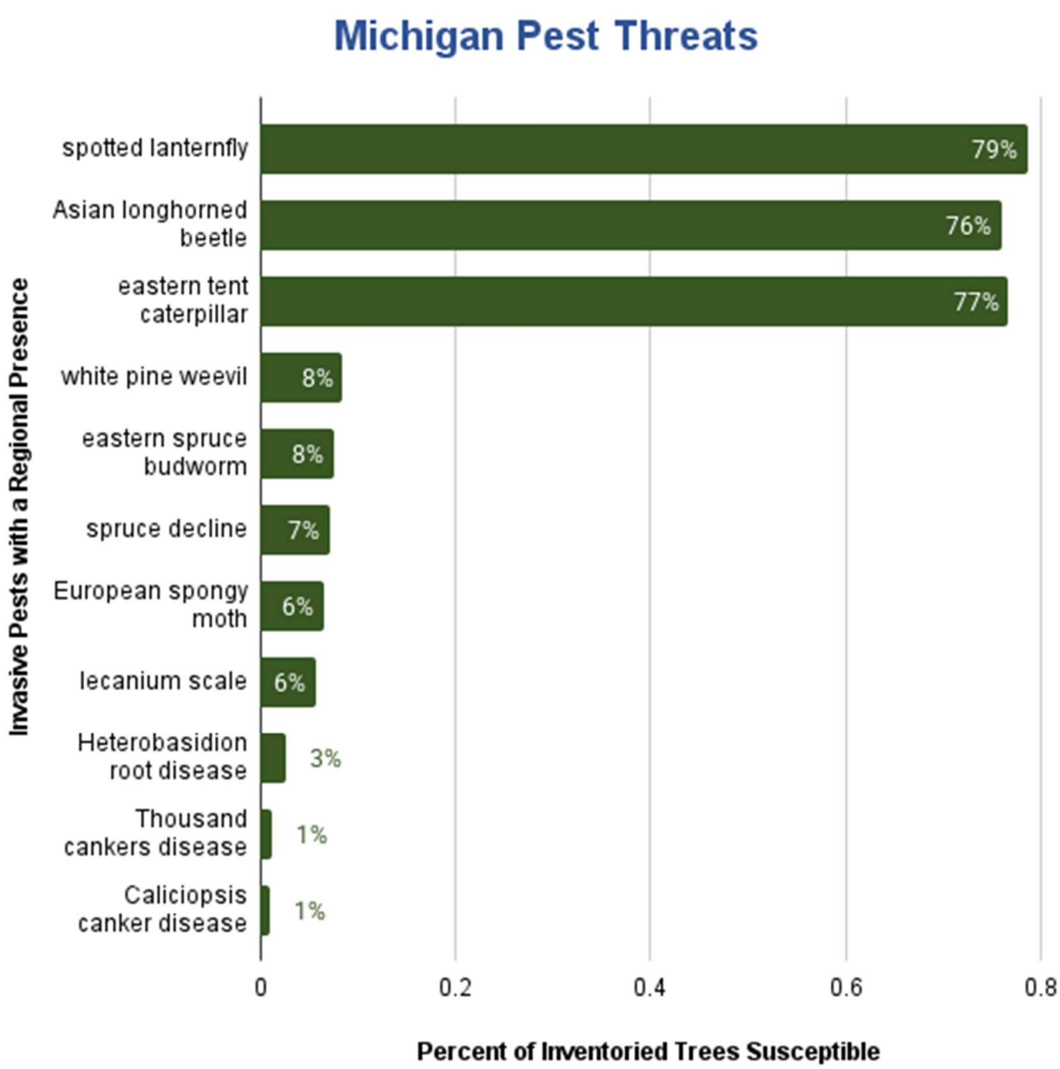


Figure 4. Susceptibility of the tree resource to pests and diseases of concern in Michigan.

PEST SUSCEPTIBILITY RECOMMENDATIONS

- Monitor trees for signs and symptoms of pests and diseases on a regular basis.
- If a contractor suspects the presence of pests or disease, act quickly to identify the pest and begin management. Consult the Michigan Department of Natural Resources (DNR) or Michigan State University's (MSU's) extension offices, if necessary.
- Prepare a Pest Management Plan to guide responses to future pest or disease infestations.
- When planting trees, select pest- or disease-resistant species or cultivars whenever possible. Plant to increase species diversity and reduce pest-related risks.
- Use preventative pesticide treatments on high-value or historic trees that are susceptible to problematic pests and/or diseases in Cass City.
- Spotted lanternflies may prefer the Tree of Heaven as a host, but they can impact many native species, such as maple, willow, apple, birch, and hickory. We did not find Tree of Heaven in public spaces, but their presence in private spaces can contribute to pest problems throughout the city. Control Tree of Heaven populations where practical.
- Burning diseased trees after removal is sometimes appropriate, depending on the tree and pest species. Consult local ordinances, Michigan's DNR, the U.S. Department of Agriculture and/or MSU's extension office for proper removal and disposal techniques.

CONDITION

During the inventory, we assigned each of the 1,755 trees a condition rating based on several factors. These factors include the structure and condition of roots, branches, trunks, foliage, and the presence of pests or disease. The categories of tree conditions are Good, Fair, Poor, and Dead.

Figure 5 provides the condition rating breakdown for trees inventoried in Cass City. Most trees were in Good or Fair condition (88%). 12% of the trees were in Poor or Dead condition.

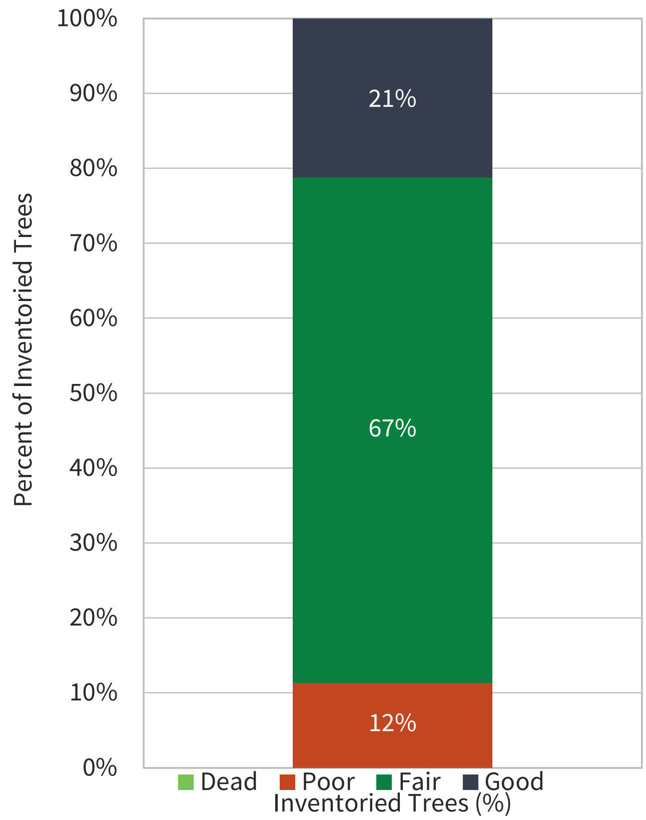


Figure 5. Condition of inventoried trees.

CONDITION RECOMMENDATIONS

- Remove dead and dying trees as soon as possible. Prioritize High-risk trees first to reduce hazards, create space for new planting, and improve the appearance of Cass City's streets and parks.
- Prioritize poor condition trees with Moderate risk ratings. If they are not recommended for removal, pruning can eliminate defects and reduce the risk of future failures.
  - Routinely monitor these trees for further decline that would necessitate removal.
- Condition ratings can improve over time with preventative maintenance cycles.
- Routinely prune established and mature trees in fair or better conditions and structurally prune/train young trees (YTT) to reduce future maintenance needs.
- We recommend using the ANSI A300 (Clause 5: Pruning) standards for pruning practices and planning.

RELATIVE AGE DISTRIBUTION

Trees grow thicker each year, so we can estimate a tree population's relative age distribution by assigning age classes to the diameter of trees (see sidebar). While actual tree age cannot be determined by diameter alone, this industry method provides an estimate of the approximate age distribution of the inventoried tree population. Since trees at different stages of their life cycles need different types and frequencies of maintenance, age distribution can help inform management needs and decisions.

Age/Size Classes

Young: 0-8 inches diameter at standard height (DBH), as measured 4.5' above the ground
Established: 9-17 inches DBH
Maturing: 18-24 inches DBH
Mature: 25+ inches DBH

The size classes are based on the industry-recognized **ideal relative age distribution**, which holds that **the largest proportion of the inventoried tree population (40%) should be young trees, smaller proportions should be established and maturing trees (30% and 20%, respectively), and the smallest proportion (10%) should be mature trees.**

Figure 6 compares the age distribution of the tree population to standard industry recommendation. Overall, Cass City's trees are older than the industry recommended age distribution, with a shortage of young trees (15%), high numbers of established trees (36%), and a moderate amount of maturing and mature trees (22% and 26%, respectively).

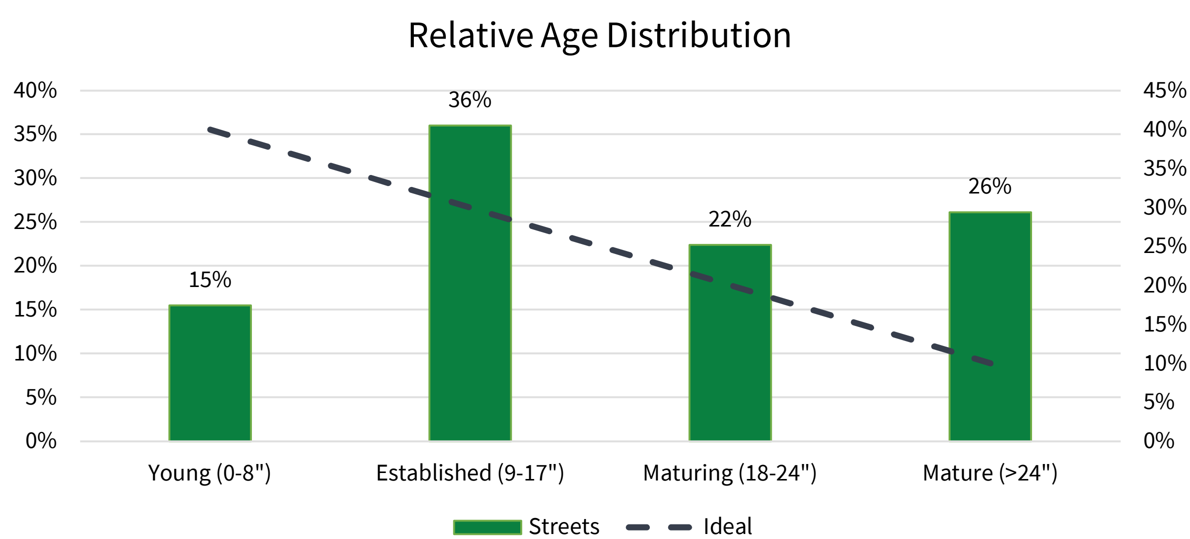
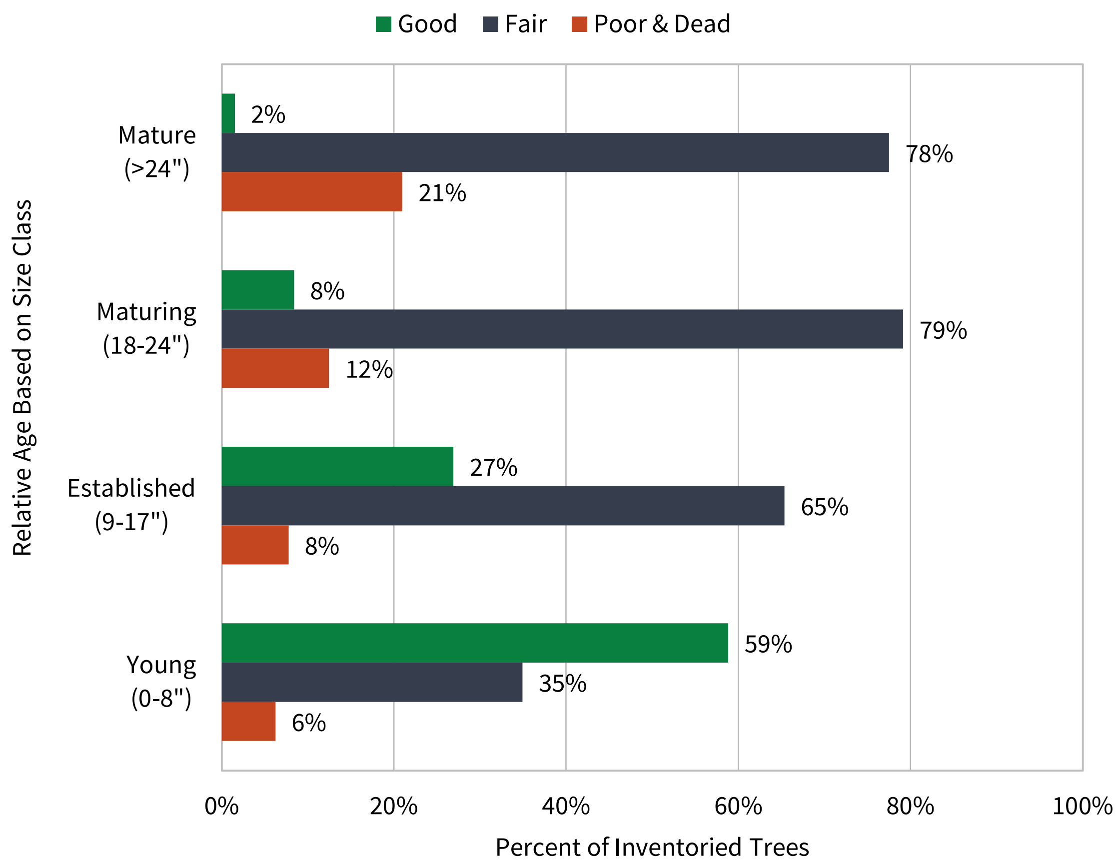


Figure 6. Relative age distribution of Cass City's inventoried trees.

Figure 7 compares tree condition ratings across the relative age classes for inventoried trees. Most trees are in Fair condition across all age classes, except for young trees. Young trees are more likely to be in good condition, while maturing and mature classed trees are more likely to be in Poor condition.



Relative Age DISTRIBUTION Recommendations

- Cass City's trees are aging, with 48% of all trees in either the 'Maturing' or 'Mature' category. Focus on initiatives to preserve trees and mitigate risks associated with large-stature trees.
- Develop & implement a succession plan for the replacement of 'Mature' trees in declining health. Where space is available, plant new young trees before and/or after removing 'Mature' trees.
- Follow the initial 5-year maintenance strategy, shown in table 7.
- Institute a 3-year young tree training (YTT) cycle to structurally prune trees in the 'Young' age class to ensure good form and maintain healthy structure as they grow.
- While the sample budget found in the *Maintenance Strategy and Example Budget* section currently includes structural pruning on a five-year rotation to prioritize high-need and high-risk maintenance activities, shift to a three-year routine pruning cycle after the initial five-year work plan.

- 15% (272) of the 1,755 inventoried trees are 'Young' trees (DBH < 8"). Consider a tree-planting program to bring the proportion of young trees in Cass City closer to the recommended 40%.

DEFECTS & OBSERVATIONS

During the inventory, arborists took note of damage, decay, structural flaws, pests/diseases, or dead parts of inventoried trees and recorded these defect observations for each tree. Where a tree had more than one defect, only the most significant defect (i.e., the defect most likely to cause whole or partial tree failure within a year) was recorded.

Dead and dying parts were the most recorded defect (24%) followed by branch attachment (10%) and decay per cavity (10%; Table 1). 42% of trees had no significant defect at the time of the inventory.

Table 1. Defect observations for inventoried trees.

Defect	Street Trees	Percent of Street Trees
None	744	42%
Dead and Dying Parts	420	24%
Branch Attachment	184	10%
Decay or cavity	181	10%
Tree Architecture	84	5%
Broken and/or Hanging Branches	73	4%
Trunk Condition	50	3%
Other	10	1%
Cracks	6	0%
Root Problems	1	0%
Total	**1,753**	**100%**

DEFECT/OBSERVATION RECOMMENDATIONS

- Dead and dying parts were the most common defect observed in Cass City's trees. Regular pruning, as done in a routine pruning cycle, can improve the quality of these trees and reduce risk associated with dying tree parts. Removal of dead limbs also improves the visual aesthetics of trees and may help improve public perceptions of the level of tree care in the city.
- We recorded 15% of trees with branch attachment or tree architecture defects. Structural pruning within the first decade of the tree's life can reduce the occurrence of these types of defects. Implementing Young Tree Training (YTT) programs and tree support/staking measures can also minimize these issues.

Infrastructure And Growing Space

In developed settings, streets, sidewalks, buildings, and utilities (both above and below ground) limit space for trees to grow. To maximize tree growth, health, and benefits, it is important to consider the amount of space available for a tree to grow. Selecting "the right tree, for the right place" not only positively impacts tree health and vigor, but it can improve public safety, reduce utility outages, increase walkability, reduce sidewalk/hardscape damage, and ensure compliance with the American with Disabilities Act (ADA). During the Cass City tree inventory, we recorded conflicts with overhead utilities (Table 2).

At the time of the inventory, 10% of trees conflicted with overhead utilities, and a further 13% of trees had overhead utilities present but were not currently conflicting with them. The majority (77%) of all inventoried trees were not in proximity or conflict with overhead utilities. Table 2 includes all tree sites (2,067) because utilities may be present above stumps (total count: 58) and potential planting sites (total count: 254). 36 stumps and 20 vacant sites had OH-utilities present.

Table 2. Infrastructure conflicts recorded during the inventory.

CONFLICT	STREET TREES	PERCENT OF STREET TREES
Overhead Utilities		
Present and Conflicting	175	10%
Present and Not Conflicting	236	13%
Not Present	1,656	77%
Total	**2,067**	**100%**

Infrastructure Recommendations

- Cass City should reduce tree conflicts with overhead electric lines by planting only small stature trees beneath or near overhead electric utilities. Plant dwarf cultivars of large-growing species to diversify options for planting under utilities.
- Maintain distance from water, sewer, gas, and electric lines underground. Installation and maintenance of underground utilities often damage tree roots. This may destabilize a tree and cause failure, reduced tree vigor, or even death.
- Plant trees at least five feet from any underground utility to allow room for large, structural roots to develop without impacting underground utilities. Call MissDig at 811 or 1-800-482-7171 to locate underground utilities. Consult municipal engineers and/or utility companies to establish appropriate planting specifications.
- Consider conflicts with other infrastructure such as buildings, signage, streetlights, and driveways. Cass City should develop and document planting guidelines which dictate required clearances for planting around public infrastructure.

Growing Space Recommendations

- Right tree, right place. Select tree species based on root system and canopy characteristics that match the planting site. Develop standards for tree planting using available growing space dimensions and/or soil volume. Plant small trees in grow spaces with limited dimensions and soil volumes.
- Develop construction and design standards for sidewalks, roads, and other hardscapes to accommodate tree root growth and reduce future conflicts.
- Collaborate with city planners, engineers, Arborists and other field staff. Consider trees early in the planning process when repairing or redesigning streets and sidewalks to ensure trees can be productive parts of the new streetscape.
- Options to increase growing space sizes: enlarge planting wells, site tree-wells on the back edge of the sidewalk adjacent to lawns, install new tree wells or lawns, create traffic bumps outs, incorporate Silva Cell or structural soil technology into design, etc.
- If possible, reroute sidewalks or build temporary ramps of pavement or wood over tree roots rather than removing healthy, mature trees in favor of sidewalks repairs.
- City streetscapes must balance needs for driving, parking, pedestrian access, overhead and underground utilities, street furniture, signage, lighting, and snow removal, among others. Some areas will not be suitable for trees, so consider ground cover (flowers, herbs, bushes) instead of trees.

DRG RECOMMENDED MINIMUM SPACING FOR TREE PLANTING

Overhead Utility Clearances:

Small trees (>30 feet tall at maturity) can be within 20 feet.

Medium trees (30-45 feet tall at maturity) should be planted 20 feet or further.

Large trees (>45 feet tall at maturity) should be planted 40 feet or further.

Contact local utility companies for specific local distance requirements.

Other Infrastructure Clearances:

40 feet between large trees

30 feet from intersections (approaching traffic)

30 feet between medium trees

20 feet from fire hydrants

20 feet between small trees

15 feet from utility poles, streetlights, buildings

10 feet from driveways, intersections (retreating traffic), crosswalks, important street signage

5 feet from underground utilities

Growing Space Dimensions:

Small trees - 4 feet x 4 feet

Medium trees - 6 feet x 6 feet

Large trees - 8 feet x 8 feet

Canopy Cover & Stocking Level

"Stocking" is a traditional forestry term for the density and distribution of trees. In an urban forest, the stocking level is the ratio of street ROW spaces occupied by trees to the total street ROW spaces suitable for trees, including occupied (tree/stump) and vacant sites.

In Cass City's tree inventory, trees occupy 85% (1,753) of the 2,067 total current and potential tree sites (1755 trees + 254 planting sites + 58 stumps). Therefore, the City's current stocking level is 85%.

Stocking level is a valuable way to quantify urban forest coverage of streets over time especially when canopy cover data is not available. "Canopy cover" refers to the percentage of an area covered by tree canopy when viewed from above. We can determine canopy cover measurements in several different ways; the i-Tree Canopy tool is able to provide a basic assessment of the City's total canopy cover, both public and private, as well as estimate the benefits provided by the entire urban canopy. Conducting an Urban Tree Canopy (UTC) assessment, which uses high-resolution aerial imagery, provides detailed analysis of a City's tree canopy and can incorporate socio-economic analyses to inform the level of fair canopy distribution throughout the city.

Research shows that areas with low canopy cover frequently reflect a correlation with income and race; oftentimes, this stems from decades of redlining and other discriminatory policies. Communities with fewer trees miss the benefits that trees offer, so they tend to experience increased air temperature, greater levels of stormwater runoff and flooding, and higher levels of air pollution. The concept of Tree Equity aims to rectify this issue by advocating for equal distribution of trees and their associated benefits across all areas within cities. Cass City and DRG did not conduct a Tree Equity analysis as a part of their tree inventory, but we can still take steps to analyze and improve the city's Tree Equity Score.

Canopy Cover & Stocking Level Recommendations

- Use stocking level and canopy cover scores to set, measure, and track progress toward canopy cover and tree planting goals.
- Set **S.M.A.R.T.** (specific, measurable, attainable, relevant, and time-bound**) initial goals** and set **further goals**, after accomplishing those initial tasks. This incremental method of progress can help build capacity and public support for tree planting and care over time.
- Cass City should consider planting additional trees in areas with low stocking level/canopy cover. Developed/built-up areas of the community may require creativity and collaboration from multiple communities and departments. Include local initiatives to promote planting trees on private property or parks when site conditions limit street tree planting.
- Conducting an Urban Tree Canopy (UTC) assessment may be helpful in setting and eventually achieving Cass City's tree canopy and equity goals. Cass City should consider a UTC assessment as the next step in their urban forest management program.

Section 2:

Functions and Benefits

Section 2: Functions and Benefits

Trees play a vital role in the environment by providing a wide array of economic, environmental, and social benefits which far exceed 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, among other benefits.

ENVIRONMENTAL BENEFITS

Trees decrease energy consumption and moderate local climates by providing shade, cooling through their transpiration processes, and acting as windbreaks.

Trees act as mini reservoirs, helping to slow and reduce the amount of stormwater runoff and pollutants that reaches storm drains, rivers, and lakes by 20-60% (Johnson et al. 2017).

Trees reduce greenhouse gasses that can trap and retain heat in the atmosphere and cause the city to get warmer.

Trees can reduce street-level air pollution by up to 60% (Coder 1996).

Trees stabilize soil and provide a habitat for wildlife.

IMPROVED PUBLIC HEALTH

Trees have been shown to prevent 1,200 heat-related deaths each year in the US (McDonald et al. 2020).

By intercepting particulate matter, trees save over 850 lives and prevent 670,000 incidents of acute respiratory symptoms in the US each year (Nowak et al. 2014).

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).

INCREASED SAFETY & COMMUNITY

Tree-lined streets slow traffic and are safer for drivers, pedestrians, and cyclists (Swift etnal. 1997, Ewing & Dumbaugh 2009).

A 10% increase in neighborhood tree canopy cover has been associated with a 12-15% reduction in violent and property crimes (Gilstad-Hayden et al. 2015, O'Neil-Dunn 2012).

ECONOMIC BENEFITS

Properly placing three trees around a home can reduce energy costs for the average household by $100 to $250 per year, while shading air conditioning units can help them run up to 10% more efficiently (U.S. Department of Energy, n.d.).

Trees in a yard or neighborhood increase residential property values by an average of 10% (USDA Forest Service 2011), and commercial property rental rates are 7% higher when trees are on the property (Wolf 2007).

Shoppers spend more time and money in shopping districts with mature, healthy tree canopies, and are willing to spend 9-12% more at businesses with trees in front of them (Wolf 2005, Hughes 2013).

i-TREE RESULTS

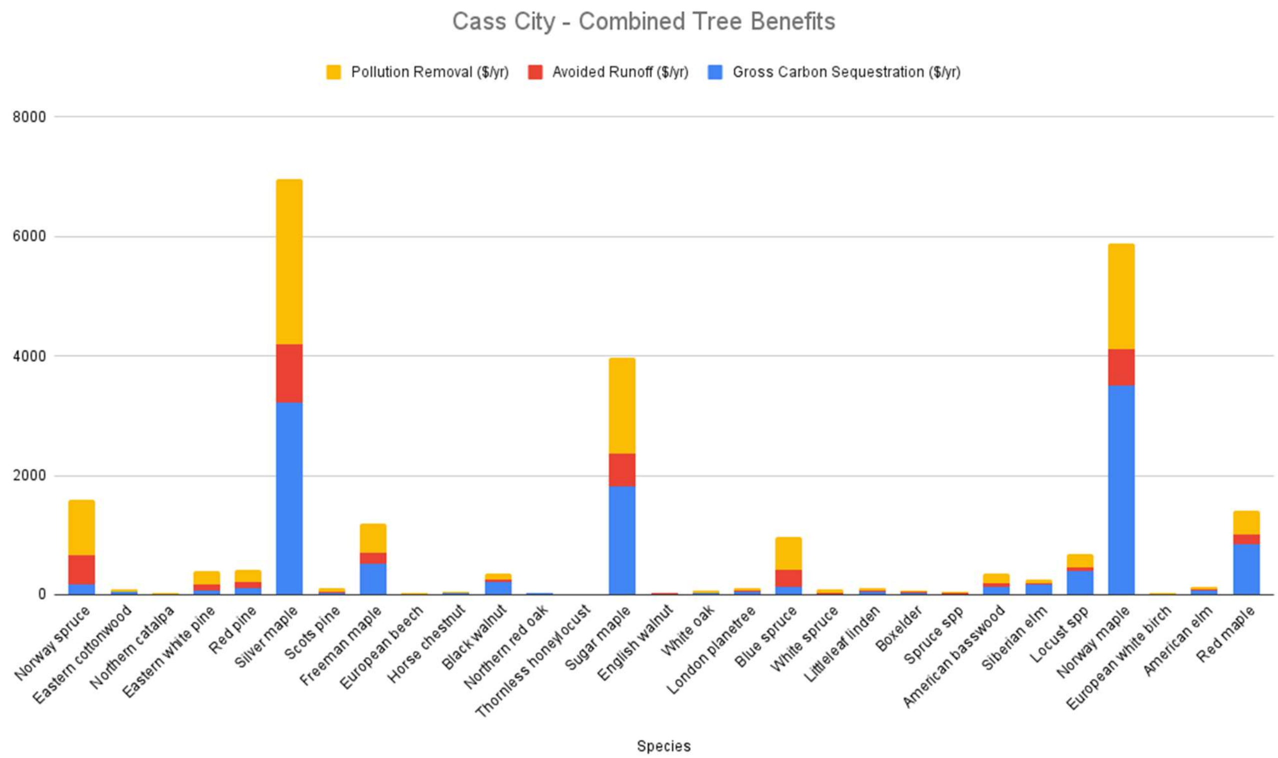
DRG used i-Tree Eco, a tool within the i-Tree suite, to model benefits provided by Cass City's inventoried public trees. i-Tree Eco combines tree inventory data with local air pollution and weather data to quantify the environmental benefits of a community's trees (Table 3). By framing trees and their benefits as dollars saved per year, i-Tree models can help communities understand trees as both a natural resource and an economic investment. Understanding the composition, functions, and economic value of trees is essential for making informed planning and management decisions. This knowledge not only helps to better understand how decisions can affect human health and environmental quality but also empowers communities to advocate for the funding required to effectively manage and care for their valuable public trees.

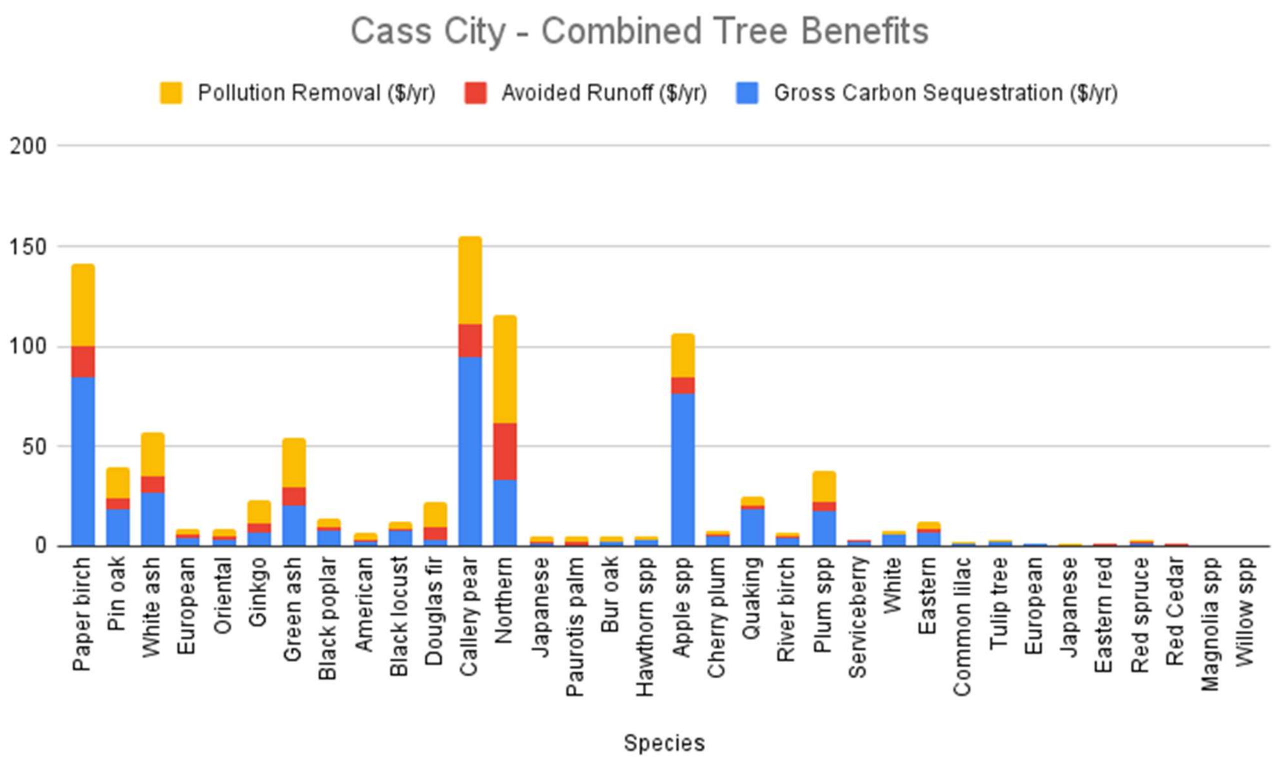
Table 3. Summary of benefits provided by Cass City's 10 most common inventoried trees.

Species	Count	Percent of Total	Carbon Storage (TON/YR)	Gross Carbon Storage (TON/YR)	Runoff Avoided (GAL)	Air pollution removed (LB/YR)
Norway maple	479	27%	369.23	8.09	69,379	0.12
Silver maple	317	18.1%	531.61	7.44	109,052	0.18
Sugar maple	250	14.3%	455.68	4.18	63,074	0.11
Red maple	140	8.0%	63.78	1.96	16,533	0.03
Blue spruce	65	3.7%	21.17	0.32	31,398	0.05
Freeman maple	53	3.0%	84.43	1.2	8,555	0.01
Norway spruce	57	3.3%	37.93	0.41	19,612	0.03
Honeylocust	52	3.0%	82.48	0.89	54,098	0.08
Callery pear	29	1.65%	6.54	0.22	1,755	0

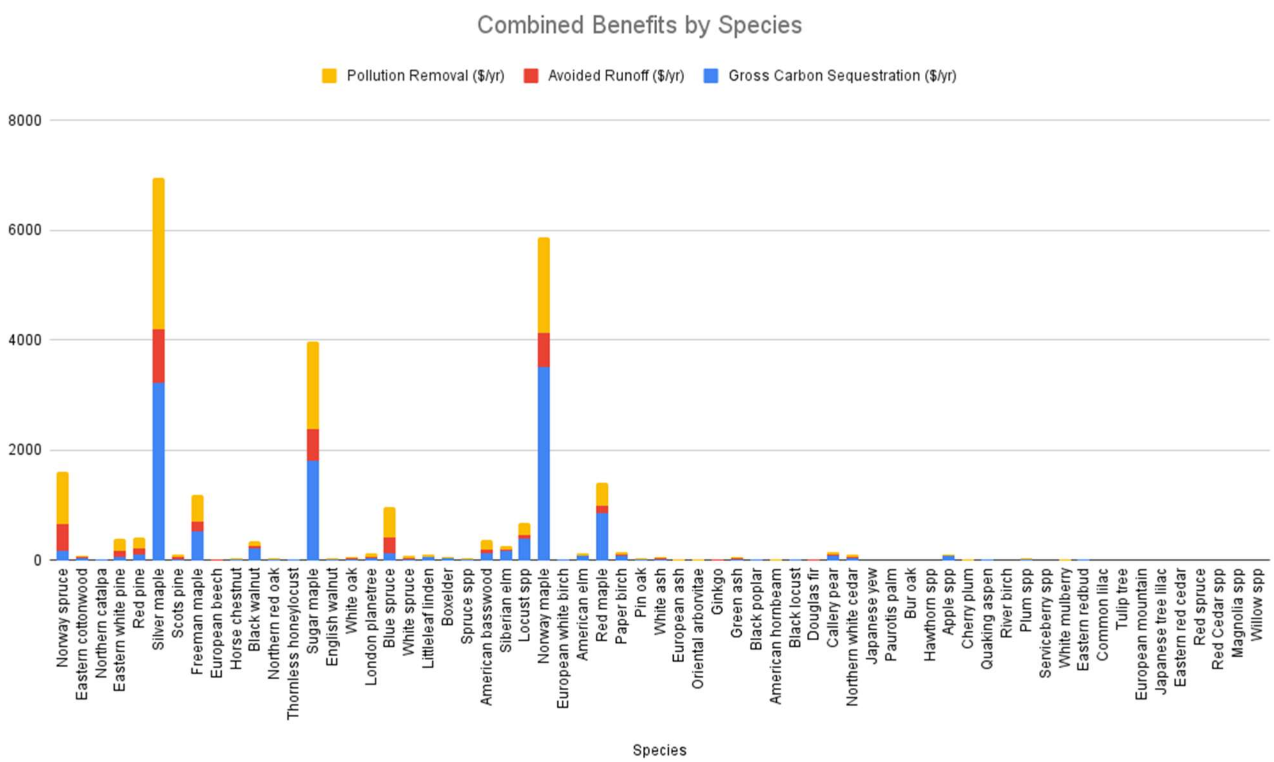
Species	Gross Carbon Sequestered ($/Yr)	Runoff Avoided ($/Yr)	Air Pollution Removed ($/Yr)	Sum Annual Benefits ($)	Replacement Value ($)
Norway maple	3500.28	619.97	1760.7	5,880.95	1514299.62
Silver maple	3220.74	974.49	2767.55	6,962.78	1285030.61
Sugar maple	1809.67	563.63	1600.7	3,974.00	1464186.83
Red maple	849.98	147.74	419.58	1,417.30	246020.13
Blue spruce	138.91	280.58	547.49	966.98	120230.66
Freeman maple	519.88	175.26	497.73	1,192.87	252418.99
Norway spruce	177.9	483.42	943.3	1,604.62	207800.39
Honeylocust	386.63	76.45	217.11	680.19	286434.58
Callery pear	94.97	15.68	44.54	155.19	27840

The following three figures show the trees in Cass City and their quantified tree benefits by type. From top to bottom, they show the 29 most common species, least common species, and all species.





Cass City - Combined Tree Benefits
Pollution Removal ($/yr)
Avoided Runoff ($/yr)
Gross Carbon Sequestration ($/yr)
200
150
100
50
0
Paper birch
Pin oak
White ash
European
Oriental
Ginkgo
Green ash
Black poplar
American
Black locust
Douglas fir
Callery pear
Northern
Japanese
Paurotis palm
Bur oak
Hawthorn spp
Apple spp
Cherry plum
Quaking
River birch
Plum spp
Serviceberry
White
Eastern
Common lilac
Tulip tree
European
Japanese
Eastern red
Red spruce
Red Cedar
Magnolia spp
Willow spp
Species



Combined Benefits by Species
Pollution Removal ($/yr)
Avoided Runoff ($/yr)
Gross Carbon Sequestration ($/yr)
8000
6000
4000
2000
0
Norway spruce
Eastern cottonwood
Northern catalpa
Eastern white pine
Red pine
Silver maple
Scots pine
Freeman maple
European beech
Horse chestnut
Black walnut
Northern red oak
Thornless honeylocust
Sugar maple
English walnut
White oak
London planetree
Blue spruce
White spruce
Littleleaf linden
Boxelder
Spruce spp
American basswood
Siberian elm
Locust spp
Norway maple
European white birch
American elm
Red maple
Paper birch
Pin oak
White ash
European ash
Oriental arborvitae
Ginkgo
Green ash
Black poplar
American hornbeam
Black locust
Douglas fir
Callery pear
Northern white cedar
Japanese yew
Paurotis palm
Bur oak
Hawthorn spp
Apple spp
Cherry plum
Quaking aspen
River birch
Plum spp
Serviceberry spp
White mulberry
Eastern redbud
Common lilac
Tulip tree
European mountain
Japanese tree lilac
Eastern red cedar
Red spruce
Red Cedar spp
Magnolia spp
Willow spp
Species

Annual Benefits

The i-Tree Eco model estimates the annual value of three environmental benefits: carbon sequestration, air pollutant removal, and stormwater runoff reduction. The model also calculates the lifetime carbon storage of inventoried trees as well as their replacement value. According to the i-Tree Eco model, the inventoried trees in Cass City provide over $26,000 of air quality, stormwater management, and carbon sequestration benefits each year (Illustration 1).

The benefits provided by trees vary by species. Table 4 summarizes the key tree species that provide the greatest contribution to Cass City's annual benefits based on the results of the i-Tree Eco analysis. Cass City's Norway spruce, eastern cottonwood, northern catalpa, several pine and maple species are major contributors to the annual quantifiable benefits provided by Cass City's public trees.

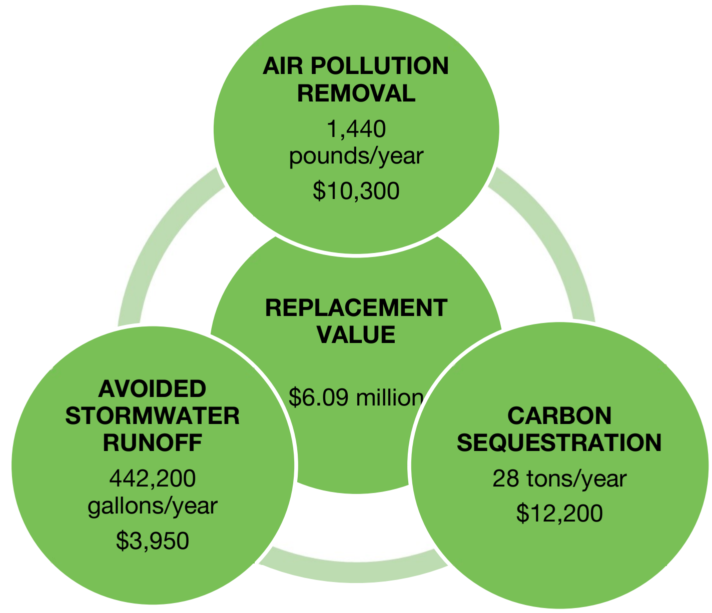


Illustration SEQ Illustration * ARABIC 1. Breakdown of annual benefits provided by inventoried trees in Cass City.

Table 4. The top 10 inventoried species which provide the greatest annual benefit per tree.

Species	Count	Annual Benefits Per Tree	Sum Annual Benefits
Norway spruce	53	$30.28	$1,604.62
Eastern cottonwood	3	$27.46	$82.37
Northern catalpa	1	$27.26	$27.26
Eastern white pine	16	$24.75	$396.06
Red pine	17	$24.52	$416.78
Silver maple	317	$21.96	$6,962.78
Scots pine	5	$21.40	$107.02
Freeman maple	57	$20.93	$1,192.87
European beech	1	$20.62	$20.62
Horse chestnut	2	$20.38	$40.76
Total	**472**	**$239.56**	**$10,851.14**

Improving Air Quality

Trees and other vegetation improve air quality by intercepting and filtering particulate matter from the air, including dust, ash, pollen, and smoke. Their leaves absorb harmful gaseous pollutants like ozone, nitrogen dioxide, and sulfur dioxide. Large plants reduce ozone formation by shading surfaces and reducing air temperatures. Since airborne pollutants can have serious effects on human health, this benefit is extremely important, especially in heavily developed areas. Removal of air pollution accounts for 39% of Cass City's total annual public tree benefits alone.

The inventoried trees in Cass City remove 1,440 pounds of airborne pollutants each year; a service valued at $10,300 (Illustration 1).

Sequestering and Storing Carbon

Trees are *carbon sinks*, which means they absorb (sequester) carbon from the atmosphere. As opposed to *carbon sources,* which release carbon into the atmosphere. Fossil fuel consuming vehicles and smokestacks emit carbon, then trees consume carbon during photosynthesis and store it in their tissue as they grow. Cass City's public trees sequester an estimated 28 tons of carbon each year, valued at $12,200, and have stored 1,830 tons of carbon over their lifetime, a service valued at $ $792,000 (Illustration 1).

Controlling Stormwater

Trees play a significant role in local hydrology and water cycling, helping to reduce the amount of stormwater runoff generated during rain events (Image 1). Since stormwater runoff can cause infrastructure damage and flooding, reducing the amount of precipitation that becomes surface runoff can save a community costs in infrastructure repair from flood damage. The inventoried trees in Cass City divert 442,200 gallons of stormwater each year. Flood mitigation services from public trees have a value of $3,950 annually (Illustration 1).

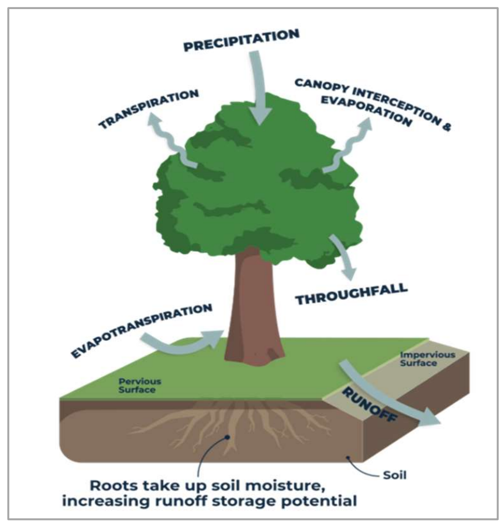


Image 1. Hydrological functions of trees. Source: 'Stormwater to Street Trees: Engineering Urban Forests for Stormwater Management', EPA publication 841 B 13 001.

Replacement Value

Replacement value is the estimated cost to replace an existing tree with a tree of a comparable size and species. Doing this is typically not feasible. Imagine replacing a 20-inch diameter tree with another one of equivalent size. It would be too heavy. Instead, we would plant a young tree, and it would take years to grow to size. So, in this sense, the term "replacement" is misleading, but the values of species-related benefits during trees' lives can approximate the overall value of inventoried public trees.

In total, Cass City's inventoried trees have a replacement value of $6,090,000. Table 5 shows replacement values per tree species with the highest overall replacement values. Northern Catalpa is the most valuable public tree in Cass City, followed by Northern Red Oak and Sugar Maple.

Table 5. Top 10 inventoried species with the highest replacement value.

Species	Count	Replacement Value Per Tree
Northern catalpa	1	$8,255.72
Northern red oak	2	$6,134.23
Sugar maple	250	$5,856.75
Thornless honeylocust	1	$5,794.08
Locust spp	53	$5,404.43
Littleleaf linden	8	$4,776.99
London planetree	8	$4,655.40
Freeman maple	57	$4,428.40
Horse chestnut	2	$4,325.85
White oak	4	$4,274.92
Total	**386**	**$53,906.77**

TREE BENEFIT RECOMMENDATIONS

- Large-stature, deciduous trees, such as oaks, tend to provide the greatest benefits. Cass City should plant these types of trees wherever possible to increase the benefits provided by their public trees. This may require enlarging existing planting spaces or creating large new planting spaces. Efforts should include preserving existing large-stature trees and proactively trimming young public trees to ensure they achieve mature status in the future.
- The protection of existing trees should be a priority, and succession-planning to replace trees and increase tree cover in parks and the right-of-way will have a significant positive impact on tree benefits in Cass City in the future. This also means planting young, large-species trees to grow and replace others that are nearing the ends of their lives.
- The benefits of public trees in Cass City included in this report account for only a fraction of the total benefits provided by the City's trees, because most trees are located on private property. Cass City should consider methods to preserve existing trees and promote new tree planting on private property throughout the city to increase tree benefits citywide.

Section 3:

Recommended Maintenance

Section 3: Recommended Maintenance

A risk rating and a maintenance activity were assigned to each inventoried tree. DRG recommends prioritizing and completing recommended maintenance activities based on a tree's assigned risk rating. This five-year tree maintenance schedule takes a multi-faceted and proactive approach to managing Cass City's public trees.

Risk Management and Recommended Maintenance

Every tree, regardless of condition, has an inherent risk of whole or partial tree failure. As part of the inventory, we conducted modified Level 2 Rapid Risk Assessments of each inventoried tree. We assign risk ratings based on the current editions of *ANSI A300 (Clause 13)* and the companion publication, *ISA Best Management Practices: Tree Risk Assessment, Second Edition*. Trees can have multiple potential modes of failure, each with its own risk rating. A single potential mode of failure with the highest risk rating was recorded for each tree during the inventory. To all the trees we inspected, we applied an inspection period of one year. Appendix B provides additional details on the International Society of Arboriculture's (ISA) risk rating system.

DRG recommends prioritizing and completing tree maintenance activities based on the severity of risk ratings assigned to each tree during the inventory. Trees with Extreme or High-Risk ratings should be attended to first, followed by trees with a Moderate Risk rating. Trees with a Low-Risk rating should be maintained once higher risk trees have been pruned or removed. The following sections describe the recommended maintenance activities for each risk rating category.

Priority Maintenance

Priority Maintenance Needs

Address the Extreme and High-Risk trees identified in the inventory as soon as possible to mitigate risk, improve public safety, maximize tree benefits, and reduce long-term costs. In general, Extreme and High-Risk maintenance activities should be completed first for larger diameter trees that pose the greatest risk. Once these trees are addressed, we recommend completing maintenance for small diameter trees.

The inventory identified:

- No Extreme Risk trees.
- No High-Risk trees

In the following sections we outline priority and routine maintenance strategies to address Moderate and Low Risk trees identified in the inventory.

Priority Maintenance Recommendations

- Remove: Trees with Extreme or High-Risk ratings recommended for removal immediately and prioritized based on their risk rating and size class. Tree removal is recommended when pruning will not correct the tree's defects, will not eliminate the risks caused by defects, or when pruning would be cost-prohibitive.
- Prune: Trees with Extreme or High-Risk ratings recommended for pruning immediately and prioritized based on their risk rating and size class. Priority pruning and removals can be performed at the same time to increase efficiency of maintenance crews.

Further Inspection

The Further Inspection data field indicates whether a tree requires additional and/or future inspections to assess and/or monitor conditions that may cause it to become a risk to people and property. The inventory identified no trees recommended for an advanced Level 3 risk assessment, 107 trees recommended for annual inspection, and 2 trees for insect and disease monitoring. Both trees recommended for insect and disease monitoring were ash which showed signs and symptoms of emerald ash borer (EAB).

Further Inspection Recommendations

- Include Annual Inspections during routine and after priority maintenance programs.
- During the inventory, DRG did not identify any trees needing an Advanced Risk Assessment (ARA). These trees would require a Level 3 risk assessment and should be assessed by an International Society of Arboriculture (ISA) Tree Risk Assessment Qualified (TRAQ) certified arborist as soon as possible to determine whether they require removal, pruning, or other corrective action to reduce risk.
- Trees recommended for insect/disease monitoring should be inspected to confirm the presence of damaging insects or diseases and determine the best course of action.

Routine Maintenance

Moderate and Low Risk Priority Pruning & Removals

Since Cass City did not have Extreme- or High-Risk trees, we recommend prioritizing Moderate-Risk prunes and removals. Finally, use routine pruning cycles (Figure 8) to proactively maintain trees with Low-Risk ratings.

The inventory identified:

- 223 Moderate-Risk trees recommended for pruning
- 94 Moderate-Risk trees recommended for removal
- 1,302 Low-Risk trees recommended for pruning
- 32 Low-Risk trees recommended for removal

Low-Risk removals pose little threat. These are generally small, dead, invasive, or poorly formed trees. Healthy trees growing in poor locations or undesirable species are also included in this category. Eliminating these trees will reduce breeding sites for insects and diseases and will increase local aesthetics.

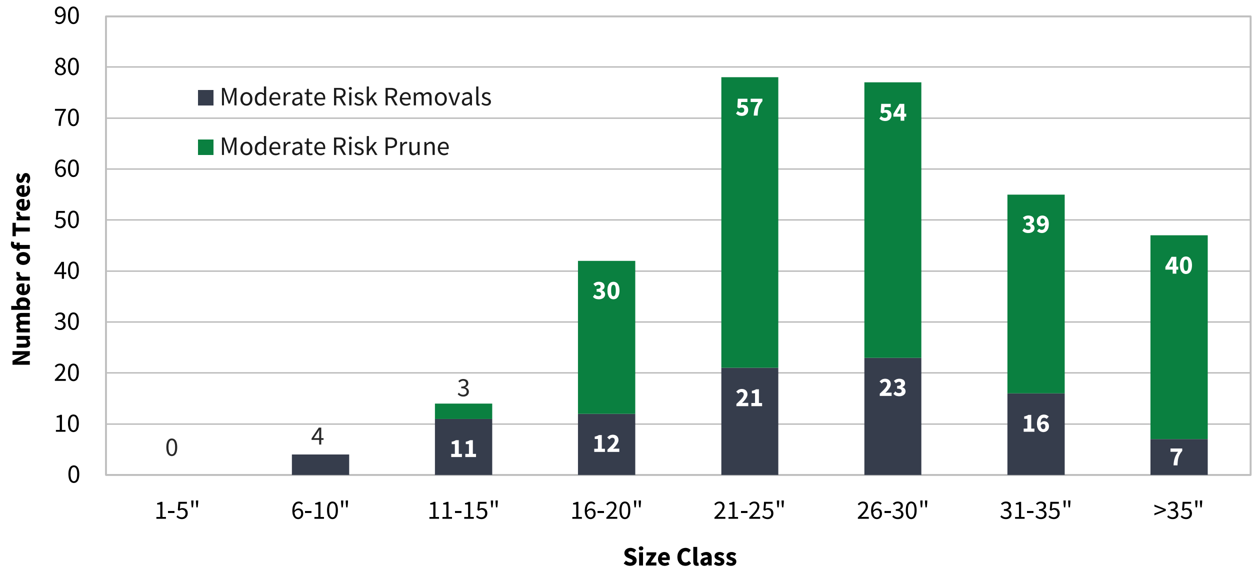


Figure 8 - Moderate-risk removal and pruning recommendations for Cass City's trees. Prioritize large size classes first, as failures can result in significant (costly) consequences.

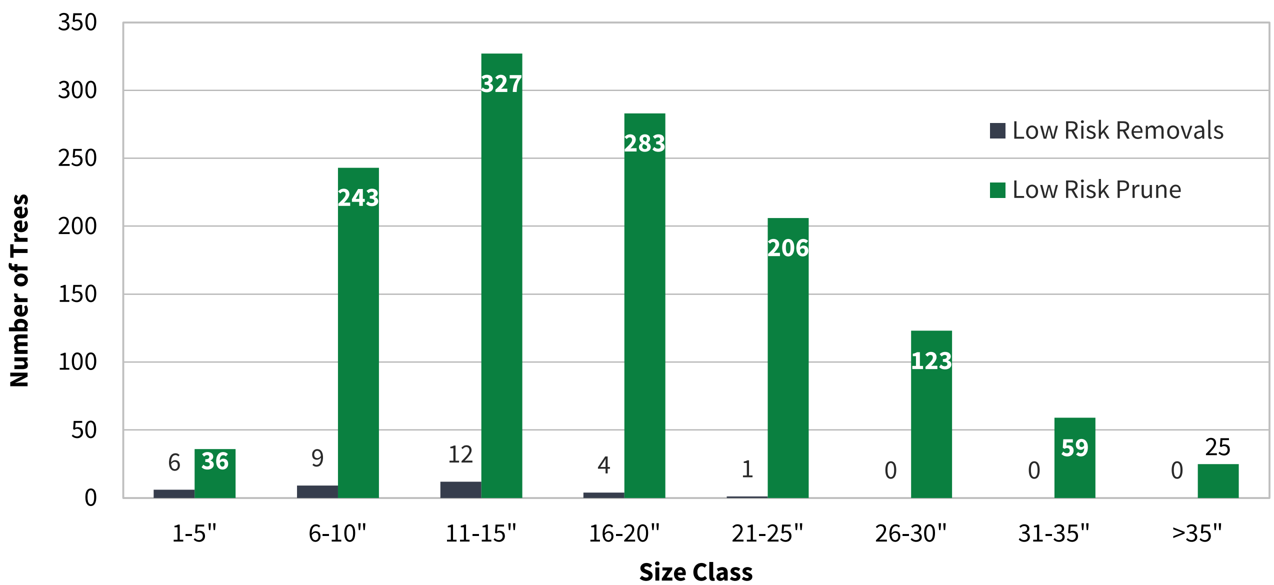


Figure 9 - Low-risk removal and pruning recommendations for Cass City's trees. These can be accomplished with routine pruning cycles for clearance and aesthetics.

MODERATE AND LOW RISK PRUNING & REMOVAL RECOMMENDATIONS

- For efficiency, address Moderate and Low Risk removals when removing nearby higher risk trees. Schedule removals/prunes by street or neighborhood.
- High-risk, moderate-risk, low-risk removals/prunes, and stump grinding can be scheduled concurrently if tree crews prefer it and are equipped for a variety of maintenance types. Use generalized tree contractors that can handle a large workload.
- Schedule Low-Risk prunes and removals after Moderate-Risk maintenance has been completed.
    - See next section, Routine Pruning Cycle, for more information on Low-Risk maintenance.

ROUTINE PRUNING CYCLE (RPC)

The routine pruning cycle (RPC) includes all Low-Risk trees with a primary maintenance need for 'prune.' These trees pose some risk but have a smaller defect size and/or a lower probability of impacting a target and, therefore, do not require priority maintenance. Over time, routine pruning can minimize reactive maintenance, limit instances of elevated risk, and provide the basis for a robust risk management program.

DRG recommends a five-year RPC (see side panel, "Proactive Pruning") to maintain the condition of the inventoried trees. However, this is not always possible based on budgetary constraints, the size of the inventoried tree population, or both. In these cases, extending the length of the RPC is an option; however, the best practice is to not exceed a 10-year pruning cycle. Tree conditions have been shown to deteriorate significantly after 10 years without regular pruning as once-minor defects worsen, reducing tree health and potentially increasing risk.

A total of 1,302 trees were rated Low Risk with a maintenance recommendation of "prune" and should become the basis of an RPC (Figure 9).

Municipalities should prune 1/5 of their public trees each year during a five-year RPC. A routine pruning cycle in Cass City would include 260 trees annually.

PROACTIVE PRUNING

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.

Routine Pruning Cycle (RPC) Recommendations

- Trees which are currently recommended for priority pruning (Extreme, High, and Moderate Risk trees with a maintenance recommendation of "prune") should be added to the RPC once their immediate defects and elevated risk are mitigated.
- Young trees which grow out of the young tree training cycle (see next section) should also be included in the RPC.
- The number of trees to be assessed and routinely pruned each year will vary depending on the number of trees which are planted and the number of trees which are removed in future years.
- Not every tree in the RPC needs pruning each cycle—thus, the actual cost to maintain an RPC will likely be lower than projected in the budget table at the end of this section (Table 7).

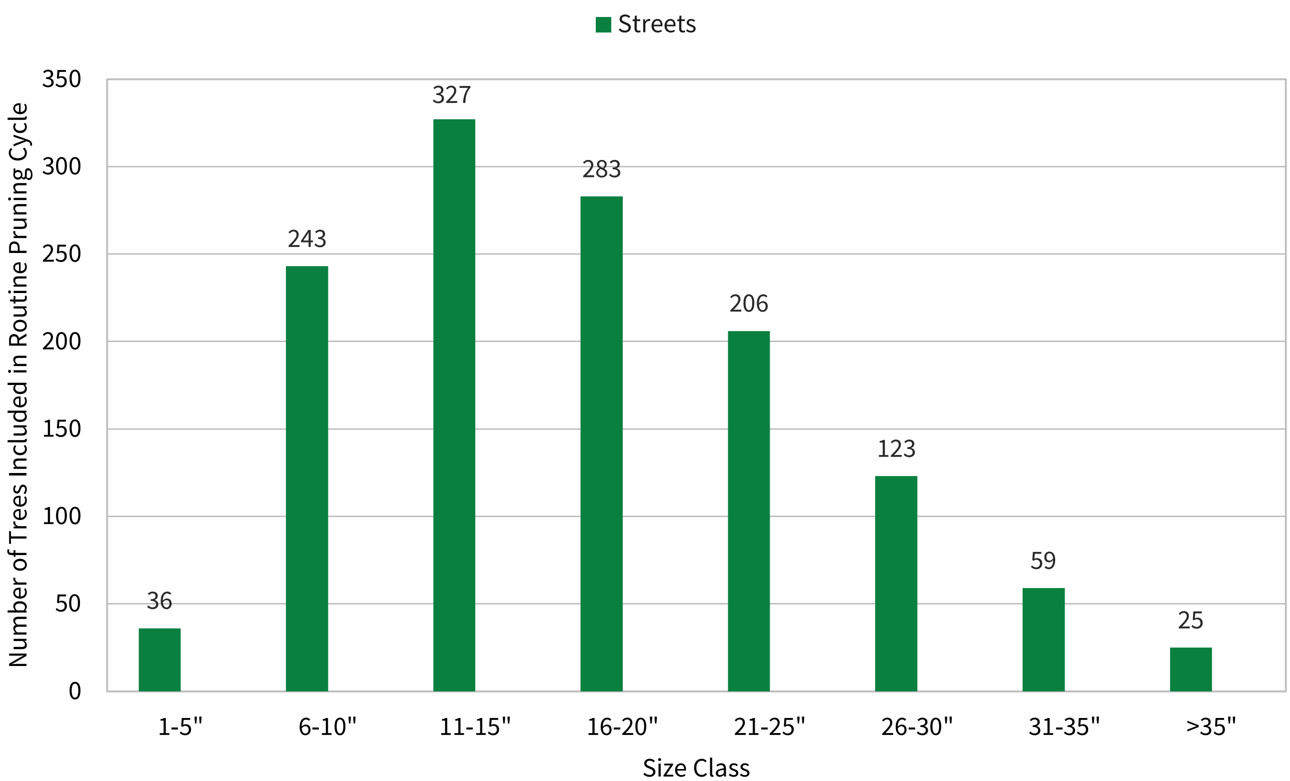


Figure 10. Trees included in the routine pruning cycle as of the completion of the inventory.

YOUNG TREE TRAINING CYCLE

Young tree training (YTT) cycles are necessary to improve the form and structure of trees that are less than 8" in diameter, both existing young trees and newly planted trees. Young tree pruning addresses structural problems such as codominant leaders, multiple limbs attaching at the same point on the trunk and crossing or interfering limbs that if not corrected can lead to problems as the tree ages.

A three-year cycle is recommended due to the rapid rate that young trees grow and the importance of correcting structural issues while the tree is young to reduce future risks and costly pruning when the tree is larger. **This analysis identified 272 small, young trees to potentially include in a YTT cycle.**

Cass City should institute a three-year YTT cycle beginning after the completion of all recommended higher priority work**.** With 272 potential young trees to train at the time of the inventory, **91 young trees would be pruned annually during the three-year cycle.** In future years, the number of trees in the YTT cycle will depend on the growth rates of young trees in the city and the number of new plantings.

YTTs reported in this *Inventory Analysis and Maintenance Strategy* are following standard definitions for 'Young' trees, including all trees less than 8" in diameter. During the inventory, DRG prescribed 104 Young Tree Trains because field staff did not prescribe trains to Evergreen trees or trees greater than 6" in diameter.

YOUNG TREE TRAINING (YTT) CYCLE RECOMMENDATIONS

- YTT is a proactive program, implemented after addressing all elevated-risk trees.
- Start the dedicated three-year YTT cycle on <u>year six</u>, following the initial five-year work plan, as shown in the example budget in the *Maintenance Strategy and Example Budget* section.
- Begin YTT programs <u>one to two years after planting and continue every three years</u> until the tree can no longer be safely pruned from the ground with a pole pruner and pruning shears. At the time of planting, <u>prune new trees minimally</u> to remove broken or crossing branches.
- Not every tree in the YTT cycle needs to be pruned each cycle – thus, the actual cost to keep a young tree pruning cycle will likely be lower than projected in the budget (Table 7).

Routine Inspections and Inventory Updates

Inspections are essential in finding potential problems with trees. We recommend using arborists trained in the art and science of planting, caring for, and maintaining individual trees. Ideally, inventory arborists are ISA Certified and hold the ISA Tree Risk Assessment Qualification (TRAQ). To streamline workflows and reduce costs, perform Level 1 and 2 assessments during regular tree maintenance activities, such as routine pruning. 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.

To keep costs regular, 1/5 of public trees inventoried should be re-inspected each year. Currently, 1,629 public trees in Cass City are not recommended for removal. So, during a five-year inventory-update program, 326 trees would be inspected annually to update their associated records.

Routine Inspections and Inventory Update Recommendations

- Public trees should be regularly inspected and attended to as needed. Inspections are essential after major storms because they may damage trees and increase the risks trees pose to the public.
- Level 1 walk-by or drive-by tree assessments are a cost-effective inspection method after storms. Level 1 assessments can also identify trees which may need more detailed inspections. When trees require additional or new work, they should be added to the maintenance schedule. Update the budget to reflect additional work. Utilize asset management software such as TreeKeeper® to make updates, edits, and keep a log of work records.
- Routinely schedule inventory updates every 5-10 years. Large-scale tree inventories consist of Level 2 assessments. These are 360-degree walk-around inspections to visually assess a tree's condition up-close to the roots, trunk, branches and canopy. We performed Level 2s during Cass City's inventory.

Tree Planting and Stump Removal

Routinely planting trees is an important part of maintaining and growing Cass City's tree canopy and maximizing the tree benefits provided to the community. We report and map vacant sites in public space because they are opportunities to plant new young trees. We also recommend planting after removing trees and stumps. During the inventory of Cass City's public space, DRG Arborists identified:

- **254 potential planting sites**
- **58 stumps**

Most of these sites were located along the streets. **We did not collect *planting sites* in parks**, so there are likely more opportunities to plant in Cass City's parks.

When selecting a species for planting, we must consider species growth characteristics, environmental preferences, and tolerance to urban conditions to match the location and space available. Planting the "right tree in the right place" will ensure the tree thrives, increasing its benefits, improving tree survival and condition, reducing future tree care costs, and minimizing conflicts with other infrastructure. Along the streets,

- 15 (6%) of the vacant sites were suitable for a small tree,
- 42 (17%) were suitable for a medium tree, and
- 197 (78%) were suitable for a large tree.

Tree Planting and Stump Removal Recommendations

- Include Stump removal should in tree removal contracts. Conduct Quality Assurance and Quality Control (QAQC) checks of the contractor's work to ensure they remove stumps completely.
- Plan Stump Removal well in advance of tree-planting initiatives, in some cases, years in advance. If possible, avoid planting in a location where a stump was recently removed. Decomposing roots can cause air pockets, nutrient depletion, and space constraints that can impact the establishment of newly planted trees.
- Cass City should strive to plant the largest possible tree in each vacant planting site. Large-stature, deciduous trees provide the greatest benefits to the community. See the strategies for providing sufficient growing space outlined in the Growing Space Recommendations section.
- To avoid loss of public trees, Cass City should aim for, at minimum, a 1-for-1 replacement rate of planted to removed trees. Ideally, the community will surpass this. Aim for a 2-for-1, or even a 3-for-1 replacement rate to increase urban canopy coverage and benefits. The budget in Table 7 includes a 2-for-1 replacement strategy to show the costs of maintaining such a planting program.
- Species selection during planting: consider tolerance to heat, drought, salt, and climate change, among other factors. Select appropriate trees based on space available to grow.

- Where space along the streets is limited and traditional methods are not possible, the community should consider alternative options for installing and increasing public tree canopy, including:
    - Creation of pocket parks.
    - Improvement and maintenance of existing parks and public grounds.
    - Setback planting programs: allow tree planting beyond, but within 20 feet of the ROW.
    - Encourage tree planting on private property via education, tree giveaways, etc.
- Where possible, Cass City should enlarge and improve tree planting areas along the streets by:
    - Enlarging the dimensions and soil volume of planting strips and planting wells.
    - Considering use of structural soils or Silva Cells to improve root movement through soils and reduce infrastructure conflicts.
    - Working with other city departments, such as engineering, to ensure that planning for new developments or street improvements considers trees during the design process.
- Continue to seek out and apply for grant funding to support tree planting projects.
- Continue to develop and foster partnerships with groups such as ReLeaf Michigan, who promote and support tree planting goals.

Maintenance Strategy And Example Budget

Using the Cass City tree inventory data, below we provide an example, a 5-year annual maintenance schedule and budget. Table 7 details the recommended tasks to complete each year. We base budget projections on Cass City's current tree-care contract rates, staff costs, industry knowledge, and public bid tabulations. Following this or a similar schedule can shift Cass City's tree-care program from a reactive to a more proactive model.

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

- No less than $134,440 for the first year of implementation.
- No less than $132,690 for the second year.
- No less than $131,040 for the third year.
- No less than $130,240 for the fourth year.
- No less than $123,390 for the fifth year.

These annual budget funds are needed to ensure that elevated risk trees are addressed as soon as possible, and that the vital young tree training and routine pruning cycles can be established. If routing efficiencies and/or contract specifications allow more tree work to be completed each 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.

Table7. Example maintenance schedule and budget for a five-year tree management program.

ACTIVITY COST			YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		FIVE-YEAR COST
Activity	Diameter	Cost/Tree	Count	Cost	Count	Cost	Count	Cost	Count	Cost	Count	Cost	
Moderate Priority Removals	1-5"	$150	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	6-10"	$350	1	$350	1	$350	0	$0	0	$0	2	$700	$1,400
	11-15"	$700	0	$0	0	$0	0	$0	4	$2,800	7	$4,900	$7,700
	16-20"	$900	0	$0	0	$0	4	$3,600	4	$3,600	4	$3,600	$10,800
	21-25"	$1,300	0	$0	5	$6,500	6	$7,800	5	$6,500	5	$6,500	$27,300
	26-30"	$1,400	0	$0	6	$8,400	6	$8,400	6	$8,400	5	$7,000	$32,200
	31-35"	$1,500	7	$10,500	6	$9,000	2	$3,000	1	$1,500	0	$0	$24,000
	>35"	$2,000	7	$14,000	0	$0	0	$0	0	$0	0	$0	$14,000
Activity Total(s)			15	$24,850	18	$24,250	18	$22,800	20	$22,800	23	$22,700	$117,400
Low Priority Removals	1-5"	$150	0	$0	0	$0	4	$600	0	$0	2	$300	$900
	6-10"	$350	0	$0	1	$350	2	$700	2	$700	4	$1,400	$3,150
	11-15"	$700	1	$700	2	$1,400	3	$2,100	4	$2,800	2	$1,400	$8,400
	16-20"	$900	2	$1,800	2	$1,800	0	$0	0	$0	0	$0	$3,600
	21-25"	$1,300	1	$1,300	0	$0	0	$0	0	$0	0	$0	$1,300
	26-30"	$1,400	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31-35"	$1,500	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	>35"	$2,000	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			4	$3,800	5	$3,550	9	$3,400	6	$3,500	8	$3,100	$17,350
Stump Removals	1-5"	$75	0	$0	1	$75	1	$75	1	$75	1	$75	$300
	6-10"	$75	2	$150	1	$75	2	$150	1	$75	2	$150	$600
	11-15"	$100	3	$300	3	$300	3	$300	3	$300	3	$300	$1,500
	16-20"	$100	4	$400	4	$400	3	$300	5	$500	4	$400	$2,000
	21-25"	$125	1	$125	1	$125	2	$250	1	$125	1	$125	$750
	26-30"	$125	0	$0	0	$0	1	$125	1	$125	1	$125	$375
	31-35"	$175	1	$175	1	$175	0	$0	0	$0	0	$0	$350
	>35"	$250	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			11	$1,150	11	$1,150	12	$1,200	12	$1,200	12	$1,175	$5,875
Moderate Priority Pruning	1-5"	$150	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	6-10"	$150	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	11-15"	$250	0	$0	0	$0	0	$0	0	$0	3	$750	$750
	16-20"	$250	0	$0	2	$500	0	$0	0	$0	28	$7,000	$7,500
	21-25"	$300	0	$0	10	$3,000	6	$1,800	25	$7,500	16	$4,800	$17,100
	26-30"	$300	20	$6,000	5	$1,500	14	$4,200	15	$4,500	0	$0	$16,200
	31-35"	$350	10	$3,500	5	$1,750	19	$6,650	5	$1,750	0	$0	$13,650
	>35"	$400	15	$6,000	20	$8,000	5	$2,000	0	$0	0	$0	$16,000
Activity Total(s)			45	$15,500	42	$14,750	44	$14,650	45	$13,750	47	$12,550	$71,200
Routine Inspection	Drive-by Assessment	$1	163	$163	163	$163	163	$163	163	$163	163	$163	$815
	Walk-by Assessment	$5	163	$815	163	$815	163	$815	163	$815	163	$815	$4,075
	Condition Monitoring	$5	22	$110	22	$110	22	$110	22	$110	21	$105	$545
Activity Total(s)			348	$815	348	$815	348	$815	348	$815	347	$815	$4,075
Young Tree Training (3-year Cycle)	1-5"	$150	56	$8,400	55	$8,250	55	$8,250	55	$8,250	55	$8,250	$41,400
	6-10"	$150	2	$300	2	$300	2	$300	2	$300	2	$300	$1,500
Activity Total(s)			58	$8,700	57	$8,550	57	$8,550	57	$8,550	57	$8,550	$42,900
Routine Pruning - Low Risk (5-year Cycle)	1-5"	$150	8	$1,200	8	$1,200	8	$1,200	8	$1,200	4	$600	$5,400
	6-10"	$150	49	$7,350	49	$7,350	49	$7,350	49	$7,350	47	$7,050	$36,450
	11-15"	$250	66	$16,500	66	$16,500	66	$16,500	66	$16,500	63	$15,750	$81,750
	16-20"	$250	57	$14,250	57	$14,250	57	$14,250	57	$14,250	55	$13,750	$70,750
	21-25"	$300	42	$12,600	42	$12,600	42	$12,600	42	$12,600	38	$11,400	$61,800
	26-30"	$300	25	$7,500	25	$7,500	25	$7,500	25	$7,500	23	$6,900	$36,900
	31-35"	$350	12	$4,200	12	$4,200	12	$4,200	12	$4,200	11	$3,850	$20,650
	>35"	$400	5	$2,000	5	$2,000	5	$2,000	5	$2,000	5	$2,000	$10,000
Activity Total(s)			264	$65,600	264	$65,600	264	$65,600	264	$65,600	246	$61,300	$323,700
Replacement Tree Planting and Maintenance	Purchasing	$100	51	$5,100	51	$5,100	51	$5,100	51	$5,100	48	$4,800	$25,200
	Planting & Watering	$150	51	$7,650	51	$7,650	51	$7,650	51	$7,650	48	$7,200	$37,800
	Mulching	$25	51	$1,275	51	$1,275	51	$1,275	51	$1,275	48	$1,200	$6,300
Activity Total(s)			153	$14,025	153	$14,025	153	$14,025	153	$14,025	144	$13,200	$69,300
Activity Grand Total			745		898		905		905		884		4,337
Cost Grand Total				$134,440		$132,690		$131,040		$130,240		$123,390	$651,800

Conclusion

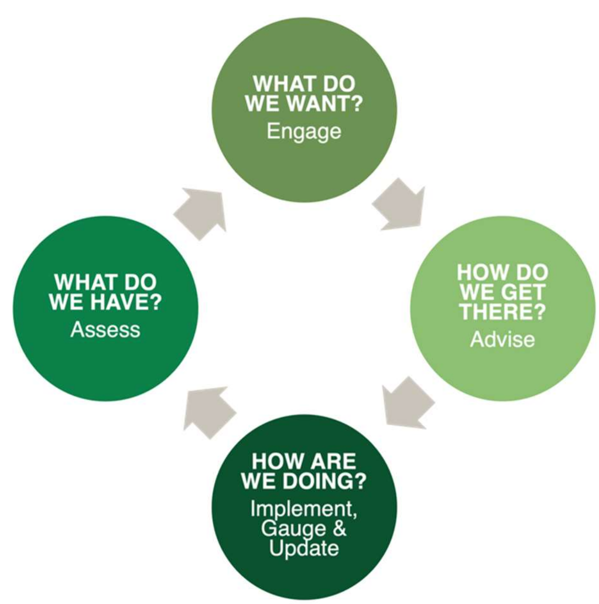
When properly cared for, public trees offer valuable, enduring benefits that surpass the time and resources invested into their planting, maintenance, and eventual removal. **The 1,755 inventoried public trees generate at least $26,450 annually in estimated benefits, including stormwater reduction, carbon sequestration, and air pollutant removal**. It is important to note that these are just the quantifiable benefits provided by trees in the community. The complete array of benefits from Cass City's public trees extends far beyond what can be calculated through inventory data and i-Tree modeling alone. The successful execution of this five-year maintenance program is expected to reduce risks to Cass City's people and property and amplify the benefits provided by the community's public trees.

Following this five-year maintenance initiative, with a focus on proactive tree care, necessitates a substantial upfront investment. While removing and pruning Extreme-, High- and Moderate-Risk trees can be costly, it is a vital step to enhancing public safety and reducing long-term tree maintenance expenses. After completing Moderate-Risk maintenance, the remaining tasks can be spaced out over a more extended period, as dictated by budget, staffing, or equipment availability. Use our *Tree Inventory Analysis & Maintenance Strategy* to advocate for increases in the budget to support growing the community and its urban forest.

Cass City is making commendable progress toward cultivating a sustainable and resilient urban forest. To stay on course, it is crucial to establish clear goals, take action to achieve those goals, regularly update inventory data to assess progress, and be prepared to revise objectives as needed in an iterative manner. The *Urban Forest Program Continuum*, as designed by DRG and illustrated on Page 2, can serve as a valuable roadmap for Cass City as it continues its ongoing mission to elevate the care of the community's public trees. This mission will enrich the lives of all residents, workers, and recreational enthusiasts within Cass City.

Evaluating and Updating This Plan

This *Inventory Analysis & Maintenance Strategy* provides management priorities for the next five years. To ensure the maintenance schedule and budget remain accurate, it is important to update the tree inventory using TreeKeeper® or other asset management software continuously as work is completed. Then the software can provide updated species distribution, maintenance needs, and benefit estimates. Keeping the inventory up to date empowers the community to assess its progress over time. This flow chart shows an adaptive management cycle to help set and evaluate goals.



Below are some examples of implementing the steps of this cycle:

- Schedule and assign high-priority tree work as soon as possible.
    - Address new, lower priority work requests as they are received.
- Prepare planting plans early, well before tree and stump removals in a designated area.
    - Select species best suited to the available sites.
- Annually compare the number of trees planted to the number of trees removed.
- Keep track of current planting site availability. Calculate the stocking level.
    - $Stocking\ Level\ (\%) = \frac{Public\ trees\ present}{Total\ public\ tree\ sites\ (inventory\ total)}$ x 100
    - $Public\ trees\ present = Total\ Inventory\ Count - Stumps - Vacant\ Sites$
    - $Public\ trees\ present = 2067\ - 58\ - 254\ = 1755$ Public Trees Present
    - $Current\ stocking\ level\ (\%) = \frac{1755}{2067}\ x\ 100 = 84.9\%$
    - Adjust future planting plans accordingly.
- Annually compare species diversity with the previous year after planting new trees.
    - Monitor changes in species and genera abundance.
    - Are they within the 10-20-30 percentage thresholds? (species-genera-family)
- 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

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

Ewing, R. and Dumbaugh, E. (2009). The built environment and traffic safety: a review of empirical evidence. Journal of Planning Literature, 23(4), 347-367.

Gilstad-Hayden, K., Wallace, L.R., Carroll-Scott, A, et al. (2015). Greater Tree Canopy Cover Is Associated with Lower Rates of Both Violent and Property Crime in New Haven, CT. Landscape and Urban Planning, 143, 248–253. https://doi.org/10.1016/j.landurbplan.2015.08.005.

Hughes, N. (2013). Trees Mean Business. Invest From the Ground Up, California Urban Forests Council. https://investfromthegroundup.org/trees-mean-business/

Johnson, Z. S., Koski, T., and O'Conner, A. (2017). The hidden value of landscapes. http://webdoc.agsci.colostate.edu/hortla/Colorado_Water_2017.pdf

McDonald, R.I., Kroeger, T., Zhang, P. et al. (2020). The Value of US Urban Tree Cover for Reducing Heat-Related Health Impacts and Electricity Consumption. Ecosystems, 23, 137–150. https://doi.org/10.1007/s10021-019-00395-5

McPherson, E.G., Simpson, J.R., Peper, P.J., Maco, S.E., & Xiao, Q. (2005). Municipal forest benefits and costs in five U.S. cities. Journal of Forestry. 103(8): 411-416.

Miller, R. W., & Sylvester, W.A. (1981). An Economic Evaluation of the Pruning cycle. Journal of Arboriculture, 7(4), 109–112.

Nowak, D.J., Hirabayashi, S., Bodine, A., and Greenfield, E. (2014). Tree and Forest Effects on Air Quality and Human Health in the United States. Environmental Pollution, 193, 119–129. https://doi.org/10.1016/j.envpol.2014.05.028.

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. https://pdfs.semanticscholar.org/26a2/4c5361ce6d6e618a9fa307c4a34a3169e309.pdf?_ga=2.266051527.959145428.1587418896-558533249.1587418896

Swift, P., Painter, D., and Goldstein, M. (1997). Residential street typology and injury accident frequency. Swift and Associates.

Troy, A., Grove, M., and O'Neil-Dunn, J. (2012). The relationship between tree canopy and crime rates across an urban–rural gradient in the greater Baltimore region. Landscape and Urban Planning, 106, 262–270.

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

Ulrich, R.S. (1986). Human Responses to Vegetation and Landscapes. Landscape and Urban Planning, 13, 29–44.

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

USDA Forest Service. (2011). Trees pay us back in the Inland Empire Region. https://www.fs.fed.us/psw/topics/urban_forestry/products/18/804uesd_uep_tpub_InlandEmpire.pdf

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

US Department of Energy. (n.d.) Low-Income Community Energy Solutions.

https://www.energy.gov/eere/slsc/low-income- community-energy-solutions

Wolf, K. L. (1998). 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. https://www.naturewithin.info/CityBiz/Biz3Ps-FS5.pdf

Wolf, K. L. (1999). Grow for the Gold: Trees in Business Districts. Washington State DNR: Community Forestry Program Number 14. https://www.naturewithin.info/CityBiz/TreeLink.PDF

Wolf, K.L. (2005). Business district streetscapes, trees, and consumer response. Journal of Forestry, 103(8), 396-400. https://nacto.org/docs/usdg/city_trees_retail_wolf.pdf

Wolf, K. L. (2007). City trees and property values. Arborist news, 16(4), 34-36.

Appendix A
Summary of Recommendations

SECTION	RECOMMENDATION
Species & Genus Diversity	● Avoid or limit planting of Norway, sugar, and silver maples and increase planting of other species until Norway, sugar, and silver maples make up less than 10% of public trees. ● Avoid or limit planting of the genus Acer (Maples) and increase planting of other genera until Acer makes up less than 20% of public trees. ● Remove volunteer trees that have invasive tendencies while they are small. These include species such as Norway maple and Callery/Bradford Pear. ● Increase planting of uncommon species and genera.
Pest Susceptibility	● Monitor trees for signs and symptoms of pests and diseases on a regular basis. ● If a contractor suspects the presence of pests or disease, act quickly to identify the pest and begin management. Consult the Michigan Department of Natural Resources or Michigan State University's extension offices, if necessary. ● Prepare a Pest Management Plan to guide responses to future pest issues. ● When planting, select pest- or disease-resistant species or cultivars whenever possible. Plant to increase species diversity and reduce pest-related risks. ● Use preventative pesticide treatments on high-value or historic trees that are susceptible to problematic pests and/or diseases in Cass City. ● Spotted lanternflies may prefer the Tree of Heaven as a host, but they can impact many native species, such as maple, willow, apple, birch, and hickory. We did not find Tree of Heaven in public spaces, but their presence in private spaces can contribute to pest problems throughout the city. Control Tree of Heaven populations where practical. ● Burning diseased trees after removal is sometimes appropriate, depending on the tree and pest species. Consult local ordinances, Michigan's DNR, the U.S. Department of Agriculture and/or MSU's extension office for proper removal and disposal techniques.
Condition	● Remove dead and dying trees as soon as possible. Prioritize High-risk trees first to reduce hazards, create space for new planting, and improve the appearance of Cass City's streets and parks. ● Prioritize poor condition trees with Moderate risk ratings. If they are not recommended for removal, pruning can eliminate defects and reduce the risk of future failures. ● Routinely monitor these trees for further decline that would necessitate removal. Condition ratings can improve over time with preventative maintenance cycles. ● Routinely prune established and mature trees in fair or better conditions and structurally prune/train young trees (YTT) to reduce future maintenance needs. ● Use the ANSI A300 (Clause 5: Pruning) standards for practices and planning.

SECTION	RECOMMENDATION
Relative Age Distribution	• Cass City's trees are aging, with 48% of all trees in either the 'Maturing' or 'Mature' category. Focus on initiatives to preserve trees and mitigate risks associated with large-stature trees. • Develop & implement a succession plan for the replacement of 'Mature' trees in declining health. Where space is available, plant new young trees before and/or after removing 'Mature' trees. • Follow the initial 5-year maintenance strategy, shown in table 7. • Institute a 3-year young tree training (YTT) cycle to structurally prune trees in the 'Young' age class to ensure good form and maintain healthy structure as they grow. • While the sample budget found in the Maintenance Strategy and Example Budget section currently includes structural pruning on a five-year rotation to prioritize high-need and high-risk maintenance activities, shift to a three-year routine pruning cycle after the initial five-year work plan. • 15% (272) of the 1,755 inventoried trees are 'Young' trees (DBH < 8"). Consider a tree-planting program to bring the proportion of young trees in Cass City closer to the recommended 40%.
Defects & Observations	• Dead and dying parts were the most common defect observed in Cass City's trees. Regular pruning, as done in a routine pruning cycle, can improve the quality of these trees and reduce risk associated with dying tree parts. Removal of dead limbs also improves the visual aesthetics of trees and may help improve public perceptions of the level of tree care in the city. • We recorded 15% of trees with branch attachment or tree architecture defects. Structural pruning within the first decade of the tree's life can reduce the occurrence of these types of defects. Implementing Young Tree Training (YTT) programs and tree support/staking measures can also minimize these issues.
Infrastructure Conflicts	• Cass City should reduce tree conflicts with overhead electric lines by planting only small stature trees beneath or near overhead electric utilities. Plant dwarf cultivars of large-growing species to diversify options for planting under utilities. • Maintain distance from water, sewer, gas, and electric lines underground. Installation and maintenance of utilities underground often damages tree roots. This may destabilize a tree and cause tree failure, reduced tree vigor, or even tree death. • Plant trees at least five feet from any underground utility to allow room for large, structural roots to develop without impacting underground utilities. Call MissDig at 811 or 1-800-482-7171 to locate underground utilities. Consult municipal engineers and/or utility companies to establish appropriate planting specifications. • Consider conflicts with other infrastructure such as buildings, signage, streetlights, and driveways. Cass City should develop and document planting guidelines which dictate required clearances for planting around public infrastructure.

SECTION	RECOMMENDATION
Growing Space	● Right tree, right place. Select tree species based on root system and canopy characteristics that match the planting site. Develop standards for tree planting using available growing space dimensions and/or soil volume. Plant small trees in grow spaces with limited dimensions and soil volumes. ● Develop construction and design standards for sidewalks, roads, and other hardscapes to accommodate tree root growth and reduce future conflicts. ● Collaborate with city planners, engineers, Arborists and other field staff. Consider trees early in the planning process when repairing or redesigning streets and sidewalks to ensure trees can be productive parts of the new streetscape. ● Options to increase growing space sizes: enlarge planting wells, site tree-wells on the back edge of the sidewalk adjacent to lawns, install new tree wells or lawns, create traffic bumps outs, incorporate Silva Cell or structural soil technology into design, etc. ● If possible, reroute sidewalks or build temporary ramps of pavement or wood over tree roots rather than removing healthy, mature trees in favor of sidewalk repairs. ● City streetscapes must balance needs for driving, parking, pedestrian access, overhead and underground utilities, street furniture, signage, lighting, and snow removal, among others. Some areas will not be suitable for trees, so consider ground cover (flowers, herbs, bushes) instead of trees.
Canopy Cover & Stocking Level	● Use stocking level and canopy cover scores to set, measure, and track progress toward canopy cover and tree planting goals. ● Set S.M.A.R.T. (specific, measurable, attainable, relevant, and time-bound) initial goals and set further goals, after accomplishing those initial tasks. This incremental method of progress can help build capacity and public support for tree planting and care over time. ● Cass City should consider planting additional trees in areas with low stocking level/canopy cover. Developed/built-up areas of the community may require creativity and collaboration from multiple communities and departments. Include local initiatives to promote planting trees on private property or parks when site conditions limit street tree planting. ● Conducting an Urban Tree Canopy (UTC) assessment may be helpful in setting and eventually achieving Cass City's tree canopy and equity goals. Cass City should consider a UTC assessment as a next step in their urban forest management program.
Tree Benefits	● Large-stature, deciduous trees, such as oaks, tend to provide the greatest benefits. Cass City should plant these types of trees wherever possible to increase the benefits provided by their public trees. This may require enlarging existing planting spaces or creating large new planting spaces. Efforts should include preserving existing large-stature trees and proactively trimming young public trees to ensure they achieve mature status in the future. ● The protection of existing trees should be a priority, and succession-planning to replace trees and increase tree cover in parks and the right-of-way will have a significant positive impact on tree benefits in Cass City in the future. This also means planting young, large-species trees to grow and replace others that are nearing the ends of their lives. ● The benefits of public trees in Cass City included in this report account for only a fraction of the total benefits provided by the City's trees, because most trees are located on private property. Cass City should consider methods to preserve existing trees and promote new tree planting on private property throughout the city to increase tree benefits citywide.

SECTION	RECOMMENDATION
Priority Maintenance	● Remove: Trees with Extreme or High-Risk ratings recommended for removal immediately and prioritized based on their risk rating and size class. Tree removal is recommended when pruning will not correct the tree's defects, will not eliminate the risks caused by defects, or when pruning would be cost-prohibitive. ● Prune: Trees with Extreme or High-Risk ratings recommended for pruning immediately and prioritized based on their risk rating and size class. Priority pruning and removals can be performed at the same time to increase efficiency of maintenance crews.
Further Inspection	● Include Annual Inspections during routine and after priority maintenance programs. ● During the inventory, DRG did not identify any trees needing an Advanced Risk Assessment (ARA). These trees would require a Level 3 risk assessment and should be assessed by an International Society of Arboriculture (ISA) Tree Risk Assessment Qualified (TRAQ) certified arborist as soon as possible to determine whether they require removal, pruning, or other corrective action to reduce risk. ● Trees recommended for insect/disease monitoring should be inspected to confirm the presence of damaging insects or diseases and determine the best course of action.
Routine Maintenance	● For efficiency, address Moderate and Low Risk removals when removing nearby higher risk trees. Schedule removals/prunes by street or neighborhood. ● High-risk, moderate-risk, low-risk removals/prunes, and stump grinding can be scheduled concurrently if tree crews prefer it and are equipped for a variety of maintenance types. Use generalized tree contractors that can handle a large workload. ● Schedule Low-Risk prunes and removals after Moderate-Risk maintenance has been completed.
Routine Pruning Cycle (RPC)	● Trees which are currently recommended for priority pruning (Extreme, High, and Moderate Risk trees with a maintenance recommendation of "prune") should be added to the RPC once their immediate defects and elevated risk are mitigated. ● Young trees which grow out of the young tree training cycle (see next section) should also be included in the RPC. ● The number of trees to be assessed and routinely pruned each year will vary depending on the number of trees which are planted and the number of trees which are removed in future years. ● Not every tree in the RPC needs pruning each cycle—thus, the actual cost to maintain an RPC will likely be lower than projected in the budget table at the end of this section
Young Tree Training (YTT) Cycle	● YTT is a proactive program, implemented after addressing all elevated-risk trees. ● Start the dedicated three-year YTT cycle on year six, following the initial five-year work plan, as shown in the example budget in the *Maintenance Strategy and Example Budget* section. ● Begin YTT programs one to two years after planting and continue every three years until the tree can no longer be safely pruned from the ground with a pole pruner and pruning shears. At the time of planting, prune new trees minimally to remove broken or crossing branches. ● Not every tree in the YTT cycle needs to be pruned each cycle – thus, the actual cost to keep a young tree pruning cycle will likely be lower than projected in the budget (Table 7).

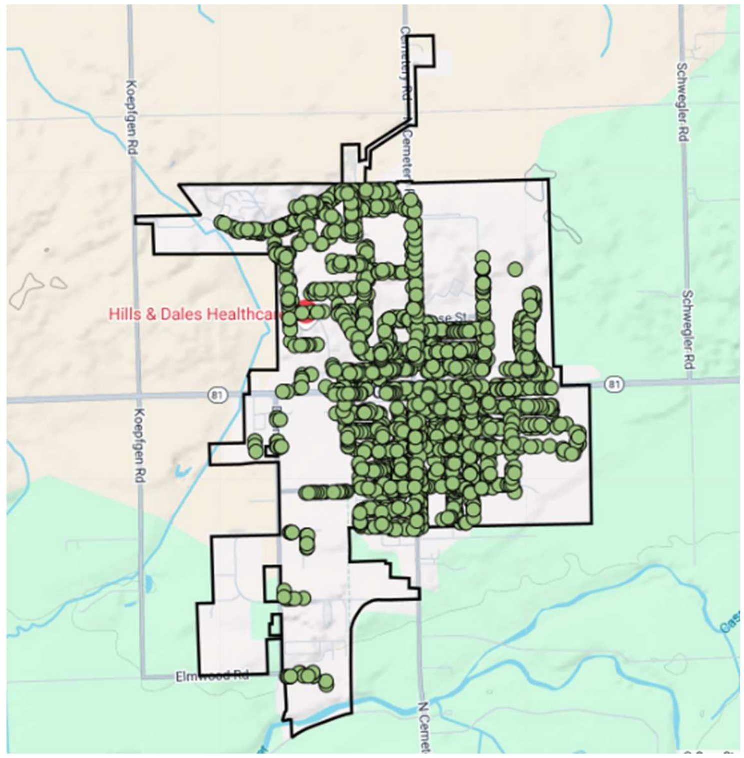
SECTION	• RECOMMENDATION
Routine Inspections and Inventory Updates	• Public trees should be regularly inspected and attended to as needed. Inspections are essential after major storms because they may damage trees and increase the risks trees pose to the public. • Level 1 walk-by or drive-by tree assessments are a cost-effective inspection method after storms. Level 1 assessments can also identify trees which may need more detailed inspections. When trees require additional or new work, they should be added to the maintenance schedule. Update the budget to reflect additional work. Utilize asset management software such as TreeKeeper® to make updates, edits, and keep a log of work records. • Routinely schedule inventory updates every 5-10 years. In large-scale tree inventories, like Cass City, we perform Level 2 assessments on all trees. These are 360-degree walk-around inspections to visually assess a tree's condition up-close to the roots, trunk, branches and canopy.
Tree Planting and Stump Removal	• Include Stump removal should in tree removal contracts. Conduct Quality Assurance and Quality Control (QAQC) checks of the contractor's work to ensure they remove stumps completely. • Plan Stump Removal well in advance of tree-planting initiatives, in some cases, years in advance. If possible, avoid planting in a location where a stump was recently removed. Decomposing roots can cause air pockets, nutrient depletion, and space constraints that can impact the establishment of newly planted trees. • Cass City should strive to plant the largest possible tree in each vacant planting site. Large-stature, deciduous trees provide the greatest benefits to the community. See the strategies for providing sufficient growing space outlined in the Growing Space Recommendations section. • To avoid loss of public trees, Cass City should aim for, at minimum, a 1-for-1 replacement rate of planted to removed trees. Ideally, the community will surpass this. Aim for a 2-for-1, or even a 3-for-1 replacement rate to increase urban canopy coverage and benefits. The budget in Table 7 includes a 2-for-1 replacement strategy to show the costs of maintaining such a planting program. • Species selection during planting: consider tolerance to heat, drought, salt, and climate change, among other factors. Select appropriate trees based on space available to grow. • Where space along the streets is limited and traditional methods are not possible, the community should consider alternative options for installing and increasing public tree canopy, including: ○ Creation of pocket parks. ○ Improvement and maintenance of existing parks and public grounds. ○ Setback planting programs: allow tree planting beyond, but within 20 feet of the ROW. ○ Encourage tree planting on private property via education, tree giveaways, etc. • Where possible, Cass City should enlarge and improve tree planting areas along the streets by: ○ Enlarging the dimensions and soil volume of planting strips and planting wells. ○ Considering use of structural soils or Silva Cells to improve root movement through soils and reduce infrastructure conflicts. ○ Working with other city departments, such as engineering, to ensure that planning for new developments or street improvements considers trees during the design process. • Continue to seek out and apply for grant funding to support tree planting projects. • Continue to develop and foster partnerships with groups such as ReLeaf Michigan, who promote and support tree planting goals.

Appendix B
Study Area and Data Collection

Study Area

As of the 2017 US Census, Cass City had a population of 2,429 people living within the roughly 1.8 square mile community. The Cass River, a tributary to the Saginaw River flows through the southernmost area of the Village.

The 2025 Cass City inventory focused on public trees, largely in the center of the Village limits.



Data Collection

DRG collects tree inventory data using a customized ArcPad program, called Rover, loaded onto pen-based field computers. At each site, the following data fields were collected:

1. Date of Inventory
2. Species (Common Name)
3. Species (Botanical Name)
4. Overhead Utilities
5. Multi-stem
6. Size (DBH)
7. Defect
8. Condition
9. Primary Maintenance Need*
10. Risk Rating
11. Further Inspection
12. Address
13. Coordinates

*Maintenance needs are based on Best Management Practices: Tree Risk Assessment, Third Addition (International Society of Arboriculture 2025). The knowledge, experience, and professional judgment of DRG's arborists ensure the high quality of inventory data.

EQUIPMENT AND BASE MAPS

Inventory arborists use FZ-G1 Panasonic Toughbook® units with internal GPS receivers. Geographic information system (GIS) map layers are loaded onto these units to help locate sites during the inventory. Arborists use a combination of GPS location data and aerial background imagery to locate and place each site.

ADDRESSING

In addition to XY geographic coordinates for each inventoried site, addressing information was also collected during the inventory. While geographic coordinates allow spatial representation of the data within a geographic information system, such as TreeKeeper® or ArcMap, addressing information allows each site to be located in the field without use of a GPS. The following fields were collected as part of the addressing of each site:

- **Address:** The numeric address of the parcel nearest to the site. This field is automatically filled by the data collection program where parcel addressing is available. When parcel addressing was not available, the arborist used their best judgement to assign a logical address number to the site.
- **Suffix:** Indicates whether the arborist needed to manually assign an address number to the site. If the arborist added the address number manually, this field reads "X". If the data collection program assigned an address number, this field is left blank.
- **Street:** The street to which the assigned parcel is addressed. The Address and Street fields, together, provide the street address of the site (e.g., 111 Example Rd.). The street is usually assigned by the data collection program based on parcel data included in the program.
- **On Street:** The street on which the site is physically located. Assigned by the data collection program.
- **Side:** Indicates on what side of the parcel a site is physically located. Assigned by the arborist, this field can read front, side, rear, median, or N/A.
    - **Front** – The site is located on the front side of the parcel. The Street and On Street names should match.
    - **Side** – The site is located on the side of the parcel. The Street and On Street names will likely not match.
    - **Rear** – The site is located on the rear side of the parcel, which only happens when a parcel occupies the full space between two roads. The Street and On Street names will not match.
    - **Median** – The site is located in a median. Technically, sites located in medians do not have addresses but are assigned to the closest parcel address to aid in finding them in the field. All median sites will have Suffix = X.
    - **N/A** – The site is located in a park or other public grounds rather than along the street ROW. Since these sites may be anywhere within a public grounds parcel, a side designation is not necessarily useful and is omitted.

Appendix C
Risk Assessment

Every tree, regardless of defects, condition, location, and other factors, has an inherent risk of whole or partial tree failure. Risk assessment seeks to provide a metric of the level of risk associated with any given tree to allow for risk management to be undertaken by a tree manager. The current editions of ANSI A300 (Clause 13) standards and the ISA's associated publication Best Management Practices: Tree Risk Assessment were used to guide an organized, systematic, and reproducible method for assessing tree risk.

Trees can have multiple modes of potential failure with varying levels of risk associated with each. During the inventory, the mode of failure with the greatest associated risk was recorded as the overall risk rating for the tree. The specified time frame for the risk assessment was one year.

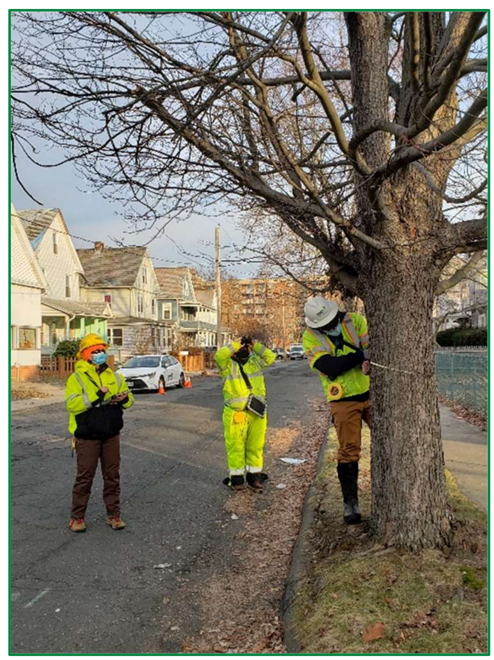
Risk ratings can help tree managers set priorities and organize tree work. Generally, trees with higher risk ratings should be maintained or removed first, to lower the risk and liability associated with these trees. It is up to the tree manager to decide what level of risk is acceptable and under what circumstances.

Levels of Risk Assessment

Arborists assess tree risk using different tools and at different levels of detail. ISA best management practices suggest three levels of risk assessment, from least to most intensive.

Level 1: Limited Visual Assessment

A walk-by or drive-by assessment is designed to quickly scan a large population of trees and identify those which need a more advanced assessment due to defects with an imminent or probable likelihood of failure. Level 1 assessments do not typically result in risk ratings but rather provide a list of tree locations with any recommended remedial action. A recommendation for which trees should be assessed at the next level of assessment may be recommended. This method may be a good option when funding for a full inventory and risk assessment is not available or after major storms when a rapid survey of damage is needed.



DRG arborists conducting a Level 2 risk assessment.

Level 2: Basic Assessment

A detailed, 360-degree visual inspection of individual trees assessing the site, roots, trunk, and branches resulting in an assessment of the tree's health and a risk rating that can be used to prioritize tree work within a large population of trees. DRG applies level two guidelines during most inventories and rapid tree assessments.

Level 3: Advanced Assessment

Additional inspection following a Basic Assessment that uses specialized equipment to provide more detailed information about an individual tree, typically to help make management decisions about that specific tree. Advanced assessments may require use of a bucket truck to reach defects in the crown of the tree, equipment, and experience to perform sonic tomography to map decay pockets, or sampling of diseased plant tissue for identification in a lab, to name a few examples.

Process of Risk Assessment

The primary components of a risk assessment in line with the current editions of ANSI A300 (Clause 13) standards and the ISA's Best Management Practices: Tree Risk Assessment are as follows.

Time Frame

Tree risk should be assessed within a specified time frame. Since all trees are likely to experience whole or partial tree failure at some point during their existence, and since the conditions of a tree and site can change dramatically over time, setting a specific time frame for risk assessment is essential to conveying risk accurately and determining appropriate management practices. Most risk assessments will have a specific time frame of one to three years. Predictive power decreases as time increases, so assessments are not typically done for more than a five-year period.

Likelihood of Failure

The first step in assessing tree risk involves determining the likelihood that the tree or tree part will fail within the specified time frame. Site factors, such as slope, soil texture and saturation, and recent grading or tree removals, are considered in tandem with tree factors such as health, species-specific failure profile, damage, and structural defects. The likelihood of failure is then characterized as either:

- *Improbable* – The tree or tree part is not likely to fail during normal weather conditions and may not fail in extreme weather conditions within the specified time frame.
- *Possible* – Failure may be expected in extreme weather conditions, but it is unlikely during normal weather conditions within the specified time frame.
- *Probable* – Failure may be expected under normal weather conditions within the specified time frame

Likelihood of Target Impact

The next step is to determine how likely it is that the tree or tree part in question will impact a target if it fails. This involves consideration of the potential targets located around a tree, which may include fixed structures such as houses or playground equipment with a constant occupancy rate and mobile targets such as people or vehicles with lower occupancy rates, as well as an assessment of where a tree or tree part will land if it fails. The likelihood of target impact is then characterized as either:

- *Very Low* – The chance of the failed tree or tree part impacting the specified target is remote.
- *Low* – There is a slight chance that the failed tree or tree part will impact the target.
- *Medium* – The failed tree or tree part could impact the target, but it is not expected to do so.
- *High* – The failed tree or tree part is likely to impact the target.

COMBINED LIKELIHOOD OF FAILURE & TARGET IMPACT

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

The likelihood of failure and the likelihood of impacting a target are combined using the matrix below to determine the likelihood of failure impacting a target.

CONSEQUENCE OF FAILURE & TARGET IMPACT

The consequences of a tree failing and striking a target are a function of the value of the target and the amount of injury, damage, or disruption that could be caused by the failure and impact. Considerations when determining potential consequences include the size of the part which may fail, the fall distance, characteristics of the target, and whether there are any structures which may protect the target. Consequences of failure and target impact are characterized as either:

- *Negligible* – Does not result in personal injury, involves low-value property damage, or disruptions that can be replaced or repaired.
- *Minor* – Involves minor personal injury, low- to moderate-value property damage, or small disruption of activities.
- *Significant* – Involves substantial personal injury, property damage of moderate- to high-value, or considerable disruption of activities.
- *Severe* – Involves serious personal injury, high-value property damage, or major disruption of important activities.

RISK RATING

The combined likelihood of failure & target impact is then combined with the consequence of failure & target impact in the matrix, below, to produce a risk rating. There may be multiple modes of potential tree failure and multiple targets to consider, and each combination of failure and target will result in a different risk rating. The overall highest risk rating is usually used as the risk rating for the tree.

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

RISK MITIGATION, PRIORITIZATION, AND RESIDUAL RISK

Once a risk rating is assigned, the final step is to determine whether risk mitigation is necessary and prioritize risk mitigation work. Extreme and High-Risk trees should be managed first, followed by Moderate Risk trees as time and budgets allow, or as deemed necessary by the tree manager. Low Risk trees can typically be maintained during routine maintenance cycles or when time and budgets allow.

Risk mitigation can take many forms. Common methods of mitigation include tree removal or pruning to remove parts that may fail. Other forms of mitigation may include cabling and/or bracing weak branch unions, moving targets such as sheds or play equipment outside the anticipated impact zone, excluding targets from the impact zone using fencing or other barriers, and/or monitoring the tree. Ultimately, it is up to the tree manager to decide what mitigation techniques are appropriate for each tree and what level of risk is acceptable.

Residual risk is the risk remaining after mitigation and considering the residual risk after a mitigation action may help tree managers determine the best actions to take. For example, a tree with a large dead limb over a busy intersection might have a High-Risk rating, but removal of that limb would sufficiently mitigate the risk such that the residual risk is low. In this case, it may be best to remove the dead limb but retain the tree. In other cases, there may not be any mitigation option short of tree removal which will reduce risk to an acceptable level, in which case the tree should be removed.