MEMORANDUM

cityofnovi.org

TO: VICTOR CARDENAS, CITY MANAGER

FROM: JEFFREY HERCZEG, DIRECTOR OF PUBLIC WORKS
KEITH SALOWICH, FORESTER/CONTRACTS SUPERVISOR

SUBJECT: 2024 URBAN TREE MANAGEMENT PLAN UPDATE

DATE: MAY 1, 2025

This memo is a follow-up to the questions about the Tree Fund budget from the City Council Budget Session on April 16, 2025. City staff do not plan on moving forward with the tree inventory update ($140K). Per best practices, the inventory would normally be completed in conjunction with the Management Plan; however, due to the limited funding in the Tree Fund, it will be removed from the final version presented to City Council.

Additionally, as recommended by the prior Management Plans (see below and attached), the planting costs have been reduced/removed, and maintenance costs have been increased in the proposed FY 2025/26 Budget. These changes are being made to better align with the maintenance numbers recommended in the Tree Management Plan. The total for tree maintenance now will be just under $600K (below), which is more consistent with future fiscal years.

<u>Tree Maintenance Funding in Proposed FY 2025/26 Budget</u>

Forestry Maintenance - Nonmotorized	8,000
Forestry Maintenance - Major Streets	25,000
Forestry Maintenance - Local Streets	500,000
Forestry Maintenance - Municipal Streets	10,000
Tree Maintenance	10,000
Forestry Maintenance - Storm Response	19,000
Invasive Species Removal	25,000
TOTAL	**597,000**

This budget will include reactive tree planting for trees removed from resident right-of-way or critical reactive maintenance for the city municipal properties or parks. While the Management Plan is the ideal best practice, staff recommend these budget reductions, while the future of the Tree Fund is considered by City Council.

In 2023-24, the City of Novi commissioned Davey Resource Group to evaluate the City's tree inventory and update the 2017 Urban Tree Management Plan. The purpose of this project was to analyze the previous plan's successes and weaknesses and to better inform future management decisions.

The report identified 40,802 trees, planting sites, and stumps along Novi's streets and in city parks. The trees in Novi provide $14.4 million annually in ecosystem services through cleaning the air, managing stormwater, and carbon sequestration and avoidance, among other benefits. See ATTACHMENT A for a more detailed look into the myriad benefits Novi's urban forest provides.

Key findings from the Urban Tree Management Plan and Urban Tree Canopy Report are listed below. The full report is included.

PRUNING PLAN: A routine maintenance pruning schedule was developed utilizing the previous iteration of the 2017 management plan. That pruning work was carried out between 2018 to 2023. All street trees larger than 3 inches in trunk diameter were pruned along local roads. This proactive pruning work improved urban forest health, reduced tree risks, and decreased incidences of storm damage. However, street trees along major roads and a young tree training program were not incorporated into that plan for budgetary reasons.

A proactive pruning cycle in which all City-owned trees are pruned on a five-year rotation remains the industry best practice. However, pruning Novi's trees at this frequency is not feasible under the current budget allocation. As such, staff recommends adopting a seven-year pruning plan to proactively prune trees along both local and major roads, plus implementing a young tree training program. Young trees are much cheaper to prune and many future growth form problems that increase tree risk can be avoided through young tree training.

The table in ATTACHMENT B breaks down the associated costs of both pruning models. More comprehensive information on the associated maintenance costs of Novi's street urban forest can be found on pages 50 to 61 of the management plan.

PLANTING: Along with the updated Management Plan, Davey also prepared the City of Novi's first comprehensive Urban Tree Canopy Report. The report found that 37% (7,426 acres) of Novi is shaded by trees and that tree cover percentage increased by 9.3% from 2012 to 2022 (the latest year in which sufficient imagery was available). This is a testament to Novi's prioritization of preserving existing trees and its planting efforts over the last 10 years. See ATTACHMENT C for more information on Novi's current canopy coverage.

The report also found that tree cover is not equitably distributed throughout the city and identified high-priority planting areas. Identifying areas as high-priority planting sites was based on assessing stormwater interception potential, addressing urban heat island effect, and social equity conditions (median household income, concentration of residents of vulnerable ages, etc.)

Staff will make a concerted effort to plant trees in high-priority planting areas using this report as a resource. In addition to planting on public property, the City should also seek out ways to encourage planting trees on private property, such as the existing seedling giveaway program. Other innovative ways to incentivize planting on private property could further bolster beneficial tree canopy.

TREE ORDINANCE: The Urban Tree Canopy Report shows that nearly one-third of the City's existing tree cover is on vacant land—much of which is privately-owned, regulated woodland. Those trees are vulnerable to development of those properties. To date, Novi's Woodlands Protection Ordinance (Chp. 37) has helped maintain canopy cover by either saving trees from removal during development or requiring that they be replaced via on-site plantings and/or contributions to the City's Tree Fund.

A similar tree ordinance in Canton Township was recently challenged and was ruled unconstitutional first in 2021, then again on appeal in 2024. Davey recommends strengthening Novi's existing Woodlands Protection Ordinance. The ordinance should also be expanded to protect publicly owned trees, such as street trees, which are <u>not</u> specifically protected by any Novi ordinance currently.

Novi's existing tree ordinance will also soon no longer meet the standards of the Arbor Day Foundation's Tree City USA program, as their standards will be changing to require public tree protections beginning in 2026. Novi has held Tree City USA status for 32 years, but that could be jeopardized if the tree ordinance is not expanded.

CONCLUSION: The updated Urban Tree Management Plan and Novi's first-ever Urban Tree Canopy Cover Report have highlighted the positive impacts of Novi's strong investment in its urban forest. Canopy cover has increased 9.3% over the past 10 years and all street trees greater than 3 inches in diameter along local roads have been proactively pruned at least once since 2018, which makes for a healthier urban forest that poses lower risk and reduces reactive maintenance costs.

The Davey Urban Tree Management Plans have also charted a course for continued improvement. The existing proactive pruning plan needs to be broadened to also include trees along major roads and a young tree training program. Planting efforts need to be directed toward priority planting areas to maximize the impact of the City's tree planting program. Finally, the City's tree ordinance needs to be expanded to include public tree protection and strengthened in the wake of recent court activity.

ATTACHMENT A
pg. 27 of the 2024 Tree Management Plan

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 U.S (McDonald et al., 2020).
- By intercepting particulate matter, trees save over 850 lives and prevent 670,000 incidents of acute respiratory symptoms in the United States 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 et al., 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).

ATTACHMENT B
Pg. 50-61 of the 2024 Tree Management Plan

Estimated Costs for Urban Forestry Management Plan- Street Trees only

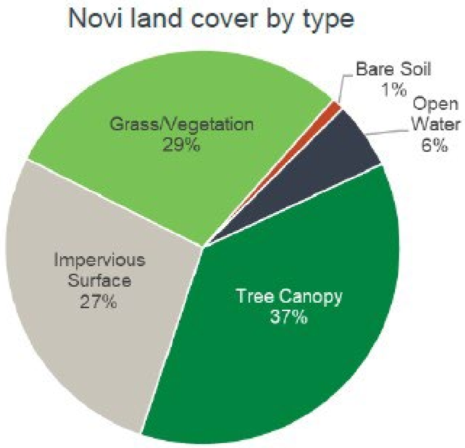
		Trees Pruned per Year	Cost per Year	Cost of Full Pruning Cycle
Five-year Cycle	**Routine Pruning**	2,049	$258,890	$1,294,450
	Young Tree Training	3,256	$222,408	$1,112,040
	TOTAL	5,305	$481,298	$2,406,490

		Trees Pruned per Year	Cost per Year	Cost of Full Pruning Cycle
Seven-year Cycle	**Routine Pruning**	1,464	$184,999	$1,294,993
	Young Tree Training	2,326	$158,880	$1,112,160
	TOTAL	3,790	$343,879	$2,407,153

ATTACHMENT C

Pg. 3 of Tree Canopy Report

Urban Tree Canopy Cover Summary

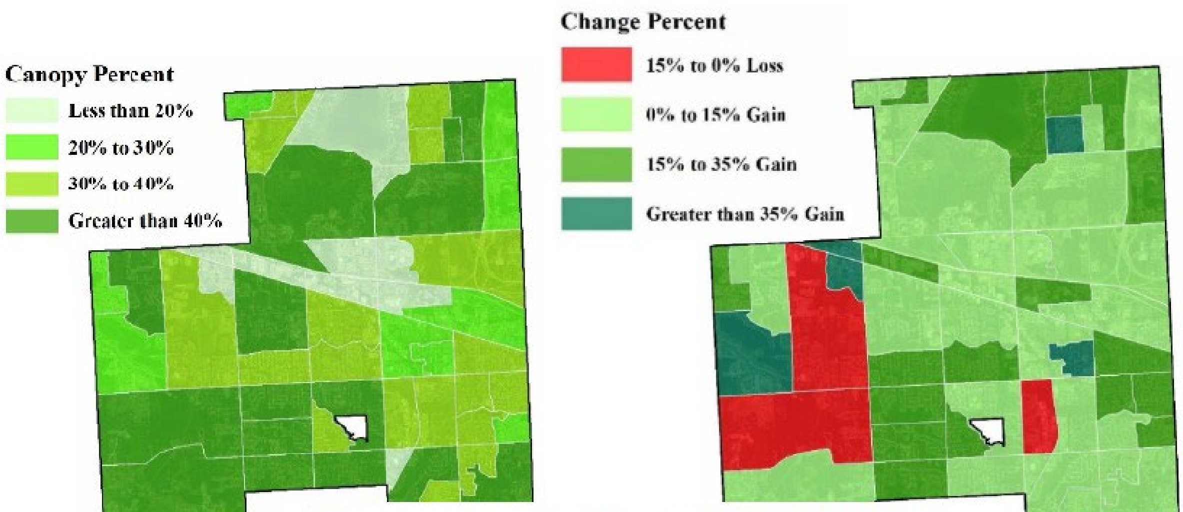


37% Tree Canopy Cover

7,426 acres of trees in Novi in 2022

9.3% Tree Canopy Growth in 10 years

+634 acres of trees, 2012–2022



Tree canopy cover and change (2012-2022) in Novi

Tree Management Plan City of Novi, Michigan

PREPARED FOR:

City of Novi
Department of Public Works
26300 Lee BeGole Drive

Novi, Michigan 48375

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PREPARED BY:

Davey Resource Group, Inc.

295 S. Water Street, Suite 300

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ACKNOWLEDGMENTS

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

EXECUTIVE SUMMARY

Tree Management Plan Novi, Michigan

This Tree Management Plan was crafted by DRG specifically for the City of Novi, aimed at enhancing both the short-term and long-term maintenance strategies for the city's inventoried public trees. Through comprehensive analysis of the tree inventory, DRG has developed a deep understanding of the current conditions and needs of Novi's urban forest. This foundation has informed the creation of a proposed maintenance schedule and proactive tree care protocols. The plan leverages detailed analysis of inventory data, along with insights into the city's existing urban forestry initiatives and its future goals. Additionally, this document outlines the economic, environmental, and social benefits that Novi's trees offer to the community and introduces a robust tree risk management program designed to safeguard these green assets.

State of the Existing Urban Forest

The ongoing tree inventory in the City of Novi, initiated in 2006 and regularly updated, encompasses trees, stumps, and potential planting sites located along public street rights-of-way (ROW), as well as in selected parks and municipal properties. As of the latest update, the inventory comprises 40,802 sites, including 40,557 trees, 34 stumps, and 211 designated planting sites. An analysis of the data from the tree inventory reveals several key findings:

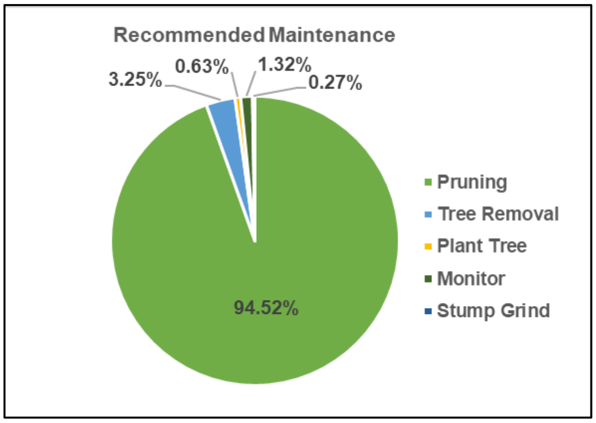
- *Acer* species (maple trees) represent 27% of the total tree population on streets and in parks, indicating a decrease from 29% in 2017. This prevalence raises concerns about biodiversity and resilience within the urban forest.
- The distribution of tree diameters varies from the ideal, with an excess of young and established trees but fewer maturing and mature trees than recommended, reflective of an imbalance in age diversity.
- The overall condition of the inventoried trees is assessed as Good, reflecting general health and vigor.
- The health of the tree population is currently threatened by several pests, including the Japanese beetle (*Popillia japonica*), spotted lanternfly (*Lycorma delicatula*), Asian longhorned beetle (*Anoplophora glabripennis*), and tent caterpillar moth (*Malacosoma disstria*), which represent significant risks to tree health.

These insights assist in shaping targeted management strategies to sustain and enhance the ecological value of Novi's urban forest.

Tree Maintenance and Planting Needs

Trees provide many environmental and economic benefits that justify the time and money invested in planting and maintenance. Recommended maintenance needs include: Pruning (94.52%), Tree Removal (3.25%), Plant Tree (0.63%), Monitor (1.32%), and Stump Grind (0.27%). Maintenance should be prioritized by addressing trees with the highest associated risk first. Trees should be planted to mitigate removals and create canopy.

Novi's urban forest will benefit greatly from a young tree training cycle (YTT) and a five-year routine pruning cycle. Proactive pruning cycles improve the overall health of the tree population



and should eventually reduce program costs. In most cases, pruning cycles will correct defects in trees before they worsen, which will avoid costly problems. Based on inventory data, at least 2,049 street trees should be cleaned each year during the routine pruning cycle.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed (1,287 total trees) or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind).

Citywide tree planting should focus on replacing tree canopy recommended for removal and establishing new canopy in areas that promote economic growth, such as business districts, recreational areas, trails, parking lots, areas near buildings with insufficient shade, and areas where there are gaps in the existing canopy. Various tree species should be planted; however, the planting of *Acer* (maple) should be limited. The city's existing planting list offers smart choices for species selection.

REMOVAL

Total Street and Park Tree Removals = 1,288 trees
Dead and Poor = 1,203 trees
Fair or Better = 85 trees
Stumps = 34

PRIORITY PRUNING

Total = 664 trees
Number of park trees = 252
Number of street trees = 405

ROUTINE PRUNING CYCLE (5 year)

Total = 12,325 trees
Number of park trees in cycle each year = approx. 415
Number of street trees in cycle each year = approx. 2,049

YOUNG TREE TRAINING PRUNE (5 year)

Total = 20,463 trees
Number of park trees in cycle each year = approx. 784
Number of street trees in cycle each year = approx. 3,256

TREE PLANTING

Number of trees each year = at least 519
Number of park trees to replant = at least 60
Number of street trees to replant = at least 459

Urban Forest Program Needs

Adequate funding will be needed for the city to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for both streets and parks for the first year of this seven-year program is $1,057,421. This total will decrease to approximately $787,931 per year by Year 3 of the program. High-priority removal and pruning is costly; since most of this work is scheduled during the first year of the program, the budget is higher for that year. After high-priority work has been completed, the urban forestry program will mostly involve proactive maintenance, which is generally less costly. Budgets for later years are thus projected to be lower. The graphic below illustrates the annual breakdown of a combined street and municipal facility projected budget for the recommended maintenance activities covered in this report.

Year One **$1,057,421**

932 Removals
365 Priority Prunes
0 Stump Removals
RP Cycle: 1/7 of Public Trees Cleaned
YTT Cycle: 2,886 Trees
519 Trees Recommended for Planting and Follow-Up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year Two **$845,600**

324 Removals, 292 Priority Prunes
RP Cycle: 1/7 of Public Trees Cleaned
YTT Cycle: 2,886 Trees
519 Trees Recommended for Planting and Follow-Up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Years 3-7 **$787,931 per year**

RP Cycle: 1/7 of Public Trees Cleaned annually
YTT Cycle: 2,886 Trees annually
519 Trees Recommended for Planting and Follow-Up Care
Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

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

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

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INTRODUCTION

The City of Novi, with its population of over 66,500 residents, cherishes the splendor and benefits offered by its extensive urban forest. This asset is carefully managed by the city's forestry program, which is responsible for the upkeep of trees, stumps, and designated planting areas within parks, public spaces, and along street rights-of-way (ROW). The dedication of Novi's Department of Public Works is evident in their long-standing commitment to nurturing a robust urban forest.

Financial support for this vital urban forestry program is sourced from the Tree Fund. A pivotal moment in the program's history was the comprehensive inventory of public trees conducted in 2006. The city not only adheres to a tree ordinance but also allocates an annual budget towards tree-related initiatives. Novi's commitment to urban greening is further highlighted by its celebration of Arbor Day and its distinguished status as a Tree City USA for 32 consecutive years. This commitment is underscored by the 14 Tree City USA Growth Awards, a testament to the city's ongoing efforts to enhance environmental quality through superior tree care.

A testament to these investments is the recent urban tree canopy analysis, which revealed that Novi boasted a canopy cover of 37% in 2022 imagery, marking a consistent growth over the past decade. This growth not only exemplifies Novi's dedication to expanding its green landscape but also reinforces the city's role as a steward of urban environmental health and sustainability.

Approach to Tree Management

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

In 2023, Novi worked with DRG to update the management plan that was created in 2018. This plan considers the diversity, distribution, and general condition of the inventoried trees, but also provides a prioritized system for managing public trees.

This plan is divided into five sections:

- *Section 1: Street Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations found in the street tree population.
- *Section 2: Park Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations found in the park tree population.
- *Section 3: Benefits of the Urban Forest* summarizes the economic, environmental, and social benefits that trees provide to the community. This section presents statistics of an i-Tree Streets benefits analysis conducted for Novi.

- *Section 4: Tree Risk Management Program* summarizes a tree risk management strategy and outlines plan for specific actions, procedures, and objectives for managing risk associated with the city's urban forest.
- *Section 5: Street & Park Tree Management Program* utilizes the inventory data to develop a prioritized maintenance schedule and projected budget for the recommended tree maintenance over a five-year period along with an alternative seven year period.

This *Management Plan* is designed to help the community understand the current state of its public trees, set future goals and benchmarks, anticipate future program needs, and focus on proactive maintenance. The Urban Forest Program Continuum (shown below) outlines the steps to effectively and sustainably manage and care for Novi's urban forest.

SECTION 1: STREET TREE INVENTORY ANALYSIS

Starting in 2006, arborists from DRG embarked on a comprehensive evaluation and inventory of trees, stumps, and potential planting locations situated along the public roadways of the city. Since the initial data collection, the inventory has been updated to include new findings and additional locations. The extensive inventory encompassed a total of 33,379 sites, comprising 33,302 trees, 32 stumps, and 45 designated planting areas.

Of the 33,379 sites collected, 69% were collected along residential and secondary roadways, 26% were collected along major thoroughfares and primary roadways, and the remaining 5% were collected along Islands, Medians, and off Right-of-Way (ROW). Figure 1 provides a detailed breakdown of the number and type of sites inventoried. The city's public street rights-of-way were selected by Novi for the inventory.

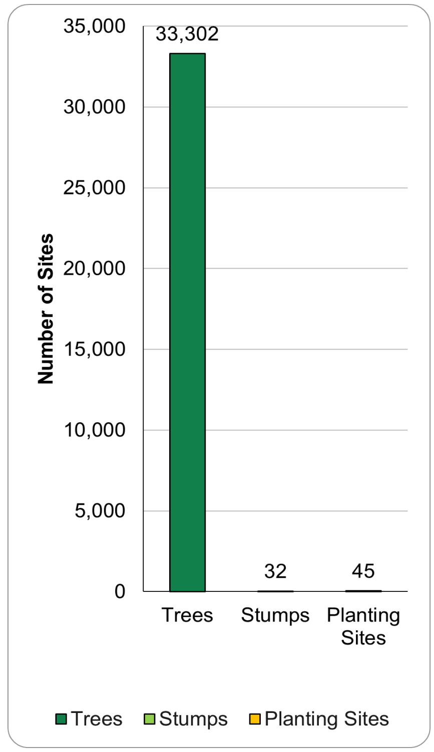


Figure 1. Street ROW sites collected during the inventory.

Assessment of Tree Inventory Data

Through data analysis and the application of expert judgment, insights are drawn to provide a comprehensive overview of the current conditions within the surveyed tree population. Recognizing trends in the data can help guide short-term and long-term management planning. In this plan, the following criteria and indicators of the inventoried tree population were assessed:

- *Species Diversity*, the variety of species in a specific population, affects the population's ability to withstand threats from invasive pests and diseases. Species diversity also impacts tree maintenance needs and costs, tree planting goals, and canopy continuity.
- *Diameter Size Class Distribution Data*, the statistical distribution of a given tree population's trunk-size class, is used to indicate the relative age of a tree population. The diameter size class distribution affects the valuation of tree-related benefits as well as the projection of maintenance needs and costs, planting goals, and canopy continuity.
- *Condition*, the general health of a tree population, indicates how well trees are performing given their site-specific conditions. General health affects both short-term and long-term maintenance needs and costs as well as canopy continuity.

- *Observations* include inventory data analysis that provides insight into past maintenance practices and growing conditions; such observations may affect future management decisions.

Species Diversity

Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics such as the devastating results of Dutch elm disease (*Ophiostoma novo-ulmi*) throughout New England and the Midwest. 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 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 U.S. 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's 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. Therefore, the 10-20-30 Rule is a common urban forestry industry metric for species diversity: a single species should represent no more than 10% of the urban forest, a single genus no more than 20%, and a single family no more than 30%. Some communities may be in the position to pursue more aggressive diversity goals, such as a 5-10-15 metric of species diversity.

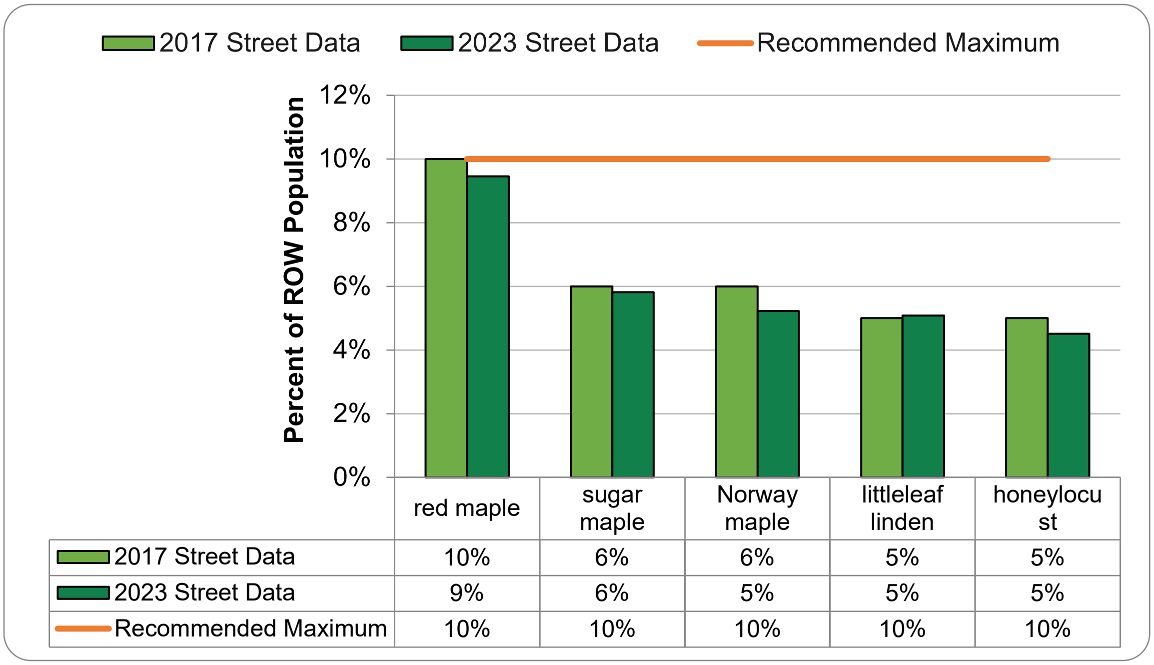
THE ROLE OF NON-NATIVE TREE SPECIES IN THE URBAN ENVIRONMENT

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.

FINDINGS

Analysis of Novi's tree inventory data indicated that the street tree population had relatively good diversity, with 68 genera and 211 species represented.

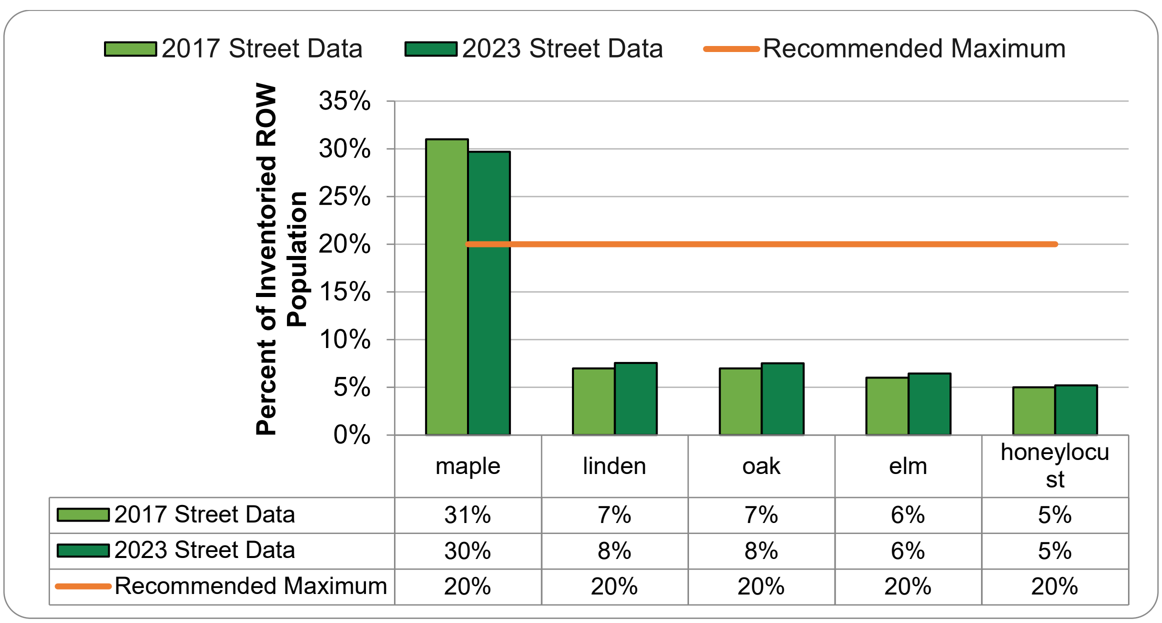
Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory to the street tree populations. *Acer rubrum* (red maple) are just below the recommended 10% maximum for a single species in a population, comprising 9% of the inventoried street tree population. Sugar maple (*Acer saccharum)* (6%), Norway maple (*Acer platanoides*) (5%), littleleaf linden (*Tilia cordata*) (5%), and honeylocust (*Gleditsia triacanthos* var. *inermis*) (5%) follow as the other most commonly found street tree species. Overall, the species diversity has improved from the 2006 and 2017 inventory analyses, but will need to continue to maintain desired diversity levels.



	red maple	sugar maple	Norway maple	littleleaf linden	honeylocu st
2017 Street Data	10%	6%	6%	5%	5%
2023 Street Data	9%	6%	5%	5%	5%
Recommended Maximum	10%	10%	10%	10%	10%

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

Figure 3 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory to the street tree populations. Maple far exceeds the recommended 20% maximum for a single genus in a population, comprising 30% of the inventoried street tree population. Following are linden (8%), oak (8%), elm (6%), and honeylocust (5%).



	maple	linden	oak	elm	honeylocu st
2017 Street Data	31%	7%	7%	6%	5%
2023 Street Data	30%	8%	8%	6%	5%
Recommended Maximum	20%	20%	20%	20%	20%

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

DISCUSSION/RECOMMENDATIONS

Maple species dominate the street tree population. This is a concern because of its over abundance in the landscape and the potential impacts of pests and disease may have on maple trees in the future. Continued diversity of tree species is an important objective that will ensure Novi's urban forest is sustainable and resilient to future invasive pest infestations. This metric has improved from 34% in 2006 and 31% in 2017, and will need to continue to reach the desired diversity level of less than 20%.

Considering the large quantity of maple in city's population, along with its susceptibility to Asian longhorned beetle (ALB, *Anoplophora glabripennis*), the planting of maple should be significantly limited to minimize the potential for loss in the event that ALB threatens Novi's urban tree population.

To foster a more resilient urban canopy, it is advisable to diversify the species planted, focusing on those species which are less common but well-adapted to urban conditions. Appendix A provides a list of recommended tree species for future planting initiatives, aimed at enriching Novi's urban biodiversity and ensuring the long-term health and sustainability of its forest.

Diameter Size Class Distribution

Analysis of a tree population's relative age distribution can be performed by assigning age classes to the diameter of trees. While actual tree age cannot be determined by diameter alone, this industry standard method provides an estimate of the approximate age distribution of the inventoried tree population.

Age/Size Classes

Young: 0-6 inches diameter at standard height (DSH), as measured 4.5' above the ground

Established: 7-18 inches DSH

Maturing: 19-24 inches DSH

Mature: >24 inches DSH

Since trees at different stages of development need different types and frequencies of maintenance, age distribution can help inform management needs and decisions.

The size classes (left) 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 portions should be established and maturing trees (30% and 20%, respectively), and the smallest proportion (10%) should be mature trees.

FINDINGS

Figure 4 compares Novi's diameter size class distribution of the inventoried street tree population. The diameter size class distribution of the street tree populations trends toward an ideal distribution, with a disproportional amount in the young and established category; however, the maturing and mature categories fall significantly short in comparison to the residual of the population. When comparing the current distribution to the 2017 data analysis, the distribution has not significantly shifted, although the population of young trees has grown further from the recommended portion for its size category.

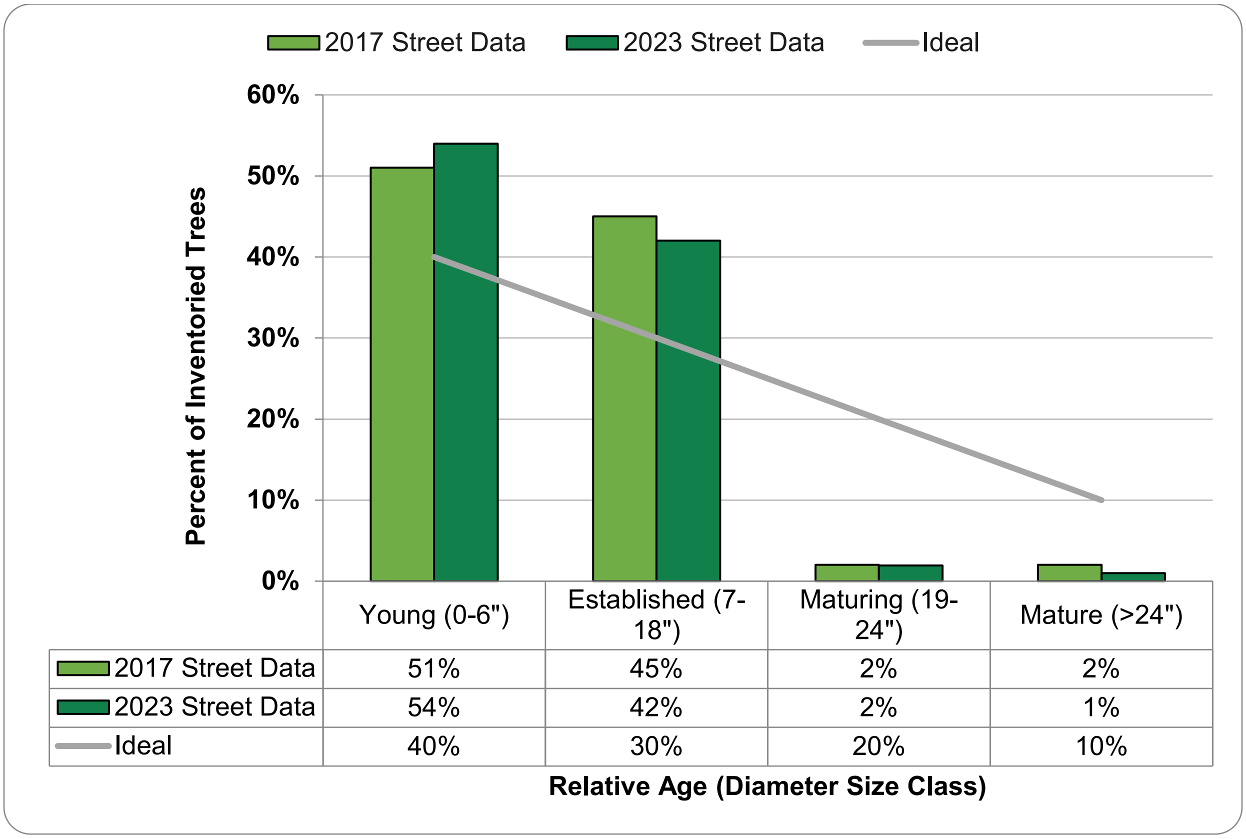


Figure 4. Comparison of diameter size class distribution for street inventoried trees to the 2017 distribution.

DISCUSSION/RECOMMENDATIONS

While it appears that Novi might be overwhelmed with young trees, the actual challenge lies in the scarcity of established, maturing, and mature trees. This imbalance highlights a skewed age distribution within the urban forest. Novi should aim to cultivate a diverse age range among its trees, not just at street or park levels, but across the entire city, to ensure a healthy, resilient urban canopy.

Achieving a more balanced age distribution requires a comprehensive maintenance strategy that boosts the survival rates of young trees, allowing them to progress into larger, more mature categories. DRG recommends that Novi continues to invest in a strong planting and maintenance initiative. Such a program is crucial for introducing young, vigorous trees that can fill the voids in the tree canopy and serve as replacements for aging, deteriorating trees.

To safeguard the urban forest's future, it's imperative for the city to champion tree preservation and adopt proactive longevity of older trees but also facilitate a gradual normalization of the tree age distribution. Strengthening the city's tree preservation ordinance is a crucial step to protect the investments made in planting and maintaining trees and the benefits they provide. In addition, tree planning and care will allow the distribution to normalize over time. Recommended species lists and information on species selection can be found in Appendices A and B respectively.

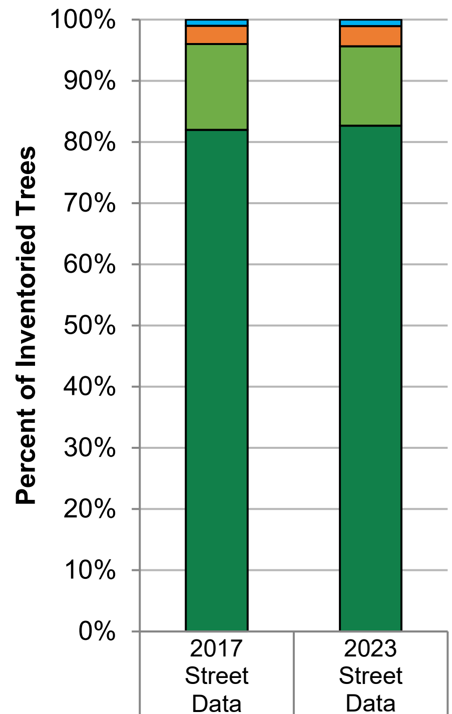
Condition

The condition of individual trees are assessed and assigned based on methods defined by the International Society of Arboriculture (ISA). Several factors were considered for each tree, including root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition of each inventoried tree was rated Good, Fair, Poor, or Dead. Figures 5 and 6 illustrate the general health and distribution of young, established, mature, and maturing trees relative to their condition.

Comparing the condition of the inventoried tree population with relative tree age (or size class distribution) can provide insight into the stability of the population. Trees across all age classes are generally in Good condition. In general, trees in the young age class are more likely to be in Good condition, while maturing and mature age classes are more likely to have more trees in Poor condition.

FINDINGS

Most of the inventoried trees were recorded to be in Good condition, 83% (Figure 5). Based on these data, the general health of the overall inventoried tree population is rated Good. This is a slight positive shift from the 2017 data analysis that showed fewer trees in Good condition and more in Fair condition. Figure 6 illustrates that most of the trees were rated to be in Good condition across the age classes, with similar condition distribution as the 2017 inventory analysis found.



	2017 Street Data	2023 Street Data
Dead	1%	1%
Poor	3%	3%
Fair	14%	13%
Good	82%	83%

Figure 5. Condition of inventoried street trees.

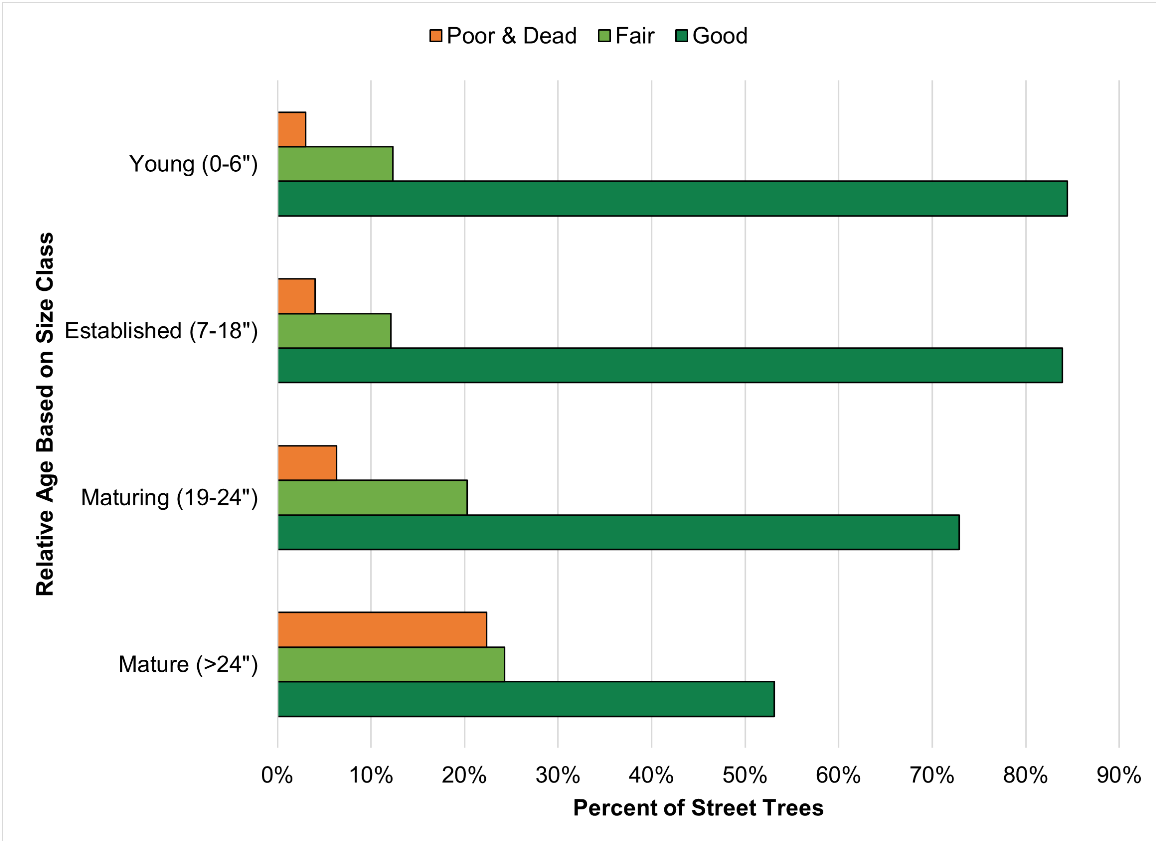


Figure 6. Tree condition by relative age during the street tree inventory.

DISCUSSION/RECOMMENDATIONS

Analysis has provided the following insight into maintenance needs and historical maintenance practices:

- The similar trend in condition across street trees reveals that growing conditions and/or past management of trees were consistent.
- Dead trees should be removed.
- Younger trees rated in Fair or Poor condition may benefit from structural pruning that may improve their health over time. Pruning should follow *ANSI A300* (ANSI 2023).
- Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Proper tree care practices are needed for the long-term general health of the urban forest. Many of the newly planted trees were improperly mulched or had staking hardware attached to them long after they should have been removed. Following guidelines developed by ISA and those *ANSI A300* (ANSI 2023) will ensure that tree maintenance practices ultimately improve the health of the urban recommended by forest.

Other Observations

Observations were recorded during the inventory to further describe a tree's health, structure, or location when more detail was needed. Where a tree had more than one defect, only the most significant defect (i.e., the defect causing the greatest detriment to the tree and/or most likely to cause whole or partial tree failure within a year) was recorded.

FINDINGS

Stress and Wound were most frequently observed and recorded (7% and 6% of inventoried street trees, respectively) (Table 1).

Table 1. Observations Recorded During the Street Tree Inventory.

Defect	Street Trees	Percent of Street Trees
Stress	2,024	6%
Wound	1,783	5%
Pest Problem	156	0%
Improper Mulching	61	>1%
Other	55	>1%
Girdling Root	17	>1%
Storm Damage	3	>1%
None	29,203	88%
Total	**33,302**	**100%**

DISCUSSION/RECOMMENDATIONS

Unless slated for removal, trees noted as under stress (2,024 trees) or wounded (1,783 trees) should be regularly inspected. Corrective actions should be taken when warranted. If their condition worsens, removal may be required. Of the 2,024 trees noted for stress 6.6% were recommended for removal (133 trees). Of the 1,783 trees noted for wounded, only 6.5% were recommended for removal (116 trees).

The costs for treating deficient trees must be considered to determine whether removing and replacing the tree is the more viable option.

Infrastructure Conflicts

In developed settings, like a street, growing space for trees can be limited both above and below ground. To maximize tree growth, health, and benefits, it is important to consider the amount of space available (above and below ground) 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 Novi inventory, tree conflicts with overhead utilities and hardscape (Table 2) were observed and recorded.

Existing or possible conflicts between trees and infrastructure recorded during the inventory include:

- *Clearance Requirements*—The inventory noted trees blocking the visibility of traffic signs or signals, streetlights, or other safety devices. This information should be used to schedule pruning activities.
- *Overhead Utilities*—The presence of overhead utility lines above a tree or planting site was noted; it is important to consider these data when planning pruning activities and selecting tree species for planting.

FINDINGS

There were 3,089 street trees recorded with some type of clearance issue, representing approximately 9% of the inventoried street tree population (Table 2). Most of those (8%) were related to conflicts with wires. Sign conflicts, in which the canopy of a tree comes within a certain perimeter with surround traffic sign, included a total of 344 street trees (1%). It is imperative that these trees are addressed in an expeditious manner to avoid any disruptions in service.

Table 2. Street Trees Noted to be Conflicting with Infrastructure.

Presence	Number of Street Trees	Percent
Wires	2515	8%
Sign	344	1%
Hydrant	164	>1%
Light	44	>1%
Building	12	>1%
Sight Line	5	>1%
Other	5	>1%
Total	**3089**	**9%**

DISCUSSION/RECOMMENDATIONS

Tree canopy should not interfere with vehicular or pedestrian traffic, nor should it rest on buildings or block signs, signals, or lights. Pruning to avoid clearance issues and raise tree crowns should be completed in accordance with *ANSI A300* (2023). See side panel ("DRG Recommended Minimum Spacing for Tree Planting").

- Novi should reduce tree conflicts with overhead electric lines by planting only small stature trees beneath or near overhead electric utilities.

- Consider looking for dwarf or small cultivars of typically large-stature trees to diversify small-stature planting lists.
- Tree roots can damage water and sewer pipes, gas lines, and electric conduit. Installation and maintenance of these utilities often results in cut tree roots, which may destabilize trees and cause tree failure, reduce tree vigor, or kill the tree.
- Plant trees at least 5 feet (or at a distance agreed upon with municipal engineer and/or utility company) from any underground utility to allow room for large, structural roots to develop without impacting the utility.
- Conflicts with other infrastructure such as buildings, road signage, streetlights, and driveways should also be considered. Novi should enforce planting guidelines which dictate required clearances for different types of infrastructure.
- Although sidewalk heaving was not recorded as a part of this inventory, this issue is common in the urban forest. In the past five years, 582 service requests were received by the City relating to sidewalk and tree conflict – 70% of which resulted in sidewalk repair/replacement and root removal and 10% of which prompted root pruning without sidewalk repair. Novi launched a pilot program in 2023 to address heaved sidewalks and remove roots, or entire trees where necessary. To further address this issue, the City should develop and implement Best Management Practices to prevent heaving (e.g., choosing appropriate-sized trees for each site's growing space, using innovate sidewalk design and/or alternative materials) and to mitigate the issue with minimal impact to the tree (e.g., proper root pruning methods).

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 locally specific 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

Potential Threats from Pests

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

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

FINDINGS

Japanese beetle (*Popillia japonica*), spotted lanternfly (*Lycorma delicatula),* and Eastern tent caterpillar (*Anoplophora glabripennis*) are known threats to a large percentage of the inventoried street trees (53%, 48% and 47%, respectively).

There were 183 ash trees inventoried along Novi's streets and roadways. Private trees that were not part of this inventory also showed symptoms of infestation.

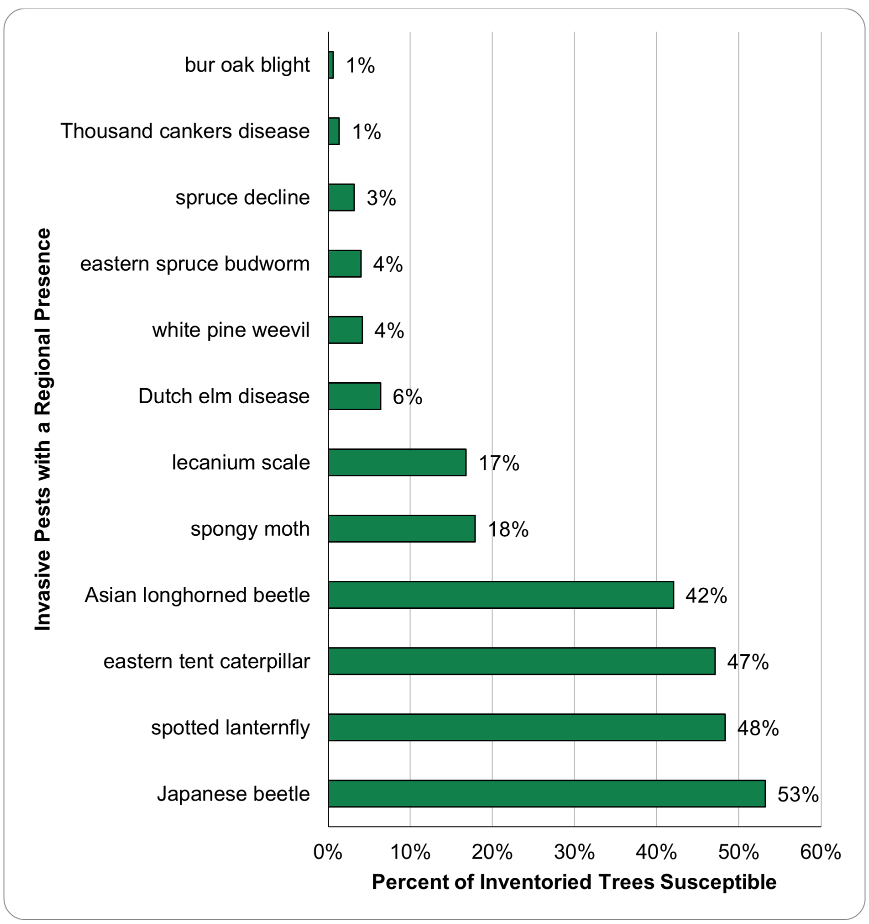


Figure 7. Potential impact of insect and disease threats noted during the street inventory.

DISCUSSION/RECOMMENDATIONS

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

SECTION 2: PARK TREE INVENTORY ANALYSIS

Beginning in 2006, DRG arborists assessed and inventoried trees, stumps, and planting sites in specified parks, and public facilities. This data has been amended and new sites have been added since the initial field attributes were collected. A total of 7,423 sites were collected during the inventory: 7,255 trees, 2 stumps, and 166 planting sites. Of the 7,423 sites collected, 32% were collected in and around facilities, and the remaining 66% were collected in parks. Figure 8 provides a detailed breakdown of the number and type of sites inventoried.

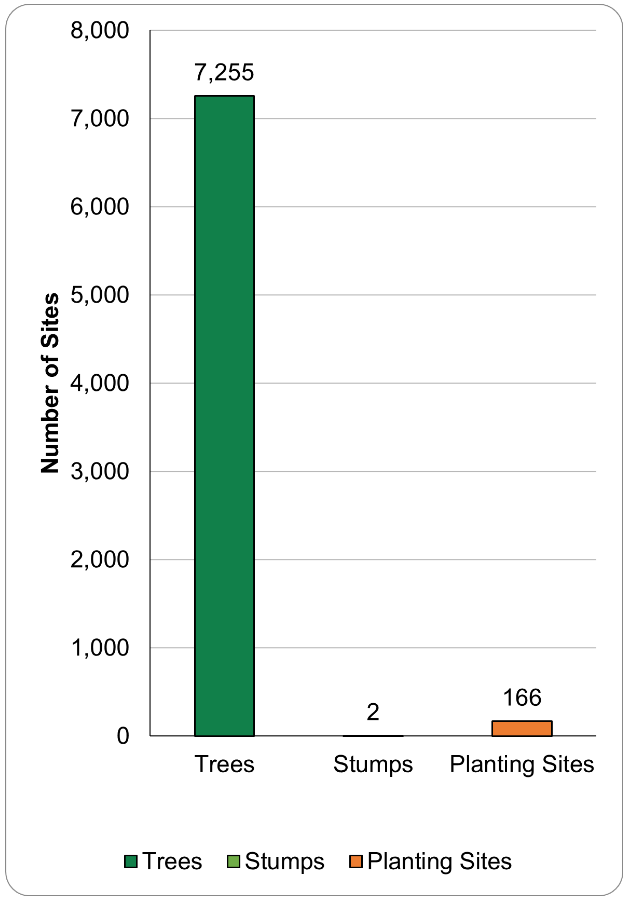


Figure 8. Park sites collected during the inventory.

Thirty-seven community parks and facilities were selected by Novi for the tree inventory. Notable inventoried parks include: Community Sports Park, Lakeshore Park, Rotary Park, Ella Mae Power Park, Meadowbrook Commons, Wildlife Woods Park, Fuerst Park, Novi Ice Arena, and Brookfarm Park.

Assessment of Tree Inventory Data

Data analysis and professional judgment are used to make generalizations about the state of the inventoried tree population. Recognizing trends in the data can help guide short-term and long-term management planning. In this plan, the following criteria and indicators of the inventoried tree population were assessed:

- *Species Diversity*, the variety of species in a specific population, affects the population's ability to withstand threats from invasive pests and diseases. Species diversity also impacts tree maintenance needs and costs, tree planting goals, and canopy continuity.
- *Diameter Size Class Distribution Data*, the statistical distribution of a given tree population's trunk-size class, is used to indicate the relative age of a tree population. The diameter size class distribution affects the valuation of tree-related benefits as well as the projection of maintenance needs and costs, planting goals, and canopy continuity.

- *Condition*, the general health of a tree population, indicates how well trees are performing given their site-specific conditions. General health affects both short-term and long-term maintenance needs and costs as well as canopy continuity.
- *Observations* include inventory data analysis that provides insight into past maintenance practices and growing conditions; such observations may affect future management decisions.

Species Diversity

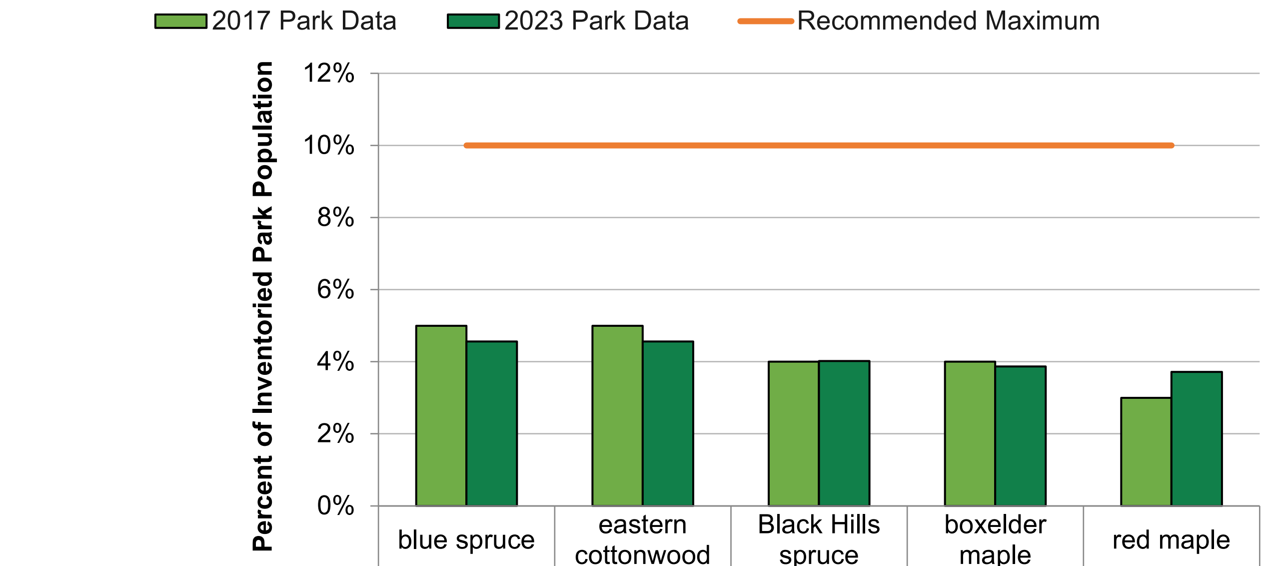
Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics such as the devastating results of Dutch elm disease (*Ophiostoma novo-ulmi*) throughout New England and the Midwest. 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 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 U.S. 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's 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. Therefore, the 10-20-30 Rule is a common urban forestry industry metric for species diversity: a single species should represent no more than 10% of the urban forest, a single genus no more than 20%, and a single family no more than 30%. Some communities may be in the position to pursue more aggressive diversity goals, such as a 5-10-15 metric.

FINDINGS

Analysis of Novi's park tree inventory data indicated that the park tree population had relatively good diversity, with 59 genera and 131 species represented.

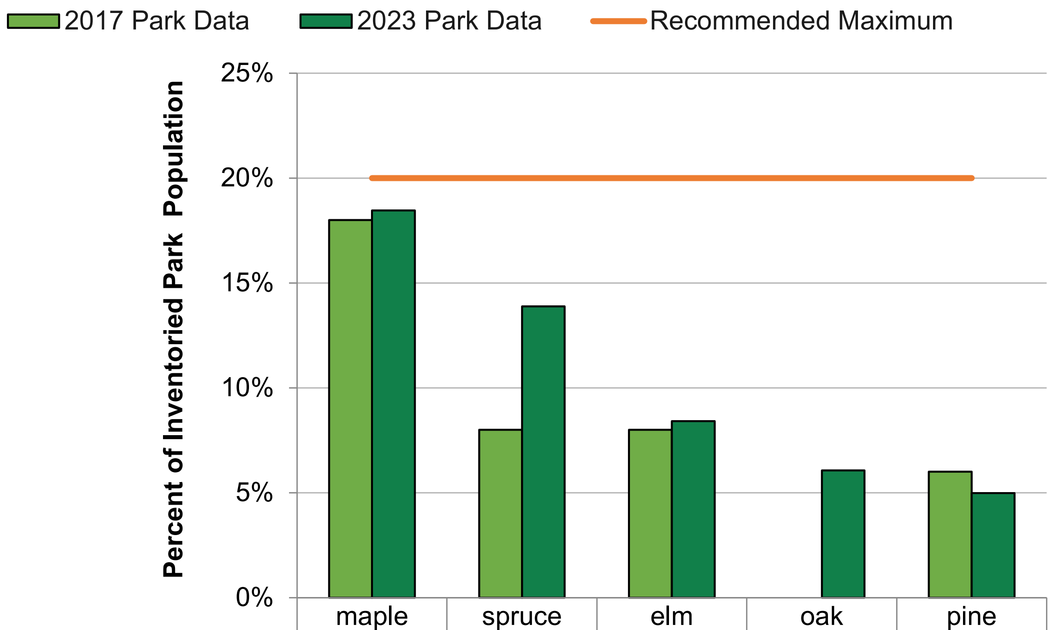
Figure 9 uses the 10% Rule to compare the percentages of the most common species identified during the inventory to the park tree populations. None of the identified species exceed the recommended 10% maximum for a single species in a population.



	blue spruce	eastern cottonwood	Black Hills spruce	boxelder maple	red maple
2017 Park Data	5%	5%	4%	4%	3%
2023 Park Data	5%	5%	4%	4%	4%
Recommended Maximum	10%	10%	10%	10%	10%

Figure 9. Five most abundant species of the inventoried population compared to the 10% Rule.

Figure 10 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory to the park tree populations. None of the identified genera exceed the recommended 20% maximum for a single genus in a population. *Acer* (maple) are approaching the 20% threshold with 18%.



	maple	spruce	elm	oak	pine
2017 Park Data	18%	8%	8%		6%
2023 Park Data	18%	14%	8%	6%	5%
Recommended Maximum	20%	20%	20%	20%	20%

Figure 10. Five most abundant genera of the inventoried population compared to the 20% Rule.

DISCUSSION/RECOMMENDATIONS

Acer (maple) is the most dominant genera in the park tree population. While the *Acer* species (18%) does not currently reach the 20% benchmark for the defined public space, it is approaching that threshold for being a biodiversity concern.

Considering the large quantity of *Acer* (maple) in city's overall population, along with its susceptibility to Asian longhorned beetle, the planting of *Acer* (maple) should be significantly limited to minimize the potential for loss in the event that Asian longhorned beetle threatens Novi's urban tree population. See Appendix A for a recommended tree species list for planting.

Diameter Size Class Distribution

Analysis of a tree population's relative age distribution can be performed by assigning age classes to the diameter of trees. While actual tree age cannot be determined by diameter alone, this industry standard method provides an estimate of the approximate age distribution of the inventoried tree population. Since trees at different stages of development need different types and frequencies of maintenance, age distribution can help inform management needs and decisions.

Age/Size Classes

Young: 0-6 inches diameter at standard height (DSH), as measured 4.5' above the ground

Established: 7-18 inches DSH

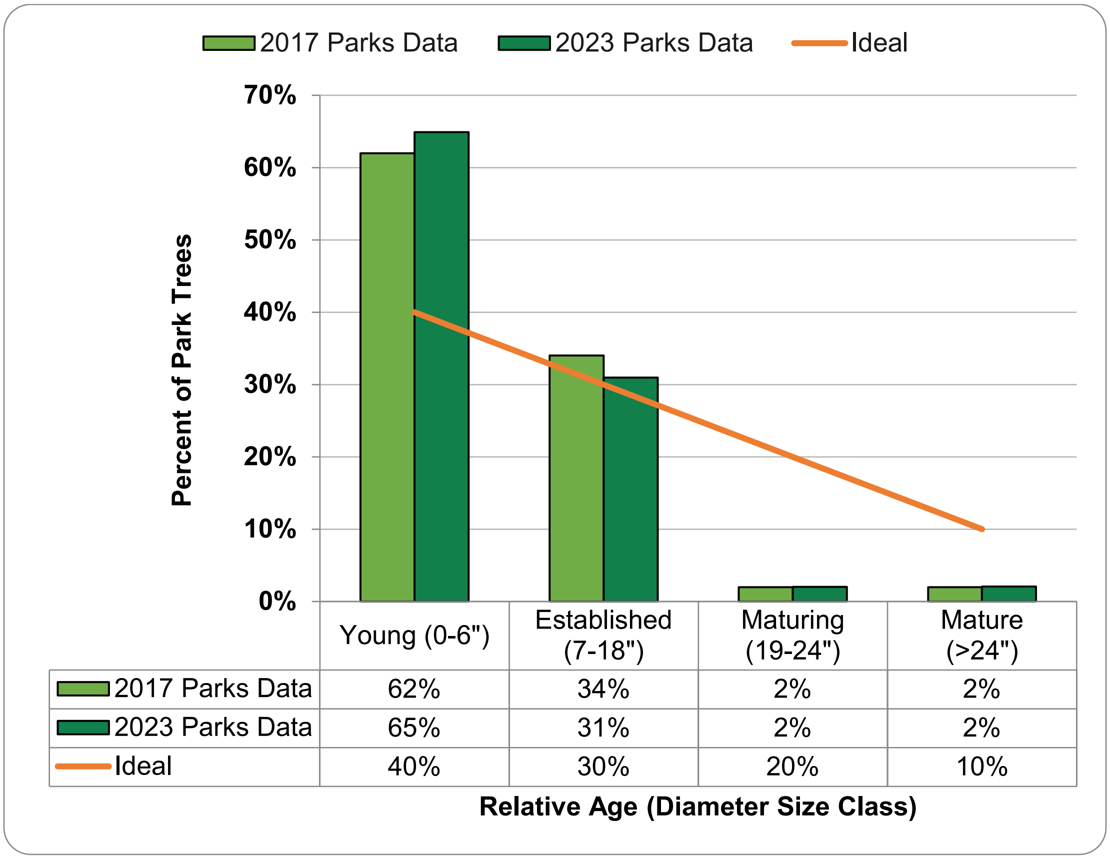
Maturing: 19-24 inches DSH

Mature: >24 inches DSH

The size classes (left) 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 portions should be established and maturing trees (30% and 20%, respectively), and the smallest proportion (10%) should be mature trees.

FINDINGS

Figure 11 compares Novi's diameter size class distribution of the inventoried park tree population. The diameter size class distribution of the park tree populations has a disproportional amount of trees in the young and established category, and the maturing and mature categories fall significantly short in comparison to the residual of the population.



	Young (0-6")	Established (7-18")	Maturing (19-24")	Mature (>24")
2017 Parks Data	62%	34%	2%	2%
2023 Parks Data	65%	31%	2%	2%
Ideal	40%	30%	20%	10%

Figure 11. Diameter size class distribution for inventoried trees.

DISCUSSION/RECOMMENDATIONS

Novi's parks have a significant proportion of young trees, and has too few maturing and mature trees, which is reflected in the skewed distribution. One of Novi's objectives is to have an uneven-aged distribution of trees at the street, park, and citywide levels. DRG recommends that Novi support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in tree canopy and replace older declining trees. The city must promote tree preservation and proactive tree care to ensure the long-term survival of older trees.

Additionally, tree planting and tree care will allow the distribution to normalize over time. See Appendix A for a recommended tree species list for planting. See Appendix B for planting suggestions and information on species selection.

Condition

The condition of individual trees are assessed and assigned based on methods defined by the International Society of Arboriculture (ISA). Several factors were considered for each tree, including: root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition of each inventoried tree was rated Good, Fair, Poor, or Dead. Figures 12 and 13 illustrate the general health and distribution of young, established, mature, and maturing trees relative to their condition.

Comparing the condition of the inventoried tree population with relative tree age (or size class distribution) can provide insight into the stability of the population. Trees across all age classes are generally in Good condition. In general, trees in the young age class are more likely to be in Good condition, while maturing and mature age classes are more likely to have trees in Poor condition.

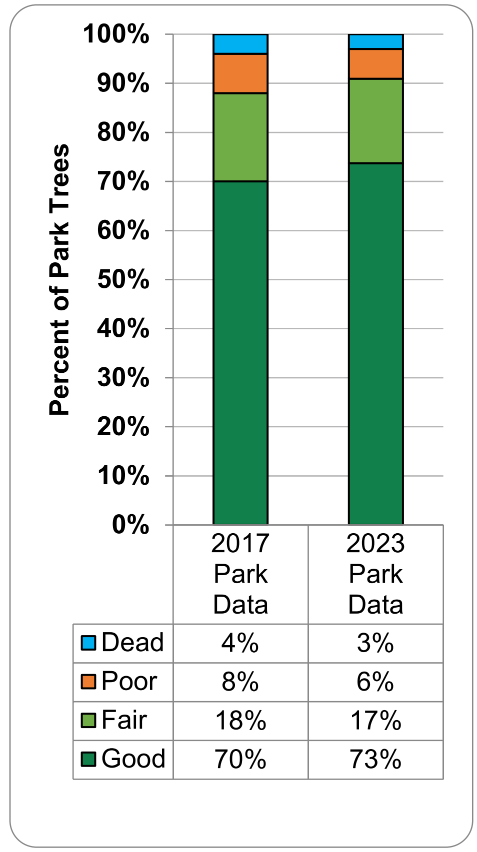


Figure 12. Condition of inventoried park trees.

FINDINGS

Most of the inventoried park trees were recorded to be in Good or Fair condition, 73% and 17%, respectively (Figure 12). Based on these data, the general health of the overall inventoried tree population is rated Good. Figure 13 illustrates that most of the young and established trees were rated to be in Good condition, and that maturing and mature park trees were more likely to be rated as being in worse condition.

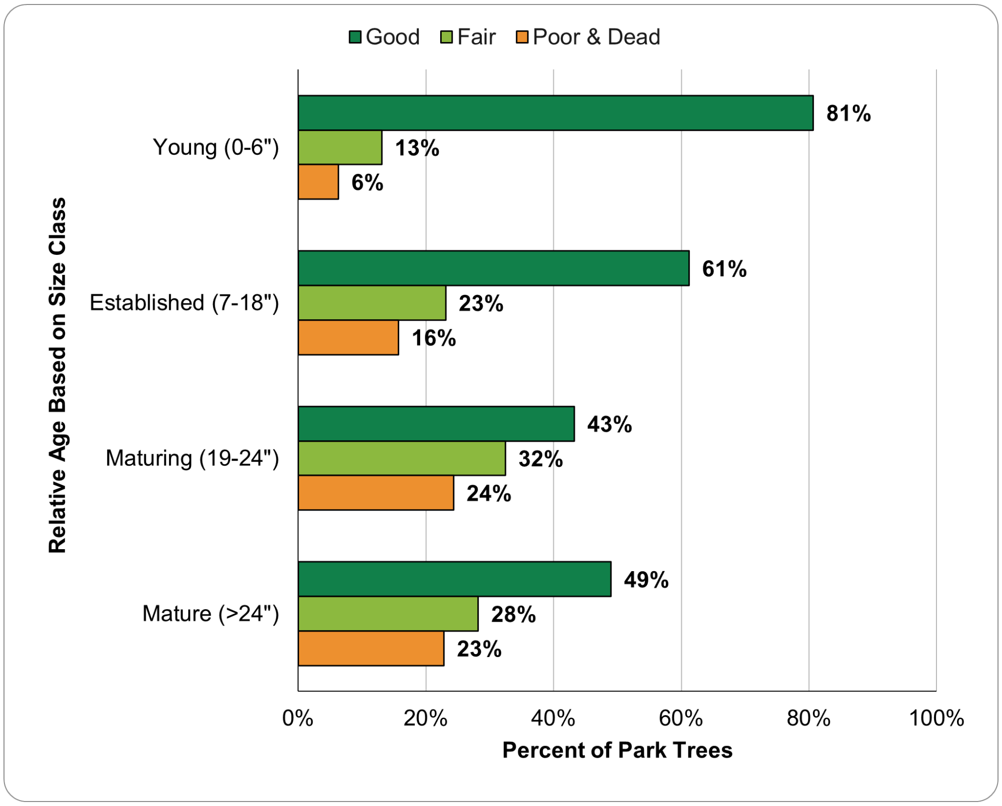


Figure 13. Park tree condition by relative age.

DISCUSSION/RECOMMENDATIONS

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

- The similar trend in condition across park trees reveals that growing conditions and/or past management of trees were consistent.
- Dead trees should be removed because of their failed health; these trees will likely not recover, even with increased care.
- Younger trees rated in Fair or Poor condition may benefit from improvements in structure that may improve their health over time. Pruning should follow *ANSI A300* (ANSI 2023).
- Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Proper tree care practices are needed for the long-term general health of the urban forest. Many of the newly planted trees were improperly mulched or had staking hardware attached to them long after they should have been removed. Following guidelines developed by ISA and those recommended by *ANSI A300* (ANSI 2023) will ensure that tree maintenance practices ultimately improve the health of the urban forest.

Other Observations

Observations were recorded during the inventory to further describe a tree's health, structure, or location when more detail was needed. Where a tree had more than one defect, only the most significant defect (i.e., the defect causing the greatest detriment to the tree and/or most likely to cause whole or partial tree failure within a year) was recorded.

FINDINGS

Stress and Wound were most frequently observed and recorded (7% and 4% of inventoried park trees, respectively).

Table 3. Observations Recorded During the Park Tree Inventory

Defect	Park Trees	Percent of Park Trees
Stress	476	7%
Wound	319	4%
Pest Problem	56	1%
Improper Mulching	126	2%
Other	9	>1%
Girdling Root	2	>1%
Comm Plaque	53	1%
None	6,214	86%
Total	**7,255**	**100%**

DISCUSSION/RECOMMENDATIONS

Unless slated for removal, trees noted as under stress (476 trees) or wounded (319 trees) should be regularly inspected. Corrective actions should be taken when warranted. If their condition worsens, removal may be required. Of the 476 trees noted for stress, only 8% were recommended for removal. Of the 319 trees noted for wound, 6% were recommended for removal.

The costs for treating deficient trees must be considered to determine whether removing and replacing the tree is the more viable option.

Infrastructure Conflicts

In developed settings, like a street, growing space for trees can be limited both above and below ground. To maximize tree growth, health, and benefits, it is important to consider the amount of space available (above and below ground) 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 Novi inventory, tree conflicts with overhead utilities and hardscape (Table 4) were observed and recorded.

Existing or possible conflicts between trees and infrastructure recorded during the inventory include:

- *Clearance Requirements*—The inventory noted trees blocking the visibility of traffic signs or signals, streetlights, or other safety devices. This information should be used to schedule pruning activities.
- *Overhead Utilities*—The presence of overhead utility lines above a tree or planting site was noted; it is important to consider these data when planning pruning activities and selecting tree species for planting.

FINDINGS

There were 236 park trees recorded with some type of clearance issue (Table 4). Most of those (2%) were related to conflicts with wires. Building conflicts, in which the canopy of a tree comes within a certain perimeter with surround building, included a total of 33 park trees (>1%).

Table 4. Park Trees Noted to be Conflicting with Infrastructure.

Presence	Number of Street Trees	Percent
Wires	160	2%
Sign	20	>1%
Hydrant	10	>1%
Building	33	>1%
Catch Basin	13	>1%
None	7019	97%
Total	**7255**	**100%**

DISCUSSION/RECOMMENDATIONS

Tree canopy should not interfere with vehicular or pedestrian traffic, nor should it rest on buildings or block signs, signals, or lights. Pruning to avoid clearance issues and raise tree crowns should be completed in accordance with *ANSI A300* (ANSI 2023).

- Novi should reduce tree conflicts with overhead electric lines by planting only small stature trees beneath or near overhead electric utilities.
- Consider looking for dwarf or small cultivars of typically large-stature trees to diversify small-stature planting lists.
- Tree roots can damage water and sewer pipes, gas lines, and electric conduit. Installation and maintenance of these utilities often results in cut tree roots, which may destabilize trees and cause tree failure, reduce tree vigor, or kill the tree.
- Plant trees at least 5 feet (or at a distance agreed upon with municipal engineer and/or utility company) from any underground utility to allow room for large, structural roots to develop without impacting the utility.

- Conflicts with other infrastructure such as buildings, road signage, streetlights, and driveways should also be considered. Novi should enforce planting guidelines which dictate required clearances for different types of infrastructure.

Potential Threats from Pests

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

Many pests target a single species or an entire genus. The inventory data were analyzed to provide a general estimate of the percentage of trees susceptible to some of the known pests in Michigan (see Figure 14). It is important to note that the figure only presents data collected from the inventory. Many more trees throughout Novi, including those on public and private property, may be susceptible to these invasive pests.

FINDINGS

Japanese beetle (*Popillia japonica*), spotted lanternfly (*Lycorma delicatula)*, and forest tent caterpillar moth (*Malacosoma disstria*) and are known threats to a large percentage of the inventoried street trees (45%, 43%, and 42%, respectively).

There were 175 ash trees inventoried within Novi's parks and facilities. Private trees that were not part of this inventory also showed symptoms of infestation.

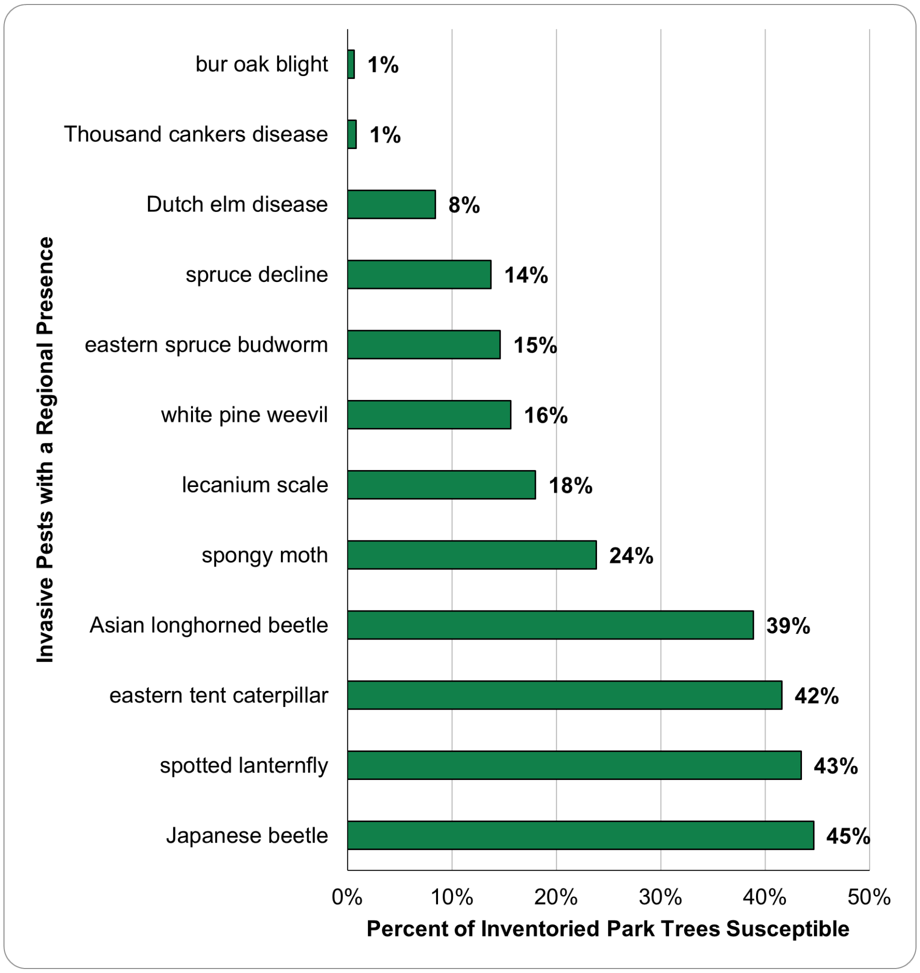


Figure 14. Potential impact of insect and disease threats noted during the park inventory.

DISCUSSION/RECOMMENDATIONS

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

SECTION 3: BENEFITS OF THE URBAN FOREST

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 U.S (McDonald et al., 2020).
- By intercepting particulate matter, trees save over 850 lives and prevent 670,000 incidents of acute respiratory symptoms in the United States 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 et al., 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 Novi'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 5). 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 5. Summary of benefits provided by Novi's inventoried trees.

Most Common Trees Inventoried		Count	Percent of Total	Benefits Provided by Inventoried Trees				
				CO_2 Stored	CO_2 Sequestered	Avoided Runoff	Air Pollution Removed	Replacement Value
Common Name	Botanical Name		%	tons	tons/year	gal/year	lbs/year	Dollars
Red maple	*Acer rubrum*	3,598	8.9%	373.6	19.6	164,645	800	$1,845,755
Sugar maple	*Acer saccharum*	2,226	5.5%	786.4	11.2	228,217	1,120	$2,910,287
Norway maple	*Acer platanoides*	1,911	4.7%	406.5	16.9	134,152	660	$2,054,156
Littleleaf linden	*Tilia cordata*	1,828	4.5%	139.9	6.0	89,821	440	$1,006,457
Callery pear	*Pyrus calleryana*	1,667	4.1%	159.4	7.4	66,973	320	$806,178
Thornless honeylocust	*Gleditsia triacanthos v. inermis*	1,633	4.0%	292.3	9.5	116,518	580	$1,574,172
Freeman maple	*Acer x freemanii*	1,548	3.8%	175.3	9.5	127,254	620	$826,109
Apple spp	*Malus spp.*	1,406	3.5%	86.9	4.3	24,504	120	$450,819
Blue spruce	*Picea pungens*	1,320	3.3%	164.0	3.5	78,024	380	$1,028,105
Tulip tree	*Liriodendron tulipifera*	1,278	3.1%	105.6	5.8	101,013	500	$755,593
Elm spp	*Ulmus spp.*	1,195	2.9%	95.3	4.0	58,140	280	$500,814
Northern red oak	*Quercus rubra*	1,142	2.8%	230.2	6.5	113,762	560	$1,232,460
Sweetgum	*Liquidambar styraciflua*	1,118	2.8%	63.0	3.6	64,554	320	$799,194
Japanese zelkova	*Zelkova serrata*	818	2.0%	54.2	2.2	69,692	340	$558,840
London planetree	*Platanus hybrida*	782	1.9%	107.7	3.5	86,806	420	$884,112
All Other Trees Inventoried		17,143	42.2%	3,612	97.3	1,429,715	7,020	$13,939,394
Total		**40,613**	**100%**	**6,853**	**210.6**	**2,953,793**	**14,480**	**$31,172,445**

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. **The inventoried trees in Novi provide over $108,210 of air quality, stormwater management, and carbon sequestration benefits each year** (Figure 15).

Table 6 summarizes the key tree species that provide the greatest contribution to Novi's annual benefits based on the results of the i-Tree Eco analysis of the public tree inventory. **Black poplar, as well as silver maple, northern catalpa, hickory, and various oak, are among the major contributors to the annual quantifiable benefits** within the public tree resource.

Table 6. The inventoried species that provide the greatest annual benefit per tree.

Tree species	Benefits provided per year per tree
Black poplar	$13.38
Silver maple	$9.44
Northern catalpa	$8.99
Hickory species	$7.52
White mulberry	$7.48
Overcup oak	$7.32
Swamp chestnut oak	$7.24
Black walnut	$7.18
Eastern cottonwood	$6.69
Babylon weeping willow	$6.40

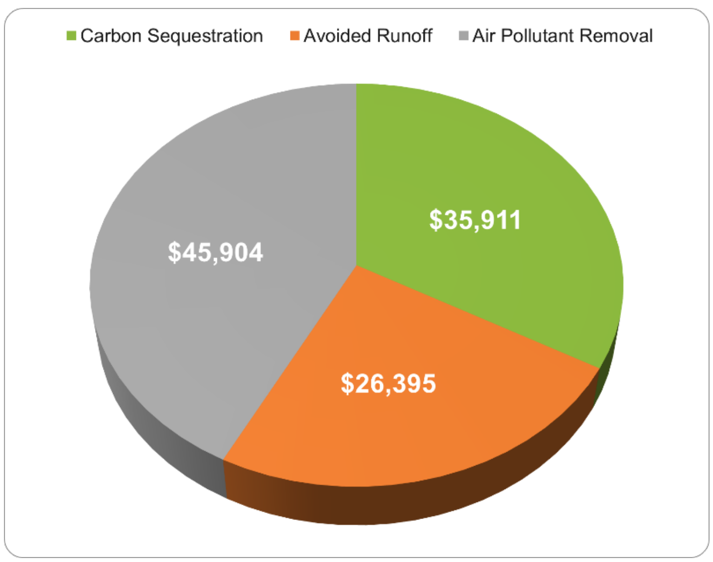


Figure 15. Breakdown of total annual benefits provided to Novi.

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 also absorb harmful gaseous pollutants like ozone, nitrogen dioxide, and sulfur dioxide; and 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. **42% of Novi's annual public tree benefits are associated with air pollution removal.**

The inventoried trees in Novi remove 14,480 pounds of airborne pollutants each year; a service valued at $45,904 (Table 5).

SEQUESTERING AND STORING CARBON

Trees are carbon sinks, which means they absorb carbon from the atmosphere– the opposite of carbon sources which produce and emit carbon into the atmosphere. While carbon is released from fossil fuel consuming vehicles and smokestacks, it is absorbed by trees during photosynthesis and stored in their tissue as they grow. **Novi's public street trees sequester (absorb) an estimated 211 tons of carbon each year, valued at $35,911, and have stored 6,853 tons of carbon over their lifetime, valued at $1,168,730** (Table 5)**.**

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 (Figure 16). Since stormwater runoff can cause infrastructure damage and flooding, reducing the amount of precipitation that becomes surface runoff can save a community cost in infrastructure repair and flooding mitigation**. The inventoried trees in Novi divert 2.95 million gallons of stormwater each year valued at $26,395** (Table 5).

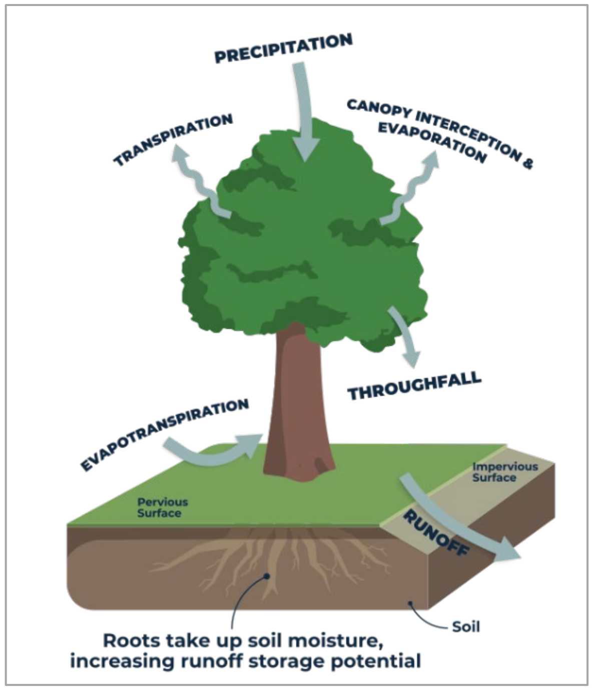


Figure 16. Hydrological functions of trees. Source: 'Stormwater to Street Trees: Engineering Urban Forests for Stormwater Management', EPA publication 841 B 13 001.

REPLACEMENT VALUE

Replacement value is the approximate cost to replace an existing tree with a tree of a similar size and species. While doing this is typically not possible – for example, to replace a 20-inch diameter tree with another tree of similar size would not be feasible – replacement value can provide an idea of the overall value of the inventoried public trees in Novi.

In total, Novi's inventoried trees have a replacement value of $31.17 million. Table 7 compares the per-tree replacement value of the street and park trees with the overall highest replacement values. **Northern catalpa is the most valuable tree in Novi among the inventoried tree population**, with overcup oak, swamp chestnut oak, white mulberry, and Babylon weeping willow also making the top five.

Table 7. Inventoried species with the highest per tree replacement value.

Most Common Trees Inventoried		Count	Percent of Total	Replacement Value	
				Per Inventoried Trees	Per Tree
Common Name	Botanical Name		%	Dollar	Dollar
Northern catalpa	*Catalpa speciosa*	4	0.0%	$13,914.74	$3,478.69
Overcup oak	*Quercus lyrata*	8	0.0%	$23,822.44	$2,977.81
Swamp chestnut oak	*Quercus michauxii*	8	0.0%	$23,366.65	$2,920.83
White mulberry	*Morus alba*	7	0.0%	$19,637.41	$2,805.34
Babylon weeping willow	*Salix babylonica*	34	0.1%	$88,643.13	$2,607.15
White oak	*Quercus alba*	255	0.6%	$637,185.60	$2,498.77
Silver maple	*Acer saccharinum*	761	1.9%	$1,843,605.68	$2,422.61
Hickory species	*Carya spp.*	8	0.0%	$18,936.64	$2,367.08
Dawn redwood	*Metasequoia glyptostroboides*	314	0.8%	$569,599.33	$1,814.01
Black walnut	*Juglans nigra*	510	1.3%	$916,209.93	$1,796.49
All Other Trees Inventoried		38,704	95.3%	$27,017,523.45	$524.36
Total		**40,613**	**100%**	**$31,172,445.00**	**$767.55**

TREE BENEFIT RECOMMENDATIONS

- Large-stature, deciduous trees tend to provide the greatest benefits. Novi should plan to plant these types of trees wherever possible to increase the benefits provided by the public trees. This may require enlarging existing tree planting spaces or creating large new tree planting spaces to accommodate large street trees. It also should include preserving existing large-stature trees and providing proactive care to young public trees to ensure they achieve mature status in the future.
- Oak were often among the largest contributors to tree benefits and are not currently overabundant in Novi. Planting oak will help to increase the benefits provided by public trees.
- The public trees in Novi account for only a fraction of the total benefits provided by the city's trees indicating that many of the trees which provide benefits to Novi are located on private property. Novi should consider methods to preserve existing trees on private property throughout the city to increase tree benefits. Novi has initiated a program of providing free seedlings to residents through giveaways, encouraging tree planting on private property. This initiative plays a vital role in engaging the community in managing the urban forest and contributes to the expansion of Novi's tree canopy.

SECTION 4: TREE RISK MANAGEMENT

The idea of managing the risk associated with different components of a city's gray and green infrastructure is not a new concept. Most communities have risk management programs established for the most basic infrastructure such as streets, utilities and sidewalks. Priority is given to those assets with the greatest need and impact to the community. Like other assets, trees inherently have both a public risk as well as significant public benefits. To reduce risks and maximize benefits, the City of Novi should assess risk and take corrective action through a systematic approach.

A successful risk management program seeks a balance between risk and benefit in an effort to manage trees effectively and prioritize the use of limited resources. The only way to eliminate risk is to eliminate all trees. Recognizing this is not desirable nor reasonable, the goal of a risk management system is to decrease public safety concerns as much as possible by identifying those trees with the greatest chance of impacting the public, thus reducing the overall risk of the urban forest and improving public safety community-wide.

Summary of Current Risk Management Practices

Within the City of Novi, tree risk management and assessments are primarily driven by citizen-initiated requests. Additionally, staff are encouraged to observe and record trees of elevated risk levels or that require additional inspection. Follow-up to these observations and requests consist of an inspection using industry-accepted best management practices and an issuance of a tree maintenance work order, as appropriate.

Photograph 3. *Large decay pocket in the trunk cavity observable from the ground-based inspection process.*

To an untrained eye, tree risk concerns may not be identified until a defect is severe (e.g., tree death). Relying on citizen requests may result in responding to primarily highly elevated tree risk concerns. Moreover, there are no guarantees that tree concerns are reported equally across the community. Certain populations or neighborhoods may be more engaged or more likely to report concerns than others. If tree maintenance is primarily allocated based on requests, a community runs the risk of inequitably serving its population.

With a proactive plan of action, trees are assessed and reviewed on a systematic basis. Those trees located within high priority areas (based on land use, and frequency of usage) or with specific risk profiles (e.g., tree condition) can be identified and an assessment methodology can be implemented to increase the chances of identifying a tree concern prior to failure and possibly causing irreparable damage. The city can then use these data to determine how best to prioritize tree maintenance activities. In addition to improving public safety, systematic approaches to tree maintenance have also been shown to be more cost-effective over the long term, taking care of small problems before they become big, expensive problems. Ultimately, this systematic approach will place the city in a position to minimize damages incurred to person or property, reduce long-term costs, and improve public perception.

At the end of the day, the primary goal of a successful tree risk management program is to provide a systematic approach to identify concerns, prioritize response, and implement corrective actions within a reasonable time frame. It is unreasonable to assert that all risk can be addressed with the establishment of a tree risk management program. However, the protocol illustrated in this section uses the information collected during the tree inventory as a key to prioritize the work to be performed first and establishes the method by which the work is to be performed in accordance to industry standards.

Risk Assessment Methodology

Trees are living, dynamic systems, and because of this they are subject to failure. The risk associated with a tree is a product of two factors; a defect within the tree and the interaction between the tree's defect and with surrounding persons and/or property. In the context of this discussion, risk assessment is referenced as described in the *ANSI A300* (2023)and the companion publication *Best Management Practices: Tree Risk Assessment*, published by the International Society of Arboriculture.

In the ANSI A300 system, there are three levels of risk assessment. Each level is built on the one before it. The lowest level is designed to be a cost-effective approach to quickly identifying tree risk concerns, whereas the highest level is intended to provide in-depth information to make a decision about a particular tree. These levels are:

- **Level 1** inspection is defined as a Limited Visual assessment, which is often conducted as a walk-through or windshield survey designed to identify obvious defects or specified conditions.
- **Level 2** inspection is defined as a Basic assessment and is a detailed, 360-degree visual inspection of a tree and its surrounding site, and a synthesis of the information collected.
- **Level 3** inspection is an Advanced assessment and is performed to provide detailed information about specific tree parts, defects, targets, or site conditions. A level 3 inspection may use specialized tools or require the input of a particular expert.

Each level of risk assessment has an intended purpose and usefulness. In order to determine the risk associated with a tree, an arborist must first identify the defects of concern. The severity and extent of those defects will determine the likelihood of that tree part to fail within a given timeframe or inspection interval. The inspection interval is determined by the arborist and the person or entity responsible for the tree. This should be based on the anticipated frequency of inspections by an arborist and the current state of the tree's overall health including any structural weaknesses or pest or disease issues.

In addition to the potential for failure of a tree part due to a tree defect, an arborist will have evaluated the targets associated with the tree and determine the likelihood for the failed tree part impacting the identified targets. Targets can range from persons or property that have an inherent value associated with them. An arborist must consider the occupancy rating of identified targets. A picnic table or shelter may always be present within the area, but people or cars may have intermittent association with the tree and its defects. It is not that these potential targets are not important, but the risk level should be based on the likelihood of a failure impacting a particular target. If these targets are not always present, the likelihood of presence of these targets when the failure occurs should be considered as part of determining a risk level.

The final variable in determining the risk associated with an identified tree part is defining the consequence of the failed tree part impacting the target. In level two and three assessments, it may be necessary to evaluate several tree defects in association with different targets to determine the principal risk rating to assign to an individual tree. This will always be the highest risk rating that is determined for the tree. Once all these variables are taken into consideration, a risk rating is assigned to the tree overall.

Tree Risk Management Protocol

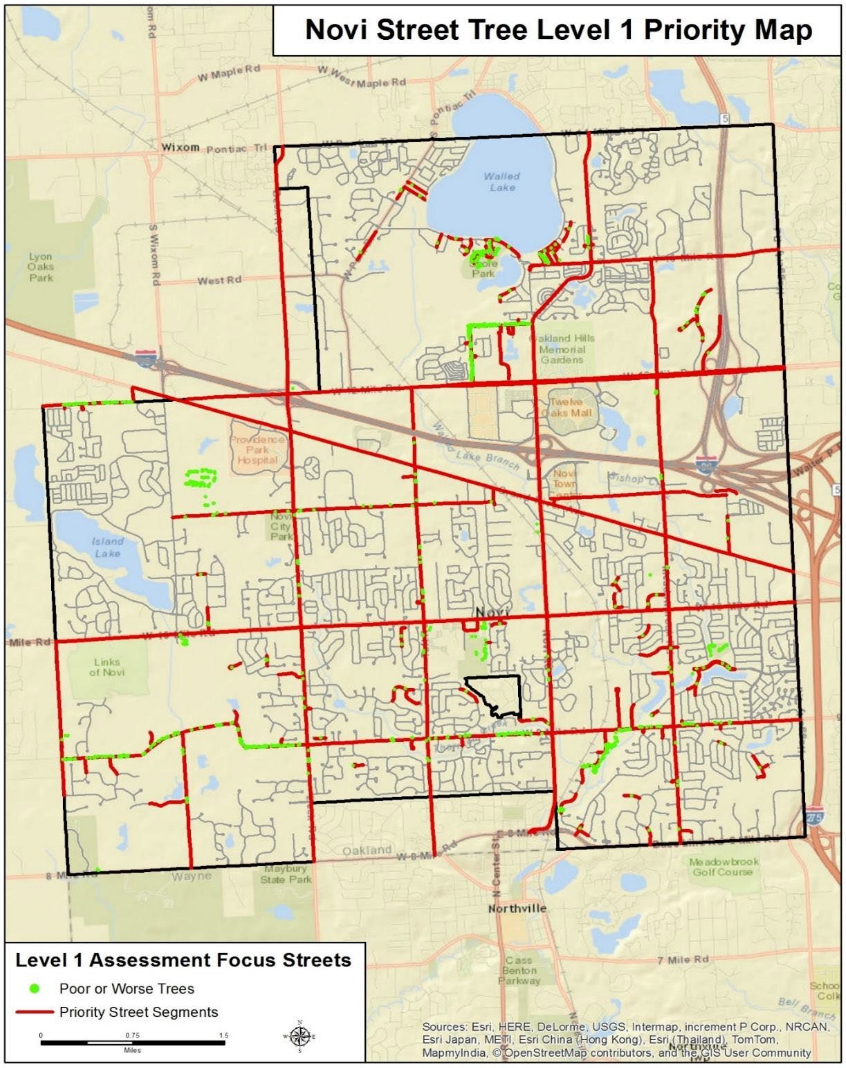
Considering an elevated tree risk level inherently requires a target, it is reasonable to determine what areas of a given community have targets that could lead to an elevated risk level. Commonly, these include major thoroughfares, business districts, or emergency routes. Particular parks or areas of a park may be more highly used than others. All of these factors should be considered when establishing tree risk assessment protocol and directly assessing tree risk.

Information contained in the city's tree inventory data can be used to yield a listing of trees. Particular tree risk profiles (e.g., size of tree, species, etc.) can be used to determine timing and frequency of the city's tree inspection cycles. For example, the size of a tree relates to the relative age of the tree and in conjunction with the Condition rating for the tree may lend insight into which trees may have an elevated probability of possible tree defects.

One of the primary factors that are part of the risk assessment process is the potential for the tree defect to fail. In an effort to quantify this potential across the city, trees of a certain DBH (seven inches and greater) with a Condition value of Poor or worse were identified. There is a strong, but not absolute, correlation between the condition of a tree and the extent and severity of tree defects within the tree. This in turn translates to the likelihood of those tree defects within the tree parts to potentially fail. This helps identify potential tree risk concerns and frame prioritization of tree risk assessment. This does not mean that trees in relatively Good condition or better are without significant defect or vice versa, but rather serves as a way to allocate limited resources to identify and address tree risk. Based on available funding, an initial assessment can be accomplished at the city scale or as identified in Map 1, in and along the highest priority areas and streets.

The map is an illustration of a combination of priority areas weighed by land use and where trees where identified in the inventory as being in Poor or worse condition. The map follows major thoroughfares, neighborhoods with certain tree characteristics (Poor or worse condition), and certain high traffic areas like those zoned for commercial use. In addition to this, attention was devoted to those streets and spaces that have specific "public good" usage such as medical facilities and neighborhoods with elevated population densities.

Along with tree inventory analytics and a standard assessment cycle, additional tree assessments should be completed along the priority street segments illustrated in the map below after major storm events and included as part of an emergency preparedness program. See Appendix D for a complete listing of Level 1 roadways.

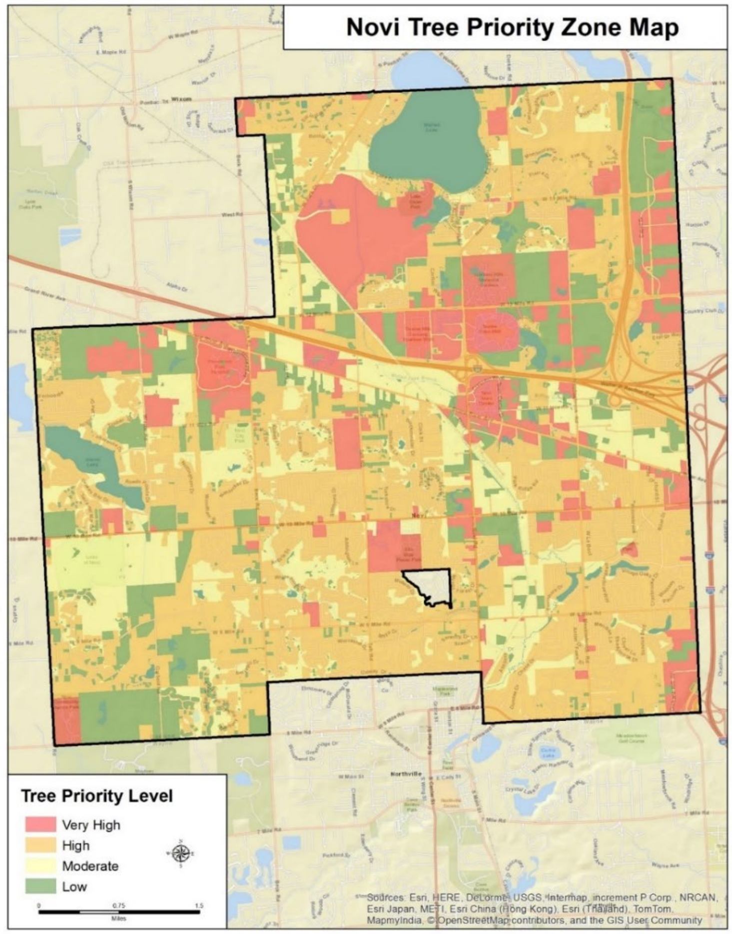


Map 1. Novi Level One Priority Streets.

STEP 1. ESTABLISH TREE RISK ZONES

In order to prioritize the initial and future tree work, it will be important to not only delineate the type of inspections needed but locations in which the inspections take place. The first step to this prioritization process was to identify those streets and public space areas of the city with the greatest potential for trees of an elevated risk. Several factors associated with the tree risk evaluation process were utilized to establish priority zones for the city.

Map 2 reflects a prioritization of the parcel information and is weighted according to land usage and impact on public services with consideration given to those individual public parks with elevated usage. The factor employed to serve as the initial delineation of the city into management areas is through the land use GIS layer provided by the city. These land uses are identified in a GIS layer and are weighted based on the potential for association with high value target such as persons or life-giving services (utilities) and emergency access routes.



Map 2. Novi Tree Priority Level.

STEP 2. ASSESS THE PUBLIC URBAN FOREST

Based on an assessment of the city's inventory data, the frequency of inspection should be based on a prioritization of purpose and frequency of usage of the property, and in the cases of street trees of the adjacent property. These would only include the trees owned and managed by the city.

- Those properties controlled by the city along with the trees immediately adjacent to private properties within a **Very High priority** zone should be assessed on an annual basis using the Level 1 methodology (Table 8).

- Public trees falling within a **High priority** zone should be assessed on a two- to four-year interval using the Level 1 methodology. Both priority levels would include a Level 2 or 3 as request by the initial inspector or homeowner.
- **All priority areas** should receive a five- to seven-year Level 2 inspection with a Level 3 assessment as requested. This inspection interval should precede the routine pruning cycles to allow for the information such as diameter, maintenance recommendation, and risk assessment to factor in budget and overall management decisions.

In the sample budget provided, an allotment of 40 total hours for the parks and public spaces and 80 total hours for the street ROW has be allocated to be divided among the three inspection levels. These allocations should be sufficient over the course of a typical growing season, and do not account for the 5- to 7-Year Level 2 citywide inspection. A listing of the specific inspection levels and synopsis of timing can be found below:

- **Level 1** inspection is included in the budget for trees that cannot be addressed in Year 1 and following years to see if the risk associated with those trees has increased. It also includes areas with large host populations to be inspected for pests. A tree that is requested for a further inspection through the Level 1 process will need at least a Level 2 inspection, but could require a Level 3 (an aerial inspection or cavity/decay measurement tool may be required). Level 1 inspections will most often result in either no action or immediate action. The intended purpose of Level 1 inspection is to identify and remediate immediate tree risk concerns. The level of inspection can take many forms, from a post storm windshield survey or regular walk-throughs of assessment areas.
- **Level 2** inspection also included in the budget tables for the report, and is intended as a follow-up to a Level 1 inspection as a baseline inspection for a specific tree of concern. It is recommended that this be performed using TRAQ methodology on an individual tree basis that has been noted for further inspection.

  It is recommended that the entire public managed urban forest be evaluated using the tree risk categorization of this methodology on a cyclic basis of 5–7 years. This would not require the use of the TRAQ methodology but would require elements from it including the identification of tree defect associated with the evaluation, and residual risk after mitigation activity is performed. This will coincide with the cyclic pruning cycles.
- **Level 3** inspection should be performed if the tree defect of note is not directly observable from the ground or without the use of extraordinary measures. This methodology will provide a more detailed information regarding individual tree parts, defects, targets, or site conditions. This assessment can take many forms and may employ one or more of the following measures—aerial inspection, assessment of internal decay, root excavation, and evaluation most commonly.

In the instances of a significant storm events, such as a tornado, ice or wind, Level 1 inspection will be necessary for those areas directly affected as way of re-prioritizing the immediate needs of urban forest. This can span multiple zones and priority types. If the entire city is affected, then inspection should follow prioritization levels accordingly, and continue as budgets allow for.

Table 8. Priority and Timing of Inspection Intervals

Priority	Timing of Inspections	Inspection Type
Very High	Annual	Level 1, Level 2–3 upon request
High	2–4 Years	Level 1, Level 2–3 upon request
Very High - Low	5–7 Years	Level 2, Level 3 upon request
All Zones	After Storm Events	Level 1, Level 2–3 upon request

The assessment prioritization process will need to be revaluated on a periodic cycle as updated information in the tree database and GIS becomes available or as trees are removed due to poor condition or as rezoning and future development occurs. It is recommended that this prioritization of the primary inspection streets and public areas occur in association with the Level 2 inspections on a 5- to 7-year cycle. Many of the main city streets and most frequented parks/public spaces will not change, but some of the residential and secondary roadways will upon revaluation. In addition to updated GIS information, prioritization will need to be given to those areas affected by a storm event, construction activity, or pest or disease outbreak.

Parks or public spaces which have an increased occupancy and frequency rate, such as ITC Community Sports Park, Elle Mae Power Park and Lakeshore Park, will have an elevated risk associated with the tree defects merely based on that fact. As previously discussed, an increased interaction between targets, i.e., persons or property, results in an increase in risk. Because of this, it will be important to delineate the parks and public spaces into high and low usage. The usage rate can be based on an established or a cursory survey for the parks system for the different locations, and the distinction between high and low should be based on the city's acceptable level of risk for those spaces. It will be important to note that street trees will often be by their very nature subject to higher occupancy rates than park/public space trees. Just like the streets, the different levels of usage in combination with relative age and condition ratings of the tree population for those parks and public spaces will distinguish how often those spaces should be evaluated and level in which they should be inspected.

The results of the inspection process should be reincorporated back into the existing tree inventory database in order to keep the information as current as possible. It is recommended that work performed as either preventative or as part of a mitigation plan be tracked in the tree database as well.

STEP 3. PRIORITIZE TREE MAINTENANCE ACTIVITIES

The evaluation of the community's trees is just the beginning of the process. Trees will require a maintenance assignment in order to mitigate their associated risk. Based on the different defects assessed at the time of inspection, priority will be given to those trees that demonstrate the greatest risk to the surrounding targets associated with them.

Those trees found to be in immediate need of maintenance should be addressed as soon as reasonable and as budgets will allow for. It is recommended that that trees in Poor or worse condition in close association with established targets, whether removal or priority prune, be addressed in year one of the program implementation. The important aspect of the priority assignment is that there is systematic approach, and that the trees are being addressed as soon as practical. Once the initial and any follow-up inspection is complete for a single or grouping of trees, then a mitigation plan should be developed. In the case of a single tree, that plan will be encompassed in the TRAQ form; in the case of a grouping of trees, such as a specific management area, a plan should be developed that includes a prioritized listing according to maintenance task and risk assignment such as the one illustrated in Section 4 of this document.

If it's determined that funding for such activities are lacking, the results of the tree data should be used to advocate for additional funding for tree maintenance. Those streets and parks that have the greatest usage should take precedence when deciding which individual trees should be addressed first. For those trees determined to fall within the boundary between the public right-of-way and private property, ownership will need to be assigned prior to mitigation measures. Trees in natural areas not in proximity to trail systems, landscaped areas, or shelters should be excluded from the cyclic inspection and subsequent maintenance program. The fall zone for individual trees will help determine the proximity threshold for targets in these natural or wooded areas.

Staff Training

An integral part of the process is the training of city staff to identify and assess tree defects and, particularly, the targets associated with them. In addition to this, training on policy and procedure of the protocols and methodology described in this section will help support the city's risk management program. Training in the assessment of trees can take on many forms, from informal seminars for general staff up to and including formal accreditation, or qualification components for those city staff who regularly work with trees or in maintenance roles. This will allow the city staff to gain the necessary tools, familiarity, and expertise with industry standards to make informed decisions regarding the city's urban forest and correctly report tree concerns. Nothing will take the place of years of experience, but training can allow the identified city staff to have the required knowledge base to put those professional experiences into context.

In-depth training should first be offered to those city staff who regularly assess trees. This training should include a primer in ANSI A300 and Tree Risk Assessment Qualification methodologies. While a complete training program might include completion of the Tree Risk Assessment Qualification, a less formalized program should include:

- Assessment of Targets and Occupancy Frequency – identifying targets associated with an individual or grouping of trees, and the frequency of those interactions.
- Signs, Severity, and Extent of Tree Defects – evaluating tree defects and assessing the probability of the associated tree part.
- Tree Risk Profiles – analyzing tree data to incorporate a prioritization level and maintenance request.
- Risk Assessment Walk Through – risk assessment evaluation demonstration for different level of inspections.

Additional training and dissemination of the city's approach to tree risk management and general tree care can be distributed in less formal settings to other city staff. Such a training should develop an understanding and recognition of the city's approach but does not need to get deep into the biology, function, and structure of trees. Ideal participants would be risk management personnel, emergency personnel, and city staff who regularly drive streets and may informally report tree concerns. Training topics should include:

- Tree Basics – review of tree biology and anatomy concepts.
- Principals of Tree Risk Evaluations – outline of different tree inspection types and general inspection methodology.
- Elements of a Tree Risk Management Program – overview a city's tree risk management program with policy and procedure review.

The risk assessment methodology and protocols described in this report were developed by the International Society Arboriculture (ISA) and are part of their training curriculum and credentials. Based on the development status of the individual arborist and use of the risk assessment protocols, additional trainings may be necessary. It is recommended that the city have at least one Tree Risk Assessment Qualified (TRAQ) accredited individual to provide guidance to the other tree assessors and arborists in making tree assessment. Any residual staff arborists should be or in the process of obtaining Certified Arborist status. Both credentials and associated training can be obtained through the ISA, and each have recurrent trainings as part of their renewal process. This will enable the individual arborists to stay current on industry standards and the latest arboricultural practices.

Reevaluate Program Effectiveness

As previously discussed, adjustments to the tree risk management protocols and procedures will need to be made as those factors that define tree risk change within the city. Changes to land usage through zoning, annexation of adjoining properties, or adjustments to transportation routes will all affect the dynamics of the tree risk management program. The management of tree risk should be evaluated holistically, and should incorporate changes to industry standards, new methodologies, and technologies. It is recommended that a periodic evaluation of these changes and adjustments be made to the program on the 5- to 7-year cycle to optimize the program's effectiveness. The timing of this should be immediately prior to the citywide Level 2 assessment.

Along with a general reevaluation of the tree risk policies and procedures, thought should be given not only to the mitigation but also to the prevention of tree risk. One way this is possible is through the establishment of sound arboricultural practices in accordance to the *ANSI A300* standards discussed throughout this document. Another way in which risk can be avoided is through planting in accordance to the site conditions, and choosing species with lower susceptibility to structural, pest. and disease issues.

NOVI'S RISK MANAGEMENT PROGRAM SYNOPSIS

The following steps should be considered integral to Novi's risk assessment protocol:

1. Identify risk management priority or inspection zones.
2. Determine inspection interval and type (i.e., level 1, level 2, level 3) for each zone/priority type.
3. Execute inspections/assessments at a regular basis.
4. Address risk concerns identified.
5. Implement regular staff training and communication as part of the program.
6. Repeat inspections at regular intervals.
7. Assess program effectiveness and make adjustments, as necessary.

SECTION 5: STREET AND PARK TREE MANAGEMENT PROGRAM

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

While implementing a tree care program is an ongoing process, tree work must always be prioritized to reduce public safety risks. DRG recommends completing the work identified during the inventory based on the maintenance task and condition rating; however, routinely monitoring the tree population is essential so that other priority trees can be identified and systematically addressed. While regular pruning cycles and tree planting are important, priority work must sometimes take precedence to ensure that risk is expediently managed.

Priority and Proactive Maintenance

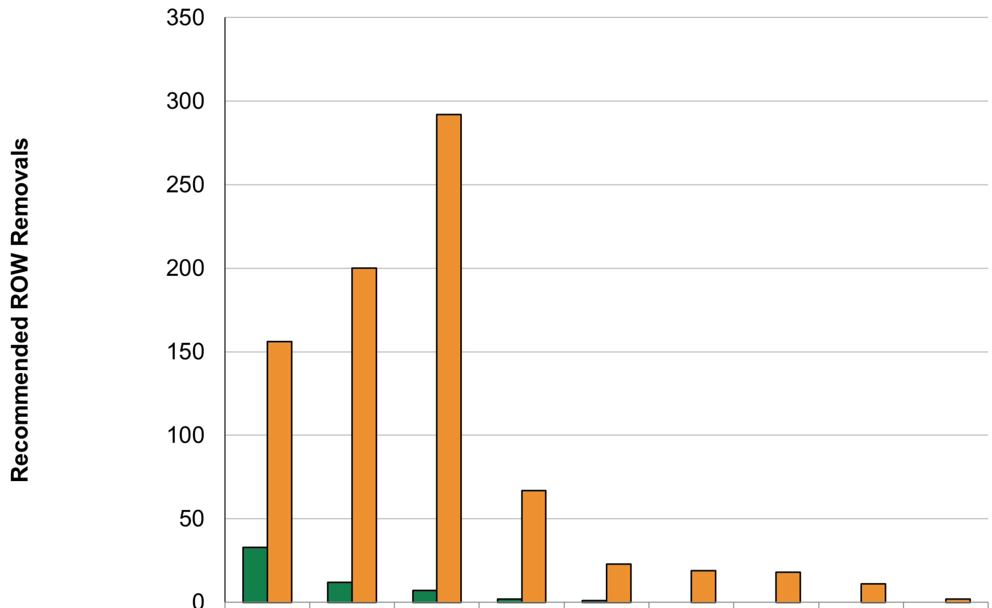
In this plan, the recommended tree maintenance work was divided into either priority or proactive maintenance. Priority maintenance includes tree removals and pruning of trees with an assessed condition rating of Poor and Dead. Proactive tree maintenance includes pruning of trees with an assessed condition rating of Good and Fair. Tree planting, inspections, and community outreach are also considered proactive maintenance.

TREE AND STUMP REMOVAL

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

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

Figure 17 presents tree removals by condition rating and diameter size class. The following sections briefly summarize the recommended removals identified during the street tree inventory.

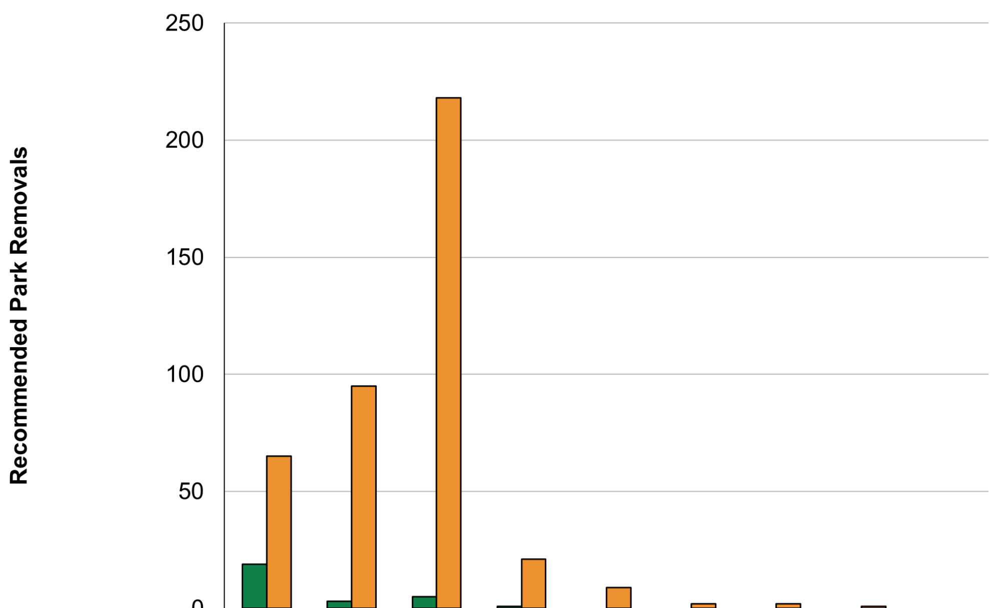


	1-3"	4-6"	7-12"	13-18"	19-24"	25-30"	31-36"	37-42"	>43"
Routine Removal	33	12	7	2	1	0	0	0	0
Priority Removal	156	200	292	67	23	19	18	11	2

Size Class

Figure 17. Street tree removals by condition rating and diameter size class.

Figure 18 presents tree removals by condition rating and diameter size class. The following sections briefly summarize the recommended removals identified during the Park tree inventory.



	1-3"	4-6"	7-12"	13-18"	19-24"	25-30"	31-36"	37-42"	>43"
Routine Removal	19	3	5	1	0	0	0	0	0
Priority Removal	65	95	218	21	9	2	2	1	0

Size Class

Figure 18. Park tree removals by condition rating and diameter size class.

FINDINGS

The inventory identified 788 Poor and Dead street trees and 413 Poor and Dead park trees recommended for priority removal. In addition to this, the inventory identified 55 Fair or better and street trees and 28 Fair or better park trees recommended for removal.

Fair or better condition trees noted for removal are generally invasive, or poorly formed trees that need to be removed. A majority of the trees in this category are under 12 inches or less in DBH. Eliminating these trees will reduce breeding site locations for insects and diseases and will increase the aesthetic value of the area. Healthy trees growing in poor locations or undesirable species such as *Ailanthus altissima* (tree of heaven) are generally included in this category.

Overall the inventory (both in streets and parks) identified 117 ash trees recommended for removal. A total of 32 stumps along streets and 2 stumps in parks were recommended for removal. Almost all of these stumps were smaller than 19 inches in diameter. Stump removals should occur when convenient.

DISCUSSION/RECOMMENDATIONS

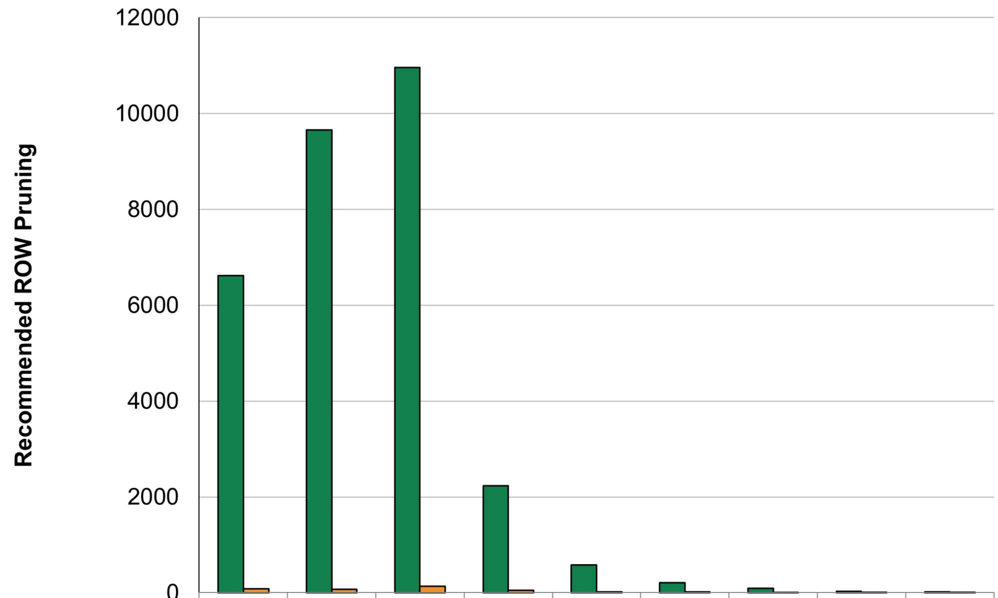
Unless already slated for removal, trees noted as having stress (2,502 trees, both datasets combined) or wound (2,107 trees, both datasets combined) should be inspected on a regular basis. This plan's budget includes funds earmarked to perform Level 1 assessments at these sites each year. Corrective action should be taken when warranted. If their condition worsens, tree removal may be required. Proactive tree maintenance that actively mitigates elevated-risk situations will promote public safety.

Updating the tree inventory data can streamline workload management and lend insight into setting accurate budgets and staffing levels. Inventory updates should be made electronically and can be implemented using TreeKeeper® 8 or similar computer software.

TREE PRUNING

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

Figure 19 presents the number of priority street trees recommended for pruning by size class. The following sections briefly summarize the recommended pruning maintenance identified during the inventory.

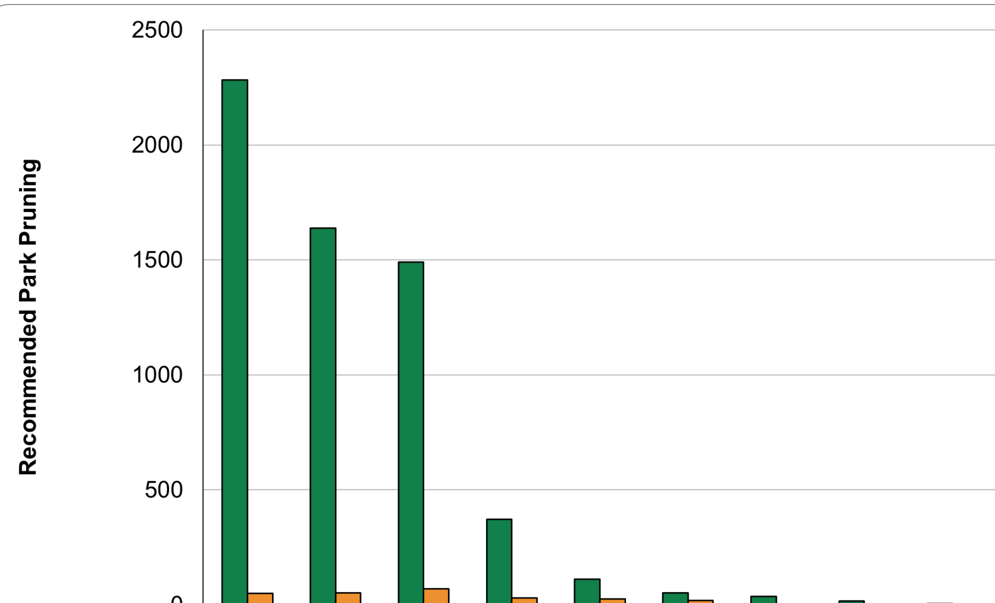


	1-3"	4-6"	7-12"	13-18"	19-24"	25-30"	31-36"	37-42"	>43"
Routine Prune	6620	9660	10963	2234	580	206	90	35	16
Priority Prune	85	75	132	54	20	18	14	3	4

Size Class

Figure 19. Street priority pruning by diameter size class.

Figure 20 presents the number of priority park trees recommended for pruning by size class. The following sections briefly summarize the recommended pruning maintenance identified during the inventory.



	1-3"	4-6"	7-12"	13-18"	19-24"	25-30"	31-36"	37-42"	>43"
Routine Prune	2282	1638	1491	372	111	52	37	16	5
Priority Prune	50	53	70	29	25	19	3	3	0

Size Class

Figure 20. Park priority pruning by diameter size class.

FINDINGS

The inventory identified 405 priority street trees and 252 priority park trees recommended for pruning.

This pruning should be performed immediately based on location and may be performed concurrently with other priority removals and pruning. Fair or better condition trees recommended for pruning should be included in a proactive, routine pruning cycle after all the priority trees are addressed. Level 1 inspections will observe Low maintenance priority trees, and determine if further maintenance action is required.

PRUNING CYCLES

The goals of pruning cycles are to visit, assess, and prune trees on a regular schedule to improve health and reduce risk. DRG recommends that pruning cycles begin after all priority trees are corrected through removal or pruning. However, due to the long-term benefits of pruning cycles, DRG recommends that the cycles be implemented as soon as possible.

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

PROACTIVE PRUNING

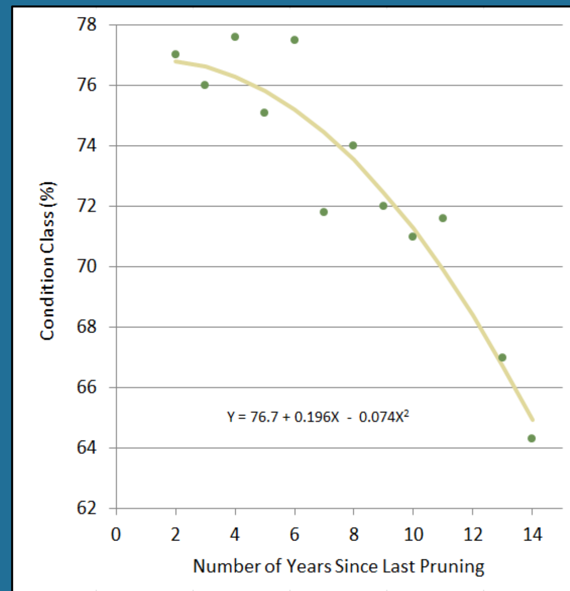


Figure 21. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

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

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

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

YOUNG TREE TRAINING (YTT) CYCLE

Trees included in the YTT Cycle are generally 6 inches DBH or less. These younger trees sometimes have branch structures that can lead to potential problems as the tree ages. Potential structural problems include codominant leaders, multiple limbs attaching at the same point on the trunk, or crossing/interfering limbs. If these problems are not corrected, they may worsen as the tree grows, increasing risk and creating potential liability.

YTT pruning is performed to improve tree form or structure; the recommended length of a YTT Cycle is three years because young trees tend to grow at faster rates (on average) than more mature trees. The YTT Cycle for Novi was extended to five years to accommodate the high number of trees needing training.

The YTT Cycle differs from the RP Cycle in that these trees generally can be pruned from the ground with a pole pruner or pruning shear. The objective is to increase structural integrity by pruning for one dominant leader.

YTT Pruning is species specific, since many trees such as *Betula nigra* (river birch) may naturally have more than one leader. For such trees, YTT pruning is performed to develop a strong structural architecture of branches so that future growth will lead to a healthy, structurally sound tree.

DISCUSSION/RECOMMENDATIONS

DRG strongly recommends that Novi implement a three-year YTT Cycle to begin after all priority trees are removed or pruned. The YTT Cycle will include existing young trees. The inventory suggests 20,463 trees 6 inches DBH or less were inventoried and are recommended for young tree training (Figures 22 & 23). Therefore, DRG recommends that an average of 6,821 street and park trees be structurally pruned each year over 3 years, beginning in Year One of the management program. If trees are planted, they will need to enter the YTT Cycle after establishment, typically a few years after planting. Young tree training is recommended to begin one to two years after planting and continue every three years until the tree can

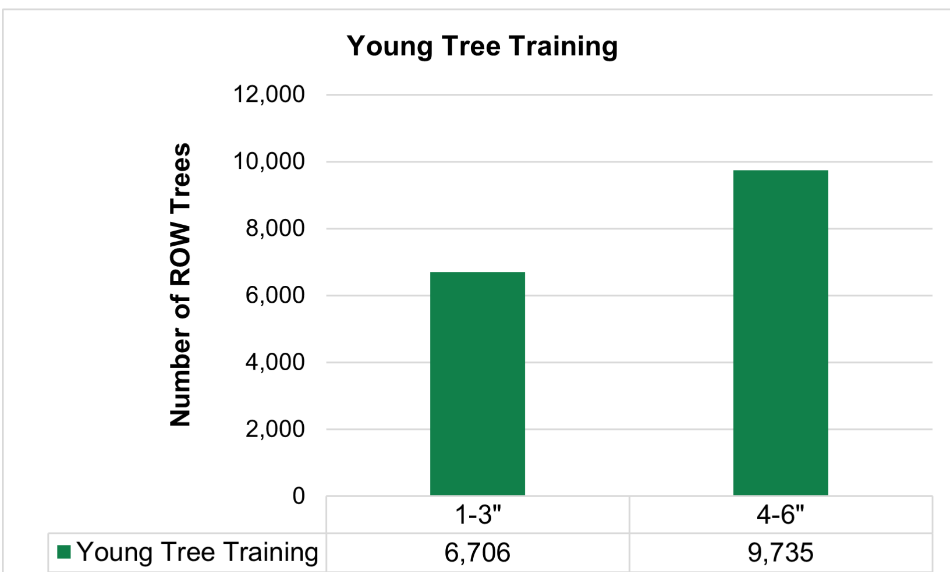


Figure 22. Street trees recommended for the YTT Cycle by diameter size class.

no longer be safely pruned from the ground with a pole pruner and pruning shears. At the time of planting, new trees should be minimally pruned to remove broken or crossing branches.

Not every tree in the young tree training cycle will need to be pruned each cycle – thus, the actual cost to maintain a young tree pruning cycle will likely be lower than projected in the budget table provided at the end of this section (Table 9). In future years, the number of trees in the YTT Cycle will be based on tree planting efforts and growth rates of young trees. The city should strive to prune approximately one-third of its young trees each year.

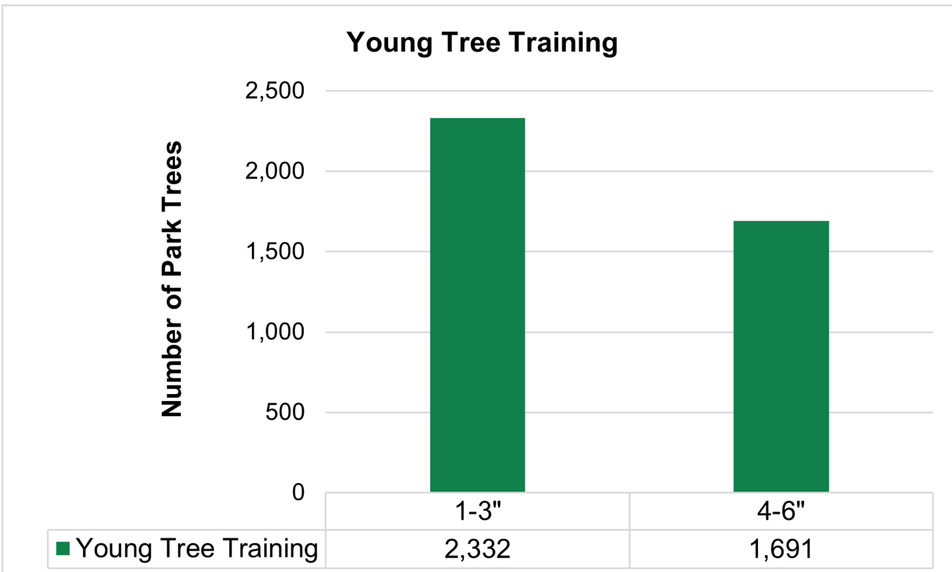


Figure 23. Park trees recommended for the YTT Cycle by diameter size class.

Routine Pruning Cycle

The RP Cycle includes established, maturing, and mature trees (mostly greater than 8 inches DBH) that need cleaning, crown raising, and reducing to remove deadwood and improve structure. Over time, routine pruning can reduce reactive maintenance, minimize instances of elevated risk, and provide the basis for a more defensible risk management program. Included in this cycle are moderate and low priority trees that require pruning and pose some risk but have a smaller size of defect and/or less potential for target impact. To ensure that all trees receive the type of pruning they need to mature with better structure and lower associated risk, two pruning cycles are recommended: the young tree training cycle (YTT Cycle) and the routine pruning cycle (RP Cycle). The defects found within these trees can usually be remediated during the RP Cycle.

THE YOUNG TREE TRAINING CYCLE (YTT CYCLE)

The recommended number of trees in the pruning cycles will need to be modified to reflect changes in the tree population as trees are planted, age, and die. Newly planted trees will enter the YTT Cycle once they become established. As young trees reach maturity, they will be shifted from the YTT Cycle into the RP

Cycle. When a tree reaches the end of its useful life, it should be removed and eliminated from the RP Cycle.

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

Why Prune Trees on a Cycle?

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

DISCUSSION/RECOMMENDATIONS

DRG recommends that the city establish a five-year RP Cycle in which approximately one-fifth of the tree population is to be pruned each year. The inventory suggests approximately 16,289 trees that should be pruned over a five-year RP Cycle. An average of 3,241 street and park trees should be pruned each year over the course of the cycle. DRG recommends that the RP Cycle begin in Year One of this five-year plan, after all Extreme and High Risk trees are pruned.

The inventory found that nearly half of all the trees (41%) on the street and park needed routine pruning.

Maintenance Schedule

Utilizing data from the City of Novi tree inventory, an annual maintenance schedule was developed that details the number and type of tasks recommended for completion each year. DRG made budget projections using industry knowledge and public bid tabulations. Actual costs were not specified by Novi. A summary of the maintenance schedule is presented (right); a complete table of estimated costs for Novi's five-year Street (Table 9) and Parks (Table 10) tree management program follows.

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

To implement the street maintenance schedule, the city's tree maintenance budget should be no less than $1,006,000 for the first year of implementation, no less than $831,000 for the second year, and no less than $799,000 for the final three years of the maintenance schedule. To implement the park maintenance schedule, the city's tree maintenance budget should be no less than $214,000 for the first year of implementation, no less than $180,000 for the second year, and no less than $151,000 for the final three years of the maintenance schedule. Annual budget funds are needed to ensure that extreme and high-risk trees are remediated and that crucial YTT and RP Cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

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

Five years is the industry best practice, however with decreased revenue impacting the funding for tree maintenance, an alternative 7 year street tree maintenance cycle has been developed in Tables 11 and 12 below.

Table 9. Estimated Costs for Five-Year Urban Forestry Management Program – Street Trees

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/ Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Dead and Poor Condition Removals	1-3"	$96	156	$14,976									$14,976
	4-6"	$96	200	$19,200									$19,200
	7-12"	$96	292	$28,032									$28,032
	13-18"	$264	67	$17,688									$17,688
	19-24"	$627	23	$14,421									$14,421
	25-30"	$1,294	19	$24,586									$24,586
	31-36"	$1,671	18	$30,078									$30,078
	37-42"	$2,384	11	$26,224									$26,224
	43"+	$2,885	2	$5,770									$5,770
Activity Total(s)			**788**	**$180,975**									**$180,975**
Fair or Better Condition Removals	1-3"	$96			33	$3,168							$3,168
	4-6"	$96			12	$1,152							$1,152
	7-12"	$96			7	$672							$672
	13-18"	$264			2	$528							$528
	19-24"	$627			1	$627							$627
	25-30"	$1,294											
	31-36"	$1,671											
	37-42"	$2,384											
	43"+	$2,885											
Activity Total(s)					**55**	**$6,147**							**$6,147**
Stump Removals	1-3"	$25											
	4-6"	$75											
	7-12"	$150											
	13-18"	$250											
	19-24"	$350											
	25-30"	$450											
	31-36"	$500											
	37-42"	$600											

	43"+	$650											
Activity Total(s)													
Poor Condition Prunes	1-3"	$60			85	$5,100							$5,100
	4-6"	$74			75	$5,550							$5,550
	7-12"	$114			132	$15,048							$15,048
	13-18"	$141	54	$7,614									$7,614
	19-24"	$213	20	$4,260									$4,260
	25-30"	$317	18	$5,706									$5,706
	31-36"	$377	14	$5,278									$5,278
	37-42"	$417	3	$1,251									$1,251
	43"+	$430	4	$1,720									$1,720
Activity Total(s)			**113**	**$25,829**	**292**	**$25,698**							**$51,527**
Routine Pruning (5-year cycle)	1-3"	$60											
	4-6"	$74											
	7-12"	$114	1,615	$184,110	1,615	$184,110	1,615	$184,110	1,615	$184,110	1,615	$184,110	$920,550
	13-18"	$141	317	$44,697	317	$44,697	317	$44,697	317	$44,697	317	$44,697	$223,485
	19-24"	$213	78	$16,614	78	$16,614	78	$16,614	78	$16,614	78	$16,614	$83,070
	25-30"	$317	25	$7,925	25	$7,925	25	$7,925	25	$7,925	25	$7,925	$39,625
	31-36"	$377	8	$3,016	8	$3,016	8	$3,016	8	$3,016	8	$3,016	$15,080
	37-42"	$417	4	$1,668	4	$1,668	4	$1,668	4	$1,668	4	$1,668	$8,340
	43"+	$430	2	$860	2	$860	2	$860	2	$860	2	$860	$4,300
Activity Total(s)			**2,049**	**$258,890**	**2,049**	**$258,890**	**2,049**	**$258,890**	**2,049**	**$258,890**	**2,049**	**$258,890**	**$1,294,450**
Young Tree Train (5-year cycle)	1-3"	$60	1,324	$79,440	1,324	$79,440	1,324	$79,440	1,324	$79,440	1,324	$79,440	$397,200
	4-6"	$74	1,932	$142,968	1,932	$142,968	1,932	$142,968	1,932	$142,968	1,932	$142,968	$714,840
Activity Total(s)			**3,256**	**$222,408**	**3,256**	**$222,408**	**3,256**	**$222,408**	**3,256**	**$222,408**	**3,256**	**$222,408**	**$1,112,040**
Vacant Tree Planting	Purchas-ing	$250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	$11,250
	Planting	$250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	$11,250
Activity Total(s)			**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**$22,500**
Replacement Young Tree Maintenance	Mulching	$250	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	$187,500
	Watering	$250	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	$187,500
Activity Total(s)			**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**$375,000**

Monitoring and Inspections	Level 1	$35	50	$1,750	50	$1,750	50	$1,750	50	$1,750	50	$1,750	$8,750
	Level 2	$50	20	$1,000	20	$1,000	20	$1,000	20	$1,000	20	$1,000	$5,000
	Level 3	$100	10	$1,000	10	$1,000	10	$1,000	10	$1,000	10	$1,000	$5,000
Activity Total(s)			**80**	**$3,750**	**80**	**$3,750**	**80**	**$3,750**	**80**	**$3,750**	**80**	**$2,750**	**$17,750**
Annual Mortality (1%) Removals	Average Tree	$222	300	$66,600	300	$66,600	300	$66,600	300	$66,600	300	$66,600	$333,000
Activity Total(s)				**$66,600**		**$66,600**		**$66,600**		**$66,600**		**$66,600**	**$333,000**
Annual Mortality (1%) Stump Removals	Average Tree	$60	300	$18,000	300	$18,000	300	$18,000	300	$18,000	300	$18,000	$90,000
Activity Total(s)				**$18,000**		**$18,000**		**$18,000**		**$18,000**		**$18,000**	**$90,000**
Annual Mortality (1%) Planting	Average Tree	$500	300	$150,000	300	$150,000	300	$150,000	300	$150,000	300	$150,000	$750,000
Activity Total(s)				**$150,000**		**$150,000**		**$150,000**		**$150,000**		**$150,000**	**$750,000**
Activity Grand Total			**6,604**		**6,050**		**5,703**		**5,703**		**5,703**		
Cost Grand Total				**$1,005,952**		**$830,993**		**$799,148**		**$799,148**		**$798,148**	**$4,233,389**

Table 10. Estimated Costs for Five-Year Urban Forestry Management Program – Park Trees

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/ Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Dead and Poor Condition Removals	1-3"	$96			65	$6,240							$6,240
	4-6"	$96			95	$9,120							$9,120
	7-12"	$96	109	$10,464	109	$10,464							$20,928
	13-18"	$264	21	$5,544									$5,544
	19-24"	$627	9	$5,643									$5,643
	25-30"	$1,294	2	$2,588									$2,588
	31-36"	$1,671	2	$3,342									$3,342
	37-42"	$2,384	1	$2,384									$2,384
	43"+	$2,885											
Activity Total(s)			**144**	**$29,965**	**269**	**$25,824**							**$55,789**
Fair or Better Condition Removals	1-3"	$96			19	$1,824							$1,824
	4-6"	$96			3	$288							$288
	7-12"	$96			5	$480							$480
	13-18"	$264			1	$264							$264
	19-24"	$627											
	25-30"	$1,294											
	31-36"	$1,671											
	37-42"	$2,384											
	43"+	$2,885											
Activity Total(s)					**28**	**$2,856**							**$2,856**
Stump Removals	1-3"	$25											
	4-6"	$75											
	7-12"	$150											
	13-18"	$250											
	19-24"	$350											
	25-30"	$450											
	31-36"	$500											
	37-42"	$600											
	43"+	$650											
Activity Total(s)													

Poor Condition Prunes	1-3"	$60	50	$3,000									$3,000
	4-6"	$74	53	$3,922									$3,922
	7-12"	$114	70	$7,980									$7,980
	13-18"	$141	29	$4,089									$4,089
	19-24"	$213	25	$5,325									$5,325
	25-30"	$317	19	$6,023									$6,023
	31-36"	$377	3	$1,131									$1,131
	37-42"	$417	3	$1,251									$1,251
	43"+	$430											
Activity Total(s)			**252**	**$32,721**									**$32,721**
Routine Pruning (5-year cycle)	1-3"	$60											
	4-6"	$74											
	7-12"	$114	298	$33,972	298	$33,972	298	$33,972	298	$33,972	298	$33,972	$169,860
	13-18"	$141	74	$10,434	74	$10,434	74	$10,434	74	$10,434	74	$10,434	$52,170
	19-24"	$213	22	$4,686	22	$4,686	22	$4,686	22	$4,686	22	$4,686	$23,430
	25-30"	$317	10	$3,170	10	$3,170	10	$3,170	10	$3,170	10	$3,170	$15,850
	31-36"	$377	7	$2,639	7	$2,639	7	$2,639	7	$2,639	7	$2,639	$13,195
	37-42"	$417	3	$1,251	3	$1,251	3	$1,251	3	$1,251	3	$1,251	$6,255
	43"+	$430	1	$430	1	$430	1	$430	1	$430	1	$430	$2,150
Activity Total(s)			**415**	**$56,582**	**415**	**$56,582**	**415**	**$56,582**	**415**	**$56,582**	**415**	**$56,582**	**$282,910**
Young Tree Train (5-year cycle)	1-3"	$60	456	$27,360	456	$27,360	456	$27,360	456	$27,360	456	$27,360	$136,800
	4-6"	$74	328	$24,272	328	$24,272	328	$24,272	328	$24,272	328	$24,272	$121,360
Activity Total(s)			**784**	**$51,632**	**784**	**$51,632**	**784**	**$51,632**	**784**	**$51,632**	**784**	**$51,632**	**$258,160**
Vacant Tree Planting	Purchasing	$250											
	Planting	$250											
Activity Total(s)													
Replacement Young Tree Maintenance	Mulching	$250											
	Watering	$250											
Activity Total(s)													
Monitoring and Inspections	Level 1	$35	25	$875	25	$875	25	$875	25	$875	25	$875	$4,375
	Level 2	$50	10	$500	10	$500	10	$500	10	$500	10	$500	$2,500
	Level 3	$100	5	$500	5	$500	5	$500	5	$500	5	$500	$2,500

Activity Total(s)			**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,375**	**$8,875**
Annual Mortality (1%) Removals	Average Tree	$133	60	$7,980	60	$7,980	60	$7,980	60	$7,980	60	$7,980	$39,900
Activity Total(s)			**0**	**$7,980**	**0**	**$7,980**	**0**	**$7,980**	**0**	**$7,980**	**0**	**$7,980**	**$39,900**
Annual Mortality (1%) Stump Removals	Average Tree	$60	60	$3,600	60	$3,600	60	$3,600	60	$3,600	60	$3,600	$18,000
Activity Total(s)			**0**	**$3,600**	**0**	**$3,600**	**0**	**$3,600**	**0**	**$3,600**	**0**	**$3,600**	**$18,000**
Annual Mortality (1%) Planting	Average Tree	$500	60	$30,000	60	$30,000	60	$30,000	60	$30,000	60	$30,000	$150,000
Activity Total(s)			**0**	**$30,000**	**0**	**$30,000**	**0**	**$30,000**	**0**	**$30,000**	**0**	**$30,000**	**$150,000**
Activity Grand Total			**1,635**		**1,536**		**1,239**		**1,239**		**1,239**		
Cost Grand Total				**$214,355**		**$180,349**		**$151,669**		**$151,669**		**$151,169**	**$849,211**

Table 11. Estimated Costs for Seven Year Urban Forestry Management Program – Street Trees

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		7-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Dead and Poor Condition Removals	1-3"	$96	156	$14,976													$14,976
	4-6"	$96	200	$19,200													$19,200
	7-12"	$96	292	$28,032													$28,032
	13-18"	$264	67	$17,688													$17,688
	19-24"	$627	23	$14,421													$14,421
	25-30"	$1,294	19	$24,586													$24,586
	31-36"	$1,671	18	$30,078													$30,078
	37-42"	$2,384	11	$26,224													$26,224
	43"+	$2,885	2	$5,770													$5,770
Activity Total(s)			**788**	**$180,975**													**$180,975**
Fair or Better Condition Removals	1-3"	$96			33	$3,168											$3,168
	4-6"	$96			12	$1,152											$1,152
	7-12"	$96			7	$672											$672
	13-18"	$264			2	$528											$528
	19-24"	$627			1	$627											$627
	25-30"	$1,294															
	31-36"	$1,671															
	37-42"	$2,384															
	43"+	$2,885															
Activity Total(s)					**55**	**$6,147**											**$6,147**
Stump Removals	1-3"	$25															
	4-6"	$75															
	7-12"	$150															
	13-18"	$250															
	19-24"	$350															
	25-30"	$450															

	31-36"	$500															
	37-42"	$600															
	43"+	$650															
Activity Total(s)																	
Poor Condition Prunes	1-3"	$60			85	$5,100											$5,100
	4-6"	$74			75	$5,550											$5,550
	7-12"	$114			132	$15,048											$15,048
	13-18"	$141	54	$7,614													$7,614
	19-24"	$213	20	$4,260													$4,260
	25-30"	$317	18	$5,706													$5,706
	31-36"	$377	14	$5,278													$5,278
	37-42"	$417	3	$1,251													$1,251
	43"+	$430	4	$1,720													$1,720
Activity Total(s)			**113**	**$25,829**	**292**	**$25,698**											**$51,527**
Routine Pruning (7-year cycle)	1-3"	$60															
	4-6"	$74															
	7-12"	$114	1,154	$131,556	1,154	$131,556	1,154	$131,556	1,154	$131,556	1,154	$131,556	1,154	$131,556	1,154	$131,556	$920,892
	13-18"	$141	226	$31,866	226	$31,866	226	$31,866	226	$31,866	226	$31,866	226	$31,866	226	$31,866	$223,062
	19-24"	$213	56	$11,928	56	$11,928	56	$11,928	56	$11,928	56	$11,928	56	$11,928	56	$11,928	$83,496
	25-30"	$317	18	$5,706	18	$5,706	18	$5,706	18	$5,706	18	$5,706	18	$5,706	18	$5,706	$39,942
	31-36"	$377	6	$2,262	6	$2,262	6	$2,262	6	$2,262	6	$2,262	6	$2,262	6	$2,262	$15,834
	37-42"	$417	3	$1,251	3	$1,251	3	$1,251	3	$1,251	3	$1,251	3	$1,251	3	$1,251	$8,757
	43"+	$430	1	$430	1	$430	1	$430	1	$430	1	$430	1	$430	1	$430	$3,010
Activity Total(s)			**1,464**	**$184,999**	**1,464**	**$184,999**	**1,464**	**$184,999**	**1,464**	**$184,999**	**1,464**	**$184,999**	**1,464**	**$184,999**	**1,464**	**$184,999**	**$1,294,993**
Young Tree Train (7-year cycle)	1-3"	$60	946	$56,760	946	$56,760	946	$56,760	946	$56,760	946	$56,760	946	$56,760	946	$56,760	$397,320
	4-6"	$74	1,380	$102,120	1,380	$102,120	1,380	$102,120	1,380	$102,120	1,380	$102,120	1,380	$102,120	1,380	$102,120	$714,840
Activity Total(s)			**2,326**	**$158,880**	**2,326**	**$158,880**	**2,326**	**$158,880**	**2,326**	**$158,880**	**2,326**	**$158,880**	**2,326**	**$158,880**	**2,326**	**$158,880**	**$1,112,160**
Vacant Tree Planting	Purchasing	$250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	$15,750
	Planting	$250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	9	$2,250	$15,750
Activity Total(s)			**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**18**	**$4,500**	**$31,500**
	Mulching	$250	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	$262,500

Replacement Young Tree Maintenance	Watering	$250	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	150	$37,500	$262,500
Activity Total(s)			**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**300**	**$75,000**	**$525,000**
Monitoring and Inspections	Level 1	$35	50	$1,750	50	$1,750	50	$1,750	50	$1,750	50	$1,750	50	$1,750	50	$1,750	$12,250
	Level 2	$50	20	$1,000	20	$1,000	20	$1,000	20	$1,000	20	$1,000	20	$1,000	20	$1,000	$7,000
	Level 3	$100	10	$1,000	10	$1,000	10	$1,000	10	$1,000	10	$1,000	10	$1,000	10	$1,000	$7,000
Activity Total(s)			**80**	**$3,750**	**80**	**$3,750**	**80**	**$3,750**	**80**	**$3,750**	**80**	**$3,750**	**80**	**$3,750**	**80**	**$3,750**	**$26,250**
Annual Mortality (1%) Removals	Average Tree	$222	300	$66,600	300	$66,600	300	$66,600	300	$66,600	300	$66,600	300	$66,600	300	$66,600	$466,200
Activity Total(s)			**0**	**$66,600**	**0**	**$66,600**	**0**	**$66,600**	**0**	**$66,600**	**0**	**$66,600**	**0**	**$66,600**	**0**	**$66,600**	**$466,200**
Annual Mortality (1%) Stump Removals	Average Tree	$60	300	$18,000	300	$18,000	300	$18,000	300	$18,000	300	$18,000	300	$18,000	300	$18,000	$126,000
Activity Total(s)			**0**	**$18,000**	**0**	**$18,000**	**0**	**$18,000**	**0**	**$18,000**	**0**	**$18,000**	**0**	**$18,000**	**0**	**$18,000**	**$126,000**
Annual Mortality (1%) Planting	Average Tree	$500	300	$150,000	300	$150,000	300	$150,000	300	$150,000	300	$150,000	300	$150,000	300	$150,000	$1,050,000
Activity Total(s)			**0**	**$150,000**	**0**	**$150,000**	**0**	**$150,000**	**0**	**$150,000**	**0**	**$150,000**	**0**	**$150,000**	**0**	**$150,000**	**$1,050,000**
Activity Grand Total			**5,089**		**4,535**		**4,188**		**4,188**		**4,188**		**4,188**		**4,188**		
Cost Grand Total				**$868,533**		**$693,574**		**$661,729**		**$661,729**		**$661,729**		**$661,729**		**$661,729**	**$4,870,752**

Table 12. Estimated Costs for Seven Year Urban Forestry Management Program – Park Tree

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		7-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Dead and Poor Condition Removals	1-3"	$96		$0	65	$6,240											$6,240
	4-6"	$96		$0	95	$9,120											$9,120
	7-12"	$96	109	$10,464	109	$10,464											$20,928
	13-18"	$264	21	$5,544													$5,544
	19-24"	$627	9	$5,643													$5,643
	25-30"	$1,294	2	$2,588													$2,588
	31-36"	$1,671	2	$3,342													$3,342
	37-42"	$2,384	1	$2,384													$2,384
	43"+	$2,885															
Activity Total(s)			**144**	**$29,965**	**269**	**$25,824**											**$55,789**
Fair or Better Condition Removals	1-3"	$96															
	4-6"	$96															
	7-12"	$96															
	13-18"	$264															
	19-24"	$627															
	25-30"	$1,294															
	31-36"	$1,671															
	37-42"	$2,384															
	43"+	$2,885															
Activity Total(s)																	
Stump Removals	1-3"	$25															
	4-6"	$75															
	7-12"	$150															
	13-18"	$250															
	19-24"	$350															
	25-30"	$450															
	31-36"	$500															

	37-42"	$600															
	43"+	$650															
Activity Total(s)																	
Poor Condition Prunes	1-3"	$60	50	$3,000													$3,000
	4-6"	$74	53	$3,922													$3,922
	7-12"	$114	70	$7,980													$7,980
	13-18"	$141	29	$4,089													$4,089
	19-24"	$213	25	$5,325													$5,325
	25-30"	$317	19	$6,023													$6,023
	31-36"	$377	3	$1,131													$1,131
	37-42"	$417	3	$1,251													$1,251
	43"+	$430															
Activity Total(s)			**252**	**$32,721**													**$32,721**
Routine Pruning (7-year cycle)	1-3"	$60															
	4-6"	$74															
	7-12"	$114	213	$24,282	213	$24,282	213	$24,282	213	$24,282	213	$24,282	213	$24,282	213	$24,282	$169,974
	13-18"	$141	53	$7,473	53	$7,473	53	$7,473	53	$7,473	53	$7,473	53	$7,473	53	$7,473	$52,311
	19-24"	$213	16	$3,408	16	$3,408	16	$3,408	16	$3,408	16	$3,408	16	$3,408	16	$3,408	$23,856
	25-30"	$317	7	$2,219	7	$2,219	7	$2,219	7	$2,219	7	$2,219	7	$2,219	7	$2,219	$15,533
	31-36"	$377	5	$1,885	5	$1,885	5	$1,885	5	$1,885	5	$1,885	5	$1,885	5	$1,885	$13,195
	37-42"	$417	2	$834	2	$834	2	$834	2	$834	2	$834	2	$834	2	$834	$5,838
	43"+	$430	1	$430	1	$430	1	$430	1	$430	1	$430	1	$430	1	$430	$3,010
Activity Total(s)			**297**	**$40,531**	**297**	**$40,531**	**297**	**$40,531**	**297**	**$40,531**	**297**	**$40,531**	**297**	**$40,531**	**297**	**$40,531**	**$283,717**
Young Tree Train (7-year cycle)	1-3"	$60	326	$19,560	326	$19,560	326	$19,560	326	$19,560	326	$19,560	326	$19,560	326	$19,560	$136,920
	4-6"	$74	234	$17,316	234	$17,316	234	$17,316	234	$17,316	234	$17,316	234	$17,316	234	$17,316	$121,212
Activity Total(s)			**560**	**$36,876**	**560**	**$36,876**	**560**	**$36,876**	**560**	**$36,876**	**560**	**$36,876**	**560**	**$36,876**	**560**	**$36,876**	**$258,132**
Vacant Tree Planting	Purchasing	$250															
	Planting	$250															
Activity Total(s)																	
Replacement Young Tree Maintenance	Mulching	$250															
	Watering	$250															

Activity Total(s)																	
Monitoring and Inspections	Level 1	$35	25	$875	25	$875	25	$875	25	$875	25	$875	25	$875	25	$875	$6,125
	Level 2	$50	10	$500	10	$500	10	$500	10	$500	10	$500	10	$500	10	$500	$3,500
	Level 3	$100	5	$500	5	$500	5	$500	5	$500	5	$500	5	$500	5	$500	$3,500
Activity Total(s)			**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,875**	**40**	**$1,875**	**$13,125**
Annual Mortality (1%) Removals	Average Tree	$222	60	$13,320	60	$13,320	60	$13,320	60	$13,320	60	$13,320	60	$13,320	60	$13,320	$93,240
Activity Total(s)				**$13,320**		**$13,320**		**$13,320**		**$13,320**		**$13,320**		**$13,320**		**$13,320**	**$93,240**
Annual Mortality (1%) Stump Removals	Average Tree	$60	60	$3,600	60	$3,600	60	$3,600	60	$3,600	60	$3,600	60	$3,600	60	$3,600	$25,200
Activity Total(s)				**$3,600**		**$3,600**		**$3,600**		**$3,600**		**$3,600**		**$3,600**		**$3,600**	**$25,200**
Annual Mortality (1%) Planting	Average Tree	$500	60	$30,000	60	$30,000	60	$30,000	60	$30,000	60	$30,000	60	$30,000	60	$30,000	$210,000
Activity Total(s)				**$30,000**		**$30,000**		**$30,000**		**$30,000**		**$30,000**		**$30,000**		**$30,000**	**$210,000**
Activity Grand Total			**1,293**		**1,166**		**897**		**897**		**897**		**897**		**897**		
Cost Grand Total				**$188,888**		**$152,026**		**$126,202**		**$126,202**		**$126,202**		**$126,202**		**$126,202**	**$971,952**

Funding

The financing for Novi's urban forestry program is primarily from fees paid by developers. Figure 23 illustrates the Operations and Maintenance budgets for Forestry from 2019 to 2023, indicating a consistent decrease in revenue during this period, while expenditures were consistent despite increased costs due to inflation. In comparison to U.S. communities that participated in the 2014 Municipal Tree Census, Novi's per street tree spending, although higher than that of other Midwest cities, is 7% lower than the national average and 39% lower than cities with populations similar to Novi (50,000 to 99,999 people).

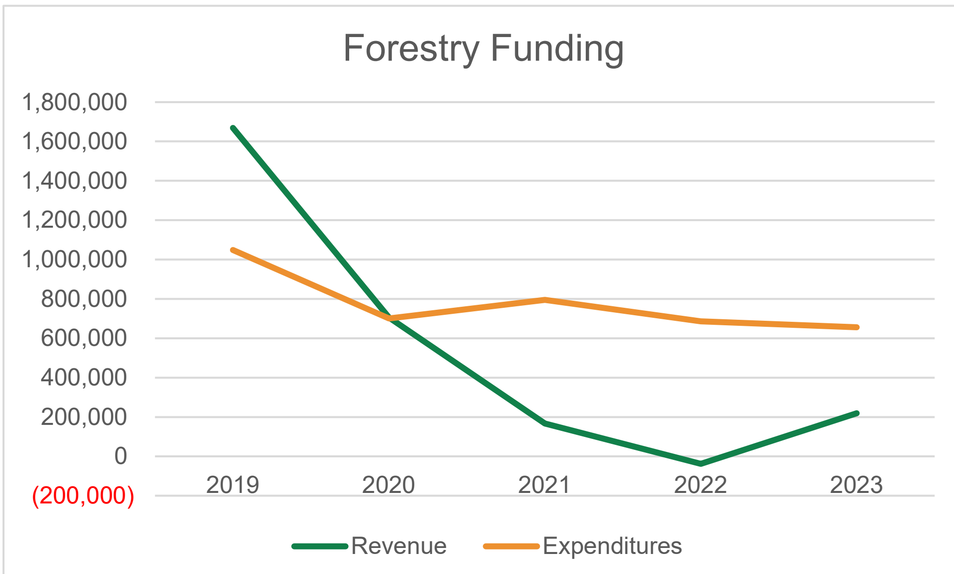


Figure 24. Forestry funding changes over the last five years.

It's noteworthy that over one-third of surveyed communities expressed that their current budget falls short of meeting the requirements of their urban forestry programs, averaging a 45% deficit below their identified needs. While Novi is no exception to this trend, the City has made significant investments in tree maintenance and notably has recently completed a five year pruning cycle. Novi is recognized as a Tree City USA and has received numerous annual Growth Awards.

Novi's goal is to continue to maintain its Forestry management in a proactive strategy. An increase in funding could eliminate the backlog of tree removal and pruning work orders, ensuring a healthier forestry resource. Recognizing that the average community budget from the 2014 Municipal Tree Care Census may not be adequate for managing public trees, a sustained annual increase is essential for Novi to achieve the desired $36.17 per public tree average for cities with populations between 50,000 to 99,999. This additional funding could facilitate:

- Resolving the backlog in tree maintenance work orders and requests.
- Enhance proactive maintenance strategies by implementing long-term planning for the street tree pruning cycle and expanding the development of a young tree training program.

- Increasing the utilization of contractors to support tree removal, tree planting, stump grinding, storm response, and tree maintenance activities for City projects and other departments.
- Accommodate the increasing size of trees. Novi has a significant population of young trees, as these trees grow and mature at the same time, maintenance costs will increase.

Beyond City budget allocation, the exploration of alternative funding sources is recommended to enhance investment in Novi's public urban forest.

Community Outreach

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

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

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

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

Inspections

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

Trees along the street ROW and parks/public spaces should be regularly inspected and attended to as needed based on the inspection findings. When trees need additional or new work, they should be added to the maintenance schedule and budgeted as appropriate. Use appropriate computer management software such as TreeKeeper® 8 to update inventory data and work records. In addition to locating potential new hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. Novi has a large population of trees that are susceptible to pests and diseases, such as ash, oak, and maple.

Inventory and Plan Updates

DRG recommends that the inventory and management plan be routinely updated using an appropriate computer software program so that the city can sustain its program and accurately project future program and budget needs:

- Conduct inspections of trees after all severe weather events. Record changes in tree condition, maintenance needs, and risk rating in the inventory database. Update the tree maintenance schedule and acquire the funds needed to promote public safety. Schedule and prioritize work based on risk.
- Perform routine inspections of public trees as needed. Windshield surveys (inspections performed from a vehicle) in line with *ANSI A300* (ANSI 2023) will help city staff stay apprised of changing conditions. Update the tree maintenance schedule and the budget as needed so that identified tree work may be efficiently performed. Schedule and prioritize work based on risk.
- If the recommended work cannot be completed as suggested in this plan, modify maintenance schedules and budgets accordingly.
- Update the inventory database using TreeKeeper® 8 as work is performed. Add new tree work to the schedule when work is identified through inspections or a citizen call process.
- Re-inventory the street ROW, and update all data fields. The original inventory was completed in 2006 and updates have not been comprehensive to date.
- Revise the *Tree Management Plan* after five years when the re-inventory has been completed.

CONCLUSIONS

The public trees of Novi play a pivotal role in enhancing the quality of life for its residents. When managed with care, these trees deliver a multitude of benefits—environmental, economic, and social—that significantly outweigh the resources invested in their care, including planting, pruning, safeguarding, and removal.

However, urban tree management presents a complex array of challenges. It involves balancing expert advice, community needs, economic and political influences, public safety concerns, legal liabilities, the biological intricacies of trees, and the impact of natural elements and extreme weather. Addressing these multifaceted issues simultaneously poses a substantial challenge.

To effectively maintain its urban forest, the city must thoughtfully navigate these complexities. Armed with the necessary knowledge and resources, Novi is in a strong position to flourish. With the successful execution of a comprehensive tree management program, Novi can ensure the long-term health and safety of both its trees and its residents.

GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

canopy spread (data field): Estimates the width of a tree's canopy in 5-foot increments.

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

clearance requirements (data field): Illustrates the need for pruning to meet clearance standards over streets and sidewalks, or where branches are considered to be interfering with the movement of vehicles or pedestrians or where they are obstructing signs and street or traffic lights.

community forest: see **urban forest**.

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

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

diameter: See **tree size**.

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

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

Espalier (Secondary Maintenance Need): Type of pruning that combines supporting and training branches to orient a plant in one plane.

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

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

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

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

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

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

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

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

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

High Risk tree: The High-Risk category applies when consequences are "significant" and likelihood is "very likely" or "likely," or consequences are "severe" and likelihood is "likely." In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.

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

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

inventory: See **tree inventory**.

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

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

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

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

location rating (data field): Describes/rates the position of a tree based on existing land use of the site, the functional and aesthetic contributions of the tree to the site, and surrounding structures or landscapes. Categories for location value include: Excellent, Good, Fair, and Poor. The location rating, along with species, size, and condition ratings, is used in determining a tree's value.

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

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

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

Moderate Risk tree: The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.

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

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

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

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

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

notes (data field): Describes additional pertinent information.

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

ordinance: See **tree ordinance**.

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

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

Palm Prune (Primary Maintenance Need): Routine horticultural pruning to remove any dead, dying, or broken fronds.

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

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

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

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

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

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

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

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

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

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

risk assessment (data fields): The risk assessment is a point-based assessment of each tree by an arborist using a protocol based on the U.S. Forest Service Community Tree Risk Rating System. In the field, the probability of tree or tree part failure is assigned 1–4 points (identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions), the size of the defective tree part is assigned 1–3 points (rates the size of the part most likely to fail), the probability of target impact by the tree or tree part is assigned 1–3 points (rates the use and occupancy of the area that would be struck by the defective part), and other risk factors are assigned 0–2 points (used if professional judgment suggests the need to increase the risk rating). The data from the risk assessment is used to calculate the risk rating that is ultimately assigned to the tree.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

tree height (data field): If collected during the inventory, the height of the tree is estimated by the arborist and recorded in 10-foot increments.

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

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

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

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

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

Utility (Secondary Maintenance Need): Selective pruning to prevent the loss of service, comply with mandated clearance laws, prevent damage to equipment, avoid access impairment, and uphold the intended usage of the facility/utility space.

Vista Prune (Secondary Maintenance Need): Pruning to enhance a specific view without jeopardizing the health of the tree.

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

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

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Appendix A

RECOMMENDED SPECIES FOR FUTURE PLANTING

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

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar	Native
*Aesculus flava**	yellow buckeye		Yes
*Betula alleghaniensis**	yellow birch		Yes
*Betula lenta**	sweet birch		Yes
Betula nigra	river birch	Heritage®	Yes
Carpinus betulus	European hornbeam	'Franz Fontaine'	
*Carya illinoensis**	pecan		
*Carya lacinata**	shellbark hickory		Yes
*Carya ovata**	shagbark hickory		Yes
*Castanea mollissima**	Chinese chestnut		
Celtis laevigata	sugar hackberry		Yes
Celtis occidentalis	common hackberry	'Prairie Pride'	Yes
Cercidiphyllum japonicum	katsuratree	'Aureum'	
*Diospyros virginiana**	common persimmon		Yes
*Fagus grandifolia**	American beech		Yes
*Fagus sylvatica**	European beech	(Numerous exist)	
Ginkgo biloba	ginkgo	(Choose male trees only)	
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'	Yes
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®	Yes
*Juglans nigra**	black walnut		Yes
*Larix decidua**	European larch		
Liquidambar styraciflua	American sweetgum	'Rotundiloba'	Yes
*Liriodendron tulipifera**	tuliptree	'Fastigiatum'	Yes
*Magnolia acuminata**	cucumbertree magnolia	(Numerous exist)	Yes
*Magnolia macrophylla**	bigleaf magnolia		Yes
*Metasequoia glyptostroboides***	dawn redwood	'Emerald Feathers'	
Nyssa sylvatica	black tupelo		Yes
*Platanus occidentalis**	American sycamore		Yes

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

Scientific Name	Common Name	Cultivar	Native
Platanus × acerifolia	London planetree	'Exclamation'	
Quercus alba	white oak		Yes
Quercus bicolor	swamp white oak		Yes
Quercus coccinea	scarlet oak		Yes
Quercus lyrata	overcup oak		Yes
Quercus macrocarpa	bur oak		Yes
Quercus montana	chestnut oak		Yes
Quercus muehlenbergii	chinkapin oak		Yes
Quercus palustris	pin oak		Yes
Quercus imbricaria	shingle oak		Yes
Quercus phellos	willow oak		Yes
Quercus robur	English oak	Heritage®	
Quercus rubra	northern red oak	'Splendens'	Yes
Quercus shumardii	Shumard oak		Yes
Styphnolobium japonicum	Japanese pagodatree	'Regent'	
Taxodium distichum	common baldcypress	'Shawnee Brave'	Yes
Tilia americana	American linden	'Redmond'	Yes
Tilia cordata	littleleaf linden	'Greenspire'	
Tilia × euchlora	Crimean linden		
Tilia tomentosa	silver linden	'Sterling'	
Ulmus americana	American elm	'Princeton', 'Valley Forge'	Yes
Ulmus parvifolia	Chinese elm	Allée®	
Ulmus x	hybrid elm	'Morton Glossy (Triumph)'	
Zelkova serrata	Japanese zelkova	'Green Vase'	

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

** denotes species that have shallow roots that may conflict with infrastructure.

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar	Native
Abies balsamea	*balsam fir*		Yes
Abies concolor	white fir	'Violacea'	
Cedrus libani	cedar-of-Lebanon		
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'	
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'	
× *Cupressocyparis leylandii*	Leyland cypress		
Ilex opaca	American holly		Yes
Picea glauca	White spruce		Yes
Picea galuca var. densata	Black Hills spruce		
Picea omorika	Serbian spruce		
Picea orientalis	Oriental spruce		
Pinus densiflora	Japanese red pine		
Pinus strobus	eastern white pine		Yes

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

Scientific Name	Common Name	Cultivar	Native
Pinus sylvestris	Scotch pine		
Pinus taeda	loblolly pine		Yes
Pinus virginiana	Virginia pine		Yes
Psedotsuga menziesii	Douglas-fir		
Thuja plicata	western arborvitae	(Numerous exist)	
Tsuga canadensis	eastern hemlock		Yes

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

Appendix B

TREE PLANTING GUIDELINES

Tree Planting

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

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

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

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

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

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

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

(hawthorn) and *Gleditsia triacanthos* (honeylocust), may have substantial thorns. These species should be avoided in high-traffic areas.

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

Tips for Planting Trees

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

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

Newly Planted and Young Tree Maintenance

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

Watering

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

Mulching

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

Lifelong Tree Care

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

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

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

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

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

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

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

Appendix C

INVASIVE PESTS AND DISEASES

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

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

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

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

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

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

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

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

Asian Longhorned Beetle

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

Adult Asian longhorned beetle
Photograph courtesy of New Bedford Guide 2011

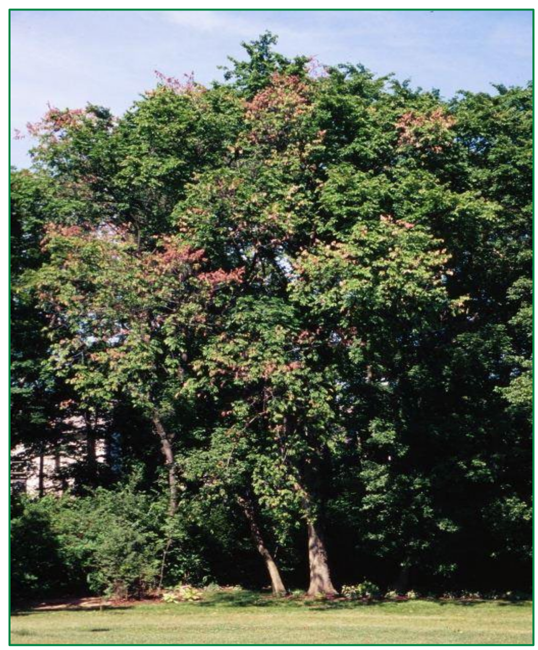
Adults are large (3/4- to 1/2-inch long) with very long, black and white banded antennae. The body is glossy black with irregular white spots. Adults can be seen from late spring to fall depending on the climate. ALB has a long list of host species; however, the beetle prefers hardwoods, including several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

Dutch Elm Disease

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

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

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



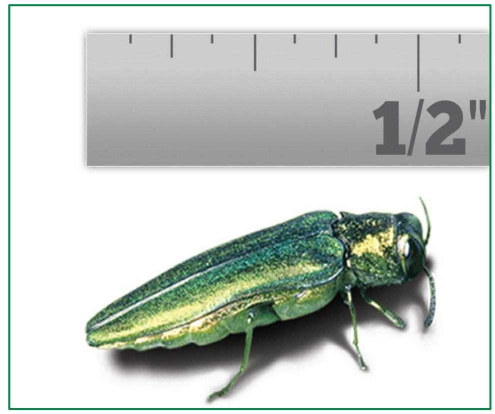
Branch death, or flagging, at multiple locations in the crown of a diseased elm
Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011)

Emerald Ash Borer

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

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

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



Close-up of the emerald ash borer
Photograph courtesy of APHIS (2011)

Spongy Moth

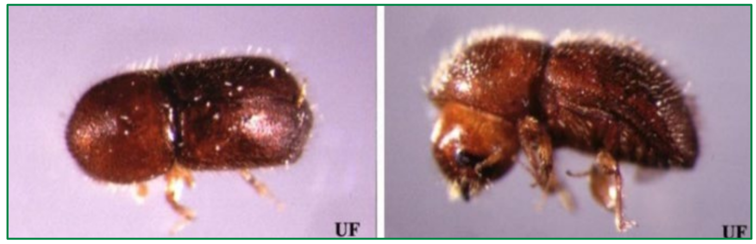
The spongy moth *(Lymantria dispar*) is native to Europe and first arrived in the United States in Massachusetts in 1869. This moth is a significant pest because its caterpillars have an appetite for more than 300 species of trees and shrubs. Spongy moth caterpillars defoliate trees, which makes the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

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

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

Close-up of male (darker brown) and female (whitish color) European spongy moths
Photograph courtesy of APHIS (2011b)

Granulate Ambrosia Beetle



Adult granulate ambrosia beetle
Photograph courtesy of Paul M. Choate, University of Florida (Atkinson et al. 2011)

The granulate ambrosia beetle (*Xylosandrus crassiusculus*), formerly the Asian ambrosia beetle, was first found in the United States in 1974 on peach trees near Charleston, South Carolina. The native range of the granulate ambrosia beetle is probably tropical and subtropical Asia. The beetle is globally present in countries such as equatorial Africa, Asia, China, Guinea, Hawaii, India, Japan, New South Pacific, Southeast Indonesia, Sri Lanka, and the United States. In the United States, this species has spread along the lower Piedmont region and coastal plain to East Texas, Florida, Louisiana, and North Carolina. Populations were found in Oregon and Virginia in 1992, and in Indiana in 2002.

Adults are small and have a reddish-brown appearance with a downward facing head. Most individuals have a reddish head region and a dark-brown to black elytra (hard casings protecting the wings). Light-colored forms that appear almost yellow have also been trapped. A granulated (rough) region is located on the front portion of the head and long setae (hairs) can be observed on the back end of the wing covers. Females are 2–2.5mm and males are 1.5mm long. Larvae are C-shaped with a defined head capsule.

The granulate ambrosia beetle is considered an aggressive species and can attack trees that are not highly stressed. It is a potentially serious pest of ornamentals and fruit trees and is reported to be able to infest most trees and some shrubs (azalea, rhododendron) but not conifers. Known hosts in the United States include: *Acer* (maple); *Albizia* (albizia); *Carya* (hickory); *Cercis canadensis* (eastern redbud); *Cornus* (dogwood); *Diospyros* (persimmon); *Fagus* (beech); *Gleditsia* or *Robinia* (locust); *Juglans* (walnut); *Koelreuteria* (goldenrain tree); *Lagerstroemia* (crapemyrtle); *Liquidambar styraciflua* (sweetgum); *Liriodendron tulipifera* (tulip poplar); *Magnolia* (magnolia); *Populus* (aspen); *Prunus* (cherry); *Quercus* (oak); and *Ulmus parvifolia* (Chinese elm). *Carya illinoinensis* (pecan) and *Pyrus calleryana* (Bradford pear) are commonly attacked in Florida and in the southeastern United States.

Xm Ambrosia Beetle

The Xm ambrosia beetle (*Xylosandrus mutilatus*), is native to Asia and was first detected in the United States in 1999 in traps near Starkville, Mississippi. By 2002, the beetle spread throughout Missouri and quickly became well-established in Florida. The species also has been found in Alabama, northern Georgia, and Texas. In addition to its prevalence in the southeastern United States, the Xm ambrosia beetle is currently found in China, India, Indonesia, Japan, Korea, Malaya, Myanmar, Papua New Guinea, Sri Lanka, Taiwan, and Thailand.

This species generally targets weakened and dead trees. Since the beetle attacks small diameter material, it may be commonly transported in nursery stock. Female adults are prone to dispersal by air currents and can travel 1–3 miles in pursuit of potential hosts. This active capability results in a broad host range and high probability of reproduction. The species is larger than any other species of *Xylosandrus* (greater than 3 millimeters) in the U.S. and is easily recognized by its steep declivity and dark brown to black elytra (hard casings protecting the wings). Larvae are white and c-shaped with an amber colored head capsule.

Known hosts in the U.S. include: *Acer* (maple); *Albizia* (silktree); *Benzoin* (northern spicebush); *Camellia* (camellia); *Carpinus laxiflora* (looseflower hornbeam); *Castanae* (sweet chestnut); *Cinnamomum camphora* (camphor tree); *Cornus* (dogwood); *Cryptomeria japonica* (Japanese cedar); *Fagus crenata* (Japanese beech); *Lindera erythrocarpa* (spicebush); *Machilus thurnbergii* (Japanese persea); *Ormosia hosiei* (ormosia); *Osmanthus fragrans* (sweet osmanthus); *Parabezion praecox*; *Platycarpa*; and *Sweitenia macrophylla* (mahogany).

Xm ambrosia beetle
Photograph courtesy of Michael C. Thomas, Florida Department of Agriculture and Consumer Services (Rabaglia et al 2003)

Hemlock Woolly Adelgid

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

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

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

Hemlock woolly adelgids on a branch

Photograph courtesy of USDA Forest Service (2011a)

Oak Wilt

Oak wilt symptoms on red and white oak leaves
Photograph courtesy of USDA Forest Service (2011a)

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

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

Pine Shoot Beetle

Mined shoots on a Scotch pine

Photograph courtesy of USDA Forest Service (1993)

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

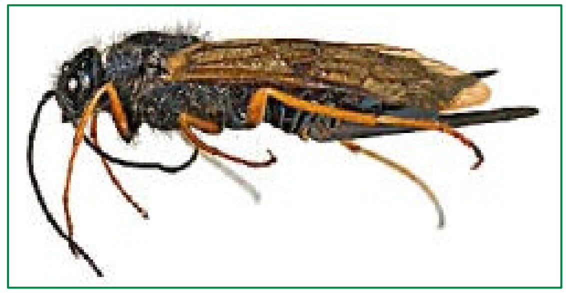
The beetle attacks new shoots of pine trees, stunting the growth of the trees. The pine shoot beetle may also attack stressed pine trees by breeding under the bark at the base of the trees. The beetles can cause severe decline in the health of the trees and, in some cases, kill the trees when high populations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

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

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

Sirex Woodwasp

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



Close-up of female Sirex Woodwasp

Photograph courtesy of USDA (2005)

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

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

Southern Pine Beetle

The southern pine beetle (SPB, *Dendroctonus frontalis*) is the most destructive insect pest of pine in the southern United States. It attacks and kills all species of southern yellow pines including *P. strobus* (eastern white pine). Trees are killed when beetles construct winding, S-shaped egg galleries underneath the bark. These galleries effectively girdle the tree and destroy the conductive tissues that transport food throughout the tree. Furthermore, the beetles carry blue staining fungi on their bodies that clog the water conductive tissues (wood), which transport water within the tree. Signs of attack on the outside of the tree are pitch tubes and boring dust, known as frass, caused by beetles entering the tree.

Adult southern pine beetles Photograph courtesy of Forest Encyclopedia Network (2012)

Adult SPBs reach an ultimate length of only 1/8 inch, similar in size to a grain of rice. They are short-legged, cylindrical, and brown to black in color. Eggs are small, oval-shaped, shiny, opaque, and pearly white.

Sudden Oak Death

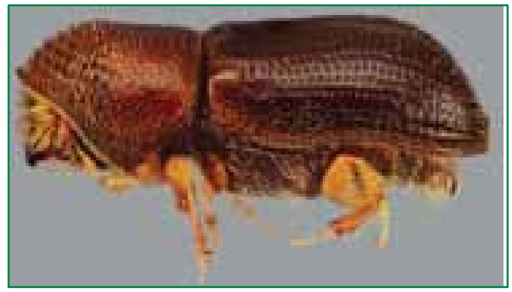
The causal agent of sudden oak death (SOD, also known as *Phytophthora* canker disease), *Phytophthora ramorum*, was first identified in 1993 in Germany and the Netherlands on ornamental rhododendrons. In 2000, the disease was found in California. Since its discovery in North America, SOD has been confirmed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

Drooping tanoak shoot Photograph courtesy of Indiana Department of Natural Resources (2012)

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

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

Thousand Cankers Disease



Walnut twig beetle, side view
Photograph courtesy of USDA Forest Service (2011b)

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

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

The tree species preferred as hosts for TCD are walnuts.

Spotted Lanternfly

Profile of spotted lanternfly adult at rest.

Photograph courtesy of Pennsylvania Department of Agriculture

The spotted lanternfly (SLF, *Lycorma delicatula*) is native to China and was first detected in Pennsylvania in September 2014. Spotted lanternfly feed on a wide range of fruit, ornamental and woody trees, with tree-of-heaven being one of the preferred hosts. Spotted lanternfly are invasive and can be spread long distances by people who move infested material or items containing egg masses. If allowed to spread in the United States, this pest could seriously impact the country's grape, orchard, and logging industries.

Adult spotted lanternfly are approximately 1 inch long and 1/2 inch wide, and they have large and visually striking wings. Their forewings are light brown with black spots at the front and a speckled band at the rear. Their hind wings are scarlet with black spots at the front and white and black bars at the rear. Their abdomen is yellow with black bars. Nymphs in their early stages of development appear black with white spots and turn to a red phase before becoming adults. Egg masses are yellowish-brown in color, covered with a gray, waxy coating prior to hatching.

The spotted lanternfly lays its eggs on smooth host plant surfaces and on non-host material, such as bricks, stones, and dead plants. Eggs hatch in the spring and early summer, and nymphs begin feeding on a wide range of host plants by sucking sap from young stems and leaves. Adults appear in late July and tend to focus their feeding on tree-of-heaven
(*A. altissima*) and grapevine (*Vitis vinifera*). As the adults feed, they excrete sticky, sugar-rich fluid similar to honeydew. The fluid can build up on plants and on the ground underneath infested plants, causing sooty mold to form.

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Appendix D
Level One Priority Roadways

Albatross Dr	Alcott Cir	Alpine Dr
Argyle St	Ashbury Dr	Austin Dr
Barclay Dr	Beck Rd	Beckenham Dr
Bristol Cir	Buffington St	Carmela Ct
Carriage Hill Dr	Cavendish Ave E	Chase Dr
Cheltenham Dr	Cherry Hill Rd	Cider Mill Dr
Clark St	Cottisford Rd	Cranbrooke Dr
Crescent Blvd	Declaration Dr	Deer Run
Delmont Dr	Drakes Bay Dr	East Lake Dr
Eight Mile Rd	Eleven Mile Rd	Ennishore Dr
Fawn Trl	Fourteen Mile Rd	Galway Dr
Garfield Rd	Glen Haven Cir	Glenda Ave
Glyme Dr	Grand River Ave	Haggerty Rd
Hartwick Dr	Heatherbrae Way	Hickory Grove Ln
Holmes Dr	Island Lake Dr	Jamestowne Rd
Kingswood Blvd	Laramie Dr	Le Bost Dr
Linhart St	Llewelyn Rd	Lochmoor Ln
Ludlow Dr	Lynwood Dr	Malott Dr
Mandalay Cir	Manor Park Dr	Maudlin St
Meadowbrook Rd	Medina Blvd	Mission Ln
Mystic Forest Dr	Napier Rd	Nilan Dr
Nine Mile Rd	Novi Rd	Old Novi Rd
Park Place Dr	Penhill St	Petros Blvd
Portsmouth Ave	Scenic Ln	Sierra Dr
South Lake Dr	Summit Dr	Sunrise Blvd
Taft Rd	Ten Mile Rd	Thirteen Mile Rd
Torino Dr	Twelve 1/2 Mile Rd	Twelve Mile Rd
Valencia Cir	Veranda Dr	Village Wood Dr

West Park Dr	Whistler Dr	White Pines Dr
Willowbrook Rd	Wimbleton Way	Wixom Rd

Urban Tree Canopy Report City of Novi, Michigan

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ACKNOWLEDGMENTS

This project supports the vision of the City of Novi to promote and enhance community wellbeing through tree conservation and improved forestry management practices. This *Urban Tree Canopy Report* describes where trees are present in Novi and identifies areas for future tree canopy growth to maximize the environmental and social benefits of trees.

EXECUTIVE SUMMARY

Urban Tree Canopy in Novi, Michigan

PROJECT OVERVIEW

In 2023, the City of Novi commissioned an urban tree canopy assessment to characterize tree canopy cover in the city and make recommendations for future work.

TREE CANOPY IN NOVI

Novi, Michigan, has a population of over 66,000 residents and contains nearly 7,400 acres of tree canopy. In total, 37% of the city is shaded by trees. Novi's trees provide residents with $14.4 million in annual savings. Tree cover is not equitably distributed across the city.

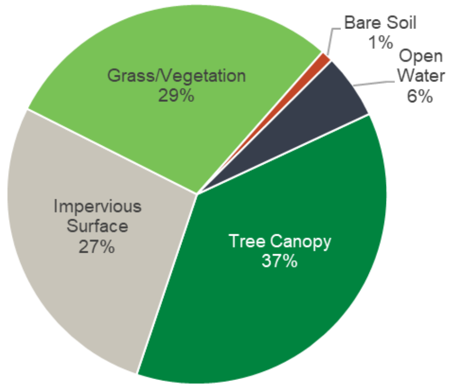
PRIORITY PLANTING AREAS

A priority planting analysis categorized 4,823 acres of preferred plantable area in Novi from Very Low to Very High priority based on the potential for trees to absorb stormwater, curb urban heat island effect, and improve quality of life. If the City, residents, and businesses of Novi were to plant trees in all locations, citywide tree cover would rise from 37.1% to 61.3%.

ACKNOWLEDGMENTS

This urban tree canopy assessment was supported by funding from the City of Novi.

Novi land cover by type

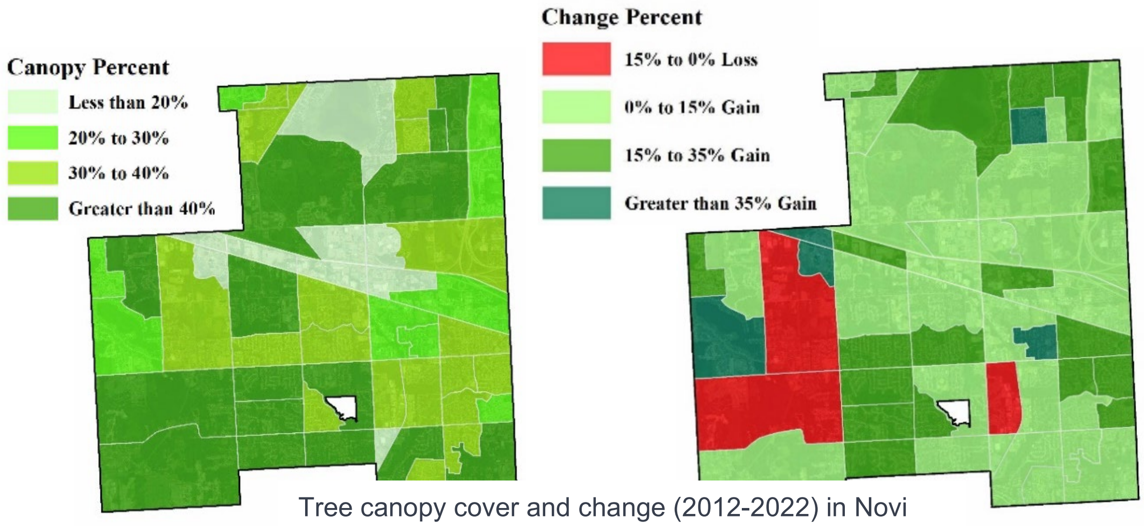


37% Tree Canopy Cover

7,426 acres of trees in Novi in 2022

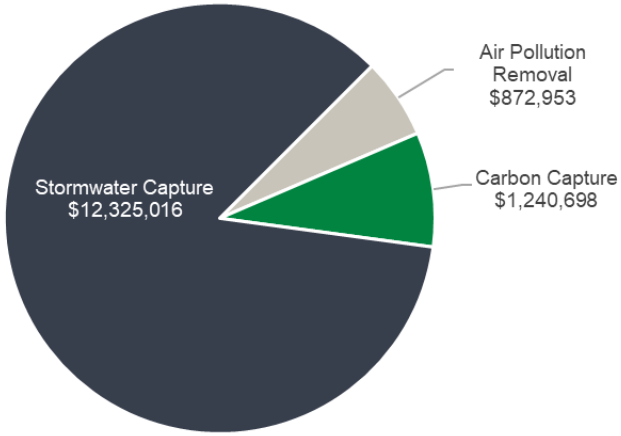
9.3% Tree Canopy Growth in 10 years

+634 acres of trees, 2012–2022



Tree canopy cover and change (2012-2022) in Novi

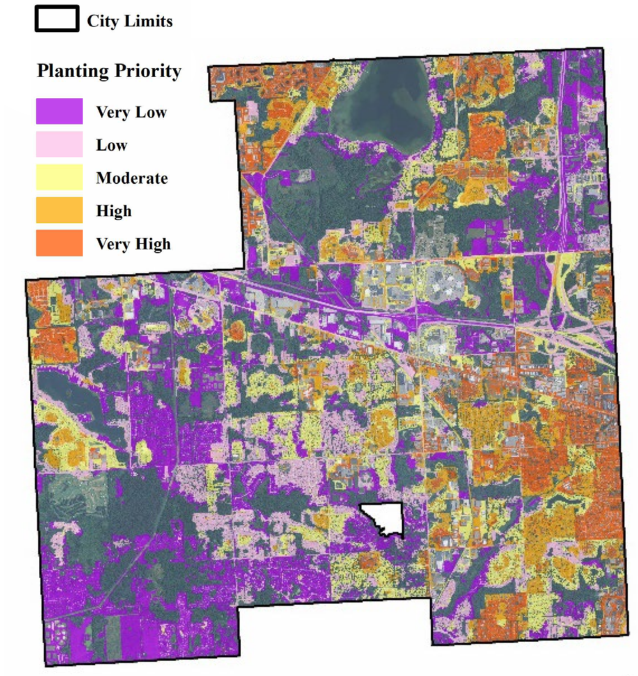
The annual benefits of Novi's trees



Novi's trees provide $14.4 million in ecosystem services *each year*

138 million gallons of stormwater absorbed
293 tons of air pollutants filtered
7,270 tons of carbon captured

Priority areas for tree planting



A priority planting analysis classified 4,823 acres of available tree planting area across Novi from Very Low to Very High priority for trees

High-priority areas are places where trees would be best positioned to capture stormwater, cool the air, and build social equity.

RECOMMENDED ACTIONS TO GROW TREE CANOPY IN NOVI

Implementing the following action steps will increase tree canopy cover over time, provide greater value and more benefits to Novi residents, and help the city realize its vision and achieve its goals for the urban forest.

- **Plant trees**
- **Preserve existing tree canopy**
- **Strengthen tree ordinances and policies**
- **Connect forestry to other city initiatives**
- **Involve the community**
- **Get regular tree canopy checkups**

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INTRODUCTION

Trees are an essential part of Novi's urban infrastructure because of the many environmental, social, and economic benefits that they provide. Trees improve our environment by absorbing stormwater and by cooling and cleaning the air. They also improve our cities by beautifying homes, neighborhoods, and business districts and by making streets and sidewalks safer and more comfortable for cyclists and pedestrians. In short, tree canopy is a significant asset that relates to multiple community goals and priorities.

In 2023, the City of Novi undertook a study to better understand its urban tree canopy—where it is located within the city, how tree canopy has changed in recent years, the benefits it provides to residents, and where potential tree planting opportunities exist. Development and support of the project was made possible by the City of Novi Department of Public Works.

This Urban Tree Canopy Report provides details findings from an urban tree canopy (UTC) assessment, canopy change analysis, and priority planting analysis and makes broad recommendations for preserving and enhancing tree canopy.

The information derived from the assessment can:

1. Establish a UTC baseline of known accuracy (% tree canopy cover).
2. Establish methodology that the City can later use to track canopy gains and losses over time.
3. Allow the City to develop a sound urban forestry management plan based on the current UTC to establish priorities and objectives that will provide collective ecosystem benefits including:
    a. Management and maintenance of existing canopy.
    b. Preservation of existing public and private trees.
    c. Planning and prioritization of tree planting efforts.

The UTC data and maps are part of a suite of management tools, including tree inventories and management plans, that are all necessary components of a comprehensive urban forestry program. They can assist and guide community reforestation efforts to maximize ecological benefits and urban forest sustainability. As management progresses, Novi is encouraged to reference these results, utilize the data for additional analyses, and continue to seek new tools and information to measure progress, report accomplishments, and inform management decisions.

URBAN TREE CANOPY ASSESSMENT

The 2023 Urban Tree Canopy Assessment consisted of a spatial analysis of Novi, including:

- land cover classification
- tree canopy cover by land use and geography
- ecosystem benefits analysis
- identification of priority planting locations based on social and environmental factors

Methods are outlined in the sections below. For technical details of methodology, refer to Appendix A.

Land Cover in Novi

Land cover was determined using 2022 National Agricultural Imagery Program (NAIP) leaf-on, multispectral imagery acquired and processed by the United States Department of Agriculture. Remote sensing and GIS (Geographical Information Systems) software extensions were used to generate the baseline percentage of existing tree canopy and land cover. Land cover was classified into five types:

1. **Tree canopy:** the area of land surface that is covered by the tree's leaf-covered branches, as seen from above.
2. **Grass and low-lying vegetation:** pervious surfaces that allow rainfall to infiltrate the soil, as typically found in parks, golf courses, and residential lawns.
3. **Impervious surfaces:** buildings, roads, sidewalks, and other paved/built areas that do not allow rainfall to infiltrate the soils.
4. **Bare soil:** areas that lack vegetation, such as vacant lots, construction sites, and baseball infields.
5. **Open water:** lakes, ponds, streams, wetlands, and other mappable water features.

Land cover in Novi is primarily tree canopy (37%), grass/low-lying vegetation (29%), and impervious surface (27%) (Figure 1, Table 1). Bare soil and open water comprise 7% of city area.

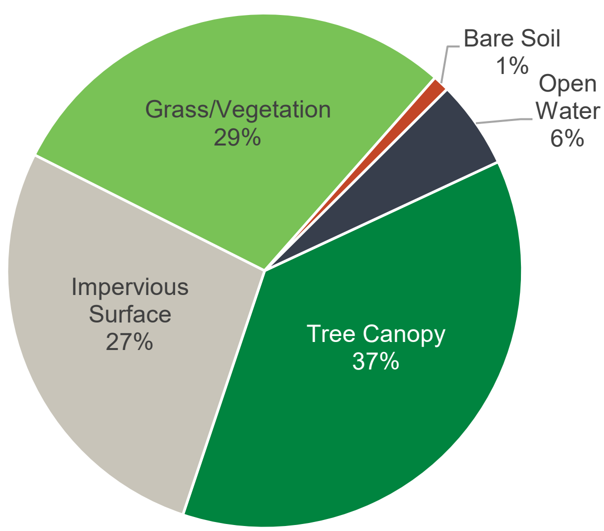


Figure 1. Land cover in Novi by type.

Table 1. Novi land cover by area and percentage of city total.

Land Cover	Acres	Percent
Tree Canopy	7,426	37.1%
Impervious Surface	5,462	27.3%
Grass/Vegetation	5,822	29.1%
Bare Soil	205	1.0%
Open Water	1,104	5.5%
Total Acres	**20,019**	

Of the five land cover classifications, impervious surface and tree canopy have the most significant impact on the quantity and quality of stormwater runoff in a community. During storm events, water collects and runs across impervious surfaces, picking up and carrying particles and pollutants. Stormwater is then intercepted by storm drains and catch-basins throughout Novi and ultimately end up in Rouge River waterways. Minimizing impervious surface allows stormwater to naturally soak into and filter through the soil, thereby reducing runoff and improving water quality.

While impervious surface has a negative impact on stormwater runoff, tree canopy has a positive effect. During a rainstorm, large amounts of water droplets accumulate on a tree's leaves and trunk that would otherwise quickly fall to the ground and concentrate into stormwater runoff. While it may not seem like one tree can hold or intercept a significant amount of rainwater, collectively, all the trees in a community's urban forest greatly reduce the amount of water that reaches the stormwater system.

CANOPY CHANGE ANALYSIS

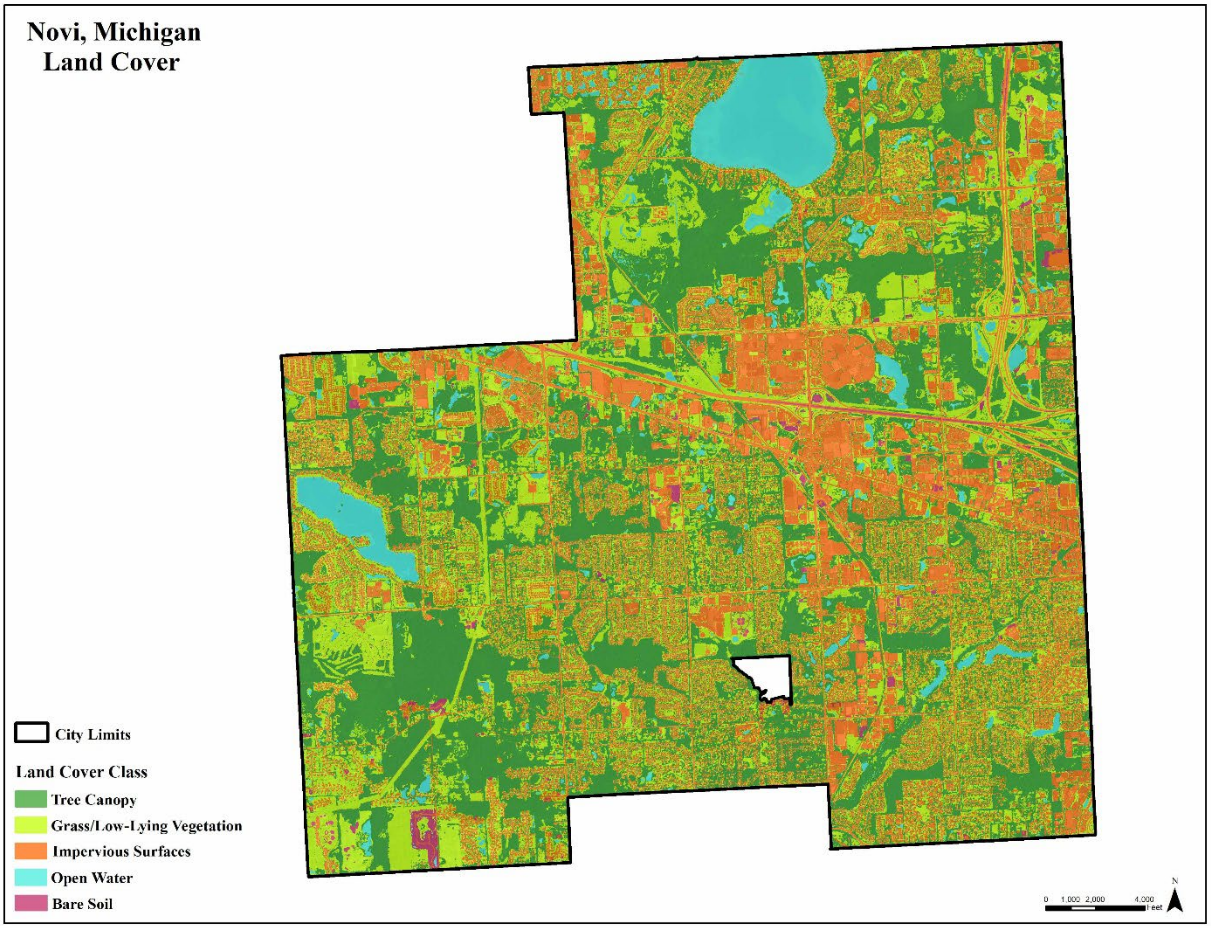
A canopy change analysis explored tree canopy changes over 10 years from 2011–2021 to see how development, human activity, and tree care have affected tree canopy in Novi. Using satellite imagery, aerial photographs, and modern GIS technologies, this analysis detected areas where tree cover has grown, remained stable, or decreased.

The findings highlight areas that have been affected by tree mortality, urban development, and storms/natural disturbances, as well as areas where reforestation and conservation efforts have proven successful. Through tree canopy change analysis, stakeholders can gather invaluable insights to guide policy decisions, allocate resources, optimize conservation initiatives, and monitor the overall health of forests and urban green spaces.

PREFERRED PLANTABLE AREA AND MAXIMUM TREE CANOPY

The urban tree canopy assessment estimated the possible land area where additional trees could be planted in Novi. For this analysis, DRG considered grass/low-lying vegetation and bare soil as possible plantable area. However, possible plantable area does not guarantee that the area is a suitable or realistic planting location if trees conflict with the intended use of the site. For example, trees may not be desirable in all parts of golf courses, cemeteries, sports fields, and fairgrounds, where some spaces are designed and intended to be open and free from trees and canopy cover.

The urban tree canopy assessment took the possible plantable land area and excluded areas that are unsuitable for tree planting due to land use conflicts to identify *preferred plantable area*. The sum of existing tree canopy area and preferred plantable area equals the *maximum tree canopy cover*.



Map 1. Land cover in Novi.

Novi Tree Canopy Cover and Change

Citywide tree canopy, measured using 2022 aerial imagery, totals 7,426 acres in Novi, equal to 37.1% of city land area. This is an increase of 9.3% in tree canopy area compared to 2012, when there were 6,791 acres of trees in Novi (Figure 2, Table 2).

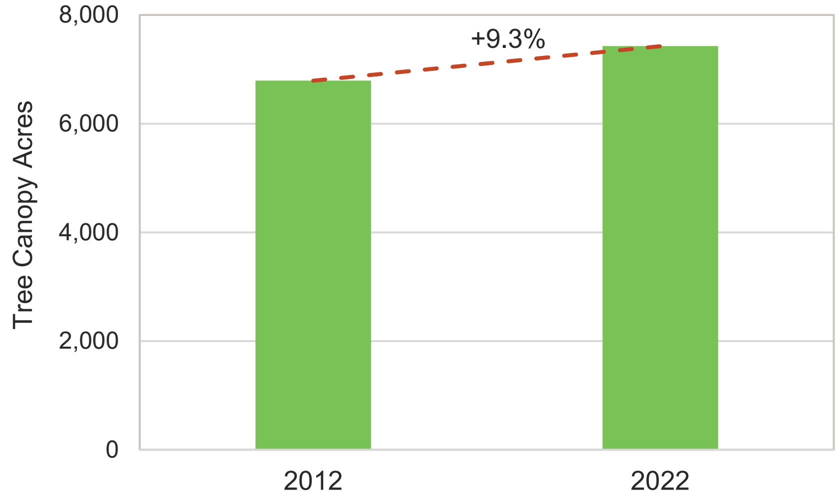


Figure 2. Tree canopy acres in 2012 and 2022.

Table 2. Tree canopy cover and change, 2012-2022.

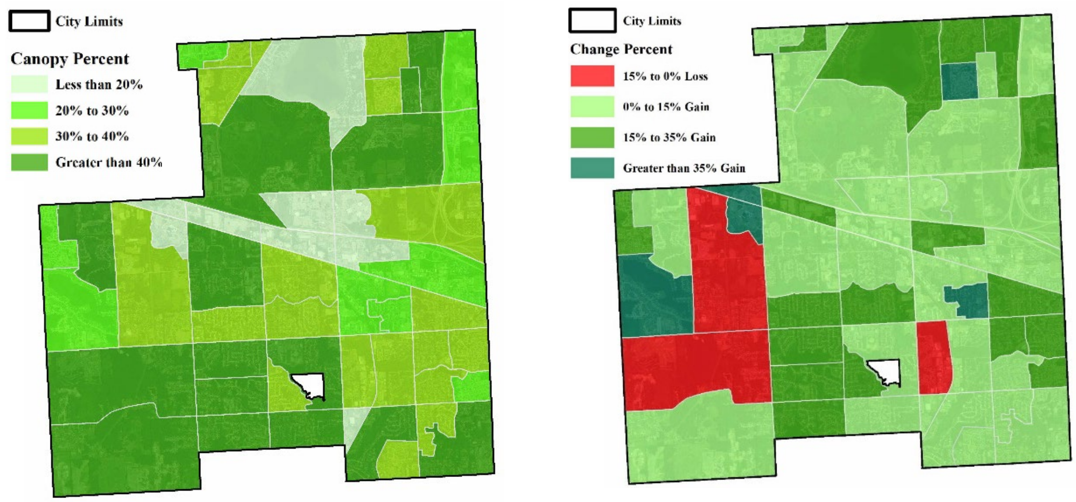
Novi	Land Area	Tree Canopy Cover			
		2012	2022	Change	Maximum
Acres	20,019	6,790	7,425	+634	12,272
Percent of City Area		33.9%	37.1%	+9.3%	61.3%

TREE CANOPY BY US CENSUS BLOCK GROUP

In Novi, tree canopy is unevenly distributed across the city, ranging from 13% to 61% tree cover among 51 U.S. Census block groups (Map 2, left). Block groups are U.S. Census-defined geographic areas that are typically made up of 600–3,000 residents.

During the study period from 2012-2022, nearly all block groups experienced a gain in tree canopy. Tree canopy change ranged from a loss of 14% tree cover to a gain of 74% tree cover (Map 2, right).

To grow citywide tree canopy over time, Novi can prioritize efforts to grow tree canopy within areas with low canopy cover and prioritize tree preservation within areas with high canopy cover.



Map 2. Tree canopy cover (left) and change (2012-2022; right) by U.S. census block group.

TREE CANOPY IN PARKS

Novi is fortunate to have many parks and green spaces for residents to enjoy. Tree cover within parks ranges from 14% at Water Tower Park, where the historic water tower and R/C Raceway Track limit space for trees, to 98% at the ITC Trailhead Park (Table 3). Average tree cover across all parks is 64%—almost twice the city average.

Maximum tree canopy considers both existing tree canopy as well as vegetated space where additional trees can be planted. In parks, low maximum tree canopy may reflect areas where impervious surface and recreational uses conflict with trees.

From 2012–2022, parks gained an average of 4% tree cover. The largest change occurred within Fuerst Park, an 8-acre park that gained 1.8 acres (+311%) of tree cover within the past 10 years.

Table 3. Tree canopy cover in parks and tree canopy change, 2012-2022.

Park	Acres	Tree Canopy	Impervious Surface	Maximum Tree Canopy	Tree Canopy Change 2012-2022
Beacon Hill Trailhead	3	20%	5%	70%	6%
Bosco Fields	81	25%	9%	56%	3%
Brookfarm Park	8	67%	1%	97%	23%
Ella Mae Power Park	28	18%	12%	45%	122%
Fuerst Park	8	28%	21%	79%	311%
Garfield Rd Conservation Area	107	83%	0%	88%	23%
Grand River Fields	9	44%	11%	60%	-52%
ITC Community Sports Park	74	15%	14%	47%	89%
ITC Trailhead Park	13	97%	2%	98%	-2%
ITC Trailhead Park Expansion	20	98%	1%	98%	-1%
Lakeshore Park	601	66%	1%	71%	4%

Park	Acres	Tree Canopy	Impervious Surface	Maximum Tree Canopy	Tree Canopy Change 2012-2022
Meadowbrook Commons	19	23%	35%	63%	148%
MSU Tollgate Farm	57	36%	8%	72%	17%
Novi Core Habitat	102	94%	0%	94%	-4%
Novi Dog Park	7	45%	8%	92%	2%
Novi Ice Arena	8	17%	58%	42%	138%
Novi Northwest Park	10	70%	0%	100%	18%
Orchard Hills West	41	94%	0%	96%	0%
Pavilion Shore Park	12	22%	15%	74%	15%
Rotary Park	65	79%	4%	85%	-9%
Ten Mile North Boardwalk	8	63%	4%	89%	49%
Ten Mile South	91	97%	2%	98%	0%
Terra Park	20	95%	0%	98%	-2%
Villa Barr Art Park	4	40%	13%	76%	-7%
Village Wood Lake Park	14	39%	1%	51%	9%
Water Tower Park	4	14%	34%	28%	-8%
Wildlife Woods Park	28	54%	7%	81%	5%
All Parks	**1,442**	**64%**	**4%**	**76%**	**62%**

TREE CANOPY BY LAND USE

In cities, it is common for tree canopy to be unevenly distributed across land uses. Tree cover is typically highest in areas where development is less dense, such as residential areas, and lowest in areas that have a lot of impervious surface, such as commercial districts.

In Novi, residential land uses account for 30% of the city's total tree canopy—single- and multi-family homes, condominiums, and mobile home parks together contain 2,197 acres of trees (Table 4). Parks and open space contain an additional 11% of Novi's tree canopy.

In contrast, commercial and industrial land uses in Novi have relatively low tree cover and a small portion the city's overall tree canopy.

Vacant land accounts for the largest portion of the city's tree canopy: nearly one-third of the city's existing tree cover is found on vacant land. This tree canopy may be at risk for removal due to the potential for future development, which could decrease average city tree cover as this land is built out.

Table 4. Tree canopy cover by land type.

Land Use Description	Acres	Canopy Percent	Impervious Percent	Maximum Tree Canopy	Percent Change 2012-2022
Agricultural / Rural Res	847	60%	6%	90%	4%
Cemetery	149	47%	10%	49%	5%
Condominium	636	34%	37%	59%	17%
Golf Course	335	50%	3%	54%	12%
Hospitality	165	18%	56%	40%	17%
Industrial	801	20%	56%	41%	-1%
Institutional	682	34%	34%	56%	9%
Medical	317	28%	39%	53%	-1%
Mixed Use	2	6%	31%	69%	-10%
Mobile Home	308	29%	36%	62%	48%
Multi-Family Housing	810	31%	38%	53%	13%
Office	689	20%	57%	38%	15%
Parking	70	16%	52%	40%	35%
Recreation / Open Space	1,467	57%	13%	71%	7%
Retail	508	10%	78%	21%	18%
Single-Family Housing	4,687	35%	26%	74%	11%
TCU	419	29%	16%	47%	2%
Vacant	3,341	59%	7%	80%	2%
Water	873	4%	1%	6%	10%

TREE CANOPY BENEFITS

Trees have been linked to many environmental, social, and economic benefits. In total, Novi's tree canopy provides $14.4 million each year in ecosystem benefits (Table 5, Figure 3). This includes removal of over 293 tons of air pollutants, interception of over 138 million gallons of stormwater, and sequestration of almost 7,270 tons of carbon *each year*. This does not include myriad other benefits including property value increases, energy savings, and health benefits.

Water Quality Improvement

Trees intercept rainwater by capturing water droplets on their leaves and bark and by absorbing rainwater through their expansive root system. These processes reduce or slow the amount of stormwater runoff that flows untreated into streams and sewers, thereby improving water quality. Without trees, communities would have to invest significantly more in stormwater infrastructure to handle the additional water flow that would otherwise have been captured by trees. This is why many municipalities are utilizing trees as part of a comprehensive approach to updating their stormwater systems and achieving compliance with local and federal regulations.

Collectively, Novi's trees capture over 138 million gallons of stormwater annually—enough water to fill nearly 210 Olympic-sized swimming pools!

Table 5. Ecosystem benefits provided by Novi's trees.

Ecosystem Benefits	Quantity	Value
Annual benefits		
Air quality: Pollutant removal (lb)	586,560	$872,953
Carbon Monoxide (CO)	5,680	$2,136
Nitrogen Dioxide (NO_2)	49,240	$5,963
Ozone (O_3)	347,840	$238,375
Sulfur Dioxide (SO_2)	53,400	$1,927
Particulate Matter ($PM_{2.5}$)	16,300	$423,326
Particulate Matter (PM_{10})	114,100	$201,226
Carbon sequestration (tons)	7,270	$1,240,698
Stormwater: avoided runoff (gal)	138,483,325	$12,325,016
Total Annual Benefits		**$14,438,667**
Accrued benefits		
Carbon storage (tons)	254,110	$43,338,756
Total Benefits		**$57,777,423**

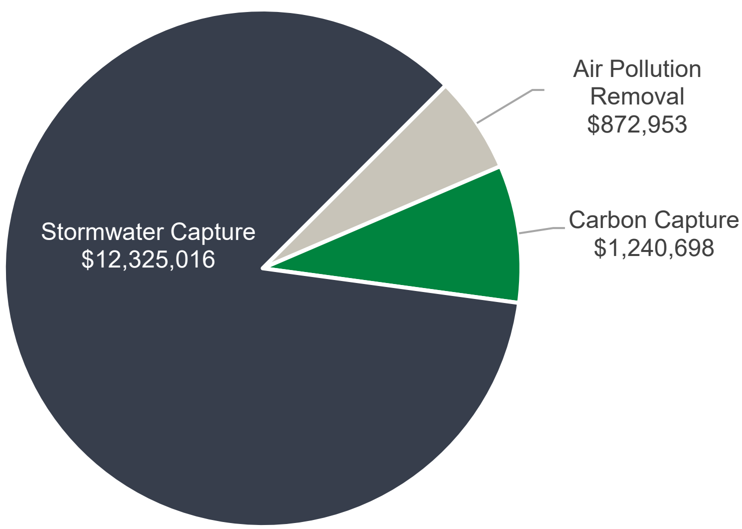


Figure 3. The value of annual benefits provided by Novi's trees.

Air Quality Improvement

Trees improve Novi's air quality by capturing fine pollutants and particulate matter on the surfaces of their leaves. Recent studies have shown a strong correlation between total tree canopy and reduced rates of pulmonary and cardiovascular disease.

Every year, Novi's urban forest collectively removes over 293 tons of pollutants from the air (Table 5). The value of this removal equates to $872,953 annually in avoided costs.

Carbon Capture

Carbon dioxide (CO_2) is a gaseous biproduct of fossil fuel combustion, such as when cars burn gasoline. In the earth's atmosphere, carbon dioxide acts as a greenhouse gas—it traps heat and contributes to global warming. Removing CO_2 from the atmosphere is an essential piece of climate change mitigation.

Trees breathe in CO_2, convert it into energy and materials, and store massive amounts of carbon in their woody tissue. Both urban and rural forests are important carbon sinks and help mitigate climate change. In total, Novi's urban forest stores 254,110 tons of carbon, which equates to $43.3 million in value (Table 5). Each year, an additional 7,270 tons are absorbed (sequestered) for over $1.2 million in additional value.

PRIORITY PLANTING ANALYSIS

The Priority Planting Analysis identified areas without existing tree canopy that may especially benefit from trees and prioritized planting locations based on optimizing benefits. Such areas may have social and/or environmental concerns that trees can help with, including health and income disparities, resident populations that are especially sensitive to heat stress, and/or documented problems with flooding.

The analysis took possible plantable land area that was estimated by the urban tree canopy assessment—consisting of vegetated areas and bare soil—and excluded areas that are unsuitable for tree planting due to land use conflicts. Examples of excluded areas include sports fields, agricultural fields, and fairgrounds. The remaining preferred plantable area was prioritized from Very Low to Very High based on a variety of environmental and social factors.

In Novi, factors that were considered for the Priority Planting Analysis fell into three categories:

1. **Stormwater runoff potential**, indicating areas where trees might be useful for absorbing stormwater to reduce strain on the sewer/stormwater system. This category considered proximity to hardscape, soil permeability, tree canopy proximity, slope, and soil erosion factors.
2. **Urban heat island**, indicating areas where trees can be planted to reduce land surface temperatures. Urbanized areas contain heat-retaining buildings and paved surfaces as well as less tree cover compared to rural areas. This results in higher land surface temperatures within cities, called the *urban heat island effect*.
3. **Social equity**, indicating areas with a higher density of low income and poverty, vulnerable age groups, people of color, low education attainment, building age, and mental health prevalence based on U.S. Census data. The analysis suggests areas where additional trees can help alleviate health and income disparities and help mitigate heat stress.

The Priority Planting Analysis categorized 4,823 acres of available tree planting areas in Novi from Very Low to Very High (Table 6). If the City, residents, and businesses of Novi were to plant trees in all locations, the City's tree cover would rise from 37.1% (7,426 acres of tree canopy out of 20,019 acres total) to 61.3% (12,272 acres of tree canopy) across both public and private property.

Table 6. Available planting areas in Novi by level of priority for stormwater runoff reduction, urban heat island, social equity, and combined (composite) environmental and social factors, in acres and percent of city land area.

Priority Rank	Stormwater		Heat Island		Social Equity		Composite	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Very Low	1,981	5%	289	5%	1,347	5%	1,845	6%
Low	1,087	6%	1,638	6%	1,371	5%	941	5%
Moderate	789	5%	1,950	6%	716	6%	801	4%
High	600	5%	791	5%	627	7%	653	5%
Very High	366	3%	155	2%	761	1%	583	3%

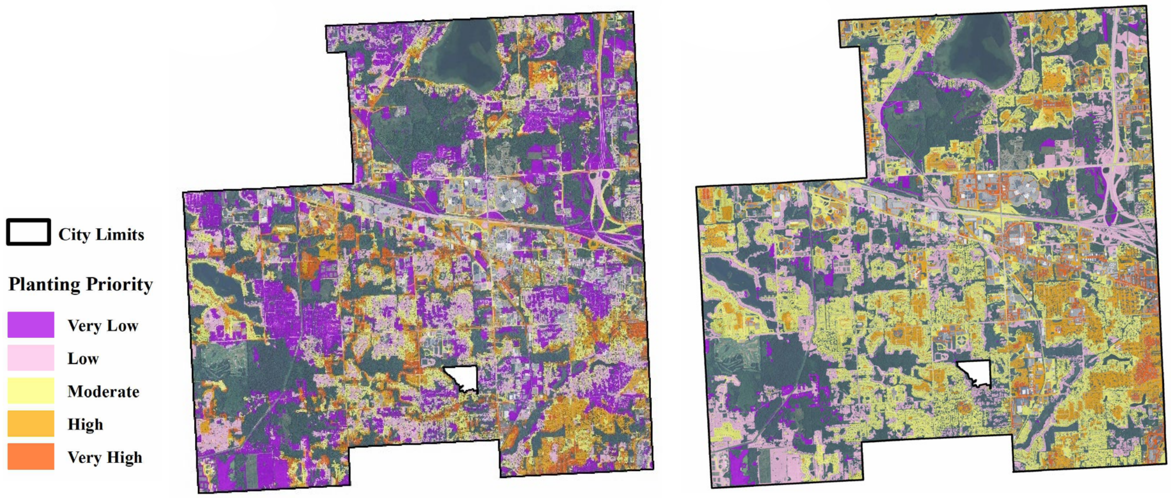
Final planting decisions should be made by city government, but the prioritized planting areas provided in this study can serve as a starting point and guideline for determining where future plantings may have the most impact on water quality, social equity and other tree benefits.

Priority Planting for Water Quality

A Priority Planting Analysis for stormwater runoff potential shows areas where tree canopy can be expanded for stormwater management, ranging from Very Low to Very High priority (Map 3). Approximately 966 acres of land, equal to 5% of Novi's total land area, is prioritized as "High" or "Very High" planting area based on projected impacts to stormwater management (Table 6). Planting this land area with trees would raise canopy cover in Novi from 37.1% to 41.9%.

Priority Planting for Urban Heat Island

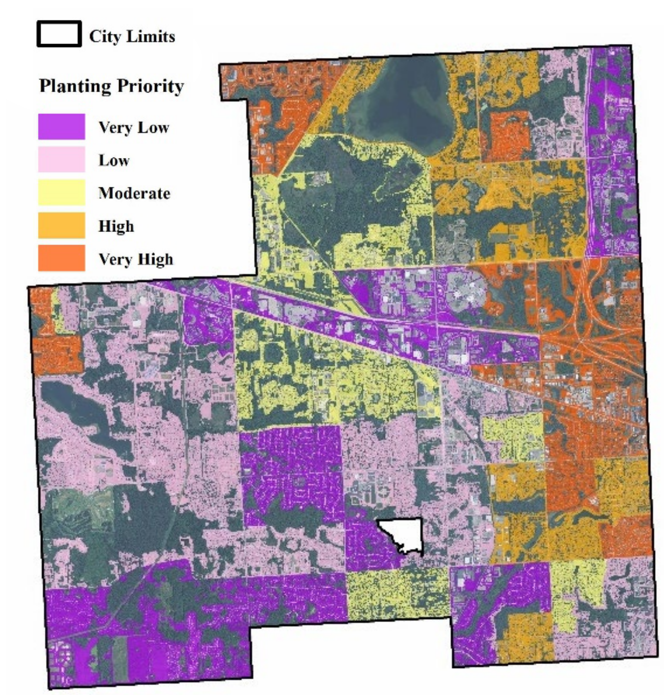
A Priority Planting Analysis for heat island shows areas where tree canopy can be expanded for urban heat island management, ranging from Very Low to Very High (Map 3). Of 4,823 acres of preferred plantable area, approximately 946 acres is prioritized as "High" or "Very High" based on its potential to mitigate urban heat island effect (Table 6).



Map 3. Possible planting areas prioritized by their potential for stormwater management (left) or urban heat island mitigation (right).

Priority Planting for Social Equity

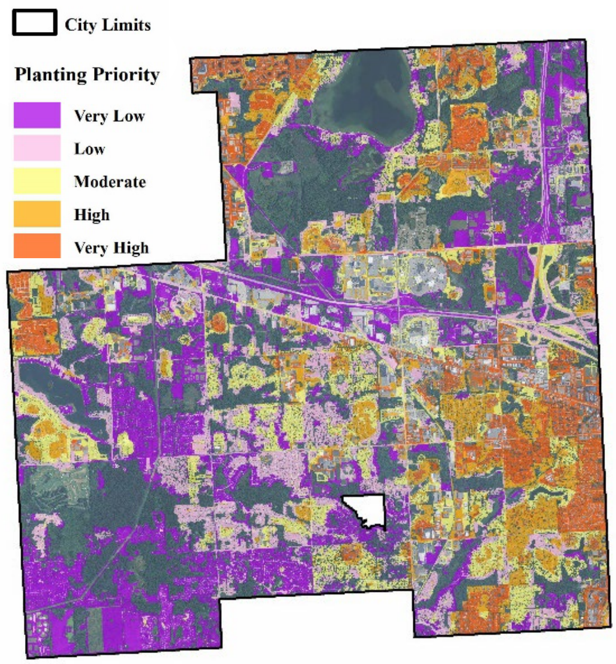
A Priority Planting Analysis for social equity shows areas where tree canopy can be expanded to maximize benefits that will have the most impact on human health, economics, and wellbeing, ranging from Very Low to Very High (Map 4). Of 4,823 acres of preferred plantable area, approximately 1,388 acres is prioritized as “High” or “Very High” based on projected impacts to social equity factors (Table 6).



Map 4. Possible planting areas prioritized by their potential to alleviate health and social disparities.

Priority Planting for Social Equity and Environmental Benefit

Overlapping all environmental and social indicators produced a composite priority planting rating based on a calculated average. The resulting map identifies areas that, if planted, have the highest potential to improve both water quality and quality of life for Novi's residents (Map 5). In total, 325 acres (35%) of the 939 acres available land area for tree canopy expansion is categorized as High or Very High based on composite social and environmental equity (Table 6). These areas indicate places where tree planting and preservation can have the greatest impact on quality of life for Novi residents.



Map 5. Possible planting areas prioritized by their potential to address a combination of environmental and social/health concerns.

RECOMMENDATIONS

Novi's urban forest is an important asset that provides innumerable social, environmental, and economic benefits. Trees may be the only community asset that appreciates in value over time. Like any asset, though, trees require proper care and attention to maximize the value and benefits that they provide. Planning and assessment efforts, such as this project, can help raise awareness about the importance of trees in Novi and develop strategies to optimize tree canopy throughout the city.

This analysis is designed to help document the urban forest in Novi, quantify the value and benefits that it provides, and develop recommendations for future planting and preservation efforts. This study should be considered as a starting point—a springboard for conversations and opportunities that can enhance the tree canopy across Novi. Based on the findings of this study, the following actions are recommended.

Plant Trees

The study identified an additional 4,823 acres of preferred plantable area in Novi that could increase tree canopy cover from 37.1% to 61.3%. Novi can make use of the Priority Planting Analysis to identify locations with a "High" or "Very High" priority planting rating. Planting in these areas will help reduce stormwater runoff, mitigate urban heat island effect, and build social equity.

The Priority Planting Analysis and maps provide a great guideline for finding planting locations based on community goals; however, they do not consider specific site factors, neighborhood preferences, or on-the-ground realities. Prior to planting, Novi will need to assess planting locations for factors that may limit their suitability for trees.

Tree planting should follow the “right tree in the right place” guideline (The Arbor Day Foundation). Before selecting a tree for planting, make sure it is the right tree—know how tall and wide it will be at maturity and whether it is well suited to the local climate, both now and in the future. Then consider site factors such as road salt, soil conditions, or existing hardscape that might limit the suitability of a tree for a specific location (“right place”).

In addition to right tree in the right place, Novi should also consider species diversity when selecting tree species to plant. This can help develop a resilient and sustainable urban forest and help lessen significant tree loss due to pests and diseases.

In addition to public tree planting, the City and its partners can also encourage private property tree planting. Working with local partners or volunteer organizations can assist with increasing community canopy through tree planting. Additional strategies such as incentive and cost-share programs, grants, education and outreach, or policy changes can encourage residents and business owners to plant trees throughout the community.

Preserve Existing Tree Canopy

While tree planting is one component of increasing and improving tree canopy, tree maintenance and preservation are also important activities. Older, larger trees contribute significantly more to a community’s current tree canopy than young, small trees. Caring for and preserving large trees should be an integral part of Novi’s strategy to maximize the benefits provided by trees and ensure a sustainable canopy over time.

Unfortunately, trees do not live forever. They will need to be removed for a variety of reasons, including natural mortality, invasive pest and disease outbreaks, extreme weather events, and development pressure, all of which can have a significant impact on community tree canopy. While trees that pose a risk can and should be removed, finding ways to encourage the retention and care of existing trees can have a substantial impact on expanding tree canopy.

Shifting the City's tree maintenance toward proactive maintenance, including a routine pruning cycle of 5-10 years, can save money that is currently spent on storm and emergency response as well as improve the health of the urban forest over time.

Strengthen Tree Ordinances and Policies

Novi's ordinances should be examined and revised to reduce barriers and provide incentives to protect and expand tree canopy. Review of internal policies and procedures and how City projects impact trees can also be helpful when identifying ways to preserve and protect existing canopy. Small changes in the design of public projects, including sidewalk installation and street and infrastructure improvements, can often significantly improve impacts to tree canopy. Similarly, protection of existing trees during development and requirements for tree replacement or compensation can reduce tree losses as Novi grows.

Connect Forestry to Other City Initiatives

As outlined in this Urban Tree Canopy Assessment Report, trees are an essential and critical part of Novi's infrastructure. A review of City of Novi plans should be conducted to identify ways that trees can be used to meet goals, recommendations, and targets of other City plans and initiatives.

Involve the Community

Outreach and education campaigns—including volunteer programs—can encourage citizens to care for and retain existing trees. Involving citizens in community tree initiatives is a great way to spread the word on the benefits of trees and develop a culture of tree appreciation that can have significant long-term impacts on tree canopy across Novi. Partnering with local organizations to help spread the word is a way to help get the message out.

Get Regular Tree Canopy Checkups

This project provided a tree canopy analysis with detailed information on the current canopy cover in Novi, as well as recommendations for supporting its growth and expansion. As initiatives are undertaken to preserve and care for existing trees and plant new ones, Novi will want to track progress and re-evaluate efforts towards meeting community goals. While a rigorous tree canopy analysis provides useful, detailed information, Novi can perform less rigorous self-assessments to track canopy changes using i-Tree Canopy. Industry standards recommend assessing tree canopy cover every 5-10 years. For information on using i-Tree Canopy visit www.itreetools.org.

Novi is encouraged to continue to use the urban tree canopy data and additional datasets to analyze relationships and connections that can help develop community objectives, understand challenges, and frame urban forest management decisions.

GLOSSARY

bare soil (land cover): Areas mapped as bare soil typically include vacant lots, construction areas, and baseball fields.

block group: A US Census-defined geographic area that is typically made up of 600–3,000 residents.

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

canopy cover: The area of land surface that is covered by tree canopy as seen from an aerial view.

carbon: An abundant chemical element that is an important building block for humans, plants, and animals; it is also found in the atmosphere, where it is part of molecules that contribute to climate change.

carbon monoxide (CO): An odorless, colorless gas in the atmosphere that results from the incomplete combustion of fuels and is toxic to humans.

carbon sequestration: Removal of carbon from the atmosphere. Trees remove carbon through a process known as photosynthesis, which converts sunlight and carbon dioxide into food.

carbon storage: Storage of carbon, such as in the wood and leaves of trees, that keeps it out of the atmosphere.

existing tree canopy: The amount of tree canopy present within the community boundary.

impervious surface (land cover): Area that does not allow rainfall to infiltrate the soil; typically includes buildings, parking lots, and roads.

i-Tree Canopy: The i-Tree Canopy tool allows users to easily photo-interpret Google aerial images of their area to produce statistical estimates of tree and other cover types, along with calculations of their estimates. This tool serves as a simple, quick, and inexpensive means for cities and forest managers to accurately estimate their tree and other cover types.

i-Tree Tools: State-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. The i-Tree Tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide. Tree benefits were calculated using the i-Tree Vue model and TR-55 hydrologic equations. i-Tree Vue estimates carbon storage and sequestration and air pollutant removal. TR-55 hydrologic equations model stormwater runoff.

land cover: Physical features on the earth mapped from satellite or aerial imagery such as bare soils, canopy, impervious, vegetation, or open water.

nitrogen dioxide (NO2): Nitrogen dioxide is a compound typically created during the combustion processes and is a major contributor to smog formation and acid deposition.

open water (land cover): Land cover consisting of water, including lakes, rivers, streams, and ponds.

ozone (O3): A strong-smelling, pale blue, reactive toxic chemical gas with molecules of three oxygen atoms. It is a product of the photochemical process involving the sun's energy. Ozone exists in the upper layer of the atmosphere as well as at the Earth's surface. Ozone at the Earth's surface can cause numerous adverse human health effects. It is a major component of smog.

particulate matter (PM10): A class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists that are 10 micrometers in size.

possible tree canopy: The amount of land that is theoretically available for the establishment of tree canopy within the city boundary, including both vegetation and impervious surfaces but excluding open water and active recreational spaces (such as ball fields).

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

species: A category of scientific classification consisting of related organisms that are capable of interbreeding.

stormwater: rain and snow melt that have the potential to collect on land and run off into streets, rivers, and streams. Large collections of stormwater runoff can contribute to flooding and sewer overflows.

sulfur dioxide (SO2): A strong-smelling, colorless gas that is formed by the combustion of fossil fuels. Sulfur oxides contribute to the problem of acid rain.

tree: A tree is defined as a perennial woody plant that may grow more than 20 feet tall. It usually has one main stem, although many species may have multiple stems.

tree benefit: An economic, environmental, or social improvement that benefits the community and results mostly from the presence of a tree. The benefit carries real or intrinsic value.

urban forest: All of the trees within a municipality or a community, both publicly and privately owned. This includes the trees along streets and in parks, residential yards, and other developed areas.

urban tree canopy assessment (UTC): A study of land cover to better understand where trees are currently present and where they could potentially be added. This assessment is typically performed using aerial photographs and spatial data.

vegetation (land cover): Vegetated area (grass, shrubs, etc.) that is not shaded by trees that allows rainfall to infiltrate the soil (“pervious”); typically includes parks, golf courses, and lawns.

APPENDIX A: URBAN TREE CANOPY ASSESSMENT METHODOLOGIES

Appendix A.1: Quantifying Land Surface Temperature

Capturing land surface temperature is essential to monitoring heat islands, air quality, and overall well-being for residents in Oakland County. To establish an understanding of how urban tree canopy affects heat island, land surface temperature analysis was conducted using Landsat 8 imagery taken during the late afternoon during summer conditions. Two images were used for this analysis a year apart to and averaged together to make the land surface temperature more accurate. The image source used for this assessment was Landsat 8 OLI-TIRS 30-meter resolution. The first image was captured on July 19, 2021 at 4:16PM. Weather conditions were cloudy with a high air temperature of 83 degrees. The second image was captured on July 25, 2023 at 4:16PM. Weather conditions were Partly Cloudy with a high air temperature of 84 degrees. For this analysis, both thermal bands (Bands 10 and 11) were averaged to produce the final surface temperature data set.

Image Pre-Processing:

Before processing the Landsat imagery, atmospheric correction was performed on the imagery to ensure that scattering due to aerosols, clouds, hazing, and other factors were removed from the imagery. This allowed for a defect-free image for the entire county for both thermal bands. After correction, the Landsat image was clipped to the county to remove area not included in the land surface temperature analysis.

Processing Steps

The following steps were implemented to transform the Landsat image from digital numbers (DN) to land surface temperature in Fahrenheit.

1) **Convert Raw Band DNs to Top of Atmosphere Radiance (TOA)**

$$L_\lambda = M_L Q_{cal} + A_L$$

where:

*L_λ = TOA spectral radiance (Watts/(m2 * srad * μm))*
M_L = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)
A_L = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number)
Q_{cal} = Quantized and calibrated standard product pixel values (DN)

2) Convert TOA Radiance to Reflectance

$$\rho\lambda' = M_\rho Q_{cal} + A_\rho$$

where:
$\rho\lambda'$ = TOA planetary reflectance, without correction for solar angle. Note that ρλ' does not contain a correction for the sun angle.
M_ρ = Band-specific multiplicative rescaling factor from the metadata (REFLECTANCE_MULT_BAND_x, where x is the band number)
A_ρ = Band-specific additive rescaling factor from the metadata (REFLECTANCE_ADD_BAND_x, where x is the band number)
Q_{cal} = Quantized and calibrated standard product pixel values (DN)

3) Convert Reflectance to At-Satellite Brightness Temperature

$$T = \frac{K_2}{ln\left(\frac{K_1}{L_\lambda} + 1\right)}$$

where:
T = At-satellite brightness temperature (K)
*L_λ = TOA spectral radiance (Watts/(m2 * srad * μm))*
K_1 = Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number)
K_2 = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number)

Constants:

```
K1_CONSTANT_BAND_10 = 774.8853
K2_CONSTANT_BAND_10 = 1321.0789
K1_CONSTANT_BAND_11 = 480.8883
K2_CONSTANT_BAND_11 = 1201.1442
```

4) Calculate Normalized Difference Vegetation Index (NDVI)

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

5) Calculate Proportion of Vegetation

$$Pv = (NDVI - NDVI_{min} / NDVI_{max} - NDVI_{min})^2$$

6) **Derive Land Surface Emissivity (reference for urban areas http://www.tandfonline.com/doi/full/10.1080/01431160600993421?scroll=top&needAccess=true)**

$$0.004Pv+0.963$$

Where:

Pv = proportion of vegetation

7) **Land Surface Temperature**

$$BT / 1 + w * (BT / p) * \ln(e)$$

where:

BT = At-satellite brightness temperature

W = wavelength of emitted radiance (~11.5 micrometers)

e = land surface emissivity

p = h * c / s (1.438 *10^{-2} m K)

h = Planck's constant (6.626 * 10^{-34} Js)

s = Boltzmann constant (1.38 * 10^{-23} J/K)

c = velocity of light (2.998 * 10^{8} m/s)

***p = 14380**

8) **Conversion from Kelvin to Fahrenheit**

$$^{\circ} F = 9/5 (K - 273) + 32$$

9) **Calculate Average Land Surface Temperature from Band 10 and 11**

Land Surface Temperature Finds:

Surface temperatures deviated throughout the city of Novi but were higher in locations with impervious surface and low amounts of tree canopy cover, as expected. The average of Bands 10 and 11 revealed the highest temperature to be 96.5 degrees Fahrenheit, while the lowest recorded value was in a forested area at 76.1 degrees. The average temperature across all cells was recorded at 80.99 degrees.

Appendix A.2: Methodology and Accuracy Assessment

Davey Resource Group Classification Methodology

Davey Resource Group utilized an object-based image analysis (OBIA) semi-automated feature extraction method to process and analyze current high-resolution color infrared (CIR) aerial imagery and remotely-sensed data to identify tree canopy cover and land cover classifications. The use of imagery analysis is cost-effective and provides a highly accurate approach to assessing your community's existing tree canopy coverage. This supports responsible tree management, facilitates community forestry goal-setting, and improves urban resource planning for healthier and more sustainable urban environments.

Advanced image analysis methods were used to classify, or separate, the land cover layers from the overall imagery. The semi-automated extraction process was completed using Feature Analyst, an extension of ArcGIS®. Feature Analyst uses an object-oriented approach to cluster together objects with similar spectral (i.e., color) and spatial/contextual (e.g., texture, size, shape, pattern, and spatial association) characteristics. The land cover results of the extraction process was post-processed and clipped to each project boundary prior to the manual editing process in order to create smaller, manageable, and more efficient file sizes. Secondary source data, high-resolution aerial imagery provided by each UTC city, and custom ArcGIS® tools were used to aid in the final manual editing, quality checking, and quality assurance processes (QA/QC). The manual QA/QC process was implemented to identify, define, and correct any misclassifications or omission errors in the final land cover layer.

Classification Workflow

1) Prepare imagery for feature extraction (resampling, rectification, etc.), if needed.
2) Gather training set data for all desired land cover classes (canopy, impervious, grass, bare soil, shadows). Water samples are not always needed since hydrologic data are available for most areas. Training data for impervious features were not collected because the City maintained a completed impervious layer.
3) Extract canopy layer only; this decreases the amount of shadow removal from large tree canopy shadows. Fill small holes and smooth to remove rigid edges.
4) Edit and finalize canopy layer at 1:2000 scale. A point file is created to digitize-in small individual trees that will be missed during the extraction. These points are buffered to represent the tree canopy. This process is done to speed up editing time and improve accuracy by including smaller individual trees.
5) Extract remaining land cover classes using the canopy layer as a mask; this keeps canopy shadows that occur within groups of canopy while decreasing the amount of shadow along edges.

6) Edit the impervious layer to reflect actual impervious features, such as roads, buildings, parking lots, etc. to update features.
7) Using canopy and actual impervious surfaces as a mask; input the bare soils training data and extract them from the imagery. Quickly edit the layer to remove or add any features. Davey Resource Group tries to delete dry vegetation areas that are associated with lawns, grass/meadows, and agricultural fields.
8) Assemble any hydrological datasets, if provided. Add or remove any water features to create the hydrology class. Perform a feature extraction if no water feature datasets exist.
9) Use geoprocessing tools to clean, repair, and clip all edited land cover layers to remove any self-intersections or topology errors that sometimes occur during editing.
10) Input canopy, impervious, bare soil, and hydrology layers into Davey Resource Group's Five-Class Land Cover Model to complete the classification. This model generates the pervious (grass/low-lying vegetation) class by taking all other areas not previously classified and combining them.
11) Thoroughly inspect final land cover dataset for any classification errors and correct as needed.
12) Perform accuracy assessment. Repeat Step 11, if needed.

Automated Feature Extraction Files

The automated feature extraction (AFE) files allow other users to run the extraction process by replicating the methodology. Since Feature Analyst does not contain all geoprocessing operations that Davey Resource Group utilizes, the AFE only accounts for part of the extraction process. Using Feature Analyst, Davey Resource Group created the training set data, ran the extraction, and then smoothed the features to alleviate the blocky appearance. To complete the actual extraction process, Davey Resource Group uses additional geoprocessing tools within ArcGIS®. From the AFE file results, the following steps are taken to prepare the extracted data for manual editing.

1) Davey Resource Group fills all holes in the canopy that are less than 30 square meters. This eliminates small gaps that were created during the extraction process while still allowing for natural canopy gaps.
2) Davey Resource Group deletes all features that are less than 9 square meters for canopy (50 square meters for impervious surfaces). This process reduces the amount of small features that could result in incorrect classifications and also helps computer performance.
3) The Repair Geometry, Dissolve, and Multipart to Singlepart (in that order) geoprocessing tools are run to complete the extraction process.
4) The Multipart to Singlepart shapefile is given to GIS personnel for manual editing to add, remove, or reshape features.

Accuracy Assessment Protocol

Determining the accuracy of spatial data is of high importance to Davey Resource Group and our clients. To achieve to best possible result, Davey Resource Group manually edits and conducts thorough QA/QC checks on all urban tree canopy and land cover layers. A QA/QC process will be completed using ArcGIS® to identify, clean, and correct any misclassification or topology errors in the final land cover dataset. The initial land cover layer extractions will be edited at a 1:2000 quality control scale in the urban areas and at a 1:2500 scale for rural areas utilizing the most current high-resolution aerial imagery to aid in the quality control process.

Table 1. Land Cover Classification Code

Land Cover Classification	Code Value
Tree Canopy	1
Impervious	2
Pervious (Grass/Vegetation)	3
Bare Soil	4
Open Water	5

To test for accuracy, random plot locations are generated throughout the city area of interest and verified to ensure that the data meet the client standards. Each point will be compared with the most current NAIP high-resolution imagery (reference image) to determine the accuracy of the final land cover layer. Points will be classified as either correct or incorrect and recorded in a classification matrix. Accuracy will be assessed using four metrics: overall accuracy, kappa, quantity disagreement, and allocation disagreement. These metrics are calculated using a custom Excel® spreadsheet.

Land Cover Accuracy

The following describes Davey Resource Group's accuracy assessment techniques and outlines procedural steps used to conduct the assessment.

Figure 1.

1. *Random Point Generation*—Using ArcGIS, 1,000 random assessment points are generated.

2. *Point Determination*—Each point is carefully assessed by the GIS analyst for likeness with the aerial photography. To record findings, two new fields, CODE and TRUTH, are added to the accuracy assessment point shapefile. CODE is a numeric value (1–5) assigned to each land cover class (Table 1) and TRUTH is the actual land cover class as identified according to the reference image. If CODE and TRUTH are the same, then the point is counted as a correct classification. Likewise, if the CODE and TRUTH are not the same, then the point is classified as incorrect. In most cases, distinguishing if a point is correct or incorrect is straightforward. Points will rarely be misclassified by an egregious classification or

editing error. Often incorrect points occur where one feature stops and the other begins.

3. *Classification Matrix*—During the accuracy assessment, if a point is considered incorrect, it is given the correct classification in the TRUTH column. Points are first assessed on the NAIP imagery for their correctness using a “blind” assessment—meaning that the analyst does not know the actual classification (the GIS analyst is strictly going off the NAIP imagery to determine cover class). Any incorrect classifications found during the “blind” assessment are scrutinized further using sub-meter imagery provided by the client to determine if the point was incorrectly classified due to the fuzziness of the NAIP imagery or an actual misclassification. After all random points are assessed and recorded; a classification (or confusion) matrix is created. The classification matrix for this project is presented in Table 2. The table allows for assessment of user’s/producer’s accuracy, overall accuracy, omission/commission errors, kappa statistics, allocation/quantity disagreement, and confidence intervals (Figure 1 and Table 3).

Table 2. Classification Matrix

	Classes	Tree Canopy	Impervious Surfaces	Grass & Low-Lying Vegetation	Bare Soils	Open Water	Row Total	Producer's Accuracy	Errors of Omission
Reference Data	Tree Canopy	365	4	10	0	1	380	96.05%	3.95%
	Impervious	1	260	6	0	0	267	97.38%	2.62%
	Grass/Vegetation	15	8	255	3	0	281	90.75%	9.25%
	Bare Soils	0	1	3	9	0	13	69.23%	30.77%
	Water	0	0	0	0	59	59	100.00%	0.00%
	Column Total	381	273	274	12	60	1000		
	User's Accuracy	95.80%	95.24%	93.07%	75.00%	98.33%		Overall Accuracy	94.80%
	Errors of Commission	4.20%	4.76%	6.93%	25.00%	1.67%		Kappa Coefficent	0.9259

4. Following are descriptions of each statistic as well as the results from some of the accuracy assessment tests.

    Overall Accuracy – Percentage of correctly classified pixels; for example, the sum of the diagonals divided by the total points ((365+260+255+9+59)/1,000 = 95.5%).

    User's Accuracy – Probability that a pixel classified on the map actually represents that category on the ground (correct land cover classifications divided by the column total [365/381 = 95.80%]).

    Producer's Accuracy – Probability of a reference pixel being correctly classified (correct land cover classifications divided by the row total [365/380 = 96.05%]).

    Kappa Coefficient – A statistical metric used to assess the accuracy of classification data. It has been generally accepted as a better determinant of accuracy partly because it accounts for random chance agreement. A value of 0.80 or greater is regarded as "very good" agreement between the land cover classification and reference image.

    Errors of Commission – A pixel reports the presence of a feature (such as trees) that, in reality, is absent (no trees are actually present). This is termed as a false positive. In the matrix below, we can determine that 4.20% of the area classified as canopy is most likely not canopy.

    Errors of Omission – A pixel reports the absence of a feature (such as trees) when, in reality, they are actually there. In the matrix below, we can conclude that 3.95% of all canopy classified is actually classified as another land cover class.

    Allocation Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than optimal match in the spatial allocation (or position) of the classes.

    Quantity Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than perfect match in the proportions (or area) of the classes.

    Confidence Intervals – A confidence interval is a type of interval estimate of a population parameter and is used to indicate the reliability of an estimate. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter based on the observed probability of successes and failures. Since all assessments have innate error, defining a lower and upper bound estimate is essential.

Table 3. Confidence intervals and accuracy assessment

Confidence Intervals

Class	Acreage	Percentage	Lower Bound	Upper Bound
Tree Canopy	7,425.5	37.1%	36.8%	37.4%
Impervious Surfaces	5,462.3	27.3%	27.0%	27.6%
Grass & Low-Lying Vegetation	5,821.5	29.1%	28.8%	29.4%
Bare Soils	205.3	1.0%	1.0%	1.1%
Open Water	1,104.5	5.5%	5.4%	5.7%
Total	20,019.2	100.00%		

Statistical Metrics Summary

Overall Accuracy =	94.80%
Kappa Coefficient =	0.9259
Allocation Disagreement =	4%
Quantity Disagreement =	1%

Accuracy Assessment

Class	User's Accuracy	Lower Bound	Upper Bound	Producer's Accuracy	Lower Bound	Upper Bound
Tree Canopy	95.8%	94.8%	96.8%	96.1%	95.1%	97.1%
Impervious Surfaces	95.2%	93.9%	96.5%	97.4%	96.4%	98.4%
Grass & Low-Lying Vegetation	93.1%	91.5%	94.6%	90.7%	89.0%	92.5%
Bare Soils	75.0%	62.5%	87.5%	69.2%	56.4%	82.0%
Open Water	98.3%	96.7%	100.0%	100.0%	100.0%	100.0%

Appendix A.3: Tree Benefits Methodology

1. How Tree Canopy Benefits Are Calculated:

1.1 Air Quality

The i-Tree Canopy v7.1 Model was used to quantify the value of ecosystem services for air quality. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports air pollutant removal rates and monetary values for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM) (Hirabayashi 2014).

Within the i-Tree Canopy application, the U.S. EPA's BenMAP Model estimates the incidence of adverse health effects and monetary values resulting from changes in air pollutants (Hirabayashi 2014; US EPA 2012). Different pollutant removal values were used for urban and rural areas. In i-Tree Canopy, the air pollutant amount annually removed by trees and the associated monetary value can be calculated with tree cover in areas of interest using BenMAP multipliers for each county in the United States.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for each of the five listed air pollutants.

1.2 Carbon Storage and Sequestration

The i-Tree Canopy v7.1 Model was used to quantify the value of ecosystem services for carbon storage and sequestration. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports carbon storage and sequestration rates and monetary values. Methods on deriving storage and sequestration can be found in Nowak et al. 2013.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for carbon storage and sequestration.

1.3 Stormwater

The i-Tree Hydro v6.0 Model was used to quantify the value of ecosystem services for stormwater runoff. i-Tree Hydro was designed for users interested in analysis of vegetation and impervious cover effects on urban hydrology. This most recent version (v6.0) allows users to report hydrologic data on the city level rather than just a watershed scale giving users more flexibility. For more information about the model, please consult the i-Tree Hydro v6.0 manual (http://www.itreetools.org).

To calculate ecosystem services for the study area, land cover percentages derived for the project area and all municipalities that were included in the project area were used as inputs into the model. Precipitation data from 2005-2012 was modeled within the i-Tree Hydro to best represent the average conditions over an eight year time period. Model simulations were run under a Base Case as well as an Alternate Case. The Alterative Case set tree canopy equal to 0% and assumed that impervious and vegetation cover would increase based on the removal of tree canopy. Impervious surface was increased 2% based on a percentage of the amount of impervious surface under tree canopy and the rest was added to the vegetation cover class. This process was completed to assess the runoff reduction volume associated with tree canopy since i-Tree Hydro does not directly report the volume of runoff reduced by tree canopy. The volume (in cubic meters) was converted to gallons to retrieve the overall volume of runoff avoided by having the current tree canopy.

Through model simulation, it was determined that tree canopy decreases the runoff volume in the project area by 138,483,325 gallons per year using precipitation data from 2005-2012. This equates to approximately 18,650 gallons per acre of tree canopy (138,483,325 gals/7,425.54 acres).

To place a monetary value on storm water reduction, the cost to treat a gallon of storm/waste water was taken from McPherson et al 1999. This value was $0.089 per gallon. Tree canopy was estimated to contribute roughly $12,325,016 to avoided runoff annually to the project area.

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Appendix A.4: Priority Planting Assessment

Summary

This project was conducted to assess priority planting locations for the city of Novi, MI. Data sources were sought across the board to analyze a variety of factors that can contribute to accessing tree canopy needs. Analysis included data sets from the city of Novi, US Department of Agriculture and US Census Bureau. The resulting analysis found plantable areas in both public and private properties across the city.

Description

To help the city of Novi increase its canopy coverage, an urban tree canopy assessment was conducted by the city to assess land cover using 2022 aerial imagery. The study was completed in 2023. An analysis to identify the most suitable locations was conducted by analyzing each planting location to assign a priority ranking for stormwater and urban heat island.

Each data source utilized the most current version available and described in the subsequent sections. Stormwater uses the most recent NAIP imagery, soil data, hydrography data, and elevation data. Heat islands were derived from averaging Landsat 8 surface temperature data from July 19, 2021 and July 25, 2023 data to find hotspots at varying points in time to locate areas of potential heat mitigation.

Methodology

In order to create a priority planting plan, the locations for planting must first be determined. Planting location polygons were created by taking all grass/open space and bare ground areas and combining them into a single dataset. Non-feasible planting areas such as agricultural fields, recreational fields, major utility corridors, airports, ROWs, etc. were restricted and noted as a query-able attribute in the final GIS dataset. This layer was reviewed and approved by the city of Novi before the analysis proceeded. The remaining planting space was consolidated into a single feature and then, exploded to multipart features creating separate, distinct polygons for each location. The final step broke polygons up again to note planting restrictions as their own feature.

<u>Stormwater:</u>

To identify and prioritize planting potential based on the stormwater analysis, locations were assessed with several environmental features, including proximity to hardscape, proximity to canopy, floodplain proximity, soil permeability, slope, and soil erosion factor (K-factor). These factors are based on numerous historic projects completed by DRG for stormwater analysis. Each factor was assessed using data from various sources and analyzed using separate grid maps. Values between zero and four (with zero having the lowest priority) were assigned to each grid assessed. A value of zero indicates that this classified piece of information yielded little or no overall value within the dataset. The grids were overlain with the values averaged to determine the priority levels at an area on the map. A priority ranging from Very Low to Very High was assigned to areas on the map based on the calculated average of all grid maps using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Areas of higher potential for runoff and erosion were considered higher priority due to their ability to diminish water quality within urban areas.

Urban Heat Island:

To identify and prioritize planting potential based on heat islands, a land surface temperature analysis was conducted. Using Landsat 8 imagery data from the United States Geological Survey (USGS), a calculation of land surface temperature by using the both Landsat 8 thermal bands. Imagery from July 19, 2021 and July 25, 2023 was used to find the radiance, at-satellite brightness temperature and proportion of vegetation, which were used to calculate the land surface temperature for each year. Surface temperatures were averaged and a priority ranking of Very Low to Very High was assigned based on the averaged temperatures using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Higher surface temperatures were considered higher priority due to the adverse effects of elevated microclimates within urban areas.

Social Equity:

To identify and prioritize planting potential based on a Social Equity, data was analyzed including census data. Census data included income, vulnerable ages, minority percent, poverty percent, education attainment, building age, and mental health prevalence. Each factor was separated to its own grid map. The values were broken into five classes and ranked from 0 - 4 (with zero being the lowest priority and 4 being the highest priority). These factors were classified into five final rankings from Very Low to Very High for each of the social equity and public health criteria using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Higher priorities of social equity give a focused effort of providing trees and tree canopy to all citizens regardless of social status. These priority areas are deemed to have the greatest return due to their importance of providing residents of the community equal access to nature.

Composite Priority:

Using zonal statistics, each raster data for stormwater, heat island, and social equity were used to calculate a total aggregate value for each individual planting location polygon. The values for each factor were statistically binned into five classes using quantile classification within ArcGIS. This classification method distributes values into groups that have an equal number of values. The higher numbers indicate higher priority for planting when assessing all factors through the same scope. These classes ranged from Very Low to Very High to mirror the criteria group rankings. These rankings were then used to combine all criteria to create a composite ranking based on all analytical factors pertaining to the city.

Once the process of identifying priority was completed, the development of planting strategies will be the next step in the process. While available planting sites may ultimately be planted over the next several decades, the trees that are planted in the next few years, should be planned for areas in most need, and where they will provide the most benefits and return on investment given a particular set of circumstances and desires to fulfill certain obligations to the community. The city of Novi can choose to target individual factors like heat islands for certain projects or select from the composite ranking to get the most return on investment across the board.

Group	Criteria	Data Origin	Last Update	Weighting
Stormwater	Distance to Hardscape	Novi Urban Tree Canopy Assessment	2023	0.30
	Distance to Canopy	Novi Urban Tree Canopy Assessment	2023	0.10
	Floodplain	National Hydrologic Dataset	2023	0.20
	Soil Permeability	Natural Resource Conservation Service	2023	0.15
	Soil Erosion	Natural Resource Conservation Service	2023	0.15
	Slope	National Elevation Dataset	2023	0.10
Urban Heat Island	Heat Islands – July 25, 2023	Earth Explorer - USGS	2023	
	Heat Islands – July 19, 2021	Earth Explorer - USGS	2021	
Census	Median Income	U.S. Census Bureau	5-year American Community Survey 2017-2021	
	Poverty Percent	U.S. Census Bureau	5-year American Community Survey 2017-2021	
	Non-High School Graduate Percent	U.S. Census Bureau	5-year American Community Survey 2017-2021	
	Vulnerable Ages (Under 5 and 65 and older)	U.S. Census Bureau	5-year American Community Survey 2017-2021	
	Older Building (Before 1970)	U.S. Census Bureau	5-year American Community Survey 2017-2021	
	Minority Population	U.S. Census Bureau	5-year American Community Survey 2017-2021	
	Mental Health Prevalence	CDC PLACES Project	2022	

Weighted Overlay Equation for stormwater priority:

("ImperviousDistance" * 0.30) + ("Floodplain" * 0.20) + ("SoilPermeability" * 0.15) + ("SoilErosion" * 0.15) + ("CanopyDistance" * 0.10) + ("SlopePercent" * 0.10)

Data Details

Stormwater

Distance to Hardscape

Source: Novi *Urban Tree Canopy Assessment*

Data: Distance to Impervious

Distance to hardscape is derived by selecting the impervious surfaces data from the Novi landcover layer. This impervious raster is used as an input layer into the Euclidean Distance tool within ArcGIS to create a layer that measures straight-line distance from each impervious surface location within the city. These distances are grouped into five classes from 0 - 4 with 4 being the closest to impervious surfaces and, therefore, the highest priority. The further a location is from an impervious surface, the lower the ranking it receives. A ranking of 0 is given to locations that are currently represented as impervious surfaces in the land cover data while the value of 4 indicates that the open area next to the impervious surface is available for planting trees to reduce the amount of runoff and sedimentation.

Distance to Hardscape	
Rank	**Distance to Impervious (ft)**
0	0
1	Over 100
2	51 - 100
3	26 – 50
4	1 – 25

Distance to Canopy

Source: Novi*Urban Tree Canopy Assessment*

Data: Distance to Canopy

Distance to canopy is derived by selecting the tree canopy data from the Novi landcover layer. This canopy raster is used as an input layer into the Euclidean Distance tool within ArcGIS to create a layer that measures straight-line distance from each canopy location within the city. These distances are grouped into five classes from 0 - 4 with 4 being the closest to Canopy and therefore the highest priority. The further a location is from the canopy, the lower the ranking it receives. A ranking of 0 is given to locations that are currently occupied by tree canopy and not plantable. Higher values in this ranking will prioritize areas that have small gaps that can be filed in order to increase tree canopy closure, which has great impact of wildlife habitat by providing larger corridors to support a variety of different species.

Distance to Canopy	
Rank	**Distance to Canopy (ft)**
0	0
1	Over 200
2	101 - 200
3	51 - 100
4	1 - 50

Floodplain

Source: National Hydrologic Dataset – USDS Geospatial Data Gateway

Link: https://datagateway.nrcs.usda.gov/

Data Attribute: Cost Distance

The floodplain is derived by using the hydrography lines from the United States Department of Agriculture (USDA) website and the Slope Percent Rise (found by calculating Slope using the Digital Elevation Model (DEM) from the USDA website). The Cost Distance tool within ArcGIS was used with these layers to create a raster dataset that shows a cost-weighted distance from the hydrography lines based on the percent rise of the land. This process identifies the first major slope break which indicates the normal stream bank channel that will fill during flooding events. The resulting data layer will show locations of where water will travel during periods of flood. These distances are grouped into five classes from 0 - 4 with 4 being in the floodplain area and therefore the highest priority. The further a location is from the floodplain, the lower the ranking it receives. A ranking of 0 is given to locations that are the furthest from the floodplain.

Floodplain - Cost Distance	
Rank	**Cost Distance (ft)**
0	Over 2,500
1	1,001 - 2,500
2	501 - 1,000
3	101 - 500
4	0 - 100

Soil Permeability

Source: *Natural Resource Conservation Service – USDA Web Soil Survey*

Link: *https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx*

Data Attribute: *Hydrologic Soils Group (HSG)*

Soil Permeability is found by analyzing the Hydrologic Soils Group (HSG) information from the USDA Soil Surveys. This data is classified into four classes: A, B, C and D. Group A soils have a high infiltration rate, Group B has a moderate infiltration rate, Group C has a slow infiltration rate, and Group D has a very slow infiltration rate. The remaining values are classified as W denoting water. These areas are typically larger bodies of water such as ponds, lakes or rivers. The rankings range from 0 - 4 with 4 being the highest priority. A ranking of 4 is given to the D classification due to its low infiltration rate. Planting in these locations will increase stormwater uptake and therefore, reduce the amount of runoff. Lower rankings are given to the A, B and C classes as these classes have higher infiltration rates where water is able to percolate through the soil without creating surface runoff leading to an decrease in harmful pollutants and sediment into streams and stormwater infrastructure over time. The W class is given a 0 ranking because these areas are classified as water and have no bearing of runoff.

Soil Permeability - HSG	
Rank	**Threat**
0	W
1	A
2	B
3	C
4	D

Soil Erosion

Source: *Natural Resource Conservation Service – USDA Web Soil Survey*

Link: *https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx*

Data Attribute: *K-factor*

Soil Erosion is found by analyzing the K-factor information from the USDA Soil Surveys. This data is classified into decimal numbers that range from 0.02 – 0.69. The higher numbers within this range mean that the area is more susceptible to sheet and rill erosion by water. Remaining values are given a value of 0 of which can represent water, quarries, pits, and other harder surface types. Water features are typically ponds, lakes and rivers. Rankings for this data are based on the susceptibility to erosion. A 0 ranking is given to areas that have little to no risk of erosion. The ranking increases as the risk of erosion increases with the highest ranking being 4. Planting in these priority areas will help decrease erosion vulnerability.

Soil Erosion – K-factor	
Rank	**K-factor (expressed as whole numbers)**
0	0 - 10
1	11 - 20
2	21 - 30
3	31 - 37
4	Over 38

Slope

Source: National Elevation Dataset – USDA Geospatial Data Gateway

Link: https://datagateway.nrcs.usda.gov/

Data: DEM

Slope is calculated by using the Digital Elevation Model (DEM) from the USDA and finding the slope percent rise of the DEM. The Percent Rise results were grouped into five classes from 0 - 4 with 4 being the highest priority as shown below. The rankings for this data are based on the percent rise of the area. The larger the percent rise of the land, the higher the planting priority. A ranking of 0 is given to areas of no percent rise and the rankings then increase as the percent rise increase with the highest ranking being 4. Planting trees on areas of high percent rise can help decrease stormwater runoff.

Slope – Percent Rise	
Rank	**Percent Rise**
0	0
1	0 - 3
2	3 - 6
3	6 - 12
4	Over 12

Urban Heat Islands

Land Surface Temperature (LST)

Source: Earth Explorer (USGS) Landsat 8 Thermal Imagery

Link: https://earthexplorer.usgs.gov/

Data Attribute: Land Surface Temperature (LST)

Land surface temperature is calculated using Landsat 8 imagery thermal bands. Using both thermal bands, a conversion from Digital Number (DN) to radiance, at-satellite brightness temperature and proportion of vegetation can be calculated. These values are used to find the land surface temperature. Imagery from July 19, 2021 and July 25, 2023 was used to create two separate surface temperature raster datasets. The two years were averaged and binned into five class from 0 - 4 based on a quantile classification with ArcGIS. Rankings are determined by the surface temperature ranges. The lowest surface temperature range received a 0 ranking. The ranking will increase as the surface temperature increases with the high rank being 4. Planting in areas of high surface temperature helps mitigation urban heat islands by providing more shade to cool not only air temperature but heat absorbed by pavements.

Land Surface Temperature – July 19, 2021 and July 25, 2023	
Rank	**Temperature (Fahrenheit)**
0	68 – 72
1	72 – 75
2	75 – 78
3	78 – 81
4	81 – 96.5

US Census

Median Household Income

Source: US Census Bureau - Median Household Income in the Past 12 Months: Census Data Table B19013

Link: https://www.nhgis.org/documentation/tabular-data

Data Attribute: AOQIE001 - Median household income in the past 12 months

Data shows the median household income earnings for each block group. Median incomes are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of income. A ranking of 0 is given to areas with high incomes. The lower the income is, the higher the ranking. A ranking of 4 is given to areas that have the lowest median income. Like with the poverty data.

Planting in these high priority areas may help address social equity issues and provide residents equal access to nature.

U.S. Census – Median Income	
Rank	**Median Income ($)**
0	No listed income
1	$155,000 - $250,000
2	$105,000 - $155,000
3	$75,000 - $105,000
4	$0 - $75,000

Vulnerable Ages (Under 5/65 and Over)

<u>Source:</u> US Census Bureau – Sex by Age: Census Data Table B01001

<u>Link:</u> https://www.nhgis.org/documentation/tabular-data

<u>Data Attribute:</u> AONTE003, AONTE020 – AONTE025, AONTE027, AONTE044 – AONTE049

Data shows the population over 65 years of age and under the age of 5 for each block group. People on these age groups are more susceptible to a number of environmental and health factors. These age groups are combined into one percentage of the population and are labeled as 'vulnerable ages.' The percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of income. A ranking of 0 is given to areas with lower percentages of vulnerable ages. The higher the percentage is, the higher the ranking. A ranking of 4 is given to areas that have the highest percent of vulnerable ages. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature as well as the environmental and health benefits from trees.

Percent of Population at a Vulnerable Age	
Rank	**Vulnerable Age Percent**
0	0%
1	0 -14.5%
2	14.5 – 18.5%
3	18.5 – 25%
4	Over 25%

Non-White Population

<u>Source:</u> US Census Bureau - Race: Census Data Table B02001

<u>Link:</u> https://www.nhgis.org/documentation/tabular-data

<u>Data Attribute:</u> AON5E002 – AON5E008 (Black or African American alone, American Indian and Alaska Native alone, Asian alone, Native Hawaiian and other Pacific Islander alone, Some other race alone, Two or more races.

Data shows percentage of population that are non-white in each block group. Percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of the percentage. A ranking of 0 is given to areas with lower percentages of non-white population. This ranking increases as the percentage of non-white residents increases. Planting in these high priority areas may help address social equity issues and provide residents with equal access to nature.

U.S. Census – Ethnicity	
Rank	**Non-White Percent**
0	None listed or 0%
1	0% - 25%
2	25% - 35%
3	35% - 45%
4	Over 45%

Families in Poverty

<u>Source:</u> US Census Bureau - Poverty Status in the Past 12 Months of Families by Family Type by Presence of Related Children Under 18 Years: Census Data Table: B17010

<u>Link:</u> https://www.nhgis.org/documentation/tabular-data

<u>Data Attribute:</u> AOQCE002 – Income in the past 12 months below poverty level

Data shows the percentage of families in each block group living below the poverty line in the past twelve months. Percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 and based on the amount of the percentage. A low ranking of 0 is given to areas with little to no families with children under the poverty line. This ranking increases as the rate of poverty increase with a ranking of 4 given to areas that have largest percentages of families in poverty. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature as well as possibly increase property values.

US Census - Families in Poverty	
Rank	**Poverty Percent**
0	0%

1	0 – 3%
2	3 – 6%
3	6 – 12%
4	Over 12%

Education Attainment

Source: *US Census Bureau - Educational Attainment for the Population 25 Years and Over: Census Data Table B15003*

Link: https://www.nhgis.org/documentation/tabular-data

Data Attribute: *AOP8E002 - AOP8E016: No Schooling Completed – 12th Grade, No Diploma*

Data shows the percentage of population 25 years and over in each block group that have not obtained a high school diploma or GED. Percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of the percentage. A low ranking of 0 is given to areas with lower percentages of people that have not obtained a high school diploma or GED. A higher ranking is given to areas that as the percentages of No Diploma increase with the top rank being 4. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature.

US Census – Education Attainment	
Rank	**Percent of No Diploma**
0	0%
1	0 – 2%
2	2 – 4%
3	4 – 6%
4	Over 6%

Building Age

Source: *US Census Bureau – Year Structure Built Census Data Table B25034*

Link: https://www.nhgis.org/documentation/tabular-data

Data Attribute: *AOTHE008 – AOTHE011 Built Before 1970*

Data shows the age range of each structure in each block group. Percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of the percentage. A ranking of 0 is given to areas with lower percentage of homes built before 1970. This ranking percentages of homes increases. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature.

US Census – Building Age	
Rank	**Building Percent**
0	0%
1	0 – 3%
2	3 – 8%
3	8 – 16%
4	Over 16%

Health

Mental Health

Source: Center for Disease Control (CDC) PLACES Project

Link: https://chronicdata.cdc.gov/browse?category=500+Cities+%26+Places

Data Attribute: Crude Prevalence

Crude Prevalence is calculated using respondents of the BRFSS survey. This number is a percentage that is calculated by dividing the weighted total of people who have reported 14 or more days during the past 30 in which their mental health was not good by the weighted number of people who responded to either survey excluding the answers of "don't know" or "refused" in regards to mental health. Data is recorded by census tract. The mental health rates are grouped into five classes using quantile classification within ArcGIS and ranked from 0 - 4. A ranking of 0 is given to the lowest prevalence. This ranking increases as the mental health rates increase with the highest ranking being 4. Planting in these priority areas will potentially help decrease mental health prevalence.

CDC – Mental Health	
Rank	**Crude Prevalence**
0	11.0 – 11.5
1	11.5 – 12.0
2	12.0 – 12.5
3	12.5 – 13.0
4	13.5 - 15