City of Traverse City

Department of Public Services

Parks & Recreation Division

Urban Forestry Update

December 2018

CONTENTS

Throughout this document there will be references to the October 2018 Tree Management Plan and Urban Canopy Tree Assessment that was completed by Davey Resource Group. Page numbers will be provided if more thorough details or assessment are appropriate. Additionally, in 1982 a document named "Street Tree Plan for Traverse City" was put together by Kielbaso Forestry Company. This document will also be referenced for historical comparison, and page numbers will be offered where pertinent information exists. Both documents are available in full as appendices in the back of this report.

TRAVERSE CITY URBAN FOREST REPORT

Traverse City is nestled between Boardman Lake and the Grand Traverse Bay of Lake Michigan in a pristine, natural setting. Our community's origin and history is based on trees and the lumber industry. City father, Perry Hannah, arrived here in 1851 and the region was evidenced with a 300 year old tree canopy. The lumber era of Traverse City helped build Michigan, Chicago, and the Mid-West. The City was once referenced as a "saw dust town."

A hundred years ago, Traverse City and the region's forest was nearly clear-cut. However, Mr. Hannah, our first Mayor and City Planner, planned the new city to include a healthy urbanized character. Current times find the City conducting an urban forest tree survey. The City engaged Davey Resource Group to assist in finalizing the inventory with an analysis of over 10,000 public trees. The study finds the diameter size class distribution of the City's tree population within Traverse City trends towards the ideal.

We now have a baseline with recommendations on how to protect, care and maintain as well as add to our urban forest. In recent years, the City has tripled our investment of plantings of additional trees into the public areas throughout the community. We will carry on conserving our natural resources for future generations while growing the quality of life in Traverse City.

Respectfully Submitted,

Martin A. Colburn
City Manager

***BUNYAN'S PROGRESS by:* Edward Richard Jones**

APOLOGY

**These stories merely tend to show
What lumberjacks and loggers know.
They don't pretend to tell us all
The many feats performed by Paul.
These records carry less than half
Of what was done by Paul's Blue Calf.**

**Inkslinger John at heavy cost
Had records full, but they were lost
When Sam's exploding sour dough
Reduced them all to shreds of snow,
And blew them skyward with a blast
To drop in driblets, while they last.
Endurance is their saving grace, ---
For each one lost, ten take its place.**

**So help yourselves, and find some more;
They bud and blossom by the score.
The better tales are Bunyan blest;
I tell a few; you tell the rest.**

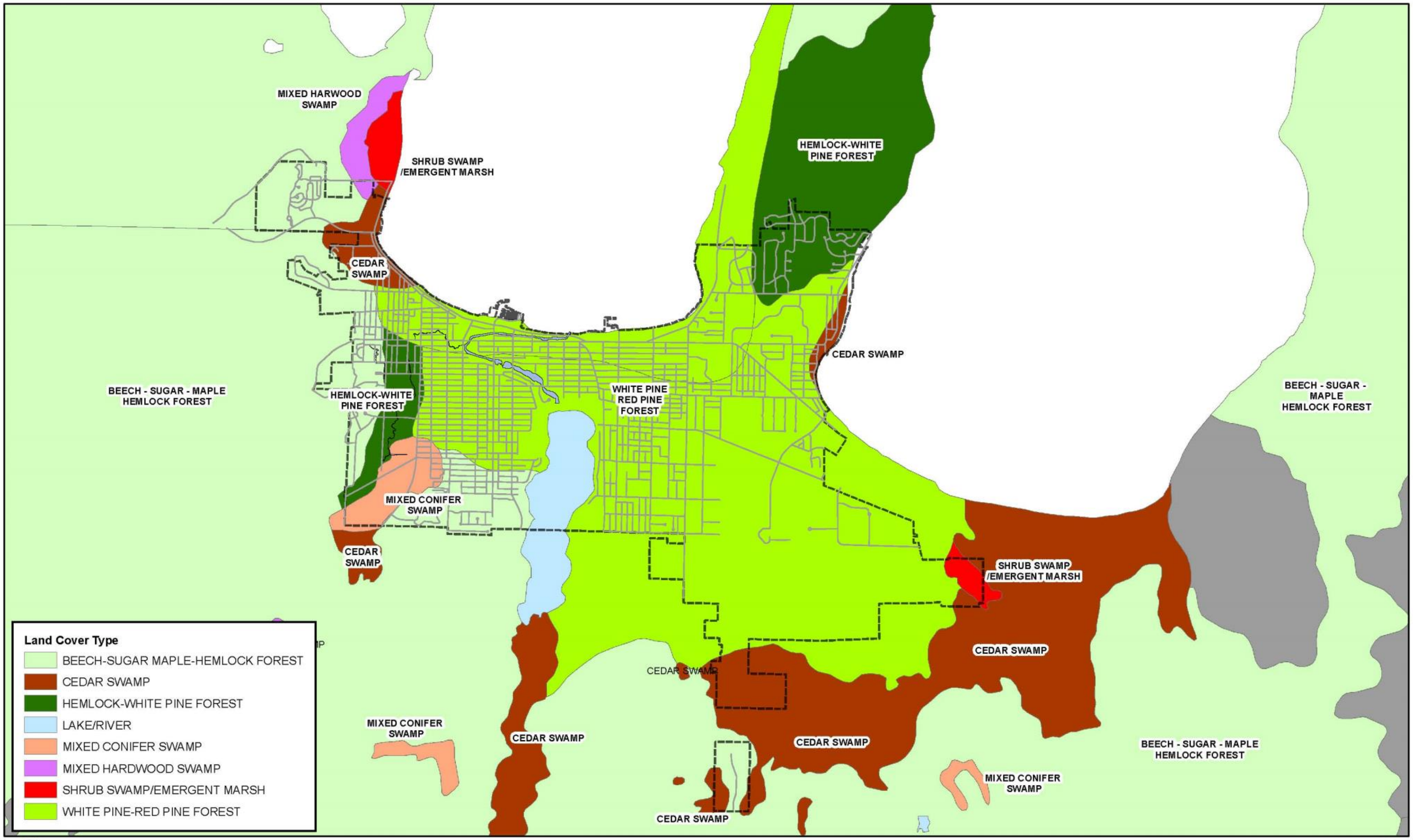
Forestry History

The presence of the logging operations within the City of Traverse City is well known, but it's important to reflect upon past forestry conditions as we consider our current and future urban canopy. The following maps and photos show a snapshot of what the City of Traverse City looked like after the logging industry made its way through the City. Areas that were originally forested were clear cut and developed, and planting efforts over the past 100 years to replace what was lost have largely been successful.

Traverse City in 1894, looking northwest. The house in the center is located at 333 6th Street.

Houses on Sixth Street in the 1890's.

Traverse City in 1896, looking north from Boughey Hill.



City of TRAVERSE CITY GEOGRAPHIC INFORMATION SYSTEMS
TC GIS

LANDUSE CIRCA 1800

Statewide database for Michigan based on original surveyors tree data and descriptions of the vegetation and land between 1816 and 1856

THIS MAP IS BASED ON DIGITAL DATABASES FROM THE CITY OF TRAVERSE CITY.TRAVERSE CITY CANNOT ACCEPT ANY RESPONSBILITY FOR ERRORS, OMMISSIONS OR POSITIONAL ACCURACY. THERE ARE NO WARRANTIES EXPRESSED OR IMPLIED.

1 INCH = 3,249 FEET

11/6/2018 GWS

Document Path: C:\Users\jswanson\Desktop\Tree Study\HistoricLandCover.mxd

Forestry Functions of the Parks & Recreation Division

The City of Traverse City Parks & Recreation Division is responsible for the full lifecycle of all City owned trees within the City of Traverse City. The Parks & Recreation Division also collaborates with residents of the City, Light and Power staff and contractors to care for and to remove trees as needed. The primary forestry functions performed by the City are broken down into five categories; planting, inventory, watering, pruning and removal.

- Planting: Nearly all of the trees planted on City property or within the right-of-way each year are placed by the Parks & Recreation Division. Each fall and spring there are planting efforts to place bareroot trees for replacement of a previously removed tree or at a newly identified planting location. Generally trees are planted that are 1 ½" – 1 ¾" in caliper size, as it provides for a good balance between cost effectiveness and likelihood of survival. Additionally, bareroot trees of our preferred size are easily transported and planted, promoting operational efficiency. Past practice was to try and plant as many trees that had been removed the year prior, so a "one lost to one replaced ratio" was the norm. In the fall of 2017 a new effort to plant additional trees was initiated and since that time we've planted 546 trees. By comparison, since 1984 we've averaged 124 trees planted a year.

  In addition to the trees that City Park & Recreation crews are planting, there are other efforts to increase tree canopy within the City and on City owned properties. More than 33,000 seedlings have been planted within City limits or on City owned property since 2014 as part of these planting efforts. (A full list of non-street tree plantings can be found in Appendix C)

- Inventory: The Parks & Recreation Division and Asset Management staff have been working collaboratively since 2016 to initiate and complete a full inventory of street trees within City limits. A proper inventory includes collecting field data for each tree that includes GPS location, position, species, size, height and condition. The field survey was started in the summer of 2016 and continued each summer until it was completed in the summer of 2018. Having a complete inventory provides us with data that helps guide planting and maintenance decisions as well as provides information that is helpful with regard to tracking workload and routine.

- Watering: City Parks & Recreation staff work in cooperation with adjacent property owners to water trees during the first two years following planting, which is the most critical period for a newly planted tree. Any tree that is not in a residential area or is not watered by a property owner is added to the City watering list. Trees in the most at-risk areas including in direct sunlight or in dry areas have a "gator bag" installed, which is a slow release watering device that is designed to save water and time. Trees without a "gator bag" are watered once or twice weekly, depending on weather and staff availability.

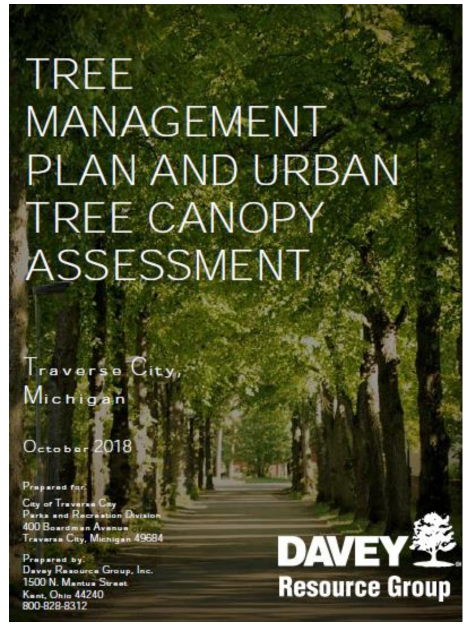
- Routine Pruning: Parks & Recreation staff are responsible for all pruning of City owned trees, with the exception of trees that Light and Power contractors trim within proximity to utility lines. Small tree pruning is done on the ground with hand tools and large tree pruning is done in the City owned bucket truck with chainsaws. Some pruning is required due to damage to trees that occurs during storm events. The majority of the pruning that the City performs is preventative and extends the life expectancy of the tree. Most pruning takes place in the winter season, specifically during periods of mild weather when snow plowing isn't required.

- Removal: A majority of tree removals the City performs are due to the death of a tree or severe damage caused by a storm event. These full removals are performed with the City bucket truck and chipper machine. Occasionally due to the size or location of a tree the need for a crane or crew skilled in working around power lines is needed, and then the appropriate contractor or Light and Power crew is called in to assist. Fully removed trees are cut down as close to flush with the ground as possible and then are added to the annual stump grinding project. Each fall, the City coordinates with a local contractor to grind all stumps from the prior year. The stump is ground down below the grade of the treelawn and the grindings are removed from the site. Fresh topsoil is brought in from our Keystone composting facility to fill the hole and seed is spread to replant the area with grass.

Management of trees proximate to sidewalks and utilities is an ongoing effort with sometimes diametrically opposed concerns. At times trees need to be removed to repair and replace sections of sidewalk and underground utilities. A large tree with roots growing upward below a section of sidewalk may necessitate its removal. The decision to remove/replace/repair the sidewalk or the tree and the effects of each decision is a topic we will be addressing more often as our City continues efforts to add approximately 14 miles of new sidewalk over the next few years. Both trees and sidewalks require robust maintenance. As we plan these new sidewalks there will be many situations which will require a decision related to tree removal or the meandering of a sidewalks. A straight sidewalk path within our existing ROW and at a constant grade is much less costly to maintain. For example, the snow removal process will take longer; require additional staking and spring lawn repair if the sidewalk was to meander. Meandering sidewalk may mean additional ROW to be purchased.

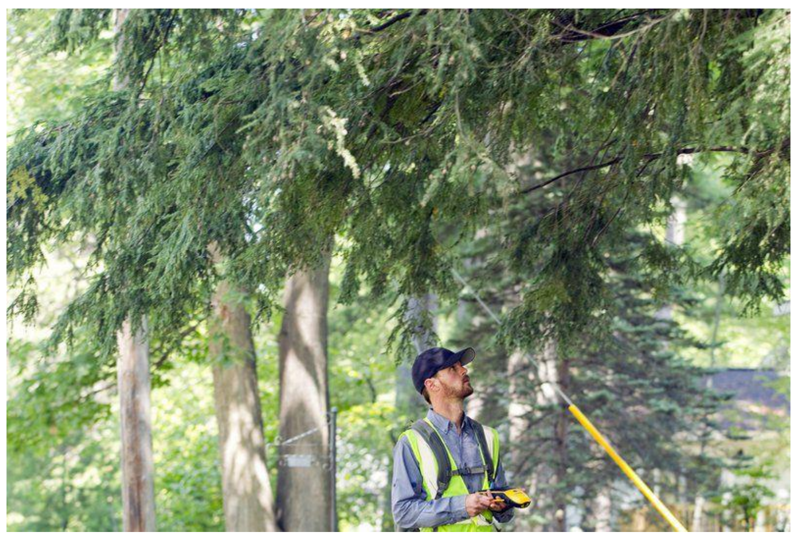
The placement, upkeep, management and planning for our trees is directly related to the infrastructure that surrounds them.

Urban Canopy Assessment, Inventory & Management Plan



- Received $17,500 grant in 2017 to complete a City wide Urban Canopy Assessment and Management Plan for City owned street trees.
- Goals of the Urban Canopy Assessment Project
  - Complete the inventory of City owned street trees.
  - Develop a comprehensive priority planting plan for City owned property and right of way.
  - Assess current inventory data and forestry practices and offer suggestions for best management practices for an urban forest of our size.
  - Assess the City as a whole (both public and private) to attain comprehensive urban canopy land cover percentage.

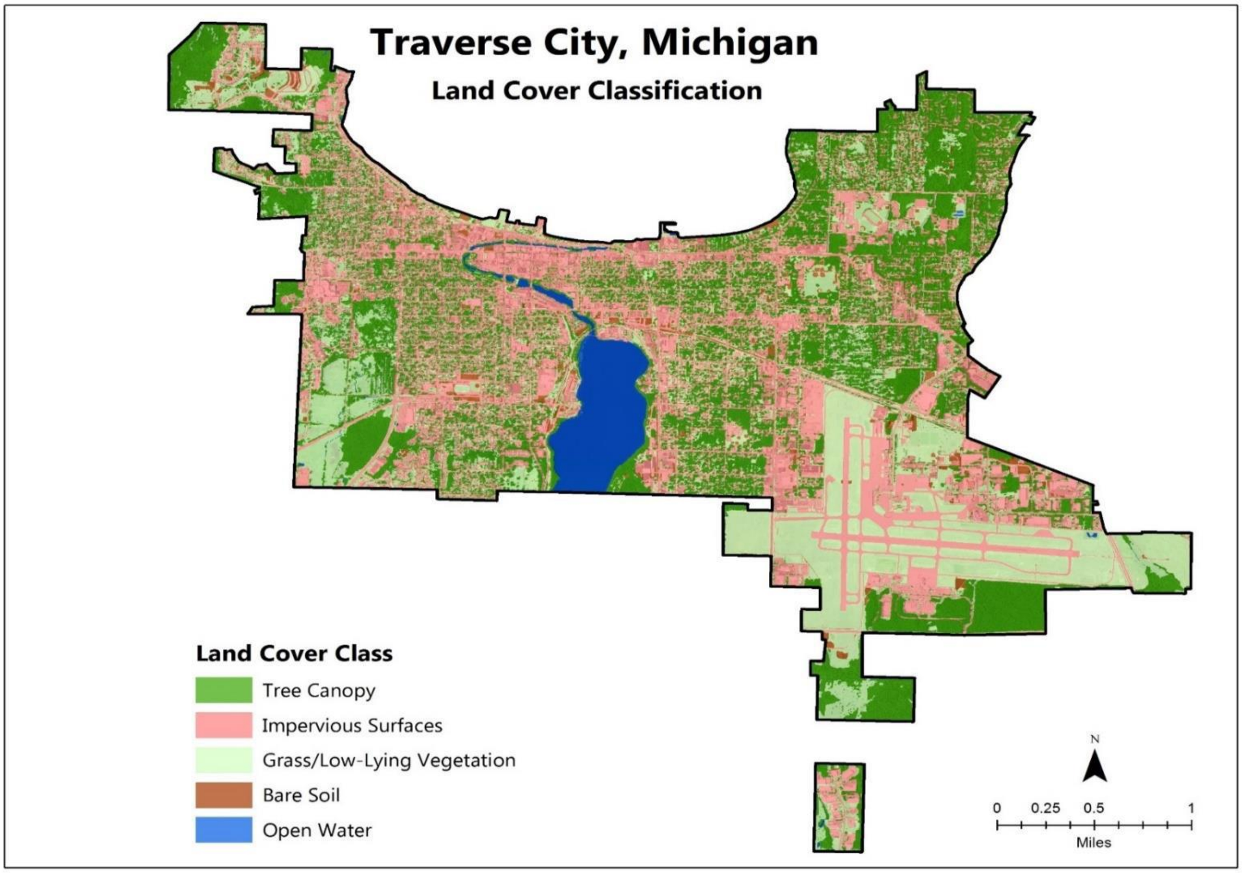
Tree Inventory Analysis



- More than 10,000 trees were inventoried in total. Of the trees inventoried, 9,756 are street trees and the remainder are found in City owned parks.
- The 2018 Davey Report shows high percentages of Sugar Maple, Norway Maple and Red Oak. The City owned Urban Forest is made up of 50% Maples, exceeding the recommended 20% threshold of best management practices.
- We are close to having an ideal distribution of young, established, maturing and mature trees per recommendations in the management plan. Additional details on this breakdown can be found on page 6 of the 2018 Davey report.
- A majority of inventoried trees were rated fair or good with regard to tree condition.

Comparison between 1982 Report and 2018 Report

- In 2018 we have 9,442 street trees in comparison to 1982, the street tree and shrub inventory listed 7,595 trees and shrubs, with approximately 531 shrubs included within the total. Based on this data, we have more than 2,300 additional street trees in 2018 as compared to 1982. The increase can partially be attributed to the planting efforts of the City, but other factors, such as including trees within traffic islands as "street trees" play a role in the data increase as well
- Nearly 70% of the trees inventoried in 1982 were Maple trees. Although our current inventory is made up of 50% Maples, we are trending toward a more balanced distribution based on our diverse annual planting plan. (page 7-10, 1982 Tree Report)



Initial Findings Summary

- The Davey Resource Group Urban Canopy Assessment identified that the city has 33% tree canopy coverage, which accounts for 1,807 acres. The 33% coverage includes both the airport and the portions of Boardman Lake and Boardman River within City limits, which limit potential planting area and future percentage goals. If the airport acreage and open water acreage are removed from the canopy coverage equation, the city would currently have 42.6% canopy coverage for the remaining 4,234 acres of land within City limits. (page 13, Davey 2018)
- Land Cover percentage varies greatly related to zoning classification. Institutional zoned property (NMC) leads the way with 65% canopy coverage and Governmental zoned areas (Cemetery, etc.) following with 46% coverage. Commercial zoned areas have the least coverage with only 17% canopy. (page 15, Davey 2018)

Tree Management Recommendations

Of the recommendations from Davey Resource Group, there are goals we are very close to attaining while others are not quite within reach without increased budget and staffing. Please refer to Table 6 on page 24 in the Davey 2018 report for additional details on their Tree Management recommendations.

- Routine Pruning: It is recommended that we preventatively prune 1,500 trees each year to stay on a 7 year pruning cycle. Currently we prune between 500 and 700 trees each year as staff levels and other demands of the Parks & Recreation personnel take priority. Increasing our pruning levels to be more in line with the Davey recommendations will assure a healthier urban forest for the long term.

- Inventory: Davey is recommending we continue to inventory our trees at a rate of 1,500 a year. This updated inventory would take place at the time of planting and pruning as part of the normal workflow and tracked via Lucity, (our work order management software). The number of trees inventoried each year would be equal to the number of trees that are planted, pruned or removed.

- Tree Planting: The number of trees to be planted annually to provide a maintained canopy percentage with the potential for minimal growth is 400 trees. Additionally, it is recommended that we water each of those trees for a 2 year period for optimal survival likelihood. After the first year of implementation City staff will be required to water 800 trees annually.

- Contingency: Due to the size of our Urban Forest and Tree Maintenance program it is recommended at minimum we employ or contract a professional forester whose responsibilities are solely focused on forestry related functions.

Takeaways and Recommended Action Plan

- Routine Pruning: Increasing our existing pruning numbers to meet recommended levels without neglecting other necessary Parks & Recreation functions is not possible with current staffing levels within the Parks & Recreation Division. Since there is currently no dedicated Forestry staff within the City, the employees who trim trees are the same that maintain our City parks, City properties and traffic islands, empty downtown garbage year round and 7 days a week in the parks from Memorial Day to Labor Day, plow during the winter, and operate Hickory Hills, etc.

A variety of options could be pursued to increase pruning levels including; adding Parks & Recreation staff, creating a small yet separate Forestry Division which only performs forestry functions for the City, or accomplish tree pruning via a contractor through the competitive bidding process. All potential options to increase pruning levels would require additional funding, and each option has its own advantages and disadvantages. Regardless of the decision reached on how to accomplish additional routine pruning, more resources are needed to take proper care of our valuable assets.

In addition to the routine pruning of street trees, there are other areas on City owned property where maintenance pruning and removals may be warranted due the need for access of Fire Department apparatus in a fire response situation. One example is the Grand Traverse Commons, specifically the stand of pine trees that are near the intersection of 14th street and Silver Lake Road. Recognizing and managing these areas differently than our street and park trees is important for the health of the forest and the safety of our residents.

- Inventory: It is currently planned for the Parks & Recreation staff to be trained to use data collection software and Lucity to keep inventory current. We are confident this new task will be easily implemented and will provide useful data for the City.

- Tree Planting: Based on the recent desire to increase tree planting in 2017, we are nearly at the Davey recommended levels of 400 trees planted annually. The Parks Division was able to increase annual planting efforts from the average 124 trees planted a year to 300+ by adding seasonal staff and by contracting with Youth Work through Child and Family Services. We will continue to plant 350-450 trees annually as long as budget continues to allow it.

If we are to accomplish the recommended levels of watering the 400 trees for a two year period, (800 trees a year) we will have to hire a seasonal staff person dedicated to watering trees. Also, for efficiency purposes we'll need to purchase a larger capacity water tank and pump so that we can meet the gallon capacity needed to water 800 trees at least once a week during periods of dry weather. The cost of a single seasonal staff person to water 800 trees is approximately $10,000 each summer. Additionally, for high risk areas we should deploy "gator bags" to increase the likelihood of tree survival. At the cost of $20 each, they are well worth the investment to boost recruitment rates. We recommend purchasing and maintaining as many as the budget allows.

- Contingency: Of all the recommendations within the contingency portion of the Tree Management Program, the professional forestry contract/staffing recommendation is the most crucial for the future of the Urban Canopy within Traverse City.

When the previous City forester retired in 2011 the duties were split up between existing staff, scaled back or discontinued. Reestablishing the Forester position could provide for a hands on professional that helps guide our planning and planting regime to personally assist with the planting and pruning process each year. Additionally, having a Forester would allow for us to reinstate our community education, outreach and public relations efforts with regard to urban forestry. Finally, adding the Forestry position back to the Parks & Recreation Division would make readily available an expert to provide a watchful eye for the urban forest, as compared to the current situation where the Forester duties are divided between multiple staff members.

Summary

The data from our recently competed inventory and the Urban Canopy Assessment and Management Plan shows that the past 36 years of forestry efforts by the City of Traverse City have resulted in a healthy and valuable urban canopy. Additionally, when the history of clear cutting and lumber harvesting are considered, the reforestation efforts within the City can be viewed as successful. However, additional investment is needed to protect the canopy we currently have and to provide for continued improvement with regard to tree canopy levels. Incrementally increasing our forestry efforts to strive toward the recommendations from the 2018 Davey report will enable the City to ensure a healthy urban forest for generations to come.

2017 Arbor Day tree planting event at Traverse Heights Elementary School.

Street Tree Plan for... Traverse City

A REPORT TO THE CITY OF TRAVERSE CITY

A MASTER PLAN FOR STREET TREE PLANTING, CARE, AND REMOVAL BASED ON THE 1982 INVENTORY OF PUBLIC STREET TREES

Kielbaso Forestry Consulting
4595 Arrowhead Road
Okemos, Michigan 48864

John P. Giedraitis
Dr. J. James Kielbaso

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ACKNOWLEDGMENTS

The survey and the preparation of this report would not have been possible without the support and assistance of many people. This study was instigated by Mr. Dale Majerczyk, Director of Public Services. His comments and suggestions contributed significantly to the study. Mr. Robert S. Anderson, the City Manager; Doc Aeschliman, Director of Parks; and the members of the City Commission gave initial and continuing support. Details concerning the past city forestry program were provided by Mr. Martin Melkild, retired City Forester of Traverse City.

Invaluable assistance was provided by successive survey assistants: Bruce Tamulis, Dallas Burrell, and Thomas Giedraitis. Their thoroughness and dedication aided in the collection of consistent, high quality data. Special recognition is also given to Anders Johanson, Manager of Michigan State University Computer Application Programming, for his personal support and staff commitment in the data processing. Thanks is also given to Jean Terrell, who patiently typed the manuscript.

Section
I

INTRODUCTION

levels through the placement of trees and other plants in the vicinity of objectionable sounds.

Trees cleanse the atmosphere by precipitating and filtering out impurities and by adding oxygen to the air. It has been shown, for example, that the volume of carbon dioxide removed from the air by an eighty foot tall beech tree is equivalent to that produced daily by two single-family dwellings. Reduction of particulate pollutants of 7,000 or more dust particles per liter of air is possible along tree-lined streets.

Trees play an important role architecturally by enhancing buildings and other structures by defining or creating functional areas or other spaces by reinforcing structural designs. For instance, a passage from The History of the Neighborhood, Traverse City Michigan, tells of some of the impact of streetside trees:

> . . . you sense yourself in a formal residential park, sheltered by overhead branches. Whether on a street, sidewalk or front lawn, the mature maple trees planted in the curbgrass shelter your passage with an overhead canopy and enhance your views.

In addition to their aesthetic values, trees can add monetary value to real property. For example, homes and building sites with trees usually sell more quickly and at higher prices than properties with no trees. Realty authorities have attributed an increased valuation per home by as much as 20%, with average increases of 5% to 10%.

During the inventory, many citizens would interrupt and express a high level of concern for our actions relating to "their" tree. While information on attitudes was not actively collected, most of the homeowners that were asked believed that city forestry activities were "good" for both themselves and the community as a whole.

A more scientific study of statewide public opinion was conducted in 1975 by the Department of Resource Development and the Cooperative Extension Service of Michigan State University. While not dealing directly with attitudes towards street trees, related issues were addressed. It was found that the level of resident satisfaction in the northwest region of Michigan was higher than it was statewide. In fact, the percentage of citizens who said they would be reluctant to leave or would never consider leaving their community was markedly higher in the region (84%) than it was in the state as a whole (62%).

In this public opinion survey, residents of Grand Traverse County were asked what the most important factors were in choosing a community in which to live. Of a list of twenty-one community characteristics, residents were asked if each was not important, slightly important, of moderate importance, or of great importance in choosing a community. The top ten most important characteristics attained from the survey are listed below.

From this citizen opinion survey, quality of air and water, natural scenery, and community physical appearance can be seen as important community issues. Street trees can provide an important factor in the attractiveness of

	Community Characteristic	% Who Indicated It Was of Great Importance in Grand Traverse County	% in State as a whole
1)	Less crime or danger there	75	78
2)	Quality of air and water	74	68
3)	Good place to raise children	63	64
4)	Natural scenery	60	41
5)	Quality of medical facilities	57	56
6)	Community physical appearance	50	50
7)	Quality of schools	50	54
8)	Size of population	50	29
9)	Friendliness of community	49	46
10)	Lower cost of living	45	52

Traverse City to present and potential residents and businesses. When seen in this light, public trees become an important goal when planning for community improvement

Local Setting

Traverse City is located in the northwest portion of the lower peninsula of Michigan. It is situated at the base of the west bay of Grand Traverse Bay on Lake Michigan. The first white settlers to the region were missionaries who arrived in 1839. In the 1840's, lumbering operations began in what is now Traverse City. Vast stands of pine and hardwoods combined with the sheltered port of Grand Traverse Bay ensured a thriving lumber business for about the next sixty years. In 1893, at the height of the era, an estimated 250 million feet of lumber was processed annually by fourteen mills operating in the county. Early pictures of the area that is now the city show the trees had been stripped off by the 1860's.

After the turn of the century, as lumber activities declined, it was discovered that the soils and climate of the region were particularly suited for fruit production, and by 1905, cherries were an important crop. Currently, there are some two million tart cherry trees and 700,000 sweet cherry trees in the region. In normal years, the Traverse area produces about half of the national tart cherry crop. In 1923, the "Blessing of the Blossoms" ceremony took place. This was the forerunner of the week-long National Cherry Festival, an event that attracts some 300,000 people to Traverse City each July and ranks among the nation's largest yearly festivals. Tourism has also developed as an important industry to Traverse City and the region, and now summer visitors are the second most important industry to the region.

Traverse City was originally settled in 1847, incorporated as a village in 1881, and as a city in 1895. Often called the cherry capitol of the world, it is the regional center for government in the northwest lower peninsula. It covers 7.9 miles, has about seventy miles of streets, and has a population of approximately 18,000.

Climate of Traverse City*

The climate of Traverse City is quasi marine or modified continental. Because of the city's proximity to Lake Michigan and because the prevailing westerly winds pass over the lake before reaching the city, the climate is quasi maritime when the wind is westerly. However, if the wind shifts to the south or southeast, it passes over a large land mass before reaching Traverse City and the climate changes to continental. But because of the prevailing westerly winds and the lake influence, winter is milder and summer is cooler than at the same latitude in Wisconsin or Minnesota.

With the lake moderating extremes, in the spring the cool lake water cools the warm air that reaches the area, and growth of plants is held back until frost is no longer likely. In the fall, the lake water, having been warmed by the summer sun, warms the cold air moving into the area and delays the first frost, thereby giving plants more time to mature.

The moderating lake effect diminishes with distance from the water. At Fife Lake, seventeen miles southeast of Traverse City, the average growing season is only 87 days, while at Traverse City, the average growing season is about 61% longer at 142 days.

Precipitation during the growing season is favorable for tree growth. In the six-month period from April to September, the average rainfall is about 17 inches and is well distributed. The rates of evaporation and transpiration are relatively low because the air is cool, the humidity high, and many days are cloudy or partly cloudy. As a result, soil moisture is usually adequate for tree growth on all but very sandy soils. Average snowfall is between 70-80 inches a year.

Traverse City lies in Zone 5 of the plant hardiness zone map developed by the Arnold Arboretum of Harvard University. This corresponds to Zone 6 on the USDA plant hardiness zone map which has a defined limit of between

*From Soil Survey of Grand Traverse County, Michigan.

-10° to -5°F for average annual minimum temperature. Since the average annual lowest temperature in Traverse City is -10°F, only trees classified as capable of surviving those temperatures should be planted.

Surface Geology and Soils of Traverse City

The last sheet of the Wisconsin Ice Age or glacial period formed the surface features of Traverse City and the surrounding area. When the last ice sheet melted and receded about 6,000 years ago, it left deposits known as the Manistee moraine. This moraine partly surrounds Traverse City and extends northward into Leelanau County and eastward from Acme. The physiographic features of Traverse City are glacial lake plain throughout most of the city and moraines in the northeast section on the Old Mission Peninsula.

There are three major soil types found over the city. These soils are described below.

(1) **East Lake - Mancelona loamy sands, 0 to 2% slope (EmA).** Found over most of the city west of Boardman Lake and River. These soils consist of well drained sand and loamy sand that are underlain by calcareous sand and gravel at a depth of 10-42 inches. This deep, well drained soil has rapid or very rapid internal drainage. The moisture-supplying capacity is fair to poor, and the soils may be droughty during dry periods. Aeration is rapid, and natural fertility is moderate or moderately high. The surface is medium acid to neutral. The potential productivity is high for trees grown on these soils. Sugar maple has a high potential growth rate on these soils.

(2) **Rubicon sand, 0 to 2% slopes (RwA).** Found over most of the city east of the lake and south of Washington Street and Munson Avenue. This type is a well drained soil that has a sand surface and subsurface layer and a sand subsoil. The soil reaction is slightly to medium acid. Aeration is rapid, natural fertility is low, and the moisture-supplying capacity is poor to very poor. The potential productivity for hardwood tree species is low.

(3) **Lake Beach and Eastport sand, 0 to 6% slopes (LeB).** Found in a strip running through the city adjacent to the west arm of Grand Traverse Bay. It includes all of the central business district, much of the Boardman neighborhood, and other areas along the lake shore. Because of the past periodic soil movement that has occurred as a result of lake action, no strong soil profile has developed. This soil consists of well drained, coarse textured material deposited by water along the lake shore. The potential productivity for hardwood trees is very low.

The impact of soils on street tree growth and management will be considered throughout the report.

Section
II

ANALYSIS OF EXISTING STREET TREES
SURVEY RESULTS

II

ANALYSIS OF EXISTING STREET TREES - SURVEY RESULTS

During the inventory, information of species types, size, and condition was recorded for each street tree. What follows in this section is an analysis of this information for the total population.

Species Composition

A total of 7,595 trees and shrubs were recorded during the 100% inventory of street trees in Traverse City. Table 1 summarizes total species composition by common name, number, and percent of the total population. Trees representing thirty-eight genera and a total of sixty-one different species were identified. The five most common genera—maple, oak, pine, elm, and ash—represent about 89% of all public street trees. Figure 2 below provides a summary for the most common genera and the species contained in each.

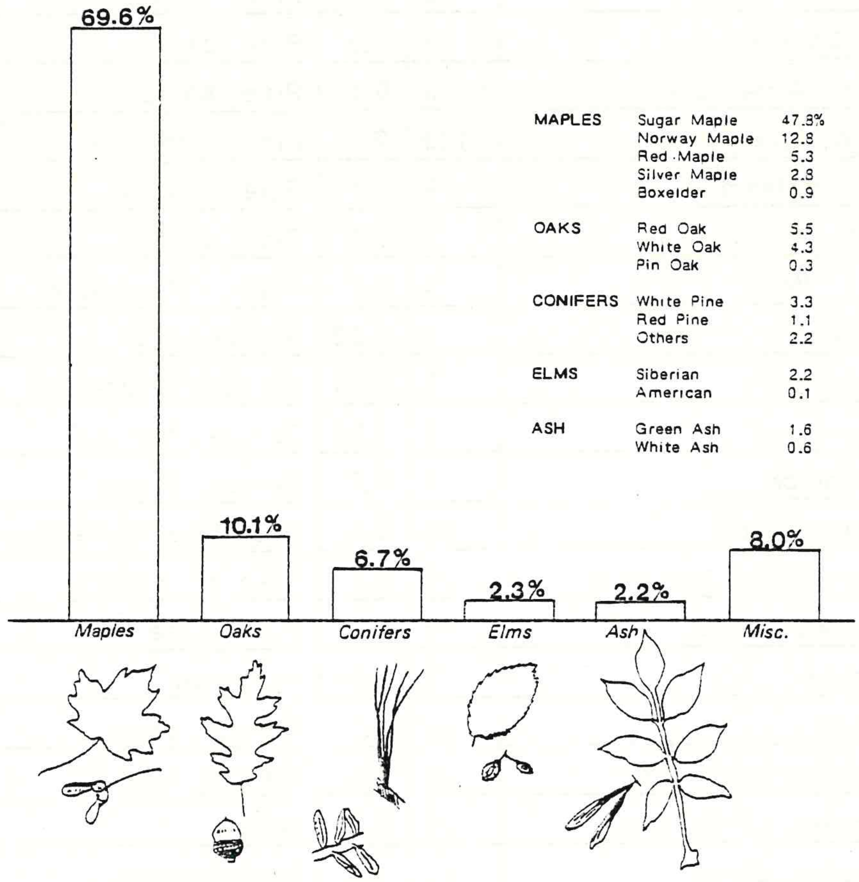

Figure 2. Species Composition by Genera (Traverse City Inventory, 1982).

Table 1. Total Species Composition (Traverse City Inventory, 1982).

SPECIES	# of Trees	% of Total	SPECIES	# of Trees	% of Total
Apple	5	0.1	Maple, Norway	902	11.9
Ash, Green	118	1.6	Maple, Norway 'Crimson King'	67	0.9
Ash, White	48	0.6	Maple, Red	402	5.3
Aspen/Poplar	29	0.4	Maple, Silver	216	2.8
Beech, American	6	0.1	Maple, Sugar	3,633	47.8
Birch	44	0.6	Mountain Ash, European	15	0.2
Boxelder	70	0.9	Mulberry	5	0.1
Bush/Hedge	81	1.0	Oak, Pin	24	0.3
Catalpa	34	0.4	Oak, Red	417	5.5
Cedar, White	43	0.6	Oak, White	324	4.3
Cherry	5	0.1	Olive, Russian	1	0.01
Cherry, Black	6	0.1	Pear	3	0.04
Cherry, Fine	5	0.1	Pine, Austrian	1	0.01
Crabapple	79	1.0	Pine, Jack	1	0.01
Elm, American	8	0.1	Pine, Mugo	2	0.03
Elm, Siberian	169	2.2	Pine, Red	82	1.1
Fir, Balsam	9	0.1	Pine, Scotch	4	0.1
Fir, Douglas	4	0.1	Pine, White	249	3.3
Fir, White	4	0.1	Plum, 'Myrobalun'	14	0.2
Ginkgo	2	0.03	Spruce, Blue	46	0.6
Hackberry	3	0.04	Spruce, Englemann	4	0.1
Hawthorn	2	0.03	Spruce, Norway	30	0.4
Hemlock	17	0.2	Spruce, White	9	0.1
Honeylocust	66	0.9	Sycamore, American	4	0.1
Hornbeam, American	9	0.1	Tree of Heaven	3	0.04
Horsechestnut	10	0.1	Tulip Tree	1	0.01
Juniper	3	0.04	Vibernum	1	0.01
Lilac	10	0.1	Walnut, Black	25	0.3
Linden, Basswood	84	1.1	Walnut, English	1	0.01
Linden, Little Leaf	18	0.2	Willow	6	0.1
Locust, Black	87	1.1	Miscellaneous	25	0.3
			TOTAL	7,595	100*

*All species included, percentages rounded off

Other species not in these five genera but also included in the upper twenty species include: black locust (87-1.1%), basswood or native linden (84-1.1%), crabapple (79-1.0%), honey locust (65-0.9%), white cedar (43-0.6%), blue spruce (46-0.6%), and birches (44-0.6%). Along with the species contained in the five most common genera, these species comprise about 95% of all trees inventoried. Each of the remaining forty-one species makes up less than 0.5% of the total population. Appendix A further details total species composition by district.

Size and Age of Street Trees

The size of each tree was recorded during the inventory. Tree size is given by its diameter in inches at breast height (dbh), or 4.5 feet above ground level. The percentage of street trees in each four-inch size classification is found in Figure 3 below.

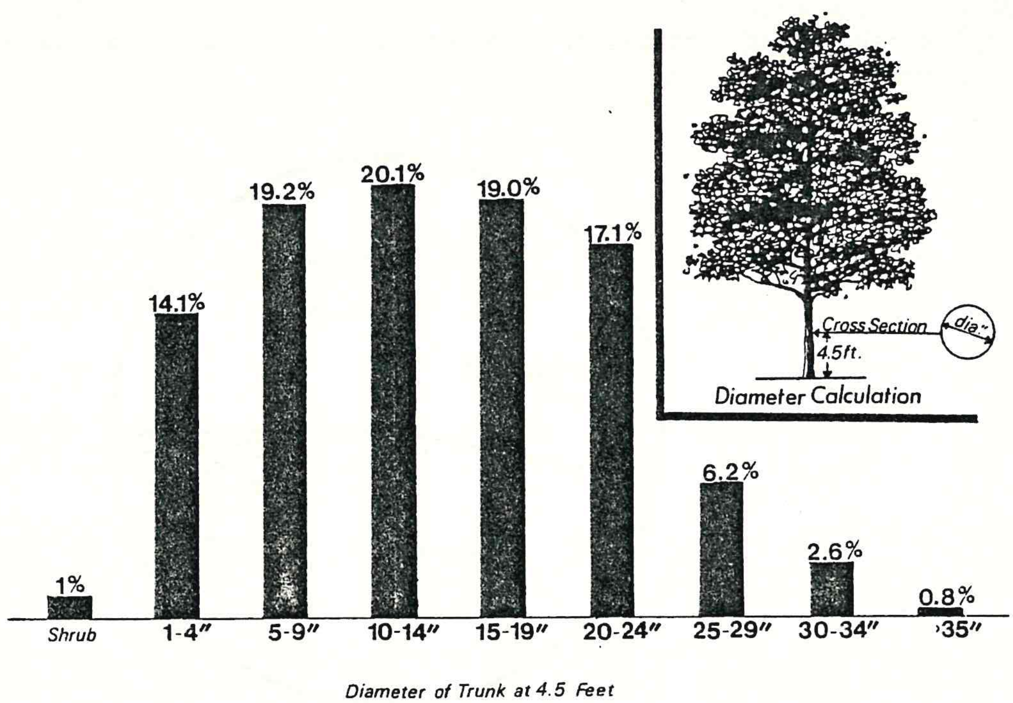

Figure 3. Percentage of Street Trees in Each Size Classification (Traverse City Inventory, 1982).

This figure shows that tree size is rather evenly distributed throughout the diameter classes. This indicates an approximately all-aged urban forest. It can be assumed that as the trees in each diameter class grow, they will move into the next larger diameter class. As the trees in the 20- to 24-inch size class move into the 25-inch or greater size classes, higher mortality can be anticipated, as these trees will be nearing the end of their natural life span. Many of the trees of 20-inch or greater diameter are probably the original street tree plantings from the turn of the century and before. While estimates relating size to lifespan are tenuous, it is believed that this segment of the population will require replacement within the next decade or two. Higher mortality could possibly occur sooner if a particularly stressful situation occurs, such as drought or insect or disease outbreaks, further weakening these mature trees.

While there is not always a direct relationship between tree size and **biological** age, a **functional** age/size relationship can be established. Trees from 1 to 9 inches in diameter may be considered funtionally young; trees 10 to 14 inches as developing or functionally intermediate; and trees 15 to 24 inches as functionally mature, that is, they are at their optimal functional size for a street tree. Trees over 25 inches in diameter can be considered functionally old or mature to overmature. While these large trees may be magnificent specimens, they are no longer at their optimal size. They are generally older, may be too large for the scale of the street and the limited growing space, may be causing problems for adjacent facilities (for example, sidewalks), and when they eventually die, their large size will make them more difficult and expensive to remove.

The relative percentages of trees found in each functional age group are presented below in Figure 4.

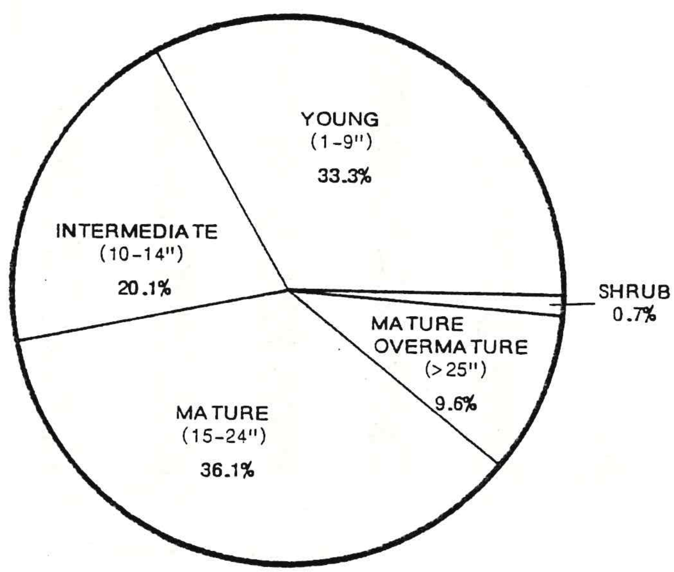

Figure 4. Percentage of Street Trees in Each Functional Age Class (Traverse City Inventory, 1982).

Both this figure and Figure 3 point out the excellent size/age distribution of the street tree population. These figures reflect Traverse City's long-standing commitment to the planting and replanting of street trees. At present, this nearly all-aged urban forest is composed of the following functional age groups: 33% young, 21% developing/intermediate, 36% mature, and 9.5% mature to overmature. However, the distribution of age groups by district reveals a slightly different picture. These district differences in the relative proportion of trees in each functional age group can be seen in Table 2.

Table 2. Functional Age of Street Trees Based on Diameter Size by District (Traverse City Inventory, 1982).

			% Street Trees by Diameter*				
District	Total Trees	Mean dbh	Young 1-9"	Inter-mediate 10-14"	Mature 15-24"	Old >25"	Shrub %
All City	7,595	14.5	33.3	20.1	36.1	9.6	0.7
One	886	15.5	30.7	15.7	38.4	14.7	0.2
Two	2,067	17.5	17.2	14.9	51.3	15.9	0.3
Three	1,141	13.6	35.7	23.0	32.8	8.0	0.4
Four	413	11.3	52.3	11.9	27.6	8.2	0
Five	818	13.6	34.6	20.1	36.9	9.4	0.4
Six	689	14.3	41.8	24.7	25.8	4.1	3.2
Seven	710	13.1	33.8	33.1	28.0	4.0	0.8
Eight	700	11.7	52.6	21.1	22.1	2.8	1.1
Nine	171	9.6	57.9	34.5	7.6	0	0

*Diameter measured at 4.5 feet above ground level

In general, this table shows that the districts with the oldest developments have a higher proportion of older trees. Districts One, Two, and Three* have a greater percentage (over 50%) of their trees in the mature and mature-to-overmature/old age groups. In fact, District Two has over 67% of its trees greater than fifteen inches in diameter. This contrasts the new developments in Districts Four, Six, Seven, and Eight. In these latter areas, the proportion of functionally young and intermediately-aged trees is considerably higher.

Profile of Species Condition

During the inventory, the condition of each tree was identified. For each tree, six factors were considered: trunk condition, growth rate, structure, insects and disease, crown development, and life expectancy. Based on a summary of these factors, a condition class ranging from 0 to 100% was assigned to the tree, and the tree was placed in one of the following five condition classes:

Excellent	90 to 100%
Good	70 to 89%
Fair	60 to 69%
Poor	50 to 59%
Very Poor	<49%

Figure 5 depicts the number and percent of all street trees by condition class. About 66% of the trees inventoried were in good to excellent condition. In addition, about 19% were rated fair, about 8% poor, and approximately 7% were rated very poor. The 14.9% rated poor or very poor may be expected to live less than ten years.

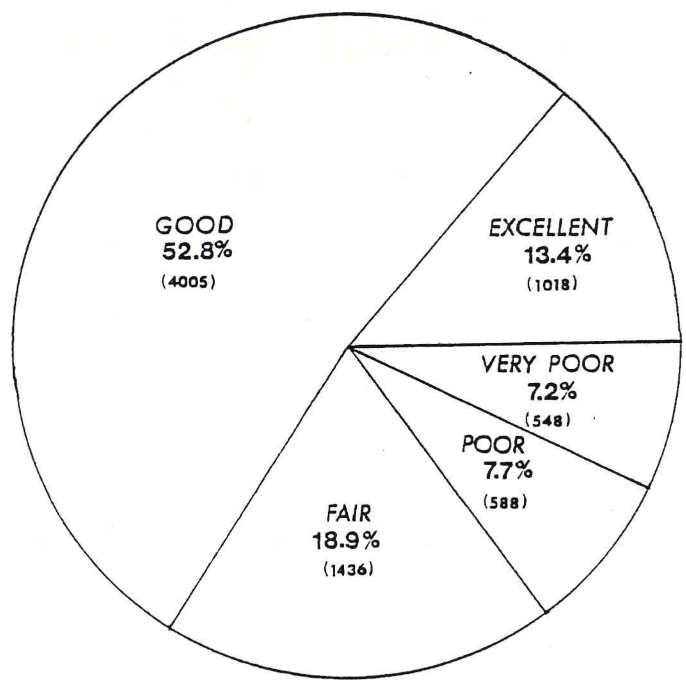

Figure 5. Percent and Number of All Street Trees by Condition Class (Traverse City Inventory, 1982).

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*See District Map on page .

A picture of how street trees perform as they grow emerges when functional ages are compared with condition classes. Condition versus age group is charted below in Figure 6. This figure shows that as trees grow older, the percentage of trees in excellent condition drops, the percentage in good condition remains about the same, and the percentage of trees in the fair and poor condition classes rises. Very poor trees would probably also show a steady percentage increase with advancing age; however, since these trees are probably removed as their conditions deteriorate, this increase is not reflected on the chart.

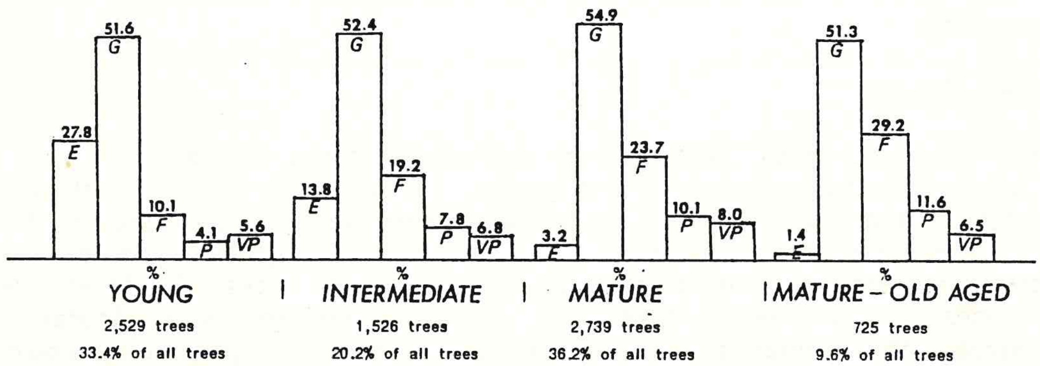

Figure 6. Condition Classes of Street Trees by Functional Age Groups (Traverse City Inventory, 1982).

Dieback in Street Trees

Symptoms

Dieback or decline is the common name given to a tree condition that has become more noticeable in recent years. Tree decline is characterized by the following symptoms. Usually, an abnormal leaf condition, such as leaf scorch, indicates that a moisture deficiency problem is involved. Often, starting in July or August, there may be a premature autumn coloration. As decline or dieback continues, there may be death of twigs and branches of increasing size in the upper crown region; this will be noticeable as many of the branches fail to leaf out in the spring. Reduced terminal growth of twigs causes development of foliage in tufts near the twig ends. Sometimes there may be abnormally large seed crops. In addition, there may be evidence of injuries, trunk and root rot, and other specific diseases.

Causes

A tree exhibiting dieback may be experiencing an insect or disease infestation, adverse environmental conditions, old age, or any combination of these conditions. Moisture stress will be present almost every summer for streetside trees, and this stress can be greatly increased during periods of drought. Low soil fertility, compacted soil, and restrictive rooting space can also be contributing factors in decline. Harmful concentrations of salt compounds building up in the soil near trees can produce decline symptoms. Cutting of roots for the construction of pipelines, sidewalks, and roads will cause additional stresses. This may be followed by root rot, and over a period of time, decline will be initiated in the tree. During the inventory, no attempt was made to diagnose dieback causes, since this usually involves knowledge of the history of the growing site and often entails microscopic analysis in a laboratory.

Survey Results

While surveying trees, dieback was recorded if there was a significant number of dead or dying branches in the crown. In all, 729 trees, or about 10% of all trees, displaying dieback symptoms were surveyed. Table 3 shows the relationship between tree size and incidence of dieback. In general, this table demonstrates that dieback is present in all sizes of street trees and increases with increasing tree size. Although dieback is a natural response to stress, the incidence in Traverse City is high. Maples are known to be sensitive to the urban conditions that cause stress. In fact, about 88% of recorded diebacks were for maples. Table 4 outlines dieback for some of the more frequent species.

Table 3. Size and Dieback in Street Trees (Traverse City Inventory, 1982).

Size (dbh)		No. of Trees with Dieback	% of Size Class with Dieback	% of all Dieback
1- 4"		83	7.7	11.4
5- 9"		88	6.0	12.1
10-14"		132	8.7	18.1
15-19"		151	10.5	20.7
20-24"		168	12.9	23.0
25"		107	14.8	14.7
	Totals	**724**		**100 %**

Table 4. Dieback Recorded for Selected Species (Traverse City Inventory, 1982).

Species	No. of Species with Dieback	% of Species with Dieback	% of all Dieback
Sugar Maple	541	14.9	74.2
Red Maple	43	10.7	5.9
Silver Maple	12	5.6	1.6
Norway Maple	44	4.9	1.9
White Oak	13	4.0	1.9
Red Oak	12	2.9	1.6
Others	64		8.8
Totals	**729**		**100 %**

Table 4 shows that sugar maple has the highest number of diebacks overall (541) and that it has the highest percentage of diebacks for any species (14.9%). This rate is three times higher than the percentage of all Norway maples experiencing dieback (4.9%).

Because about 15% of all sugar maples are experiencing dieback, a closer look will be taken to see the relationship between size and incidence of dieback in this species. Table 5 outlines this relationship and shows that the incidence of dieback is high in all size classes and increases with increasing size. That dieback occurs in all diameter classes at these high levels is somewhat unusual. However, it points out the fact that this tree is mostly intolerant of extreme urban conditions. It also points to a lack of systematic maintenance given to trees over their lifetime. A regular program of pruning, fertilization, and injury repair would probably lower the overall incidence of dieback by maintaining trees in high vigor. High vigor trees can more easily overcome occasional stresses; with low vigor trees, condition deteriorates with each additional stress. This need for systematic tree care will be addressed more completely in the following section.

Table 5. Size and Dieback in Sugar Maples.

Size (dbh)	No. of Trees with Dieback	% of Size Class with Dieback	% of all Sugar Maple Dieback
1- 4"	68	11.0	12.6
5- 9"	61	10.9	11.3
10-14:	79	14.1	14.6
15-19:	110	16.7	20.3
20-24"	137	17.3	25.3
>25"	86	19.7	16.0
Totals	**541**		**100 %**

Section
III

MANAGEMENT REQUIREMENTS: SURVEY RESULTS AND RECOMMENDATIONS

III

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The City of Traverse City is committed by ordinance, policy, and tradition to the full responsibility for management of streetside trees. Each city tree, or collectively the urban forest, has three fundamental management requirements: planting, maintenance, and removal. What follows is a description, summary, and analysis of the management requirements noted during the inventory. Recommendations for future action are included under each management requirement. In addition, program recommendations concerning standards, records and record keeping, and public relations are also provided.

Planting

Perhaps the most publicly acceptable and most visible management requirement of the urban forest in Traverse City is planting. Continuous planting and replanting over the years has established the all-aged urban forest that exists today (see Figure 3). Since planting records were established in the late 1950's, over four thousand trees and shrubs have been planted streetside and in public parks. The two principle species that have been used for streetside plantings by the city are sugar maple and Norway maple. Little leaf lindens, varieties of thornless honey locusts, green ash, and elms have also been used to a lesser extent. Over the years, this continuous planting effort has done an excellent job of planting the parkway, new subdivisions, and commercial areas. Also, continuous replanting of lost trees has not allowed large gaps to appear.

During the inventory, 3,064 planting sites and their locations were noted. A planting site is considered as a space in a sufficiently wide treelawn* about fifty feet away from the nearest street tree with no interference from private trees. The location of each of these sites is provided to the City under separate cover. The number of planting sites by district is included in Appendix A. Districts with high percentages of planting sites include Districts Six and Nine.** The high number of planting sites in District Six is probably due to the abundance of gravel roads and lack of curbing, and hence lack of clearly defined treelawns for planting. Also, over portions of this district, much of the original tree cover was preserved in development, which may lessen the need for formal city tree plantings. District Nine includes the state highways. Noticeable for the relatively large numbers of planting sites here are Garfield Avenue and Division Street.

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*Treelawn is defined as the space between the street edge and a property line.

**See District Map on page 2.

It is recommended that priorities for future planting be established. Highest priority should be given to locations most exposed to the public. These would include entranceways and main thoroughfares. Grandview Parkway is an excellent example of this principle at work. Plantings in these areas lead to favorable public reaction to the tree program and help to give visitors to the area a favorable impression of the city. The next priority should be replanting after tree removal. Prompt replanting efforts will generate public support for city forestry activities. Remaining priorities should deal mostly with filling the remaining planting spaces in residential areas. These should be established by the city forester after determining the needs and desires of the citizens.

After planting priorities have been established, it is recommended that the site be visited, its restrictions analyzed, and an appropriate species or variety selected. "The right tree in the right place" should be the general rule. In the Forester's Handbook (provided under separate cover), a suggested master tree selection list for Traverse City is provided. This list could possibly be used in conjunction with the master street tree planting plan recently developed by Mr. Martin Melkild, retired City Forester.

When selecting species for planting, the city forester should also consider the diversity, or species mix, that exists now and in the future. The recent Dutch elm disease catastrophe left Traverse City relatively untouched but serves to point out the problem associated with low species diversity. Although there is currently no comparable infestation with maples, it is recommended that a wider variety of species be planted for a greater population diversity in the future. The particular mix to be obtained is a matter of planting policy to be determined by the city forester.

The ultimate size of street tree plantings is also a policy whose review is recommended. Many cities are now moving to the use of smaller trees for streetside planting. Lower growing trees generally require more skill and expense to obtain and maintain, but they also tend to have less disruptive habits and usually have lower removal costs. The City Forester should study this concept, in light of citizen preferences and future maintenance considerations, to determine future tree size policy.

Once priorities have been established and a species for planting selected, the tree(s) must be procured. The city is fortunate in this respect in that it owns a nursery. When the planting plan is in place, plants can be obtained at a much smaller size several years in advance of streetside planting. Superior cultivars can therefore be obtained at less cost, planting times can be more easily scheduled, and trees can be specially pruned for several years before planting.

In many of the older sections of the city, trees are planted on fifteen-foot spacings. This makes replanting of a young shade tree difficult at best. Sugar maple is rather unique in its ability to grow very slowly while under shade conditions and then quickly when light is finally obtained. However, it is now realized that fifteen feet is too close for very large trees and that fifty feet is a much more appropriate distance. It is recommended that when a tree is removed from one of these mature rows, where appropriate, underplantings should be made with shade tolerant trees with a small to moderate ultimate size. Species to consider would be serviceberry and dogwood. Both have showy spring flowers, distinctive fall color, and a moderate to ultimate height. Eventually, as all the maples are removed, sugar maple or another appropriate species could be planted among the smaller trees. The homeowner shock over losing a tree and the property value loss, followed by the dissatisfaction over not having another sugar maple replanted, would be buffered. These smaller, shade tolerant trees would serve as an intermediate stage between no trees or small, scattered, thin crowned maples that had been underplanted beneath a complete canopy and the thirty or forty years that it will take to establish a new stand of functionally mature trees.

Maintenance of Existing Trees

The trees that line the streets of Traverse City lack many of the biological advantages enjoyed by forest trees. Trees growing in an unnatural, stress filled environment require intensive culture and systematic maintenance. In addition to planting, trees must be given supportive services to prolong and intensify their usefulness. From a management perspective, urban forest maintenance in Traverse City may be defined as the carrying out of practices necessary for reasonable health, vigor, and compatibility with the urban environment. Maintenance involves all practices between planting and removal. These activities may be divided into three categories: (1) growth control, (2) damage control, and (3) insect and disease control. A copy of the location of each tree requiring each of these maintenance activities is provided to the city under separate cover for budgeting and scheduling purposes.

Growth Control

There are two major types of growth control practices done to city trees. One is pruning to retard or direct growth, and the other is fertilization to enhance growth.

Pruning. Pruning is one of the most important management practices in the urban forest. Pruning requirements were identified for each tree during the inventory. Each tree was evaluated, and a pruning recommendation was recorded if the tree required one or more of the following pruning practices:

- removal of broken or hanging branches
- deadwood removal
- pruning for clearance (lifting)
- crown training
- crown thinning

If the tree needed any of these pruning practices, the individual practice was then classified as either higher or lower priority. A description of the general guidelines used for pruning recommendations are as follows:

(A) Removal of Broken or Hanging Branches

Branches, either living or dead, that are broken at some point. Hangers interfere with other branches, obstruct visibility, and create a safety hazard.
Lower Priority - only one or two branches broken or hanging that are not very large, generally no more than four inches in diameter
Higher Priority - three or more broken or hanging branches; also a large hanging branch four inches or more in diameter

(B) Deadwood Removal

Dead branches within crown.
Lower Priority - small branches one or two inches in diameter and not more than 10% or 20% of the crown
Higher Priority - larger branches over three or four inches in diameter that could cause damage or injury. Also, if more than 20% or 30% of the crown is dead

(C) Pruning for Clearance

Also known as crown lifting. Removal of branches and suckers from the trunk and all low-hanging limbs to allow for 7 to 8-foot clearance over sidewalks and about 14 feet over the road for vehicular traffic. Raise limbs for visibility on corners and for signs.
Lower Priority - if low limbs or suckers will grow to more serious problems
Higher Priority - low hanging branches or suckers obstructing views or creating clearance hazard

(D) Crown Training

Training is done on small trees to establish good form. It is the structuring and shaping of the crown while the tree is young. This is done to prevent later developmental problems such as poor branching structure.
Lower Priority - a few branches need pruning
Higher Priority - presence of V crotches, crossing branches, low branches and general poor form

(E) Crown Thinning

Thinning is a cultural practice to reduce the number of branches. This includes removal of crossing and rubbing branches. Thinning lightens the crown to reduce the possibility of wind or ice breakage. Thinning also improves sunlight and air circulation which allows better crown development and reduces insect and disease problems. Thinning may also be conducted on older trees to rejuvenate them by establishing a better crown-to-root ratio; especially useful when roots have been cut or damaged.
Lower Priority - a few or smaller branches need pruning
Higher Priority - judgment call; many or larger branches need removal

Table 6 below describes the overall management recommendations for the various pruning practices. Management recommendations for pruning practices by district are included in Appendix B. The table shows that there is a large amount of trimming to be done. The largest number of trees in need of pruning are in the thinning, deadwood, and training categories, respectively. It is recommended that the city not attempt to conduct all this pruning at once but rather establish priorities for the pruning practices. It is suggested that the most important pruning recommendations to be carried out are those that lead to a reduction of hazards to life and property. These would include the removal of hangers, deadwood removal, and pruning for clearance. Within each one of these recommended pruning practices, attention should first be given to the higher priority. For instance, removal of a higher priority hanger should take precedence over a lower priority hanger, and so on.

Table 6. Street Tree Management Recommendations - Pruning (Traverse City Inventory, 1982).

Pruning Recommendation	Total Trees	None %	Lower Priority %	Lower Priority No.	Higher Priority %	Higher Priority No.
Remove Hangers		97.1	2.3	172	0.7	51
Remove Deadwood		51.4	23.9	1,817	24.7	1,877
Trim for Clearance		90.3	7.2	550	2.4	186
Train Crown		77.7	10.8	882	11.5	870
Thin Crown		41.4	34.4	2,616	24.1	1,831
	7,595					

The next most important pruning priority is pruning to ensure the development of structural strength, shape, and form. This would include training and thinning practices. Pruning of young trees, or training, can prevent later, more expensive pruning, reduce breakage in severe storms, and provide a more pleasing street tree form. The survey found that about 73% of all trees in the 1- to 4-inch size category were in need of training. We also found about 46% of all trees in the 5- to 9-inch size category in need of some training. It is recommended that the city start a systematic program of training now to avoid increasing developmental problems in the future. Thinning of the crown is recommended as the last pruning priority.

Fertilization. Enhancing growth by fertilization is a necessary management practice to maintain tree health and vigor. The need for this activity was realized a few years ago, and a successful program of cooperation between citizens and the forestry unit was carried out in the Central Neighborhood Area (in District Two). Under this program, homeowners were canvassed, and each contributed five dollars to help defray costs. Trees were deep fed with a high nitrogen, water soluble fertilizer by city crews. Observations by Mr. Melkild have determined that as a result of this program the mortality rate of the older sugar maples in this area has been reduced.

During the inventory, 1,265 trees were found with signs of nutrient deficiency or lower than expected condition classes. These trees would benefit from fertilization. Due to the sandy nature of the soils and their mostly moderate fertility, it is recommended that systematic fertilization of trees become a standard activity for the tree care unit. In particular, as the growth of older trees slows, fertilization can help them remain in a healthy state, more able to overcome the increasing stresses brought on by old age. Young trees also benefit from application activities. In fact, about 85% of all the trees recommended for fertilization were nineteen inches or less in diameter. These trees need extra help until their root systems are developed enough so adequate water can be obtained during dry periods.

When homeowners water and fertilize their lawns, they are indirectly aiding the street trees. These practices are widespread throughout the city and should not be discouraged. A very high percent of a sugar maple's feeder roots are in the top three to five inches of soil. The prevailing sandy soils with their low ability to retain water combined with complete cover of turf competing for available moisture and nutrients can severely stress trees during dry periods. The importance of homeowner watering and feeding can be critical to keeping tree vigor high. Any future increase in the water rates should consider the higher long-term tree mortality and the associated costs for more frequent removal and replanting.

Damage Control

The second major category of management practices is damage control. Control of tree damage involves prevention and repair of injury. Damage prevention practices include removing restrictive girdling roots and cabling or bracing weak crotches or damaged trees. Damage repair activities include the treatment of cavities and wounds. The objectives of repair practices are to prevent decay and to put wounds in the best condition for healing. Table 7 below summarizes damage control maintenance requirements recorded during the survey.

Damage Prevention

Preventive maintenance is an important aspect of urban tree care. It includes removal of girdling roots and cabling and bracing operations. A girdling root is one that has grown closely appressed to the main trunk, overlapping other roots. As these roots increase in thickness, they strangle other roots and gradually restrict water and nutrient transport in the trees. If girdling roots are removed early enough, the tree may recover. A total of 450 trees were found to have girdling roots. Maple was the most common

Table 7. Summary of Damage Control Maintenance Requirements (Traverse City Inventory, 1982).

Recommendation	Total Trees	None %	Need Control %	No.
Girdling Root Removal		93.7	6.3	480
Brace/Cable		93.3	6.7	508
Repair Injury		95.2	4.8	364
	7,595			

genus experiencing this problem, with 447 or 93% of all girdling roots recorded. Norway maple had the highest species incidence, with 116 or 13% of all Norway maple trees having this problem. There are 297 or about 8% of all sugar maples with girdling roots. These two species compose about 86% of all recorded girdling root removals. It is recommended that the City Forester inspect the trees with girdling roots and determine if treatment is appropriate.

Cabling and bracing practices can lower the incidence of personal injury or property damage during severe weather. Bracing is used to support or strengthen tree structure by using bolts to join weak or split limb crotches, brace limb or trunk splits, and support trunk or crotch cavities. Cabling is used to support or strengthen tree structure by using cables connecting two or more limbs within teh same tree. Cabling is used to limit excessive limb motion or relieve pressure on weak, decayed, or split limbs or crotches. About 7% (508) of all trees were found to require cabling or bracing practices. Most of the trees in need of these preventive maintenance activities are older, larger diameter trees that have crotching patterns that were not corrected while the tree was young. It is recommended that the City Forester inspect trees identified as having cabling/bracing needs and determine which trees require immediate treatment.

Damage Repair

Cavities and trunk and butt wounds in need of repair were recorded during the inventory. A total of 364 or about 5% of all trees were found to need some sort of damage repair. Most often, this requirement was noted for mechanical injury done to the base or trunk of the tree. Mechanical injury results from damage by cars, vandals, utilities, root cuts, and frequently from lawnmowers damaging the thin bark of young tress. In fact, many trees were noted in treelawns by public buildings and along Grandview Parkway that had been damaged by city-operated lawnmowers. It is recommended that efforts be made to lessen this problem by removal of grass near these trees and/or training personnel to avoid creating such injuries.

Young trees with their thin barks are especially susceptible to injury. About 73% of all repair requirements are for trees less than 19 inches in diameter.

To lower the incidence of mower damage to young trees, it is recommended that they be mulched or have the grass around their bases removed chemically. The highest incidence of damage was recorded on red maple, with about 9% of all red maples requiring injury repair. This suggests that in the future, use of this thin-barked species should be confined to low use areas. It is recommended that the city forester inspect trees with damage repair requirements recorded to determine priorities for repair.

Insects and Disease Control

To keep city trees healthy and attractive, special management practices are sometimes necessary to protect them against two of the more important causes of plant decline and failure—insects and diseases. During the inventory, 179 trees were found with noticeable insect infestations. The most prominent insect pests are aphids and sugar maple leaf rollers. Other important insect problems identified were scales on ash and leaf miners and borers on birch.

Disease problems were also recorded during the inventory. A total of 108 trees were found to be infected. Almost one-half of the diseases recorded occurred on the elms surveyed. Common fungal disease problems encountered with elms include leaf spot and wetwood. On maples, Phyllosticta spot fungas was the most frequently counted fungal problem.

Overall, the incidence of insect and disease found in Traverse City are few, and problems are mostly localized. It is recommended that regular monitoring of pest problems be continued. Regular control by chemicals and non-chemical means should also be continued so that pest populations are not allowed to build up to epidemic levels. It is also recommended that when trees in very poor condition are found during regular tree inspections, these locations should be noted and the trees removed at the earliest possible opportunity. Trees in low vigor are readily attacked by insects and diseases. As these pests build up, they may spread onto the nearby healthy trees.

Street Tree Removals

The causes of street tree failure include natural causes such as disease, insects, and weather conditions and man-induced causes from physical injury due to vehicles, vandalism, poisoning, and root cutting for sidewalks. There are three main reasons why street trees should be removed when they fail: first, for hazard reduction to persons and property; second, to eliminate breeding sites for insects and disease; and third, dead trees detract from the visual quality of a street.

A total of 516 trees and shrubs in need of removal were identified during the survey. This is about 6% of all trees surveyed. A separate computer printout is provided to the City showing the location of each of these removals for scheduling purposes. City trees were recommended for removal when it was obvious that their condition class had deteriorated to the point where they were no longer functional and were, in fact, an increasing liability.

Several removals were noted of stumps that had resprouted. Also, forty shrubs were recommended for removal. These shrubs were planted by homeowners and are not in accordance with city clearance requirements.

Table 8 outlines the number of removals recommended by diameter class. This table shows that old age may not be the primary cause of mortality of street trees in Traverse City. City conditions are frequently unnatural and stressful for street trees. One would expect that mortality would be initially high as young trees become established, lower during their intermediate years and higher as they get older. This is not reflected on the table. In fact, recommended removals rise rather steadily through each size class. One of the reasons for this could be the lack of systematic care given to the street trees throughout their lives. A systematic maintenance program of growth control and damage control practices could lower the overall removal rate of these younger trees. This could lead to less frequent removal and replanting and would ensure that street trees would have an overall longer lifespan, thereby providing increasingly higher values over a longer period of time.

Table 8. Recommended Removals by Diameter Class* (Traverse City Inventory, 1982).

Diameter Size Class	Number	% of Size Class
1- 4"	50	4.7
5- 8"	70	4.8
9-14"	103	6.7
15-19"	108	7.5
20-24"	102	7.9
25-29"	31	6.6
30-34"	7	3.6
35-39"	1	2.8
40-49"	4	16.0
Shrubs	40	53.3
Total	**516**	
% of All Trees		**6.3%**

*Diameter measured at 4.5 feet above ground.

Table 9 provides removal recommendation figures for the more frequently occurring street tree species. Comparing the percentage of each species needing removal, red maple is highest with 8.9%, and sugar maple is second with 8.2% of all sugar recommended for removal. Of all trees over ten inches in diameter, the percent recommended for removal is greatest for sugar maple. This comparison gives some indication of how individual species are performing in their streetside locations. Sugar maples are dying about three times as fast as Norway maples. Sugar maples are widely known to be more susceptible to the stresses of streetside planting locations than are Norway maples. It should also be noted here that the sugar maples are generally slower growing and longer lived than Norways. This could account for some of the mortality differences between the species.

Table 9. Percentage of Removals by Size Classes for Selected Species (Traverse City Inventory, 1982).

Species	Total Removals	% Needing Removal	Diameter*			
			1-9"	10-14"	15-24"	25"
Sugar Maple	298	8.2	3.9	11.3	10.7	7.8
Norway Maple	25	2.8	1.4	2.2	4.7	4.2
Red Maple**	35	8.9	8.8	7.3	8.9	0
Silver Maple	11	5.1	5.9	3.9	5.9	4.3
Red Oak +	12	2.9	4.7	2.2	2.3	1.4
White Oak	10	3.1	0	4.3	3.8	2.4

*Diameter measured at 4.5 feet above ground.
**Three trees are sprouts from stumps to be removed.
+One tree stump needing sprout removal.

It can be expected that once the slight backlog of removals is completed, the rate of removals city wide will increase over the next twenty years. This predicts the need for an increasing tree removal program with even greater possible increases after any future period of dry years. This is especially true of the older sugar maple population. If a program of systematic maintenance practices was implemented, removal rates for trees under twenty-five inches in diameter would probably decrease. As the older trees move towards the end of their lifespan, their mortality rates could also possibly be lowered somewhat by increasing maintenance activities. However, except where present hazards can be readily corrected as an alternative to removal, the benefits from maintenance of already declining trees are likely to be short lived and thus marginal. It is recommended that future efforts be concentrated on systematic care of younger trees in an attempt to lower the overall removal rate.

Trees and Sidewalks

As trees grow, they may cause problems for adjacent facilities, such as above- and below-ground utilities and sidewalks. Of particular concern in Traverse City is the problem of sidewalk heaving caused by the increase in girth of the roots of the adjacent tree. The city has a responsibility to its citizens to reduce this hazard. Replacement of heaved sections is expensive both in terms of materials and manpower and often in terms of tree health.

The purpose of identifying sidewalk problems during the inventory was three-fold. First was to determine the magnitude of this problem and record the species, size, and location of this problem. A copy of this information is provided to the city under separate cover so that locations of repairs can be more easily identified. Second was to determine the relationships between size and species causing sidewalk heaving. From this information, recommendations on future plantings to avoid this problem will be made. Lastly, by noting the location of each new sidewalk section, species, size, and condition could be determined for trees injured by sidewalk repair. These data lead to recommendations for future sidewalk repair.

Size and Species Causing Heaving

The survey identified 806 instances of tree roots heaving adjacent sidewalk sections. Sidewalk heaving was noted as either a vertical displacement less than one-half inch (432 trees) or greater than one-half inch (374 trees). In all, about one out of ten street trees were causing heaving. In general, districts having older trees had a higher incidence of sidewalk heaving. District Five* had the highest percentage of trees causing this problem, with one out of five trees heaving sidewalks.

It was found that there is a direct relationship between the size (age) of trees and the incidence of heaving. Table 10 shows that as trees grow, sidewalks are more frequently lifted. In fact, the rate of heaving is over 16% when the tree is mature, and this increases to over 20% when the tree is mature to overmature. When relating species to sidewalk heaving, it is seen that certain species are more prone to this condition. Table 11 outlines this by relating species to incidence of widewalk heaving.

In all, sugar maples accounted for over 62% of all recorded instances of heaving. About 14% of all sugar maples are heaving sidewalks. Basswood and black locust were found to have the highest percentage of sidewalk heaving. This is probably because most of the trees in each of these species

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*See page 2 for District Map.

Table 10. Sidewalk Heaving by Functional Age Class of Trees (Traverse City Inventory, 1982).

Functional Age Class		No. of Heaves	% of Age Class	% of All Heaves
Young*	(1-9")	48	1.9	6.0
Intermediate	(9-14")	168	10.7	20.2
Mature	(15-24")	445	16.2	55.2
Mature/Overmature	(>25")	150	20.7	18.6
Totals		**806**		**100 %**

*Young trees have probably not caused heaving but are most likely replacements of the tree that caused heaving. Sidewalks should have been repaired when the first tree was removed.

Table 11. Sidewalk Heaving by Tree Species (Traverse City Inventory, 1982).

Species	No. of Heaves	% of Species	% of All Heaves
Basswood	15	17.8	1.9
Black Locust	15	16.9	1.9
Boxelder	11	15.7	1.4
Sugar Maple	501	13.8	62.2
Silver Maple	29	13.5	3.6
Red Maple	53	13.2	6.6
Norway Maple	102	11.3	12.7
White Oak	19	5.9	2.4
Red Oak	24	5.7	3.0
Totals	**796**		**95.7%**

populations are older. The oaks had the lowest incidence of heaving recorded. This is in spite of the fact that both these species populations are made up mostly of older trees, indicating a difference in rooting patterns. Maples characteristically have shallow, spreading root systems, and as these roots thicken, sidewalk displacement frequently occurs. Oaks, on the other hand, are generally more deeply rooted and hence interfere less frequently with sidewalks.

To determine why such a high incidence of heaving has occurred, it is necessary to consider past planting practices. Planting shallow-rooted species such as maples will eventually cause some sidewalk problems, but the frequency of heaving can be significantly reduced by planting farther away from the sidewalk. Treelawn widths throughout most of the city are six feet or greater. In fact, 86% of all trees inventoried were on a treelawn wider than six feet. However, most trees in the city are planted within three feet of the sidewalk, and more recent plantings are made at about thirty inches from sidewalk to tree. Where roots grow away from the trunk is known as the root crown. This root crown has a greater radius than the trunk at breast height (dbh). For example, a twenty-six-inch dbh tree that was planted thirty inches from the sidewalk is now seventeen inches away from the sidewalk (30"-tree radius dbh=17"). If the radius of the root crown of this tree is eight or ten inches greater than at dbh, this places the root crown within one foot of the sidewalk. If several major roots are growing out from the root crown, seeking the less restrictive growing space of the front lawn, a high incidence of sidewalk heaving can be expected as these roots increase in girth. This example reflects a common condition in the city.

Effects of Sidewalk Repair on Street Trees

When city crews repair displaced sidewalks, a fairly standard procedure is followed. The offending section is broken up and removed; the underlying material is dug up and roots cut to a minimum depth of fifteen inches. The underlying soil is replaced, and the new section poured. During the inventory, 474 new sidewalk sections adjacent to trees were recorded. This amounts to about 6% of all trees. In all, about 92% of all identified new sidewalk sections noted were adjacent to maples. As seen in Table 12, it was found that sections had been replaced more frequently next to older trees.

To more clearly demonstrate the effect of root cutting for new sidewalks, an analysis of size versus condition class was made. By comparing the condition classes for those trees that had new sections and those that did not in each diameter class, it was found that trees next to enw sidewalk sections generally had lower overall condition classes (no table shown). From this analysis and observations made by the city sidewalk crew, homeowners, and Mr. Melkild, it can be said that root cuts made for sidewalks reduce tree vigor. As an example, Table 13 shows the relationship between condition class and sidewalk replacement for sugar maple. This table demonstrates that the overall condition classes are lower for sugar maple with new sidewalks than those without new sidewalks.

Table 12. New Sidewalk Sections as Related to Functional Tree Age (Traverse City Inventory, 1982).

Functional Age (dbh)		No.	% of All New Sections
Young	(1-9")	16	3.4
Intermediate	(10-14")	61	12.9
Mature	(15-24")	298	62.9
Mature/Overmature	(>25")	99	20.8
	Totals	**474**	**100 %**

Table 13. Relationship Between Condition Class and New Sidewalks for Sugar Maple (Traverse City Inventory, 1982).

Condition Class	% With New Sidewalk	% Without New Sidewalk
Excellent	3.0	18.2
Good	50.8	49.1
Fair	24.3	16.6
Poor	11.5	8.1
Very Poor	10.4	8.0

Recommendations for Sidewalk Repair

As demonstrated by the previous section, the repair of sidewalk heaving will continue to be a major maintenance task for the city. To help prevent this problem in the future, it is recommended that shallow-rooted species, such as maples, be planted only on treelawns six feet or wider and be planted in the middle of the treelawn or a minimum of four feet from the sidewalk. This recommendation is the only long-term measure to control sidewalk heaving.

Once the city has determined that a section is in need of replacement, it is recommended that it follow the sequence outlined below:

(1) Repair the sidewalk section as soon as heaving is noticeable thereby using less labor and inflicting less damage to tree roots, or instead of immediate replacement, use asphalt between the heaved and adjacent sections forming a sort of small ramp. Replacement of the section could then be delayed until the tree dies and must be removed.

(2) Remove section.

(3) Remove soil to expose the roots causing heaving.

(4) Prune roots as little as possible to restore sidewalk grade. Paint all pruning wounds with tree wound dressing.

(5) Adjust sidewalk grade with sand.

(6) Repour sidewalk or reset section. If root crown is near, leave a semi-circle or square out of the new section to allow for lateral growth.

(7) Prune the adjacent tree. Root pruning the adjacent tree disturbs the balance between roots and crown, and for this reason there should be a proportionate amount of foliage removed to restore the balance. This pruning should be done by a qualified crew as soon as possible after the root cuts are made.

Even following these recommendations, some tree mortality will occur. This is especially true since most root cuts will involve mature and overmature trees that are naturally in lower vigor. However, these recommendations offer the greatest hope for insuring higher survival rates after root cuts for sidewalk repair.

Development of Standards and Specifications

It is recommended that the city forester of Traverse City prepare tree work standards and specifications for work to be done on street trees. These specifications should be referenced in the city ordinance and, upon their completion, be approved by the City Commission. Good standards and specifications are the basis for consistent and high quality tree management. Clear requirements for tree work are important for providing performance standards for city tree crews or for developing contracts for private contractors. To aid in the development of standards and specifications, samples of standards and specifications from the National Arborists Association and from the International Society of Arboriculture are included in the Traverse City Urban Foresters Notebook provided to the city under separate cover.

Records and Record Keeping

The importance of keeping accurate records when managing street trees can not be overemphasized. The street tree inventory that was conducted in 1982 has provided a solid base of information for future management. It demonstrates that accurate information on street tree conditions, locations, and management requirements serves a useful purpose in directing scarce resources to highest priority street tree needs.

It is recommended that as forestry activities are performed, records be kept on planting, maintenance, and removals. Eventually, these records will indicate tree species which have been most successful as street trees and will show how maintenance activities affect long-term tree performance. Also, records help show how public funds have been spent and help to direct management toward the most efficient future use of these funds.

It is further recommended that as these activity records are received this information be processed onto the current data file obtained from the inventory. A unique aspect of the inventory system used is that it produces data accessible through an interactive system so that information can be periodically updated. With this system, work performed on individual trees is recorded throughout the year, and summaries can be obtained showing work accomplished and future management requirements. The use of computerized record keeping can be an invaluable tool in the more efficient management of public trees in Traverse City. Information on computer access and program updating is provided in the Traverse City Urban Foresters Notebook provided under separate cover.

The Public and Public Trees

That citizens are concerned about the public trees of Traverse City is evidenced by the commission of this study and by the great interest expressed by homeowners during the survey. The survey crew spent a fair portion of its time confronted by mostly interested, but sometimes irate, residents. Once they were assured that no one was harming "their tree," they often asked why the study was being conducted followed by more specific questions on tree species, age, and condition. In general, most residents realized the value that the tree(s) contributed to the appearance and value of their neighborhood and property. However, some complained about sidewalk heaving, city care of the tree, too much shade, excessive litter drop, and other problems.

The comment made by Mr. Majerczyk that "No matter what else we do, they never forget what we did or didn't do to the tree in front of their house" demonstrates the personal interest that homeowners have in their trees. Afterall, the homeowner sees the tree each day, and how the care it receives is viewed plays a role in his general perception of the city government and the services it provides.

Good public relations is critical in a tree care program. Citizens should be given a role in determining management practices that directly affect "their" trees and the public trees of the community in general. For instance, a leaflet or flyer given to a homeowner when a tree is planted will let the citizens know how the city is spending their taxes. It will also encourage the homeowner to care for the tree—perhaps watering it during dry periods or periodically replenishing the mulch around its base.

Responding quickly to resident complaints and requests will improve the credibility of the tree care unit. An improved relationship between residents and the tree care unit will result in a more positive attitude towards the tree program in general and will generate more support, both verbal and monetary.

It is recommended that publicity and promotion of forestry activities be a regular function of the forestry unit. Special events, such as dedications and memorial plantings and Arbor Day, are highly visible and serve to promote general forestry activities. It is also recommended that the city apply to the State Urban Forester for an application to become a "Tree City—USA" as Traverse City fulfills all of the requirements of this National Arbor Day Foundation project.

Section
IV

FIVE-YEAR PLAN FOR THE SYSTEMATIC MANAGEMENT OF STREET TREES

IV

A FIVE-YEAR PLAN FOR THE SYSTEMATIC MANAGEMENT OF STREET TREES

The 7,514 trees lining the streets of Traverse City represent a substantial value to the city. Their value has been conservatively estimated to be about nine million dollars.* In addition to this value, the city spends about seventy-five thousand dollars a year to maintain these trees.** The annual tree care budget is about ten dollars per tree per year and an annual per capita expenditure of about four dollars.

It should be noted, especially in these times of budget restrictions and dollar-stretching efforts, that while many city expenditures involve capital investment in projects that decline in value, investment in tree planting and maintenance is an investment in a commodity that increases in value. The five-year management plan that follows is based on the results of the 1982 100% street tree inventory of Traverse City. It is recommended that the city accept this plan as a basis for future city forestry activities. In this way, the City of Traverse City will continue to protect past investments and ensure a higher future value of the urban forest.

The information collected in the inventory and presented earlier in this report indicates that the overall street tree situation is presently good. Although species diversity is fairly low, the forest is all aged, and most trees are in good to excellent condition. In addition, the maintenance requirements for most trees are neither abnormally high nor unexpected.

This plan is intended to serve as a guide. It attempts to establish tree management priorities, scheduling, and budget estimates based on the inventory results. The numbers of trees are an approximation. Costs are based on previous studies and reports from other Michigan cities, and are intended strictly as reasonable guidelines.

Based on the survey, the following recommended amount of work should be conducted over the next five years:+

(1) **Removals:**	250 per year for first two years
	150 per year for remaining three years
(2) **Planting:**	250 per year for first two years
	300 per year for remaining three years

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*See Appendix B.

**Survey response to 1980 Municipal Tree Care Questionnaire, Department of Forestry, Michigan State University, East Lansing, Michigan.

+Work activity by tree location detailed in computer print-outs provided the city under separate cover.

(3)	**Pruning:**	
	Hangers:	51 for first year 20 per year for remaining four years
	Deadwood Removal	(prune only higher priority recommendations) 1,877 total or 375 per year
	Crown Thinning	(prune only higher priority recommendations) 1,831 total or 366 per year
	Crown Lifting	100 first two years 50 per year for remaining years
	Training	(all trees in need of training) 1,692 total or 338 per year
(4)	**Fertilization:**	1,265 total or 253 per year
(5)	**Damage Control:**	
	Damage Prevention	repair girdling roots, 25 per year cable/brace, 100 per year
	Damage Repair	repair injury, 50 per year
(6)	**Insect and Disease Control**	chemical and nonchemical controls 50 per year

The cost of this work is outlined on the following maintenance activity and budget worksheet for 1983-1988.

Table . Municipal Tree Care - Traverse City.
Maintenance Activity and Budget Worksheet for 1983-1988.

	Activity	Unit Cost	1983 $ (No.)	1984 $ (No.)	1985 $ (No.)	1986 $ (No.)	1987 $ (No.)
(1)	**Removals**	90.00	22,500 (250)	22,500 (250)	13,500 (150)	13,500 (150)	13,500 (150)
(2)	**Planting**	60.00	15,000 (250)	15,000 (250)	18,000 (300)	18,000 (300)	18,000 (300)
(3)	**Growth Control**						
	Remove Hangers	6.50	322 (51)	130 (20)	130 (20)	130 (20)	130 (20)
	Remove Deadwood	55.00	20,625 (375)	20,625 (375)	20,625 (375)	20,625 (375)	20,625 (375)
	Crown Thinning	13.70	5,014 (366)	5,014 (366)	5,014 (366)	5,014 (366)	5,014 (366)
	Crown Lifting	15.00	1,500 (100)	1,500 (100)	750 (50)	750 (50)	750 (50)
	Crown Training	6.00	2,328 (388)	2,328 (388)	2,328 (388)	2,328 (388)	2,328 (388)
(4)	**Fertilization**	15.00	3,795 (253)	3,795 (253)	3,795 (253)	3,795 (253)	3,795 (253)
(5)	**Damage Control**						
	Remove Girdling Roots	40.00	1,000 (25)	1,000 (25)	1,000 (25)	1,000 (25)	1,000 (25)
	Cable/Brace	39.00	3,900 (100)	3,900 (100)	3,900 (100)	3,900 (100)	3,900 (100)
(6)	**Insect and Disease Control**	5.00	1,000 (200)	1,000 (200)	1,000 (200)	1,000 (200)	1,000 (200)
	ESTIMATED TOTAL MAINTENANCE EXPENSE		$77,000	$76,800	$70,000	$70,000	$70,000

APPENDIX A

SUMMARY OF SURVEY RESULTS BY CITY DISTRICT

APPENDIX B

COMPUTATION OF THE VALUE OF THE STREET TREE POPULATION

Computation on Average Street Tree Value:*

Diameter	14,517 inches			
Basic Value	$2,979.00			multiplied by
Species Value	75%	=	$2,234	multiplied by
Condition Value	68.25%	=	$1,525	multiplied by
Location Value	80%	=	$1,220	

Value of the Average Street Tree	**$1,220**
Total Number of Trees	**x 7,514**
	$9,166,332

Description of Values:

Mean Diameter Given from 100% street tree inventory

Basic Value Diameter times $.7854d^2$ yields basal area in square inches. This is multiplied by a basic value of $18 per sq. inch.

Species Value This is determined by tree character and habit of growth; length of life and durability; immunity from diseases and insects; and usefulness, cleanliness, and hardiness. An average species value of 75% has been assigned.

Condition Value This value is based on the mean condition class recorded from the 100% street tree inventory

Location Value Street trees are assigned an 80% location value.

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*Calculations based on 100% street tree inventory and on values given in the Michigan Forestry and Parks Association and Michigan State University, Forestry Department, "Michigan Shade Tree Evaluation Guide, 1982."

Table A.1. Species Distribution of the Most Frequently Occurring Trees by District (Traverse City Inventory, 1982)

			Percent of District Trees Represented by Each Species								
Species	Total Trees	All City	1	2	3	4	5	6	7	8	9
Sugar Maple	3,633	47.8	67.3	65.7	50.6	44.8	59.4	12.9	27.5	17.1	15.8
Norway Maple	902	11.9	9.6	13.9	16.1	10.2	14.7	3.8	13.1	4.6	18.7
Red Oak	417	5.5	0	0	1.5	2.2	4.0	23.8	7.6	19.6	1.2
Red Maple	402	5.3	1.1	5.8	5.3	5.3	7.2	8.4	3.7	6.7	0
White Oak	324	4.3	0.1	1.3	4.0	1.2	2.3	20.5	2.7	9.3	1.2
White Pine	249	3.3	0.2	0.2	0.8	0	0.2	3.5	13.2	15.7	2.3
Silver Maple	216	2.8	2.5	3.4	6.8	1.2	3.3	1.2	0.6	0.1	0
Siberian Elm	169	2.2	2.0	0.7	3.4	0.7	1.8	5.1	2.7	2.9	2.9
Green Ash	118	1.6	1.5	0.4	0.4	19.6	0.7	0.6	0	0.1	0
Black Locust	87	1.1	0.9	0.4	1.1	2.4	0.9	3.0	1.5	1.4	0
Basswood	84	1.1	3.4	1.7	0.3	1.0	0.7	0.1	0.4	0.1	0
Red Pine	82	1.1	0	0.8	0.4	0	0	3.3	2.4	2.4	2.3
Crabapple	79	1.0	1.0	0.1	0.4	3.6	0.4	0.1	0.6	1.3	18.7
Boxelder	70	0.9	1.0	0.5	1.9	0	1.2	2.5	0.1	0	0
Norway Maple 'Crimson King'	67	0.9	0.6	0.4	1.0	0	0	0.3	2.8	2.6	1.2
Honeylocust	65	0.9	1.0	0.1	1.2	3.9	0.1	0	0.3	0	12.3
White Ash	48	0.6	0.3	0.6	0.9	0.2	0.1	0.3	1.1	1.3	0.6
Blue Spruce	46	0.6	0.2	0	0.4	0.7	0	0.9	1.7	1.6	3.5
Birches	44	0.6	0.2	0.04	0.3	1.2	0.4	0.6	0.8	2.0	3.5
White Cedar	43	0.6	0.7	0	0.6	0.2	0	0.4	2.1	1.4	0
Others	450	5.9	4.1	3.1	2.3	1.2	1.2	8.7	15.1	9.7	4.1
Total	7,595										

Table A.2. Diameter Classes for Street Trees, All City and by District. (Traverse City Inventory, 1982).

District	Total Trees	Mean Diameter (inches)	Percent of District Trees in Each Diameter Class								
			1-4"	5-9"	10-14"	15-19"	20-24"	25-29"	30-34"	>35"	Shrub
All City	7,595	14.5	14.1	19.2	20.1	19.0	17.1	6.2	2.6	0.8	0.7
One	886	15.5	12.4	18.3	15.7	18,1	20.3	9.1	3.5	2.1	0.2
Two	2,067	17.5	11.6	5.6	14.9	22.6	28.7	9.9	5.1	0.9	0.3
Three	1,141	13.6	13.8	21.4	23.0	18.1	14.7	5.8	1.5	0.7	0.4
Four	413	11.3	31.0	21.3	11.9	14.3	13.3	6.1	1.9	0.2	0
Five	818	13.6	15.3	19.3	20.2	22.0	14.9	5.3	1.8	0.3	0.4
Six	689	14.3	14.8	27.0	24.7	18.1	7.7	2.8	1.2	0.1	3.2
Seven	710	13.1	10.1	23.7	33.1	20.8	7.2	2.0	0.8	1.2	0.8
Eight	700	11.7	15.7	36.9	21.1	12.1	10.0	2.3	0.1	0.4	1.1
Nine	171	9.6	17.0	40.9	29.2	5.3	3.5	2.3	1.8	0	0

*Diameter measured at 4.5 feet above ground level.

Table A.3. Condition Classes for Trees, All City and by District (Traverse City Inventory, 1982)

District	Total Trees	Percent of District Trees in Condition Class					
		Excellent	Good		Fair	Poor	Very Poor
		90-100%	80-89%	70-79%	60-69%	50-59%	49%
All City	7,595	13.4	23.2	29.6	18.9	7.7	7.2
One	886	14.7	24.6	28.3	19.0	6.9	6.5
Two	2,067	6.0	19.2	33.8	23.2	10.4	7.5
Three	1,141	14.8	27.1	28.3	16.7	7.2	5.9
Four	413	14.8	37.3	30.8	8.5	3.1	5.6
Five	818	17.0	23.3	27.0	15.4	8.1	9.2
Six	689	8.1	19.6	29.9	23.5	11.0	9.6
Seven	710	30.1	19.2	20.7	15.4	5.1	9.6
Eight	700	16.9	24.3	30.1	19.9	3.6	5.3
Nine	171	4.7	29.2	35.7	15.8	8.8	5.8

Table A.4. Number of Planting Sites Recorded by District (Traverse City Inventory, 1982).

District	Planting Sites	District	Planting Sites
All City	3,064	Five	228
One	238	Six	882
Two	315	Seven	256
Three	498	Eight	393
Four	64	Nine	190

Table A.5. Pruning Recommendations Recorded for Street Trees (Traverse City Inventory, 1982).

District	Total Trees	Percent of District Trees with Pruning Recommendations by Priority									
		Lift		Thin		Train		Deadwood		Hanger	
		Low	High	Low	High	Low	High	Low	High	Low	High
All City	7,595	7.2	2.4	34.4	24.1	10.8	11.5	23.9	24.7	2.3	0.7
One	886	9.6	1.1	33.6	30.1	10.4	18.8	21.3	33.6	3.4	0.6
Two	2,067	3.6	1.1	42.0	28.2	5.6	6.8	27.7	36.8	2.4	1.2
Three	1,141	8.2	3.2	37.0	32.3	12.2	15.2	23.7	21.4	3.1	0.4
Four	413	20.1	4.8	22.5	54.0	4.6	28.1	30.5	24.9	5.3	1.0
Five	818	7.2	1.3	40.7	20.4	13.2	13.0	25.3	23.1	2.8	0.6
Six	689	8.1	7.4	27.4	10.2	12.0	11.6	24.2	15.7	0.6	0.7
Seven	710	6.2	2.7	65.4	9.0	17.7	3.7	16.8	9.6	0.3	0.1
Eight	700	7.3	1.9	27.6	8.1	16.1	7.9	22.0	13.4	0.9	0.4
Nine	171	2.9	1.8	21.6	18.1	15.2	3.5	7.6	7.0	0.6	0

Table A.6. Management Recommendations Other Than Pruning for Street Trees (Traverse City Inventory, 1982).

		Percent of District Trees by Recommendations								
District	Total Trees	Remove	Girdling Roots	Cable/ Brace	Repair	Fertilize	Insects	Disease	Sidewalk Heave $< \frac{1}{2}''$	Sidewalk Heave $> \frac{1}{2}''$
All City	7,595	6.5	6.3	6.7	4.8	16.7	2.4	1.4	5.7	4.9
One	886	6.2	7.4	3.3	2.0	8.9	3.4	1.6	6.8	8.2
Two	2,067	7.2	9.1	7.2	2.9	13.3	0.6	0.5	5.7	5.5
Three	1,141	5.7	7.9	9.4	5.9	28.8	3.8	1.3	7.5	4.4
Four	413	8.5	6.3	4.1	0.2	38.0	4.4	0	14.8	10.9
Five	818	8.7	9.4	8.7	6.5	28.6	1.5	0.7	11.2	9.4
Six	689	8.3	0.6	9.6	10.6	8.9	2.0	3.9	1.5	1.6
Seven	710	5.2	1.1	6.2	5.9	5.8	2.4	2.4	0.4	0
Eight	700	2.6	1.4	3.4	4.7	7.7	3.6	2.4	0.3	0.7
Nine	171	4.1	6.4	0.6	10.5	20.5	4.1	0.6	0	0

Table A.7. Problems Encountered with Street Trees (Traverse City Inventory, 1982).

		Percent of District Trees by Problem				
District	Total Trees	Dieback	Injury	Rot	Sidewalk Cut	Frost Crack
All City	7,595	9.6	4.2	1.5	6.3	1.1
One	886	11.3	1.2	0.1	5.8	0.1
Two	2,067	10.1	1.0	0.4	10.3	0.2
Three	1,141	10.1	3.3	2.1	7.2	1.1
Four	413	24.5	1.5	0	10.2	0
Five	818	14.7	3.8	5.0	11.9	0.2
Six	689	4.2	8.7	4.8	0.4	2.8
Seven	710	2.4	.56	0.3	0.1	2.8
Eight	700	1.7	7.6	1.0	0.4	1.6
Nine	171	18.7	34.5	0.6	0	7.6

TREE MANAGEMENT PLAN AND URBAN TREE CANOPY ASSESSMENT

Traverse City, Michigan

October 2018

Prepared for:

City of Traverse City
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STATEMENT OF PURPOSE

Traverse City’s charm is based, in part, on its natural character and proximity to beautiful lakes, streams, trees, and natural settings. These natural resources, in turn, provide numerous community benefits from promoting clean air and water, to providing space for recreation and reflection. Particularly celebrating the contribution of trees to Traverse City’s appeal, the city has proudly been awarded Tree City USA status for nearly 30 years. To promote further growth and expansion of the city’s urban forest, the city has completed a street tree inventory and has recently embarked on a review of its ordinances and policies in partnership with the Watershed Center Grand Traverse Bay. Combined, these activities are helping to develop a foundation for community conversations and goal-setting for its urban forestry program.

The City of Traverse City Parks and Recreation Division provides a wide array of park facilities and programs for its citizens and guests to enjoy. This division prides itself in offering an attractive community with fun things to do and pleasant places for people to go to spend their leisure time.

The city sees this project as the foundation of its growing urban forestry program. Combined with the completion of the city’s tree inventory, the city’s UTC assessment, and ordinance review, this plan offers the city an unprecedented and comprehensive look at the state, breadth, and condition of its community forest. This project provides the city with guidance to protect, enhance, and expand tree canopy across Traverse City.

ACKNOWLEDGMENTS

Traverse City'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.

This project is supported in part with funding from the USDA Forest Service (USFS), State and Private Forestry through a grant from the Michigan Department of Natural Resources (DNR) Urban and Community Forestry (U&CF) Program. The U&CF Grant Program is designed to encourage communities to create and support long-term and sustained urban and community forestry programs throughout Michigan.

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

EXECUTIVE SUMMARY

This plan was developed for the City of Traverse City by DRG with a focus on addressing short-term and long-term needs for public trees. The inventory dataset was provided by the city and was in part collected by DRG in August 2018 (see numbers below).

Analysis of inventory data and information about Traverse City's existing program and vision for the urban forest were utilized to develop this *Tree Management Plan*.

DRG also performed an Urban Tree Canopy Assessment (UTC) using 2016 aerial imagery. This report summarizes those findings and provides recommendations for improving and maintaining the urban forest. A UTC can be used to measure and benchmark tree canopy as trees offer considerable community benefits such as improvements in air and water quality, property values, impacts to human health, and community well-being. Therefore, a health and expansive tree canopy is important to maintaining vibrant communities. By establishing a baseline, this assessment will guide future community forest management and reforestation efforts throughout Traverse City, Michigan.

State of the Existing Urban Forest

The combined inventory included trees along public street rights-of-way (ROW), and in parks and public facilities. The dataset provided by the city included 9,387 trees inventoried by the city prior to 2018 and 772 collected by DRG staff in August 2018 for a total of 10,159 trees. The 772 trees collected by DRG staff were located along city ROW in the downtown district and in the following parks: Clinch Park, Sunset Park, The Senior Center, American Legion Park, and Bryant Park. Analysis of the cumulative tree inventory data found the following:

- **Species Diversity.** Two species, *Acer saccharum* (sugar maple) and *A, platanoides* (Norway maple), comprise a large percentage of the publicly owned trees (20% and 15%, respectively) and threaten biodiversity.
- **Genus Diversity.** One genus, *Acer* (maple), was found in abundance at 47% of the population.
- **Relative Diameter/Age Class.** The diameter size class distribution of the inventoried tree population trends towards the ideal, with a greater number of young trees than established, maturing, or mature trees.
- **Pests.** Three species of ambrosia beetle; Granulate ambrosia beetle (*Xylosandrus crassiusculus*), Xm ambrosia beetle (*Xylosandrus mutilatus*), and Asian longhorned beetle (ALB or *Anoplophora glabripennis*), pose the greatest threats to Traverse City's urban forest.

The trees inventoried by DRG also assessed the condition of the trees which produced the following findings:

- **Condition.** The overall condition of the downtown district and select park tree population is rated good.

In addition to the inventory data, the Urban Tree Canopy Assessment (UTC) found the following:

- **Amount of Existing Canopy Cover.** The assessment revealed that in 2016, 33% of the city was covered by tree canopy. Other types of the land cover that were also measured included hard surfaces (roads, buildings, also termed "impervious" land cover) which covered 33% of Traverse City, low vegetation (lawns, agricultural areas) at 28%, open bare soil (2%), and open water (4%).
- **Location of Canopy.** The highest percentages of canopy are found in institutional (e.g., Northwestern Michigan College properties), residential, and governmental areas with 65%, 48%, and 46%, respectively. The lowest levels of tree canopy are found in commercial areas (17%) and transportation (20%). Commercial areas have the highest levels of impervious surfaces (68%) and the lowest percentage of other vegetation (12%). Additionally, roughly 25% of Traverse City's total tree canopy is found in or near the ROW.
- **Benefits Provided by Trees.** The assessment also quantified many of the benefits Traverse City receives from its tree canopy cover, totaling just over $2 million annually. Traverse City's trees remove over 111,000 tons of pollutants from the air and intercept over 21 million gallons of stormwater each year. Over 14 million tons of carbon are currently stored within the community's tree canopy. Additionally, Traverse City's trees have the capacity to increase revenue in the business district, increase property values, improve human health, and calm traffic along streets. As the community's trees mature, these benefits will only continue to increase.
- **Potential Areas to Add Tree Canopy.** Additionally, the assessment identified and ranked potential planting locations for additional tree canopy throughout Traverse City based on their impact to stormwater interception and water quality. Approximately 480 acres were identified as moderate to very high priority plantable areas on both public and private property, which, if planted, would increase overall tree canopy to 42%.

Tree Maintenance and Planting Needs

Trees provide many environmental and economic benefits that justify the time and money invested in planting and maintenance. Maintenance recommendations were not present in the 2018 dataset but should be considered for future inventory efforts. Proposed budgetary decisions were based off of relative tree age and maintaining a Routine Pruning Cycle of seven years.

Traverse City's urban forest will benefit greatly from seven-year routine pruning cycle. Proactive pruning cycles improve the overall health of the tree population and may eventually reduce tree maintenance costs. In most cases, pruning cycles will correct defects in trees before they worsen, which avoids costly problems, or may reduce incidences of tree failure and damage. Based on the inventory data, 48% of the trees in the 2018 inventory data set were between 1 and 8 inches in diameter. Proper training of the large proportion of young trees can make a positive impact on the need for costly tree work in later cycles.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind). While no specific planting sites were identified in the inventory, the UTC provides insight into the highest impact planting areas within the city which include area located along the major thoroughfares, open areas in Grand Traverse Commons, and distributed throughout the residential areas.

Furthermore, tree planting should focus on replacing tree canopy 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 until the species distribution normalizes. Similarly, due to the impending threats from emerald ash borer (EAB, *Agrilus planipennis*), all *Fraxinus* (ash) trees should be removed from the planting.

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 maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this seven-year program is $471,250. In the second year this number increases to $499,250 to facilitate establishment of trees planted in Year 1 but decreases steadily thereafter. By Year 7 the projected budget is $491,250. This is in part due to increased proactive activity such as routine tree pruning and inventory upkeep. This should in turn decrease reactionary activity associated with hazardous tree removal, service requests by citizens, and other contingency plan-based work.

Over the long term, supporting proactive management of trees through funding will reduce municipal tree maintenance costs and potentially minimize the costs to build, manage, and support certain city infrastructure. Keeping the inventory up-to-date is crucial for making informed management decisions and projecting accurate maintenance budgets. The inventory should also be expanded to include condition, primary maintenance, and risk assessments.

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

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INTRODUCTION

The City of Traverse City is home to more than 15,000 full-time residents who enjoy the beauty and benefits of their urban forest. The city's forestry program manages and maintains trees on public property, including trees, stumps, and planting sites in specified parks, public facilities, and along the street rights-of-way (ROW). In recent years, Traverse City's Parks and Recreation Division has cultivated staff and community interest in developing a strong urban forest.

Funding for the city's urban forestry program comes primarily from the city's general fund. Over the last several years, Traverse City has conducted a basic tree inventory using temporary staffing. The last 772 trees were inventoried by DRG in 2018. The city has a tree ordinance, maintains a budget of more than $2 per capita for tree-related expenses, celebrates Arbor Day, and has been a Tree City USA community for over 29 years. Several recent City-led urban forestry efforts have demonstrated a desire within the City to improve positively impact the community's trees.

Approach to Tree Management

The best approach to managing an urban forest is to develop an organized, proactive program using tools 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 August 2018, Traverse City worked with DRG to complete an existing internal tree inventory, perform an Urban Tree Canopy Assessment (UTC), and develop a management plan.

This plan considers the diversity, relative size, and distribution of the entire inventory. Condition ratings of trees inventoried by DRG in the downtown district were also collected. The following tasks were completed:

- Inventory of trees along the street ROW in the downtown tree maintenance district and in the following parks and public facilities–American Legion Park; Bryant Park; Clinch Park; Sunset Park; The Senior Center
- Assimilation and analysis of the integrated tree inventory data.
- An Urban Tree Canopy Assessment (UTC) using 2016 NAIP imagery.
- Development of a plan that prioritizes the recommended tree maintenance, planting, and future budget decisions utilizing both the inventory data and the UTC.

This plan is divided into four sections:

- *Section 1: Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: Urban Tree Canopy Assessment* analyzes the UTC findings and presents data, results, and takeaway messages.
- *Section 3: Benefits of the Urban Forest* summarizes the economic, environmental, and social benefits that trees provide to the community found in the UTC.
- *Section 4: Tree Management Program* utilizes the inventory data and UTC to develop a maintenance schedule and projected budget for the recommended tree maintenance over a seven-year period.

SECTION 1: TREE INVENTORY ANALYSIS

The data analyzed in this report came from two sources—an existing city collected inventory of street trees and selected parks, and a subset collected by DRG. City-collected data include the majority of streets and some parks. City efforts to collect park tree data are on-going.

In August 2018, an International Society of Arboriculture (ISA) certified DRG staff member assessed and inventoried trees along the street ROW, specified parks, and public facilities. A total of 772 sites were collected during this portion of the inventory. The inventoried areas—the downtown tree maintenance district and five community parks/public facilities were selected by Traverse City to complete the city's existing tree inventory. Inventoried parks and facilities include: American Legion Park, Bryant Park, Clinch Park, Sunset Park, and The Senior Center. The city assimilated this data into their existing inventory and returned them to DRG for analysis. The result was a dataset of 10,159 total trees; 772 sites from the DRG inventory remained in the inventory after merging. Percentagewise, 92% of the inventory was city provided and 8% was collected by DRG staff.

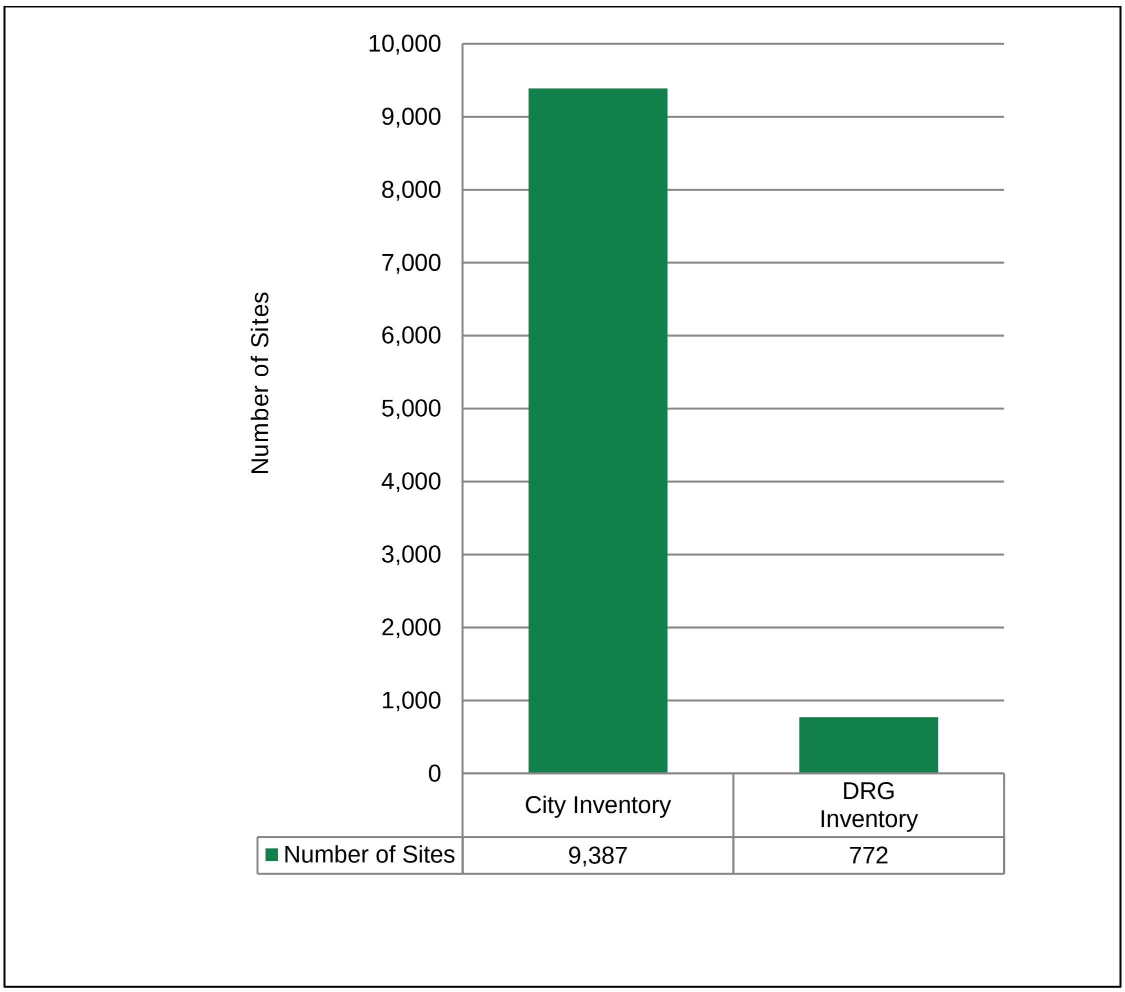


Figure 1. Composition of the 2018 tree inventory data.

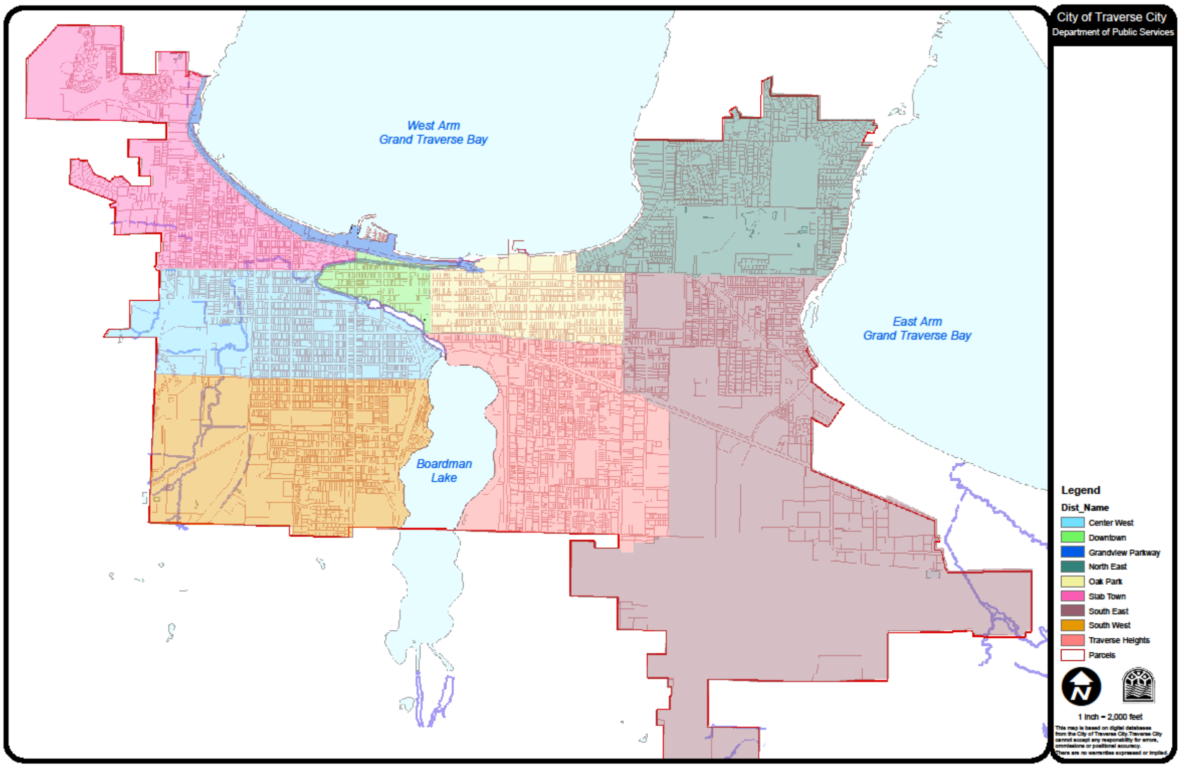


Figure 2. Tree maintenance districts.

Assessment of Tree Inventory Data

Data analysis and professional judgment are used to generalize/assess the state of the inventoried tree population. Recognizing trends in these data can help guide short-term and long-term management planning. See Appendix A for more information on data collection and site location methods. In this plan, the following criteria and indicators of the inventoried tree population were assessed:

Photograph 1. In addition to the city provided inventory, a DRG ISA Certified Arborist inventoried trees along street ROW and in community parks and facilities to provide information about trees that could be used to assess the state of the urban forest.

- *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. Information provided in this section is from the 772 DRG collected sites only and should be used as a sample, but may not be indicative of the condition of the overall inventory.

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

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

Findings

Analysis of Traverse City's tree inventory data indicated that the population had moderate diversity, with 57 genera and 129 species represented.

Figure 3 uses the 10% Rule to compare the percentages of the most common species in the inventory population. *Acer saccharum* (sugar maple) and *A. platanoides* (Norway maple) far exceed the recommended 10% maximum for a single species in a population, comprising 21% and 16% of the inventoried tree population, respectively. The next three species, *Quercus rubra* (red oak), *Pinus strobus* (eastern white pine), and *Acer rubrum* (red maple) are only at about half of the 10% threshold.

Figure 3. Five most abundant species of the inventoried population compared to the 10% Rule.

Figure 4 uses the 20% Rule to compare the percentages of the most common genera identified in the inventory population. *Acer* (maple) far exceeds the recommended 20% maximum for a single genus in a population, comprising 50% of Traverse City's inventoried tree population. *Quercus* (oak), the next highest ranked genus, encompasses 12% of the population. The next ranked genera are all below the 20% threshold.

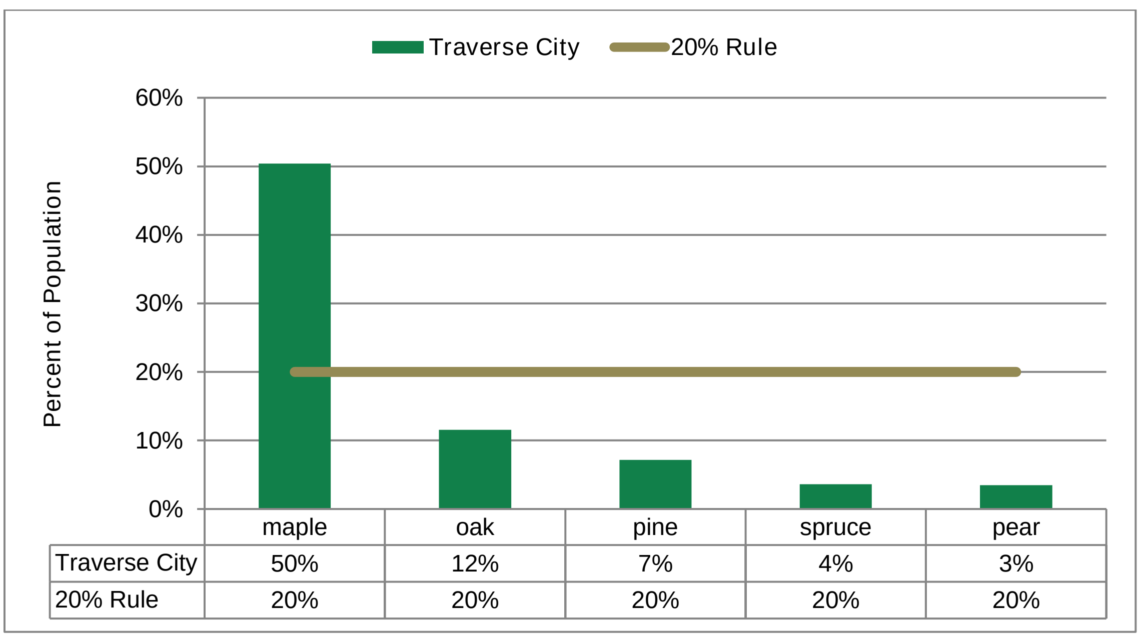


Figure 4. Five most abundant genera of the inventoried population compared to the 20% Rule.

Discussion/Recommendations

Acer (maple) dominate the streets, parks, and public facilities. This is a biodiversity concern, as maple are also extremely abundant within the natural landscape. Continued diversity of tree species is an important objective that will ensure Traverse City's urban forest is sustainable and resilient to future invasive pest infestations.

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

Diameter Size Class Distribution

Analyzing the diameter size class distribution provides an estimate of the relative age of a tree population and offers insight into maintenance practices and needs.

The inventoried trees were categorized into the following diameter size classes: young trees (1–8 inches DBH), established (9–17 inches DBH), maturing (18–24 inches DBH), and mature trees (greater than 24 inches DBH). These categories were chosen so that the population could be analyzed according to Richards' ideal distribution (1983), which proposes an ideal diameter size class distribution for street trees based on observations of well-adapted trees in Syracuse, New York. Richards' ideal distribution suggests that the largest fraction of trees (approximately 40% of the population) should be young (less than 8 inches DBH), while a smaller fraction (approximately 10%) should be in the large-diameter size class (greater than 24 inches DBH). A tree population with an ideal distribution would have an abundance of newly planted and young trees, and lower numbers of established, maturing, and mature trees (note: 83 sites in the city inventory which listed 0 inches as diameter were excluded from this analysis).

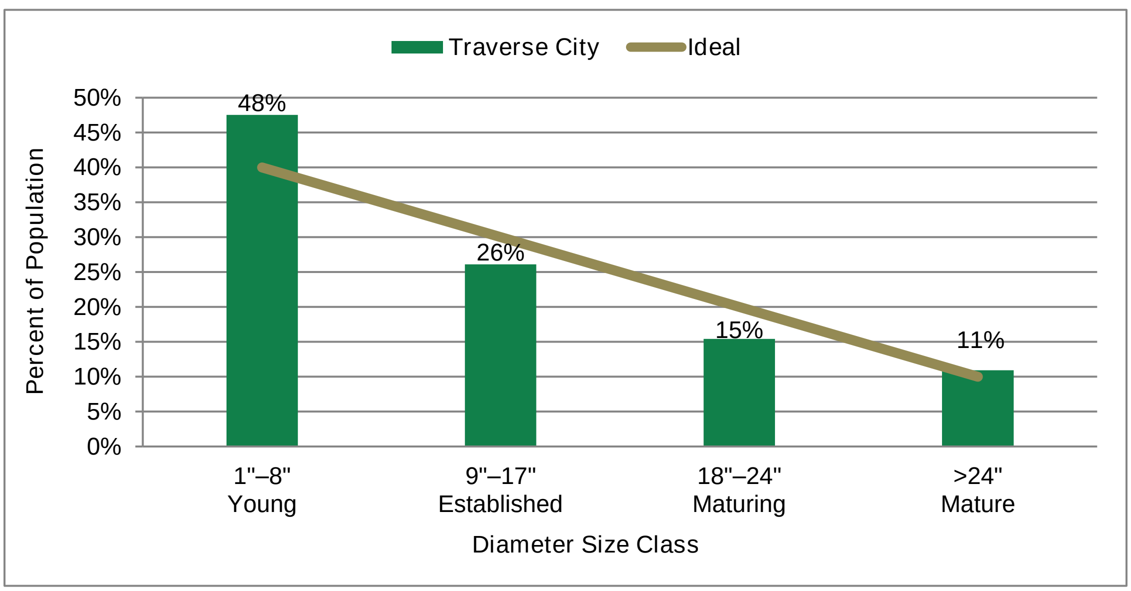


Figure 5. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Findings

Figure 5 compares Traverse City's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). Traverse City's distribution trends towards the ideal; young and mature trees exceed the ideal by 8% and 1%, respectively, while established and maturing diameter size classes fall short of the ideal.

Discussion/Recommendations

Even though it may appear that Traverse City may have too many young trees, this may not be the case. Conversely, the city may have too few established and maturing trees. One of Traverse City's objectives is to have an uneven-aged distribution of trees at the street, park, and citywide levels. DRG recommends that Traverse City 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 B for a recommended tree species list for planting. See Appendix C for planting suggestions and information on species selection.

Species Diversity by Diameter Size Class Distribution

Comparing the species composition of the tree population with relative tree age (or size class distribution) can provide insight into trends in biodiversity of the population as they relate to planting, upkeep, and mortality. Since tree species have different lifespans and mature at different diameters, heights, and crown spreads, actual tree age cannot be determined from diameter size class alone. However, general classifications of size can be extrapolated into relative age classes. The following categories are used to describe the relative age of a tree: young (0–8 inches DBH), established (9–17 inches DBH), maturing (18–24 inches DBH), and mature (greater than 24 inches DBH). Table 1 and Figure 6 shows the top five species for each relative age class and a baseline of other species in that age class.

Table 1. Number of Individuals of the Top Five Species in Each Age Class

Relative Age Class	Species 1	Species 2	Species 3	Species 4	Species 5
Young	Acer platanoides	Acer saccharum	Acer × freemanii	Pyrus calleryana	Acer rubrum
	648	350	342	219	204
Established	Acer saccharum	Acer platanoides	Pinus strobus	Acer rubrum	Quercus rubra
	590	511	160	159	157
Maturing	Acer saccharum	Acer platanoides	Quercus rubra	Pinus strobus	Quercus alba
	567	235	133	131	97
Mature	Acer saccharum	Quercus rubra	Acer platanoides	Quercus alba	Acer saccharinum
	471	162	81	75	66

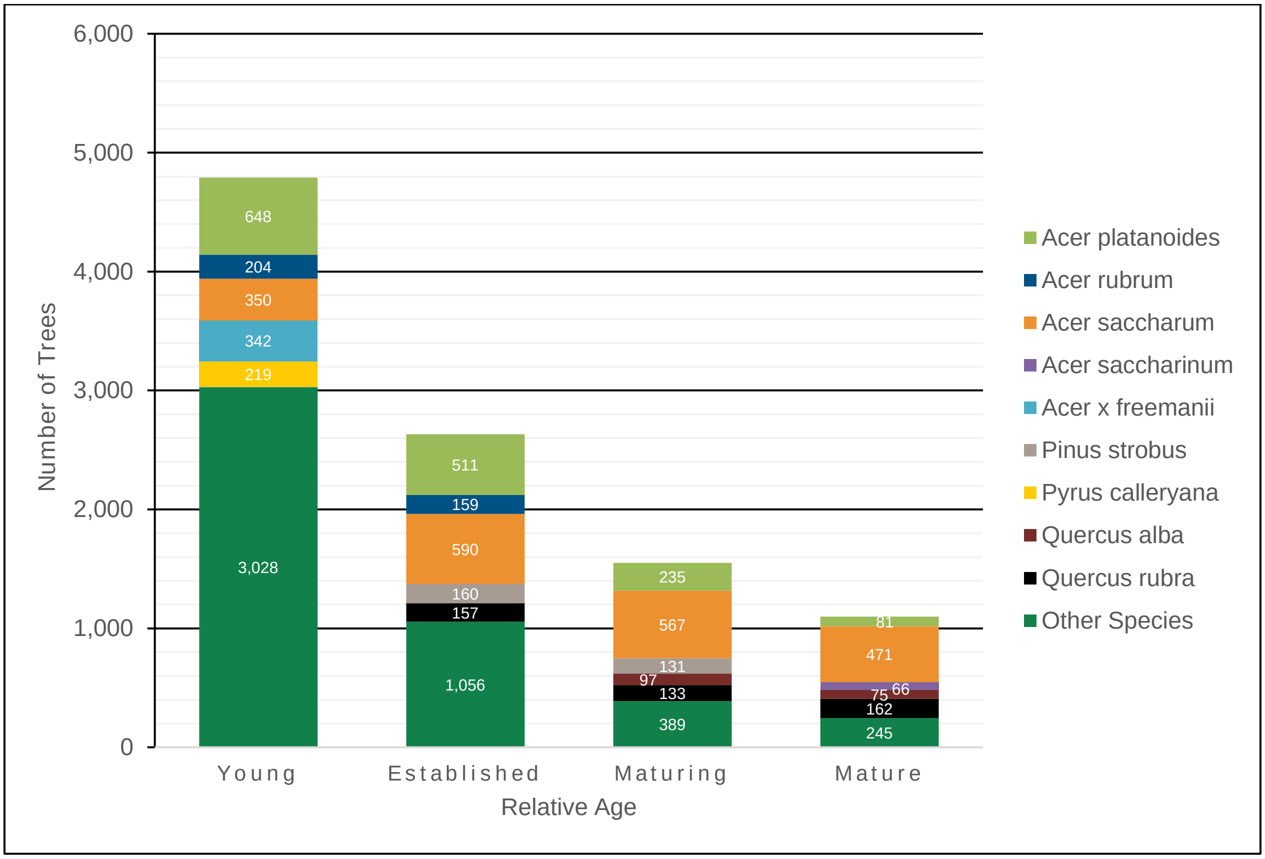


Figure 6. Top five species by each relative age class, including other species.

Findings

Acer (maple) dominate all age classes as the highest percentage species. *Acer plataniodes* (Norway maple) and *A. saccharum* (sugar maple) take the number one and two ranks on all age classes except mature trees. This age class is still comprised primarily by *Acer* (maple) but has *Quercus rubra* (red oak) as a second ranked species. However, it is apparent that a combination of species become a larger and larger proportion of the age class from mature to young age classes.

Discussion/Recommendations

These results indicate that tree species diversity increases as tree size decreases. This may be a result of an increased species palette in planting activities, or an indication of the species more likely to thrive in Traverse City. Regardless, maple is a dominant species across age classes. Planting and preservation efforts should focus on increasing diversity of the overall population across age classes. Newly planted stock should take into consideration that there is a considerable dominance by *Acer* (maple), especially in the younger age classes. This means that as these trees mature, more of the overall population will continue to be comprised of *Acer* (maple) unless planting selection changes. Furthermore, *Quercus* (oak) are at a higher percentage in the mature class and should be preserved, since they provide an anchor in pulling the diversity away from *Acer* (maple).

Planting trees is necessary to increase canopy cover and replace trees lost to natural mortality (expected to be 1%–3% per year) and other threats (for example, invasive pests or impacts from weather events such as storms, wind, ice, snow, flooding, and drought). Planning for the replacement of existing trees and identifying the best places to create new canopy is critical.

Condition

The information provided in this section is only from the 772 DRG collected sites, which make up roughly 8% of the overall inventory. This section should serve only as a snapshot or sample but may not be indicative of the condition of the overall inventory. DRG assessed the condition of individual trees adapted from 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 as Good, Fair, Poor, or Dead. Figure 7 illustrates the general health of the 772 DRG collected trees.

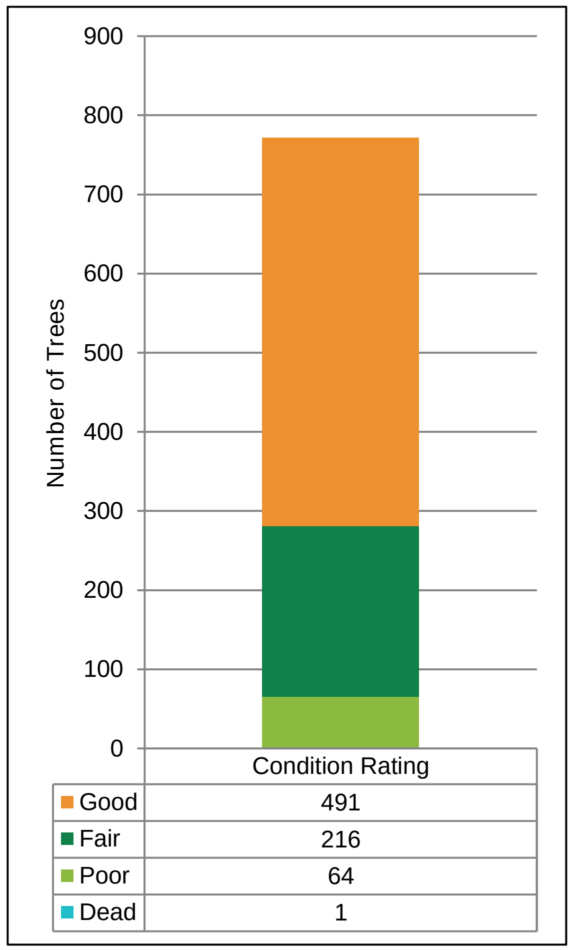


Figure 7. Conditions of the 772 DRG inventoried trees.

Findings

491 or 64% of the 772 inventoried trees were recorded to be in good condition (Figure 7). Based on these data, the general health of the DRG inventoried tree population is rated good.

Discussion/Recommendations

Even though the condition of Traverse City's this sample is typical, that may not be true for the wider population. Further data collection should be performed to more accurately ascertain the condition of the population. However, this sample does provide some insight into maintenance need and practices:

- 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 (Part 1)* (ANSI 2008).
- Poor condition ratings among mature trees are 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.
- Dead trees should be removed because of their failed health; these trees will not recover, even with increased care.
- Proper tree care practices are needed for the long-term general health of the urban forest. Following guidelines developed by ISA and those recommended by *ANSI A300 (Part 6)* (ANSI 2012) will ensure that tree maintenance practices ultimately improve the health of the urban forest.

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 D provides information about some of the current potential threats to Traverse City's trees and includes websites where more detailed information can be found.

Pests can target a single species or an entire genus, or even multiple genera or families. 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 8). It is important to note that the figure only presents data from the inventory. Many more trees throughout Traverse City, including those on public and private property, may be susceptible to these invasive pests.

Findings

Three species of ambrosia beetle; Granulate ambrosia beetle (*Xylosandrus crassiusculus*), Xm ambrosia beetle (*Xylosandrus mutilatus*), and Asian longhorned beetle (ALB or *Anoplophora glabripennis*) are known threats to a large percentage of the inventoried street trees (64%, 47%, and 45%, respectively). To DRG's knowledge, these pests were not detected in Traverse City, but if they were detected the city could see severe losses in its tree population.

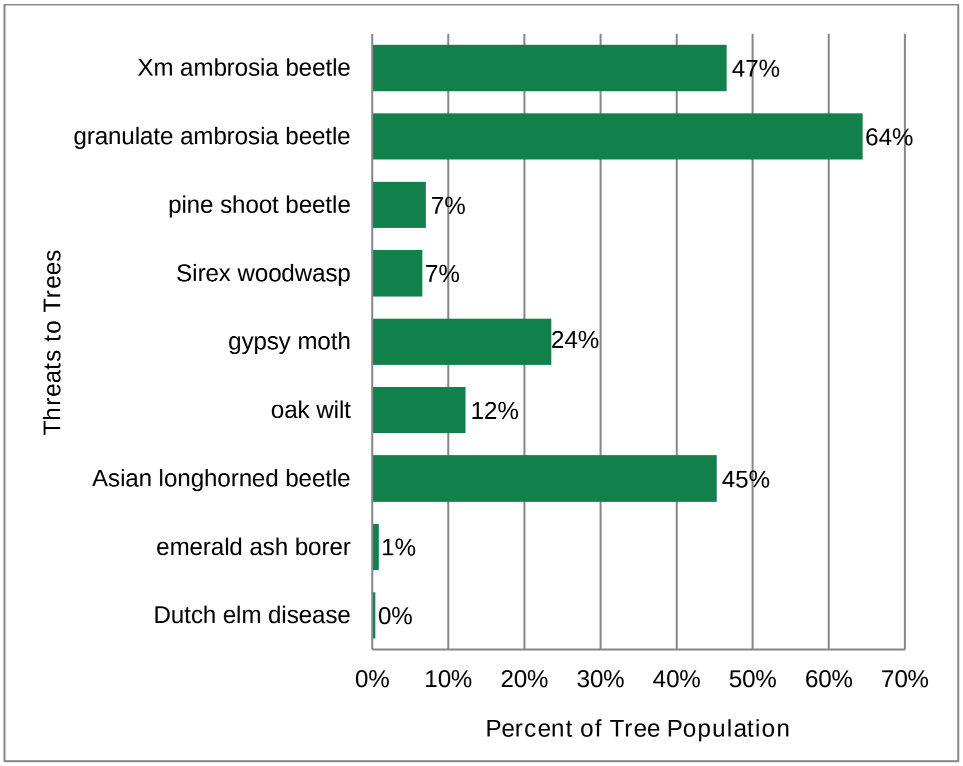


Figure 8. Potential impact of insect and disease threats noted during in the 2018 inventory dataset.

Discussion/Recommendations

Traverse City 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: URBAN TREE CANOPY ASSESSMENT

About the Assessment

The goal of this portion of the report is to provide the City of Traverse City with valuable data that will support efforts to develop community goals, prioritize tree planting and other on-the-ground projects, and establish the value of the community's tree resources among its other assets. This tree canopy assessment is especially supportive to data-backed strategies and plans for the area's current and future community forest and green infrastructure investment.

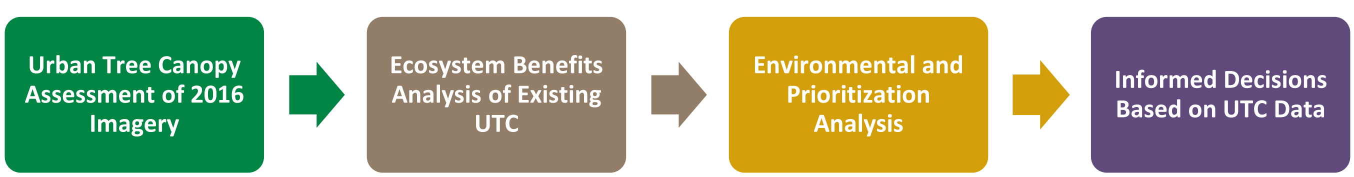
This assessment establishes tree canopy cover baseline information, identifies and quantifies the current contributions of community trees, examines opportunities for tree canopy expansion, and develops a prioritized planting plan based on environmental factors that support community goals. This assessment examines tree canopy trends across Traverse City, including both public and private properties. As trees provide public benefits, regardless of property lines, it is important to explore tree canopy in its entirety, not limited to specific ownership classes.

The information contained within this section of the report is only one of many initiatives to support Traverse City's continued investment in its community. The tree canopy assessment data, maps, tree inventory, and other management tools are all necessary components that help guide community reforestation efforts to maximize economic and ecological benefits and community forest sustainability. As management progresses, Traverse City is encouraged to refer back to these results, utilize these data for additional analyses, and continue to seek new tools and information to measure progress, report accomplishments, and inform management decisions.

Process and Methods

DRG's Tree Canopy Assessment was created using a well-established and statistically rigorous process. First, a land cover extraction was completed using the 2016 National Agriculture Imagery Program (NAIP) photography. A series of random plots were generated and manually inspected to ensure accuracy. Next, the canopy data from the land cover extraction were analyzed using i-Tree models to generate an estimate of ecosystem benefits provided by the existing tree canopy. Finally, a realistic estimate of potential canopy was created by eliminating areas not suitable for planting (e.g., impervious surfaces, sports fields). These data were used to develop planting recommendations that leverage to mitigate stormwater and maximize community benefits.

This study used a variety of data, tools, and analytical methodologies from various sources, including United States Department of Agriculture aerial imagery, census data, remote sensing technology, locally supplied data, scientific studies, and previous canopy analyses. These sources will be briefly mentioned or referenced throughout the remainder of this section of the report.



TREE CANOPY ASSESSMENT RESULTS

Based on 2016 aerial imagery, Traverse City's tree canopy is currently estimated at 33% (Table 2), which compares favorably with other Michigan communities (Table 3).

Tree canopy is just one of five land cover classifications generated by this assessment. Additional land cover data, including other vegetation (e.g., shrubs, grass, and low-lying vegetation), impervious surfaces (e.g., concrete, buildings), bare soils, and water, were also estimated using Traverse City's city boundary as the project area.

Once an overall canopy analysis is completed, these data can be segmented and examined further to identify trends, including:

- Tree canopy by land use, right-of-way vs. private property, stormwater zone;
- Environmental issues of interest (e.g., flooding, excessive heat); and
- Correlations with the people who reside and work throughout the community (socioeconomics and demographics).

Contained in this section of the report is an analysis of some of the general findings and trends of Traverse City's tree canopy assessment. However, these data can be examined and analyzed in a multitude of different and more specific ways. Traverse City is encouraged to further explore these data as new ideas, interests, or priorities arise.

Simply put, this study represents only a subset of the extensive information and findings that can be gleaned from the data analyses generated by this assessment.

Table 2. Traverse City Land Cover Classes by Percent and Area

Land Cover	(%)	Acres
Tree Canopy	33%	1,807
Impervious Surfaces	33%	1,837
Other Vegetation	28%	1,543
Bare Soil	2%	103
Open Water	4%	217

Table 3. Comparison of Tree Canopy Across Various Michigan Communities

Community	Tree Canopy (%)
Alma, MI	23%
Au Gres, MI	26%
Harbor Springs, MI	40%
Grand Rapids, MI	34%
East Lansing, MI	31%

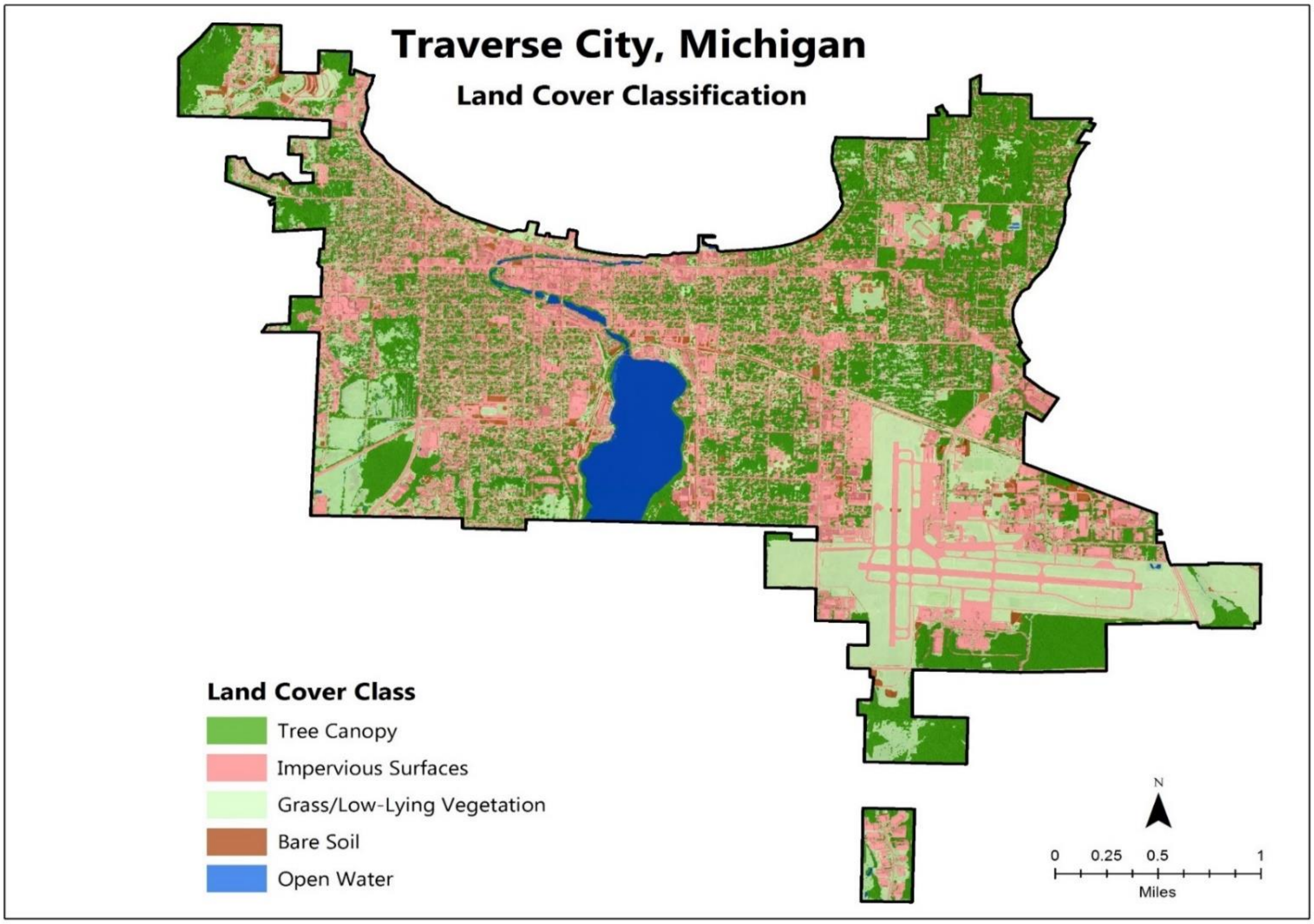


Figure 9. Traverse City land cover results.

Tree Canopy Related to Land Use

Tree canopy levels tend to correlate with land use types. In typical communities, commercial and industrial areas tend to have much lower levels of tree canopy and higher levels of impervious surfaces than residential districts. Understanding this relationship across a community can help identify policy concerns or areas of need for new outreach and education programs that would appeal to specific landowners or property types. Figure 9 illustrates a land use map of Traverse City, Michigan.

Cherry Capital Airport

The Cherry Capital Airport comprises roughly 1,056 acres or approximately 24% of Traverse City's land area. Considering the low percentage of tree canopy on airport lands (~16%) and that the airport is unlikely to significantly add trees, it is reasonable to ask whether the airport should be included in this analysis.

Ultimately, it is standard practice to include items such as airports, universities, and all other large properties that fall within a municipal boundary in urban tree canopy calculations. Independent of the control the municipal government exercises over these properties, trees on these properties still contribute substantial public benefits (e.g. human health, carbon sequestration), and the properties themselves have impacts on items such as stormwater or community aesthetics. Excluding such properties skews the results for a geographic area of interest. However, it is important to recognize the limitations such properties may place on possible or potential tree canopy when evaluating such items as ordinances, policies, or canopy goals.

Findings

- The highest levels of tree canopy are found in institutional (e.g., Northwestern Michigan College properties), residential, and governmental land uses with 65%, 48%, and 46%, respectively.
- Transportation (55%), open space/recreational (43%), and mixed use (34%) land uses have significant levels of other vegetation, indicating there may be ample space for expanding tree canopy within these land uses.
- The lowest levels of tree canopy are found in commercial areas (17%) and transportation (20%). Commercial areas have the highest levels of impervious surfaces (68%) and the lowest percentage of other vegetation (12%).
- Industrial, commercial, and medical land uses have significantly higher levels of impervious surfaces than tree canopy, which indicates that these land uses may have outsized impacts to stormwater quantity and water quality.

Takeaway. The results indicate that there is an opportunity to expand tree canopy across several land uses. Combined, institutional, residential, and governmental areas account for much of the land use in Traverse City and already have a relatively high percentage of tree canopy. Conversely, land uses with a low percentage of canopy such as commercial and industrial zones could expand tree canopy via tree planting, tree protection, or other activities. Despite this, opportunities may be limited by low percentages of other vegetation and high levels of impervious surfaces. Such differences between land cover types often indicate that trees and greenery in these zones may not be provided the appropriate emphasis that exist to expand greenery for water quality purposes.

Table 4. Land Cover by General Zoning Class in Traverse City, Michigan

General Zoning Class	Land Cover Classification				
	Tree Canopy (%)	Impervious (%)	Other Vegetation (%)	Bare Soil (%)	Water (%)
Commercial	17%	68%	12%	3%	0%
Government	46%	26%	25%	2%	1%
Industrial	25%	54%	16%	4%	0%
Institutional	65%	19%	14%	1%	0%
Medical	27%	55%	16%	2%	0%
Mixed Use	44%	14%	34%	7%	0%
Open Space/Recreational	39%	15%	43%	3%	0%
Residential	48%	27%	23%	1%	0%
Transportation	20%	24%	55%	1%	0%

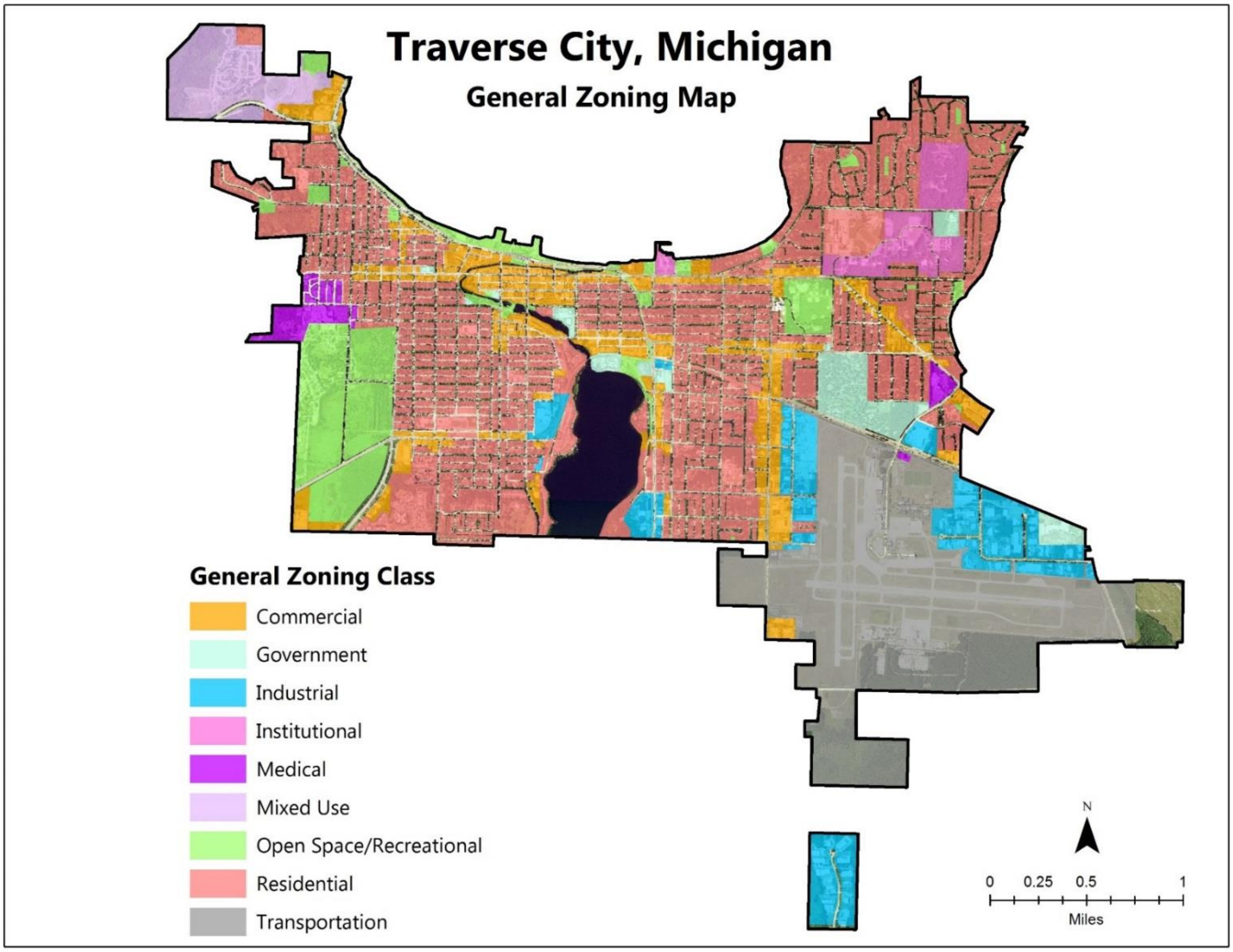


Figure 10. General zoning map of Traverse City, Michigan.

Right-of-Way Tree Canopy

Rights-of-way (ROW) often represent the few portions of a city's land area which the local government can directly influence. Unlike private property, cities can simply target ROWs with low tree canopy levels for tree planting programs. Understanding the distribution of tree canopy across a community's ROWs can help prioritize public tree planting and preservation activities.

Figure 11 illustrates the rights-of-way throughout Traverse City. The different colors convey the amount of canopy cover along community rights-of-way and public streets.

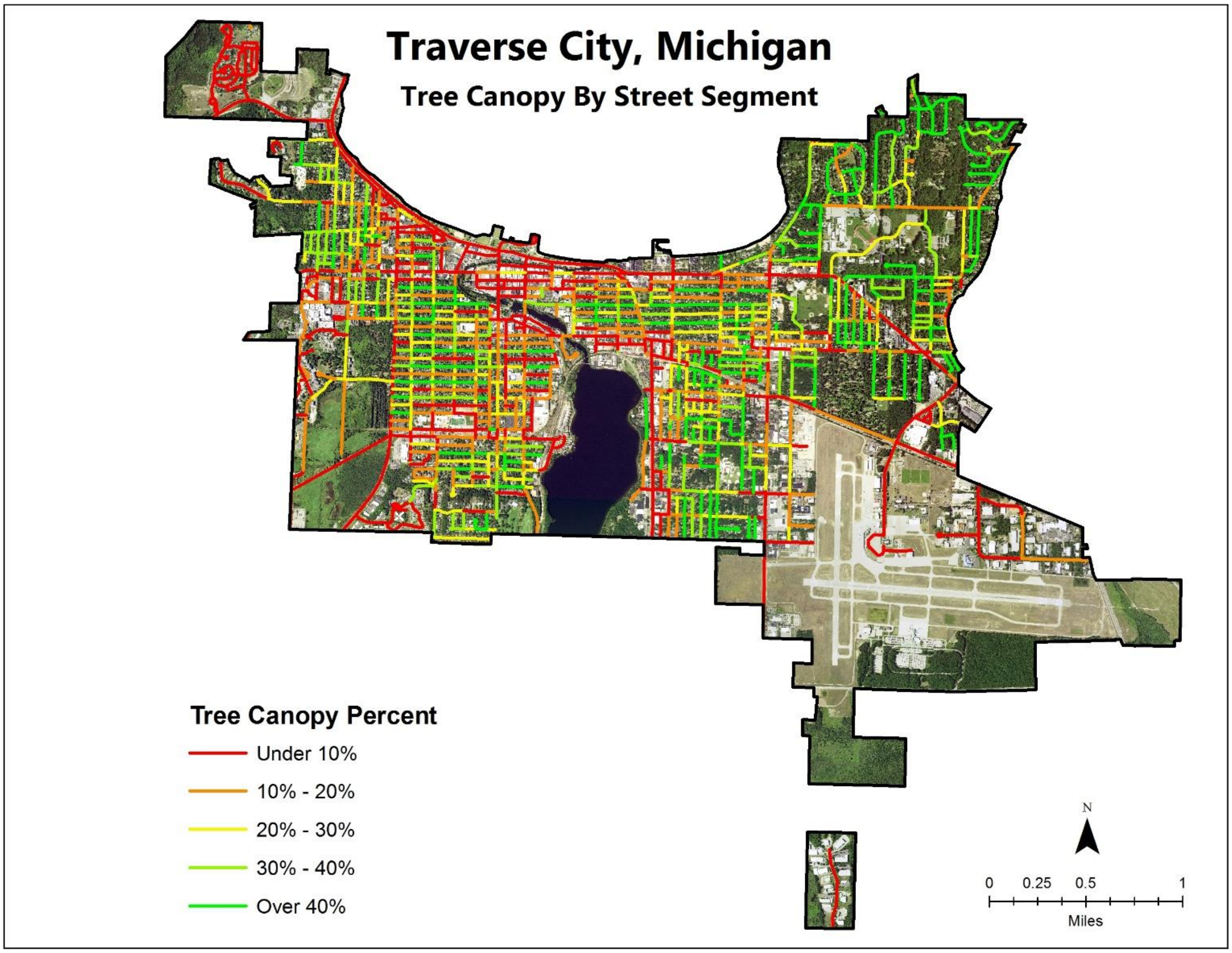


Figure 11. Map of 2016 rights-of-way in Traverse City. Canopy levels along those ROWs are indicated via color notation.

Findings

- 231 acres, roughly 25% of Traverse City's total tree canopy is found in or near the ROW.

  Takeaway. The map suggests that canopy cover is highest along residential and neighborhood areas, while major roads and corridors present the highest opportunity for new plantings, particularly major state thoroughfares. Overall, the ROW already accounts for roughly a quarter of the tree canopy across Traverse City.

SECTION 3: BENEFITS OF THE URBAN FOREST

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

Environmental Benefits

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

Economic Benefits

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

Social Benefits

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

Trees provide numerous benefits to Traverse City. Trees conserve energy, reduce carbon dioxide levels, improve air quality, and mitigate stormwater runoff. In addition, trees provide numerous economic, psychological, and social benefits that are less quantifiable.

In total, Traverse City's tree canopy provides just over $2 million each year in ecosystem benefits. This includes removal over 111,000 pounds of air pollutants, sequestration of almost 17,000 tons of carbon, and interception of 21 million gallons of stormwater – every year.

Aside from annual benefits, Traverse City's community forest currently stores 505 million tons of carbon over its lifetime, valued at nearly $8 million, as shown in Table 5.

Table 5. Estimated Ecosystem Benefits Provided by Traverse City's Tree Canopy in 2016

Traverse City Tree Canopy Ecosystem Benefits	Annual Ecosystem Benefits	
	Quantity	Value
Air: CO (carbon monoxide) removed	1,183 lbs.	$63
Air: NO_2 (nitrogen dioxide) removed	410 lbs.	$5
Air: O_3 (ozone) removed	89,706 lbs.	$8,061
Air: (sulfur dioxide) removed	3,351 lbs.	$11
Air: particulates (dust, soot, etc.) removed	16,976 lbs.	$3,172
Carbon sequestered	14,461,288 tons	$231,259
Stormwater: reduction in runoff	21,344,404 gallons	$1,899,652
Total Annual Benefits		$2,142,223
Current stored carbon*	505,487,912 tons	$8,083,545
Total		$10,225,768

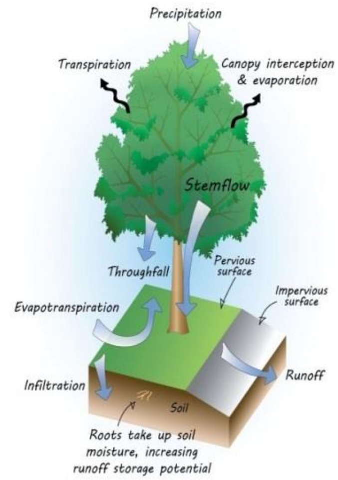
*Current stored carbon is a measure of total contribution over the life of the tree canopy, not an annual value.

Water Quality Improvement

Trees intercept rainwater by capturing water droplets on their leaves and bark, as well as through absorbing rain water through its expansive root system. Combined, these processes result in reducing or slowing the amount of stormwater runoff. Without trees, cities would have to invest in significantly more stormwater infrastructure to handle the additional water flow that would otherwise be captured by trees. In fact, many cities are utilizing trees as part of a comprehensive approach to updating their stormwater systems and achieving compliance with local and federal regulations.

Traverse City's trees capture an estimated 21 million gallons of stormwater annually. That's enough water to fill over 32 Olympic-sized swimming pools. This benefit is calculated to provide approximately $1.9 million in services to Traverse City residents each year.

To further identify and prioritize areas where stormwater runoff risk can be mitigated, the percentage of tree canopy was assessed in comparison to the stormwater zones (Figure 12). The lower the tree canopy, the more opportunity there is to mitigate stormwater runoff with additional planting or preservation efforts. Zones with lower canopy percentages include downtown and immediate surrounding area, Munson Medical Center, and the airport.



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

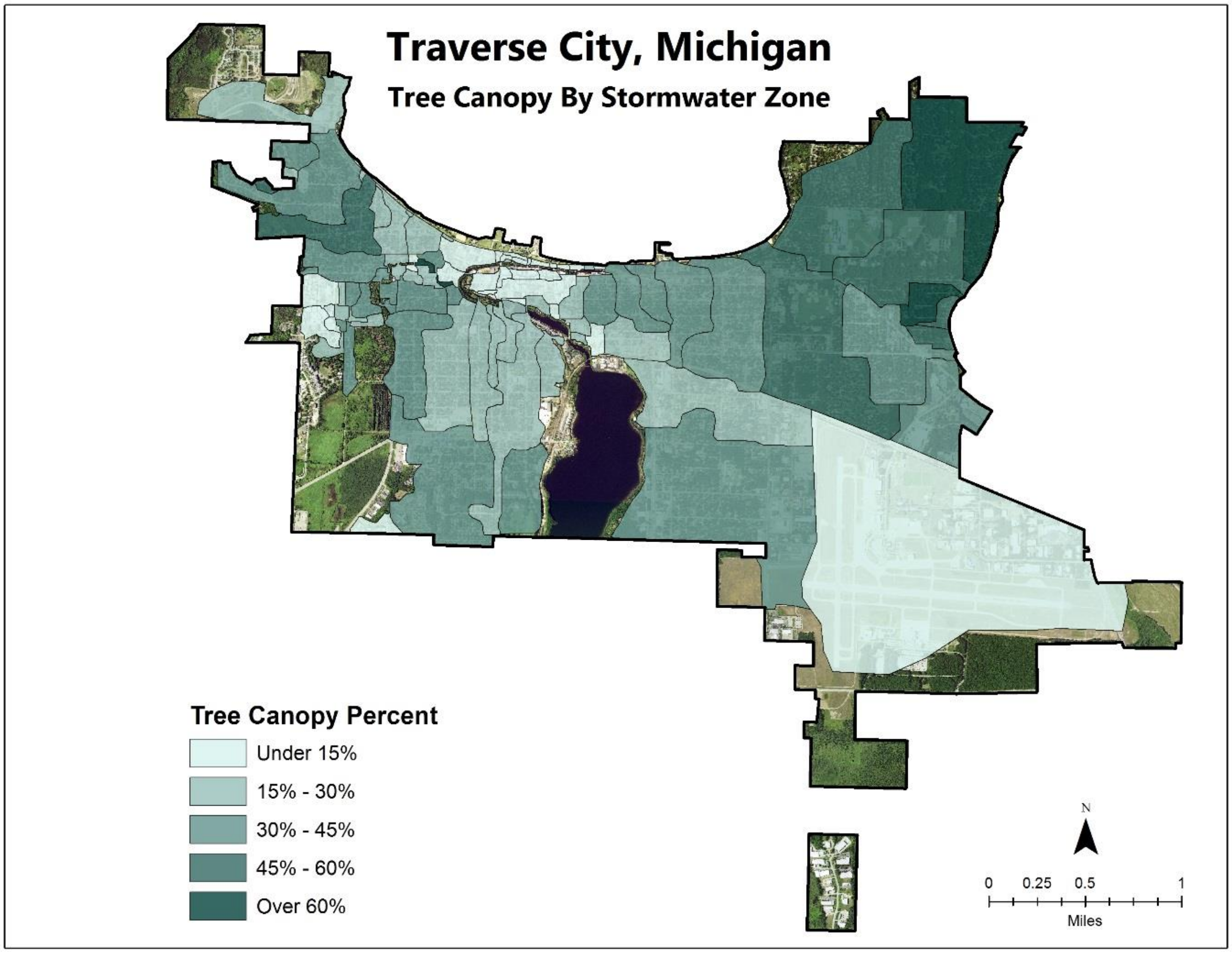


Figure 12. Stormwater zones showing the wide range of canopy percentage in each area. Focusing interception efforts within the lightest areas will have the most impact on water quality improvements.

Air Quality Improvements

Not only do trees take in carbon dioxide and produce oxygen, but they can also capture fine pollutants and particulate matter on the surfaces of their leaves. Combined, these actions can improve a city's air quality. Recent studies have shown a strong correlation between total tree canopy and reduced rates of pulmonary and cardiovascular disease.

Every year, Traverse City's community forest removes over 111,000 pounds of pollutants from the air. These include: 1,183 pounds of carbon monoxide (CO), 410 pounds of nitrogen dioxide (NO_2), 89,703 pounds of ozone (O_3), 3,351 pounds of sulfur dioxide (SO_2), and 16,976 pounds of dusts, soot, and other particulate matter. Combined, this equates to $11,312 in value annually.

Carbon Reduction

Trees store a massive amount of carbon in their woody tissue. Forests—both urban and rural—are an important carbon sink, helping to mitigate climate change. In total, Traverse City's community forest stores 505,487,912 tons of carbon which equates to over $8 million in value. Each year, an additional 14,461,288 tons are sequestered for over $230,000 in additional value.

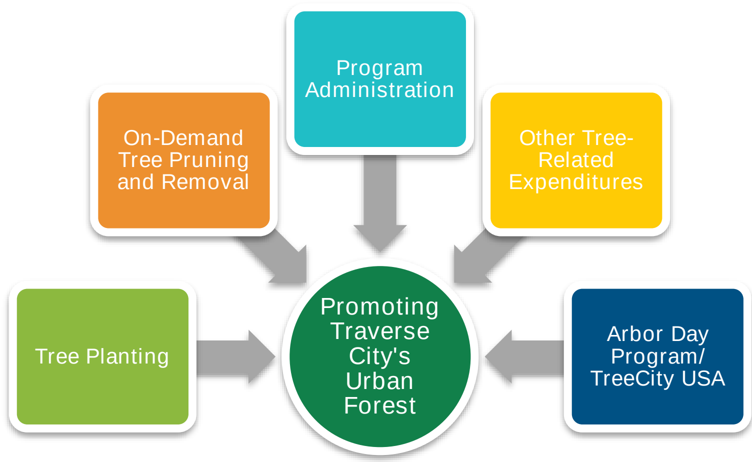
Photograph 3. Trees improve quality of life and help enhance the character of a community. Trees filter air, water, and sunlight, moderate local climate, slow wind and stormwater, shade homes, and provide shelter to animals and recreational areas for people.

These quantified benefits and the reports generated are described below.

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

SECTION 4: TREE MANAGEMENT PROGRAM

This tree management program was developed to uphold Traverse City's comprehensive vision for preserving and proactively maintaining its urban forest. This seven-year program is based on the tree inventory data and, in part, designed around the results of the UTC. The program is designed 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. At the time of writing, Traverse City's tree inventory did not include a risk assessment. DRG recommends that the inventory data be updated to include tree risk, condition, and primary maintenance recommendations. Completing work identified based on the risk should take priority, however, routinely monitoring the tree population is essential so that other high trees can be identified and systematically addressed. In the meantime, it will be necessary to continue routine and responsive tree work, as well as continuing planting and establishment efforts.

Table 6. Estimated Costs for Seven-Year Tree Management Program

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Seven-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	
Routine Pruning																	
Routine Pruning (7-year cycle)	1-8"	$50	700	$35,000	700	$35,000	700	$35,000	700	$35,000	700	$35,000	700	$35,000	700	$35,000	$245,000
	9-17"	$100	400	$40,000	400	$40,000	400	$40,000	400	$40,000	400	$40,000	400	$40,000	400	$40,000	$280,000
	18-24"	$170	225	$38,250	225	$38,250	225	$38,250	225	$38,250	225	$38,250	225	$38,250	225	$38,250	$267,750
	> 24"	$320	175	$56,000	175	$56,000	175	$56,000	175	$56,000	175	$56,000	175	$56,000	175	$56,000	$392,000
Activity Total(s)			1,500	$169,250	1,500	$169,250	1,500	$169,250	1,500	$169,250	1,500	$169,250	1,500	$169,250	1,500	$169,250	$1,184,750
Inventory																	
Tree Inventory Upkeep		$4	1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	$42,000
Activity Total(s)			1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	1,500	$6,000	$42,000
Tree Planting																	
Purchasing		$125	400	$50,000	400	$50,000	400	$50,000	400	$50,000	400	$50,000	400	$50,000	400	$50,000	$350,000
Planting and Mulching		$125	400	$50,000	400	$50,000	400	$50,000	400	$50,000	400	$50,000	400	$50,000	400	$50,000	$350,000
Watering (2-year cycle)		$100	400	$40,000	800	$80,000	800	$80,000	800	$80,000	800	$80,000	800	$80,000	800	$80,000	$520,000
Activity Total(s)			1,200	$140,000	1,600	$180,000	1,600	$180,000	1,600	$180,000	1,600	$180,000	1,600	$180,000	1,600	$180,000	$1,220,000
Contingency (i.e., annual tree and stump removal, service requests, storm damage, infrastructure repair/mitigation)																	
Annual Tree and Stump Removal				$100,000		$90,000		$85,000		$85,000		$85,000		$85,000		$85,000	$615,000
Service Requests				$10,000		$9,000		$8,000		$7,500		$7,500		$7,500		$7,500	$57,000
Storm Damage				$10,000		$9,000		$8,000		$7,500		$7,500		$7,500		$7,500	$57,000
Infrastructure Repair/Mitigation				$10,000		$10,000		$10,000		$10,000		$10,000		$10,000		$10,000	$70,000
Professional Forestry Contract/Staffing				$20,000		$20,000		$20,000		$20,000		$20,000		$20,000		$20,000	$140,000
Activity Total(s)				$150,000		$138,000		$131,000		$130,000		$130,000		$130,000		$130,000	$939,000
Tree Care Other																	
Tree and Plant Health Care, Pest Management, etc.				$1,000		$1,000		$1,000		$1,000		$1,000		$1,000		$1,000	$7,000
Activity Total(s)				$1,000		$1,000		$1,000		$1,000		$1,000		$1,000		$1,000	$7,000
Other Costs																	
Admin, Legal, Outreach				$25,000		$25,000		$25,000		$25,000		$25,000		$25,000		$25,000	$175,000
Activity Total(s)				$25,000		$25,000		$25,000		$25,000		$25,000		$25,000		$25,000	$175,000
Cost Grand Total				$491,250		$519,250		$512,250		$511,250		$511,250		$511,250		$511,250	$3,567,750

Routine Pruning Cycle

The routine pruning cycle budgets for one seventh of the tree population to be pruned each year. This includes maintenance such as cleaning, crown raising, and reducing to remove deadwood and improve structure. Over time, routine pruning can reduce reactive maintenance and provide the basis for a more proactive program.

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

Initial pruning operations should seek to remove all dead, diseased, dying, broken, or damaged limbs greater than 2 inches in diameter. Generally, no more than 25% of the live crown should be removed in any given pruning operation. Pruning should be completed by qualified employees or contractors. Under no circumstances should climbing spikes be used unless the tree is to be removed.

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 lowest diameter class at the lowest estimated per tree cost and increase once they become established. When a tree reaches the end of its useful life, it should be removed and eliminated from the routine pruning cycle.

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.

Despite Traverse City's efforts, a wholly proactive tree management program might be 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.

Young Tree Training

Included in the routine pruning cycle is efforts to guide young tree establishment. These trees are predominantly in the 1–8” diameter class. These younger trees sometimes have branch structures that can lead to potential problems as the tree ages. Such 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.

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

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

If trees are planted, they will need to enter the young tree training cycle after establishment, typically a few years after planting.

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

Maintenance Schedule

Utilizing data from the 2018 tree inventory data, 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 Traverse City.

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

To implement the maintenance schedule, the city’s tree maintenance budget is budgeted to be $169,250 for each year of the seven-year cycle. Annual budget funds are consistent, assuming that one seventh of the current population is pruned every year, which might change over time. 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.

Recommendations

DRG recommends that the city establish a seven-year routine pruning cycle in which approximately one-seventh of the tree population is to be pruned each year. The 2018 inventory data identified approximately 10,500 trees that should be pruned over a seven-year cycle. To maintain a seven-year cycle, an average of 1,500 trees should be pruned each year. DRG recommends that the routine pruning cycle begin in year 1 of this seven-year plan.

Inventory and Plan Updates

DRG recommends that the inventory and management plan be updated and managed using an appropriate computer software program so that the city can sustain its program and accurately project future program and budget needs. Updates to the inventory are essential to uncovering potential problems as they develop 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 should be regularly inspected and attended to as needed based on the inspection findings. When trees need additional or new work, they should be added to the maintenance schedule and budgeted as appropriate. In addition to locating potential new hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. Traverse City has a large population of trees that are susceptible to pests and diseases, such as ash, oak, and maple.

The 2018 inventory did not contain information concerning condition of the trees, priority maintenance recommendations, or risk assessment. DRG recommends that each year, one-seventh of the inventory be updated, including these data fields. Below are examples of these data fields based on and adapted from the International Society of Arboriculture (ISA) Best Management Practices (BMP) for Tree Inventories and Risk Assessment, and the ANSI A300 Part 9 Tree Risk Assessment standards.

- **Condition.** In general, the health and structure of each tree should be recorded based on visible root, trunk, scaffold branch, twig, and foliage conditions at the time of the inventory and adapted from the rating system established by the International Society of Arboriculture. Categories include:
    - **Good**. Tree may have a small amount of deadwood, or a very limited number of non-threatening defects. The overall form of the tree must be good, and consistent for the species in question. These trees should also generally be larger than 8” DBH for the reason listed above, but exceptions are made.
    - **Fair.** Tree has moderate amounts of deadwood, wounds, or other deficiencies, but is generally healthy. A wide variety of forms is acceptable for this group, which is meant to define the middle ground around which better or worse trees can be defined and identified.
    - **Poor.** Tree has defects, deadwood, wounds, disease, etc. that are in imminent danger of causing a need for removal. Very poor form or architecture can put an otherwise healthy tree in this category as well, though generally it is reserved for health defects.
    - **Critical.** Tree must be removed. Physical or Health defects are too far gone for the tree to be reasonably saved.
- **Dead**. Tree shows no sign of life in foliage, buds, twigs, etc.

- **Primary Maintenance Recommendation.** This field sorts and quantifies the work needed on the tree population. Proper application of these recommendations can prioritize work and guide future budgetary decisions. Categories include:
  - **Tree Clean.** These trees require selective removal of dead, diseased, dying, and/or broken wood to minimize potential risk. Priority of work should be dependent upon the Risk associated with the individual trees.
  - **Discretionary Prune.** These trees present little to no defects as it pertains to risk but may be pruned to manage for tree health or aesthetic appearance.
  - **Young Tree Training.** These are young trees that must be pruned to correct or eliminate weak, interfering, or objectionable branches in order to minimize future maintenance requirements. Generally, these trees may be up to 20 feet in height and can be worked with a pole pruner by a person standing on the ground.
  - **Remove.** Trees designated for removal have defects that cannot be cost-effectively or practically treated. The majority of the trees in this category have a large percentage of dead crown. All trees with safety risks that could be seen as potential threats to persons or property and seen as potential liabilities to the client would be in this category. This category includes large dead and dying trees that are high-liability risks as well as those that pose minimal liability to persons or property (such as trees in poor locations or undesirable species).
- **Risk Assessment.** An accurate risk assessment is the cornerstone to a comprehensive tree inventory. It provides a means to identify the individuals in the population that might need immediate work. As such, this data collection should only be recorded by qualified staff or outside contractors. DRG recommends an ANSI Level 2 tree risk assessment (ANSI 2017). This assessment includes a 360-degree ground-based visual inspection of the crown, trunk, trunk flare, above ground roots, and site conditions around the tree in relation to targets. The assessment only includes conditions that are detected from the ground. Internal, belowground, and upper crown factors cannot be assessed and may remain largely undetected. Further information can be found in The International Society of Arboriculture *Best Management Practices - Tree Risk Assessment*, *Second Edition* (E. Thomas Smiley, Nelda Matheny, and Sharon Lilly 2017).

In addition to updating the overall inventory, some further recommended considerations include:

- Conduct inspections of trees after all severe weather events. Record changes in tree condition, maintenance needs, and risk rating in the inventory database. Update the tree maintenance schedule and acquire the funds needed to promote public safety. Schedule and prioritize work based on risk.
- Perform routine inspections of public trees as needed. Windshield surveys (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* (ANSI 2011) will help city staff stay apprised of changing conditions, particularly along major thoroughfares or high-trafficked areas. 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.
- Revise the *Tree Management Plan* after seven years when the re-inventory has been completed.

Tree Planting

Although the 2018 inventory data did not include information on specific ROW recommended planting sites, information can be gathered both from the UTC and recent city planting efforts. DRG recommends the city maintain a planting goal of 400 trees every year. This includes purchasing, installation, mulching, and watering for two years.

Additionally, the UTC prioritized future planting sites both on city-owned and private property. It should be noted that these are simply possible planting areas and recognized that it may not be desirable to plant in all these areas. This analysis is intended to be used as a guide to determine where canopy expansion activities could have the greatest impact.

Ultimately, it is a best practice to improve diversity of tree species within the urban forest. Higher diversity of tree species helps ensure a community forest is resilient to invasive pests (e.g. emerald ash borer) and impacts of changing weather patterns. Lacking diversity can leave your community forest susceptible to hard impacts from either an invasive pest that attacks one genus (e.g. maple) or a species of tree that's particularly sensitive to extreme weather patterns.

The primary method to improve tree diversity is through tree planting. As Traverse City’s populations of maple (*Acer* genus) exceeds industry-accepted guidelines, the future planting of maple should be limited, and other genera promoted in its place.

In order to achieve diversity targets, the planting of region-appropriate non-native species is likely necessary. The further north in Michigan, the smaller the palette of native species becomes. Moreover, a built environment is in no-way native. Soils have been altered, concrete changes soil profiles, and the urban heat island all contribute to an environment that is far from what a tree might naturally experience in nature. For this reason, several of Michigan's native species (e.g. American beech, sugar maple) have difficulty thriving in built environments.

UTC Planting Sites Identified and Prioritized

While the land cover analysis is helpful to understand existing tree canopy distribution and value, communities are often interested in expanding tree canopy to optimize the suite of ecosystem benefits provided by its trees. Therefore, it is common practice to calculate and prioritize realistic potential planting areas based on the total of all land cover that is open ground—such as those covered in bare soil, shrubs, grass, and other low-lying vegetation.

Note: These are simply possible planting areas. It is recognized that it may not be desirable to plant in all these areas. This analysis is intended to be used as a guide to determine where canopy expansion activities could have the greatest impact.

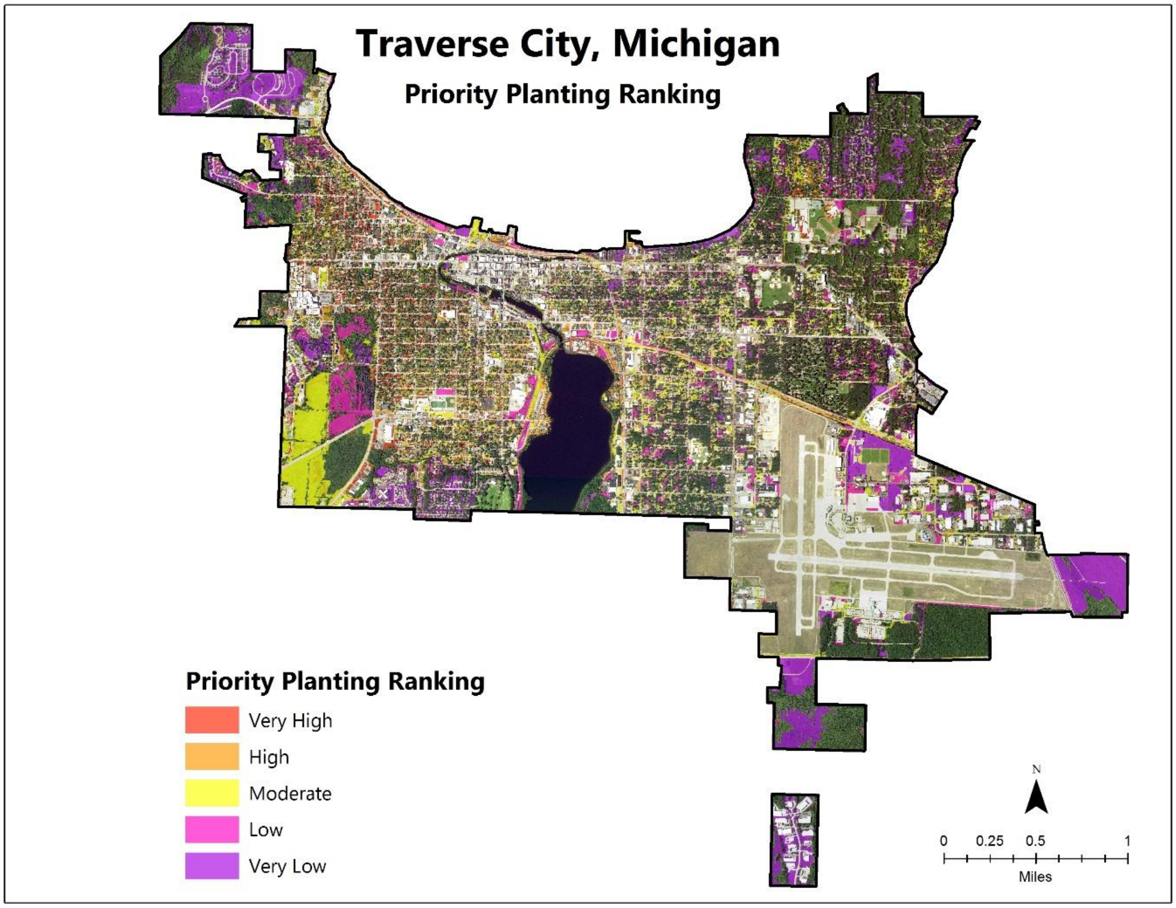


Figure 13. Prioritized planting areas in Traverse City, Michigan.

While vacant planting sites present possibilities to plant a tree, not all open spaces are desirable candidates for tree plantings (e.g., sports, agricultural fields, airports). Similarly, not all impervious areas may remain impervious forever. Trees can be added in certain locations (e.g., sidewalk cutouts, parking lot islands) to expand canopy in those areas. Some locations are clearly better suited to meeting community goals than others. In short, this study is intended to be used as a guide to determine where canopy expansion activities could have the greatest impact.

The priority models used for this analysis are largely based on the impacts of trees to stormwater interception. A number of environmental data were assessed, including proximity to hardscape, urban heat index, location within a floodplain, soil permeability, slope, a soil erosion factor, and distance to existing tree canopy (Table 7). Overlapping these data produced a runoff priority rating ranging from Very Low to Very High based on a calculated average.

Table 7. Inputs and Weights Used for Planting Area Prioritization Models

Dataset	Weight	Source
Distance to Impervious	0.25	Urban Tree Canopy Assessment
Urban Heat Island Index	0.20	Urban Tree Canopy Assessment
Floodplain Proximity	0.15	National Hydrologic Dataset
Soil Permeability	0.15	Natural Resource Conservation Service
Slope	0.10	National Elevation Dataset
Soil Erosion (K-factor)	0.10	Natural Resource Conservation Service
Distance to Tree Canopy	0.05	Urban Tree Canopy Assessment

This analysis identified just over 1,000 acres of land possibly suitable for future tree planting (Table 8). Of this area, approximately 480 acres of land (roughly 9% of Traverse City) were prioritized as "moderate", "high", or "very high" planting areas based on projected impacts to stormwater management, water quality, and relative heat index. Planting trees in these areas would greatly improve Traverse City's capacity to manage stormwater, improve water quality, and reduce the temperature effects of the built environment. If Traverse City were to plant trees in all these locations, the community tree canopy is projected to rise from 33% to 42% across both public and private property.

Table 8. Planting Priority Areas That Maximize Tree Benefits

Planting Priorities	Planting Opportunities Area (Acres)
Very Low	387
Low	210
Moderate	242
High	148
Very High	93
Total Opportunities	1,080

Areas of highest prioritization for planting are located along the major thoroughfares, open areas in Grand Traverse Commons, and distributed throughout the residential areas (Figure 13). The more populated of these areas in some cases also correspond to areas of high levels of impervious surfaces.

Impervious surfaces have greater impacts on relative heat index, as well as stormwater runoff. Areas situated next to bodies of water, streams, or drainage infrastructure can have outsized impacts on stormwater volume and quality. This suggests that Traverse City could most effectively maximize tree benefits by planting trees in these areas, but would also be limited in immediate opportunities, given the current available space.

Notably, these planting locations represent opportunities on both public and private lands. While there are significant opportunities for improving tree canopy on public properties such as parks and the city's right-of-way, long-term canopy enhancement requires the cooperation of private citizens. Generally, this can be accomplished through a variety of strategies formulated specifically for the community. Such strategies may include education, outreach, workshops, volunteering, policies, or cost-share programs.

While Traverse City may choose to plant many trees over the next several decades, the greatest impact will be achieved by starting first with those areas identified as "moderate", "high", and "very high" planting priorities. These trees are expected to provide the greatest community benefit, and have the greatest impact on stormwater and heat island management.

A determination of goals must be made locally, based on what is economically, ecologically, and politically feasible for canopy across various land uses and jurisdictions. This will require input and support from the public, local leaders, and subject matter experts to set local goals that are based on local values, local environmental and quality of life goals, compliance with federal and local clean air and water regulations, and economic development plans.

Contingency

A certain portion of tree maintenance activities will remain reactive based on responses to storm damage, unforeseen tree failure or maintenance issues, or resident-initiated inquiries. Although preventative pruning, removals, and risk assessment can help reduce the need for these efforts, some work will always remain. This fact is reflected in the funding allocated to these activities. Over time, Traverse City should anticipate a decline in the number of removals and service requests from homeowners as trees are assessed, prioritized for work, and acted upon accordingly in a proactive manner. Activities like storm response or repair to sidewalks and other infrastructure will remain constant over the years.

Traverse City also used to have forestry staffing, but with the departure of a key staff member this position has not been replaced. In discussions with Traverse City leadership, it is apparent some degree of forestry expertise (e.g. college-educated, ISA certified arborist) may be helpful to the City's forestry program; particularly in regard to tree inspections, policy initiatives (e.g. tree ordinance) and similar tasks. That said, the City's current level of activity does not likely require a full-time position dedicated to these tasks. Therefore, the City can evaluate a contractual arrangement with a qualified consultant or part-time staffing options.

Tree and Plant Health Care and Pests

Sometimes actions required for tree maintenance call for activities other than a simple pruning or removal. Diagnosis of samples, treatment, and management of pests and tree diseases all fall under the category of tree and plant health care. Although this is a small part of Traverse City's budget, more funding could be allocated as the landscape changes with regards to pests and diseases.

Traverse City should be aware of the signs and symptoms of common disease and pest 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 and focus on identifying and monitoring both common native threats as well as emerging invasive pests and disease, understanding the economic threshold, selecting the correct treatment, properly timing management strategies, recordkeeping, and evaluating results.

The inventory data suggests that the city's urban forest has a high susceptibility to Granulate ambrosia beetle (*Xylosandrus crassiusculus*), Xm ambrosia beetle (*Xylosandrus mutilatus*), and Asian longhorned beetle (ALB or *Anoplophora glabripennis*), although evidence of the pest has not been observed. See the Potential Threats from Pests portion of the inventory assessment for more information (Section 2).

Emerald ash borer (EAB) remains a significant pest in Michigan. While most public trees have likely been removed or are in the process of senescence, there likely remain a number of infested, dead, or dying trees on private property. If caught early, several treatments are available to save ash trees, but require annual or semi-annual treatment. Otherwise, all ash trees will succumb to EAB in the region.

Oak wilt is also a serious pest of local importance. The disease is introduced to oak trees via fresh wounds in the tree. For this reason, pruning, removal, or damage to oak trees should be avoided during the active growing season. If necessary, this is one of the few situations in which the immediate application of pruning paints is advised. Once infected, trees in the red oak sub-genus can succumb to infestation in a matter of weeks. Trees in the white oak sub-genera are more resistant. As oak trees often graft roots beneath the soil, one infested tree can pass the disease to other healthy trees. Breaking these root grafts and removing infested trees is critical to saving nearby oaks.

Other Costs

Funding allocated to this portion can cover a variety of different activities. Examples of these include administration, legal response to litigation and settlements due to tree-related claims, and public outreach efforts.

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. As noted in the UTC, some aspects of the urban canopy are primarily situated on private land. Through proper outreach, the value of the urban forest and the tree management program can be promoted 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 gypsy moth).
- Planting efforts and events can be coordinated to form a strong sense of community pride and establish citizen forestry.

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.

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

Policies and Ordinances

As a Tree City USA community, Traverse City maintains a basic tree ordinance protection to and guidance in the management of public trees. The city is encouraged to explore its ordinance to ensure city staff are familiar with its provisions and to make changes, as necessary, to reflect adaptations in best practices and city operations over time. In some cases, it is advisable to maintain a separate manual of standards and practices which outlines the specifications by which the city's trees are maintained. This manual can help advise city operations, as well as provide residents, contractors, and others clear communication on how public trees should be maintained.

Trees, whether on public or private property, provide innumerable public benefits – from clean air and clean water to human health and property values. Therefore, it is becoming increasingly common for municipalities to regulate how trees are treated beyond the public realm. As construction can significantly impact trees, it is particularly common to provide guidance on tree retention and protection during development activities.

The City of Traverse City's current ordinances encourages the preservation of existing trees on development sites but lacks guidance or specific measures that outline how those trees should be protected. Moreover, the ordinance does not specify requirements for tree protection, only loose encouragement. A key strategy to maximize tree canopy across the city is to establish criteria for tree preservation and protection during development activities within the city's ordinances. The city should explore its ordinances and policies to provide guidance and flexibility to maximize tree canopy on both private and public lands.

CONCLUSIONS

Every hour of every day, trees in Traverse City are supporting and improving the quality of life. When properly maintained, trees provide numerous environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

Photograph 4. A street well stocked with trees provides economic, environmental, and social benefits, including temperature moderation, reduction of air pollutants, energy conservation, and increased property values.

Managing trees in urban areas is often complicated. Navigating the recommendations of experts, the needs of residents, the pressures of local economics and politics, concerns for public safety and liability, physical components of trees, forces of nature and severe weather events, and the expectation that these issues are resolved all at once is a considerable challenge.

The city must carefully consider these challenges to fully understand the needs of maintaining an urban forest. With the knowledge and wherewithal to address the needs of the city's trees, Traverse City is well positioned to thrive. If the management program is successfully implemented, the health and safety of Traverse City's trees and citizens will be maintained for years to come.

GLOSSARY

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.

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.

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

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.

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

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

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: Good, Fair, Poor, and Dead.

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

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

diameter: See **tree size**.

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

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.

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 systems (GIS): A technology that is used to view and analyze data from a geographic perspective. The technology is a component of an organization's overall information system framework. GIS connects location to information (such as people to addresses, buildings to parcels, or streets within a network).

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.

greenspace: A land use planning and conservation term used to describe protected areas of undeveloped landscapes.

??? 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.

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

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

inventory: See **tree inventory**.

i-Tree 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, pervious, or water.

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

??? 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.

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.

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

notes (data field): When conditions with a specific tree warrant recognition, it was described in this data field. Notes can 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.

open water land cover: The land cover areas mapped as water typically include lakes, oceans, rivers, and streams.

ordinance: See **tree ordinance**.

other vegetation: Pervious cover or a vegetated area (grass, shrubs, etc.) that allows rainfall to infiltrate the soil; typically includes parks, golf courses, and residential areas.

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

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

pervious land cover: A vegetative area that allows rainfall to infiltrate the soil and typically includes parks, golf courses, and residential areas.

possible UTC: The amount of land that is theoretically available for the establishment of tree canopy within the city boundary. This includes the combination of Possible UTC - Vegetation and Possible UTC - Impervious.

possible UTC—impervious: The amount of land within the city boundary covered by impervious surface that is theoretically available for the establishment of tree canopy. This excludes all buildings and all pavement within the public right-of-way (ROW).

possible UTC—vegetation: The amount of land within the city boundary covered by non-tree vegetation that is theoretically available for the establishment of tree canopy.

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

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

riparian: Of or relating to or located on the banks of a river or stream.

risk rating: Level 2 qualitative risk assessment will be performed on the ANSI A300 (Part 9) 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.

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

side value (data field): Each site is assigned a side value to aid in locating the site. Side values include: *front*, *side*, *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* is the name of the street the arborist is walking towards or from as data are being collected. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

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.

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.

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.

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 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.

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.

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.

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 assessment (UTC): A study performed of land cover classes to gain an understanding of tree canopy coverage, particularly as it relates to the amount of current tree canopy and potential tree canopy. This assessment is typically performed using aerial photographs, GIS data, or Lidar.

vegetative swale: Constructed open-channel drainageways used to convey stormwater runoff. Vegetated swales are often used as an alternative to, or an enhancement of, traditional storm sewer pipes.

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

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APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

Of the 10,159 inventoried sites analyzed, 772 were collected by DRG. DRG inventoried these sites using a system that utilizes a customized ArcPad program loaded onto pen-based field computers equipped with geographic information system (GIS) and global positioning system (GPS) receivers. The knowledge and professional judgment of DRG's arborists ensure the high quality of inventory data.

Data fields are defined in the glossary of the management plan. At each site, the following data fields were collected:

- side
- condition (Davey only)
- attention required
- location
- mapping coordinates
- notes
- species
- stems
- tree height estimation
- tree size*

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

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

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

Site Location Methods

Equipment and Base Maps

Inventory arborists use FZ-G1 Panasonic Toughpad® unit(s) equipped with internal GPS receivers.

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

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
United States Dept of Agriculture https://www.usda.gov	2016	NAD 1983 HARN StatePlane Michigan Central; Feet

Street ROW Site Location

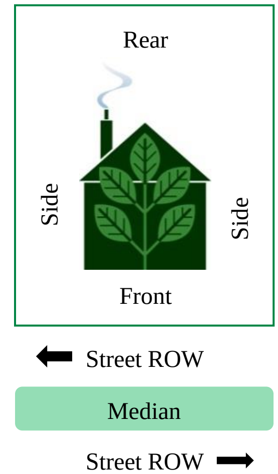
Individual street ROW trees were located using a methodology that identifies sites by *address number*, *street name*, and *side*. This methodology was developed by DRG to help ensure consistent assignment of location.

Address Number and Street Name

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

Sites in medians or islands were assigned an address number using the address on the right side of the street in the direction of collection closest to the site. Each segment was numbered with an assigned address that was interpolated from addresses facing that median/island. If there were multiple median/islands between cross streets, each segment was assigned its own address.

The *street name* assigned to a site was determined by street ROW parcel information and posted street name signage.



Side values for street ROW sites.

Side Value

Each site was assigned a *side value* and *site number*. Side values include: *front*, *side*, *side*, *median* (includes islands), or *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. *Sides* are the name of the street the arborist walks towards or away from as data are being collected. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

Park and/or Public Space Site Location

Park and/or public space site locations were collected using the same methodology as street ROW sites; however, the *on street* match the *street* name, *side value* is always *front*, and the address is consistent with any parcels.

Site Location Examples

The tree trimming crew in the truck traveling westbound on E. Mac Arthur Street is trying to locate an inventoried tree with the following location information:

Address/Street Name:	226 E. Mac Arthur Street
Side:	Side
On Street:	Davis Street

The tree site circled in red signifies the crew's target site. Because the tree is located on the side of the lot, the on street is Davis Street, even though it is addressed as 226 East Mac Arthur Street.

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

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

APPENDIX B
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 6 on the USDA Plant Hardiness Zone Map.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

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

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

Scientific Name	Common Name	Cultivar
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus palustris	pin oak	
Quercus imbricaria	shingle oak	
Quercus phellos	willow oak	
Quercus robur	English oak	Heritage®
Quercus rubra	northern red oak	‘Splendens’
Quercus shumardii	Shumard oak	
Styphnolobium japonicum	Japanese pagodatree	‘Regent’
Taxodium distichum	common baldcypress	‘Shawnee Brave’
Tilia americana	American linden	‘Redmond’
Tilia cordata	littleleaf linden	‘Greenspire’
Tilia × euchlora	Crimean linden	
Tilia tomentosa	silver linden	‘Sterling’
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	‘Green Vase’

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

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

Medium Trees: 31 to 45 Feet in Height at Maturity

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

Small Trees: 15 to 30 Feet in Height at Maturity

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

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

Further Species Recommendations from UTC

A Selection of Tree Species Suitable for Traverse City That Contribute to Stormwater Interception

Tree Species* and Mature Size		
Scientific Name	Common Name	Size
Acer rubrum	red maple	large
Acer × freemanii	Freeman maple	large
Aesculus flava	yellow buckeye	large
Aesculus hippocastanum	horsechestnut	large
Celtis occidentalis	common hackberry	large
Carpinus betulus	European hornbeam	large
Corylus colurna	Turkish hazelnut	large
Liriodendron tulipifera	tulip tree	large
Magnolia acuminata	cucumber tree magnolia	medium
Magnolia macrophylla	bigleaf magnolia	medium
Picea abies	Norway spruce	large
Platanus occidentalis	American sycamore	large
Pseudotsuga menziesii	Douglas fir	large
Tilia americana	American linden	large
Tilia cordata	littleleaf linden	large
Tilia platyphyllos	bigleaf linden	large
Tilia tomentosa	silver linden	large
Ulmus americana**	American elm	large
Zelkova serrata	Japanese zelkova	large

* *This species list is not inclusive of all trees recommended and/or suitable for Traverse City's climate. While all trees will contribute ecosystem benefits to some degree, these species were simply identified by i-Tree researchers as being in the top 10% of species for contribution to stormwater interception.*

** *Seek disease-resistant varieties only.*

APPENDIX C
TREE PLANTING

Tree Planting

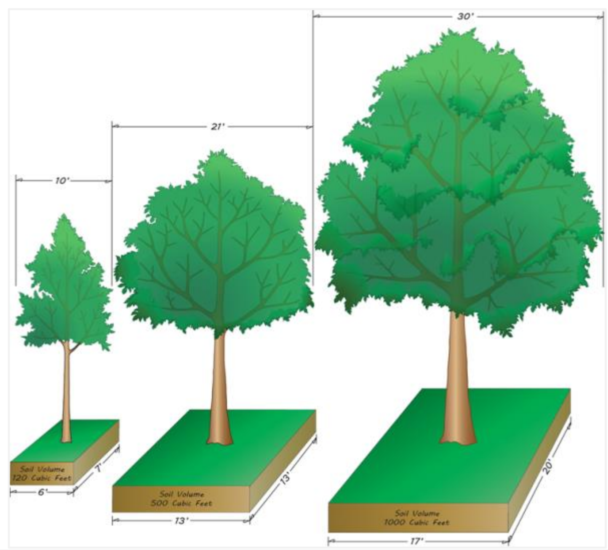
Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the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

Street ROW Planting Spaces

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



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

Tree Species Selection

Selecting a limited number of species could simplify decision-making processes; however, careful deliberation and selection of a wide variety of species is more beneficial and can save money. Planting a variety of species can decrease the impact of species-specific pests and diseases by limiting the number of susceptible trees in a population. This reduces time and money spent to mitigate pest- or disease-related problems. A wide variety of tree species can help limit the impacts from physical events, as different tree species react differently to stress. Species diversity helps withstand drought, ice, flooding, strong storms, and wind.

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

DRG recommends limiting the planting of *Acer* (maple) until the species distribution normalizes. Of the inventoried population *Acer saccharum* (sugar maple) and *A. platanoides* (Norway maple) already occupy 21% and 16%, both of which exceed the recommended 10% species maximum.

Mulch piled too deep and touching the trunk of the tree will harm and may kill the tree. Davey Resource Group suggests that any mulch piled up around a tree should be spread out into a thin layer over the growspace and moved away from the trunk.

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 D
INVASIVE PESTS AND DISEASES THAT AFFECT TREES

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

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

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

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

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

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

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

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

Asian Longhorned Beetle

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.

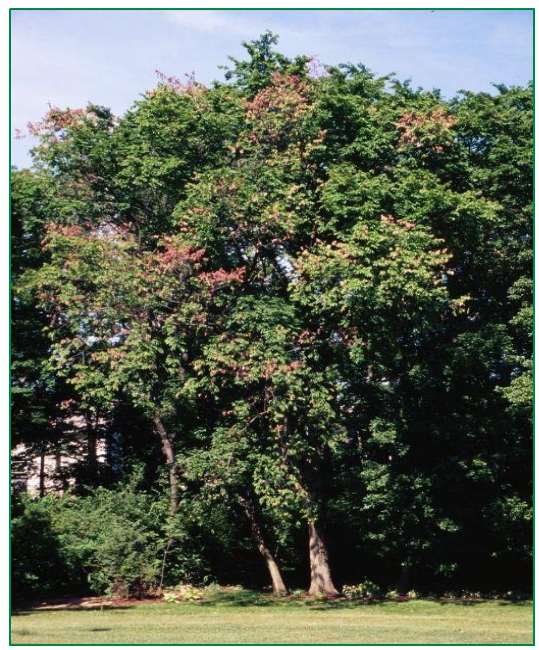
Adult Asian longhorned beetle

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.



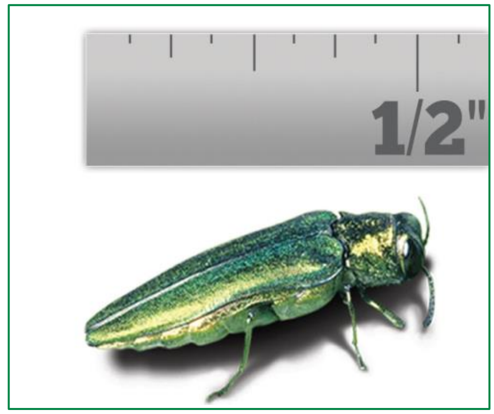
Branch death, or flagging, at multiple locations in the crown of a diseased elm

Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011)

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).

Emerald Ash Borer



Close-up of the emerald ash borer

Photograph courtesy of APHIS (2011)

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

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

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

Gypsy Moth

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

Photograph courtesy of APHIS (2011b)

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

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

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

Granulate Ambrosia Beetle

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.

Adult granulate ambrosia beetle

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

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

Xm ambrosia beetle

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

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).

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.

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APPENDIX E
UTC METHODOLOGY AND ACCURACY ASSESSMENT

Davey Resource Group Classification Methodology

DRG 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 1:2,000 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. DRG 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 DRG'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 DRG utilizes, the AFE only accounts for part of the extraction process. Using Feature Analyst, DRG created the training set data, ran the extraction, and then smoothed the features to alleviate the blocky appearance. To complete the actual extraction process, DRG 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) DRG 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) DRG 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

Land Cover Classification Code Values

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

Determining the accuracy of spatial data is of high importance to DRG and our clients. To achieve to best possible result, DRG 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 1:2,000 quality control scale in the urban areas and at a 1:2,500 scale for rural areas utilizing the most current high-resolution aerial imagery to aid in the quality control process.

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 DRG's accuracy assessment techniques and outlines procedural steps used to conduct the assessment.

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 below. The table allows for assessment of user’s/producer’s accuracy, overall accuracy, omission/commission errors, kappa statistics, allocation/quantity disagreement, and confidence intervals.

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	309	7	8	0	0	324	95.37%	4.63%
	Impervious	4	311	14	0	0	329	94.53%	5.47%
	Grass/Vegetation	15	7	273	0	0	295	92.54%	7.46%
	Bare Soils	0	1	0	10	0	11	90.91%	9.09%
	Water	0	0	0	0	41	41	100.00%	0.00%
	Column Total	328	326	295	10	41	1000		
	User's Accuracy	94.21%	95.40%	92.54%	100.00%	100.00%		Overall Accuracy	94.40%
	Errors of Commission	5.79%	4.60%	7.46%	0.00%	0.00%		Kappa Coefficent	0.9197

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 ((309+311+273+10+41/1,000 = 94.40%).

   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 [309/328 = 94.21%]).

   Producer’s Accuracy – Probability of a reference pixel being correctly classified (correct land cover classifications divided by the row total [309/324 = 95.37%]).

   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 5.79% 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 4.63% 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.

Confidence Intervals and Accuracy Assessment

Confidence Intervals

Class	Acreage	Percentage	Lower Bound	Upper Bound
Tree Canopy	1,806.8	32.8%	32.2%	33.4%
Impervious Surfaces	1,837.2	33.4%	32.7%	34.0%
Grass & Low-Lying Vegetation	1,542.7	28.0%	27.4%	28.6%
Bare Soils	102.9	1.9%	1.7%	2.1%
Open Water	217.1	3.9%	3.7%	4.2%
Total	5,506.8	100.00%		

Statistical Metrics Summary

Overall Accuracy =	94.40%
Kappa Coefficient =	0.9197
Allocation Disagreement =	5%
Quantity Disagreement =	0%

Accuracy Assessment

Class	User's Accuracy	Lower Bound	Upper Bound	Producer's Accuracy	Lower Bound	Upper Bound
Tree Canopy	94.2%	92.9%	95.5%	95.4%	94.2%	96.5%
Impervious Surfaces	95.4%	94.2%	96.6%	94.5%	93.3%	95.8%
Grass & Low-Lying Vegetation	92.5%	91.0%	94.1%	92.5%	91.0%	94.1%
Bare Soils	100.0%	100.0%	100.0%	90.9%	82.2%	99.6%
Open Water	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Tree plantings on City property by others

<u>**Brown Bridge Quiet area**</u>
2013 Red Osier Dogwood cuttings: ~200 live stakes collected and planted by GTCD

2014 Friends of the Boardman (aka Gourmet Game Dinner funds): ~500 bareroot seedlings planted.

2015 DNR Wildlife Habitat grant: 1596 herbaceous plugs on bottomlands floodplain (contracted); 78 potted trees/shrubs planted in former upland well-site; 2933 bareroot on bottomlands (~850 planted by 15 volunteers, remainder contracted)

2016-2018 DNR Wildlife Habitat grant: 70 potted trees and shrubs planted by GTCD staff and volunteers
(timber harvest staging area); 220 bareroot trees/shrubs and 40 potted trees/shrubs planted by 35
volunteers along river near Grasshopper footbridge.

2016 Adams Chapter Trout Unlimited: 80 cedars planted on bottomlands with ~8 volunteers

2017 GTB: 300 Cedars in bottomlands (~15 volunteers)

2017 DTE Energy grant: 5000 bareroot on bottomlands (~1400 planted by 61 GTCD volunteers, ~400
planted by 15 GTB volunteers, remainder contracted)

2017 Bethlehem Church/Boardman River Clean Sweep: 18 potted trees/shrubs planted by volunteers in Spoil Area #4 of bottomlands

2017 S.E.P. project area: ~1200 willow stakes collected by volunteers and planted by GTCD staff; 250 bareroot trees/shrubs (larger bareroot: 3-8' tall)

2017 Monarch Watch grant: ~1250 milkweed plugs by 3 GTCD staff

Traverse City Light and Power At the Cedar Run road property planted 1,273 trees of 16 varieties.

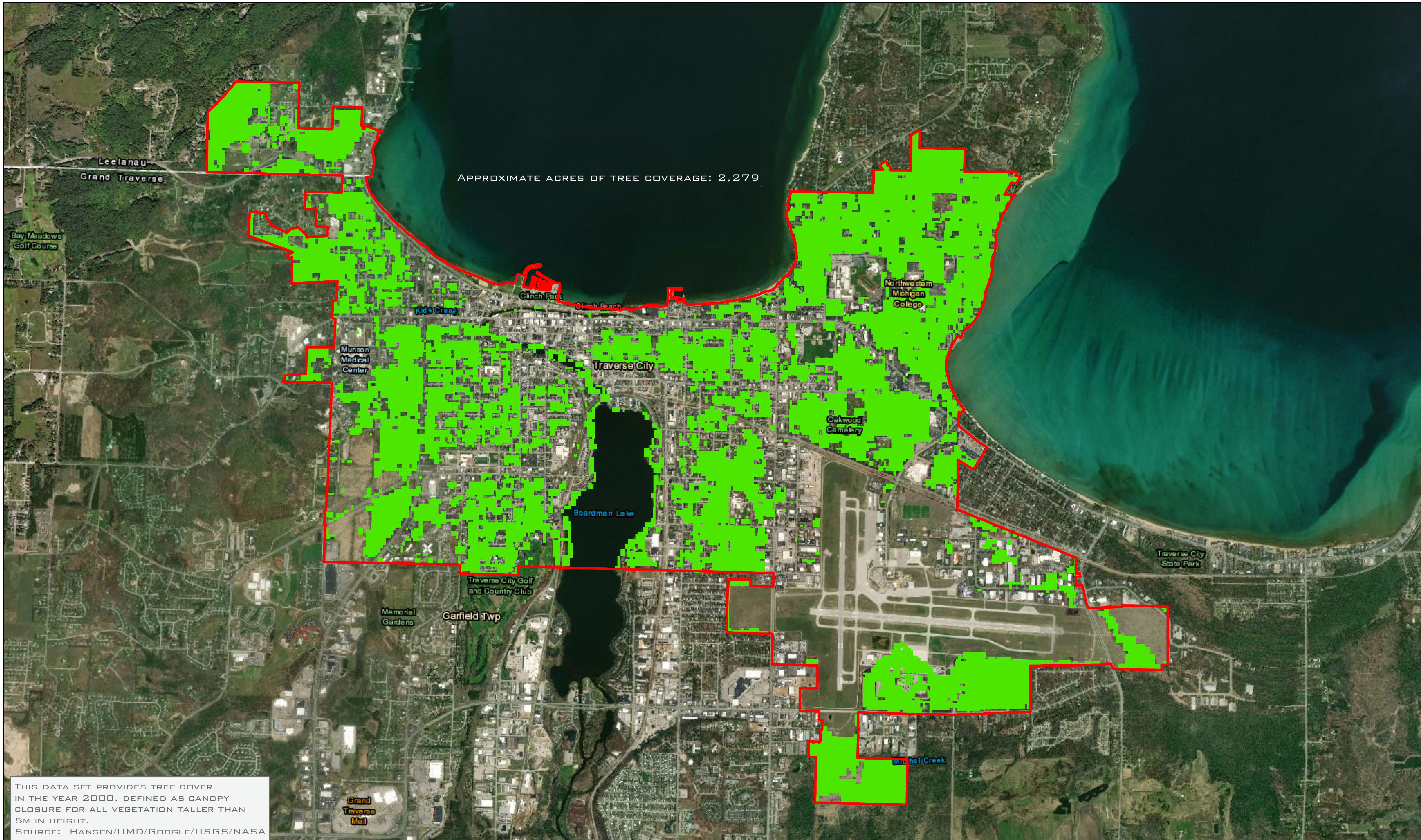
Most Commonly Planted Species:
Trees: White Pine, Red Pine, American Larch, White Cedar, Black Spruce, White Spruce, Black Cherry, Paper Birch, River Birch, Red Maple.

Shrubs: Red Osier Dogwood, Highbush Cranberry, Gray Dogwood, Silky Dogwood, Common Elderberry, Nannyberry, Ninebark, Serviceberry, Buttonbush.

EQIP Funding (NRCS/GTB/CITY MOA): ~15,000 trees planted since 2015
This program has contributed to planting efforts in the Brown Bridge Quiet Area via the USDA NRCS

Hickory Meadows (Garfield Twp/Rec Authority) : Total of 2400 seedligns planted by GTCD

Total of trees planted within the City or on its properties in recent years by the City and by others = 33,168



City of TRAVERSE CITY

Document Path: G:\GIS\GIS Requests\TreeStudy_09042018\2000TreeCoverage.mxd

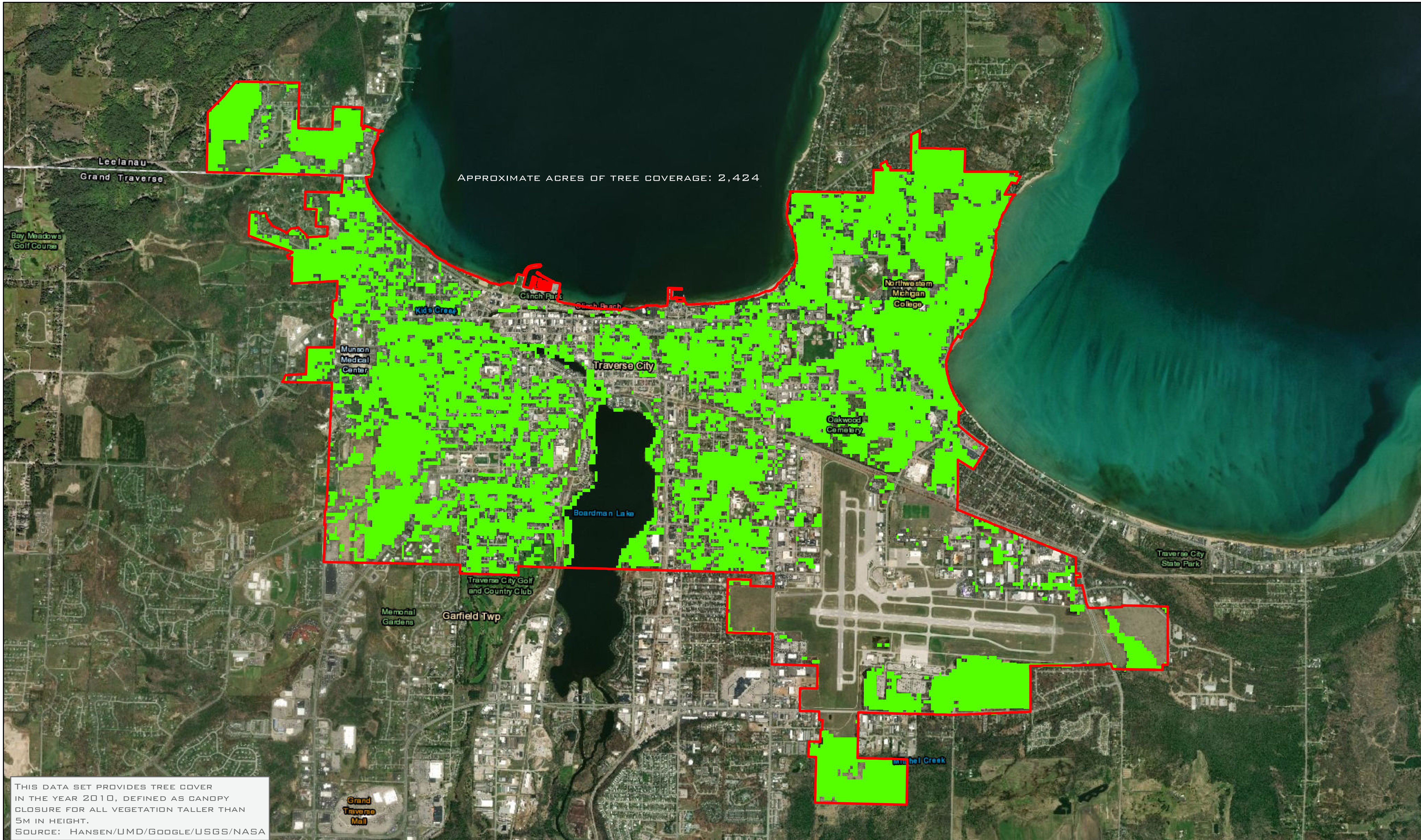
This map is based on digital databases from the City of Traverse City.Traverse City cannot accept any responsbility for errors, ommissions or positional accuracy. There are no warranties expressed or implied.

2000 TREE COVERAGE

City of Traverse City, Michigan

1 inch = 2,500 feet

9/13/2018 NBS



City of
TRAVERSE CITY

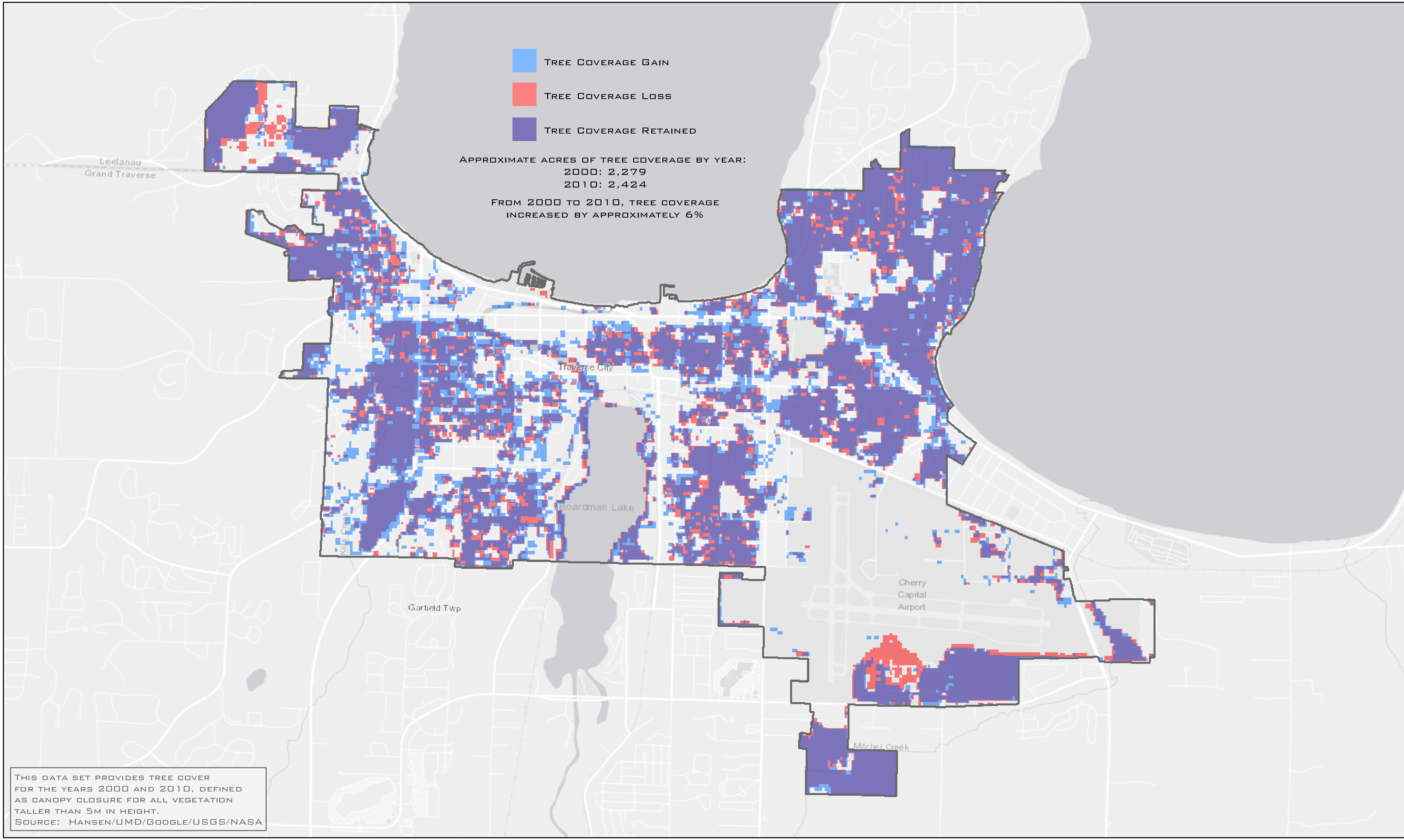
Document Path: G:\GIS\GIS Requests\TreeStudy_09042018\2010TreeCoverageNew.mxd

This map is based on digital databases from the City of Traverse City. Traverse City cannot accept any responsbility for errors, ommissions or positional accuracy. There are no warranties expressed or implied.

2010 TREE COVERAGE

City of Traverse City, Michigan

1 inch = 2,500 feet
9/13/2018 NBS



City of TRAVERSE CITY

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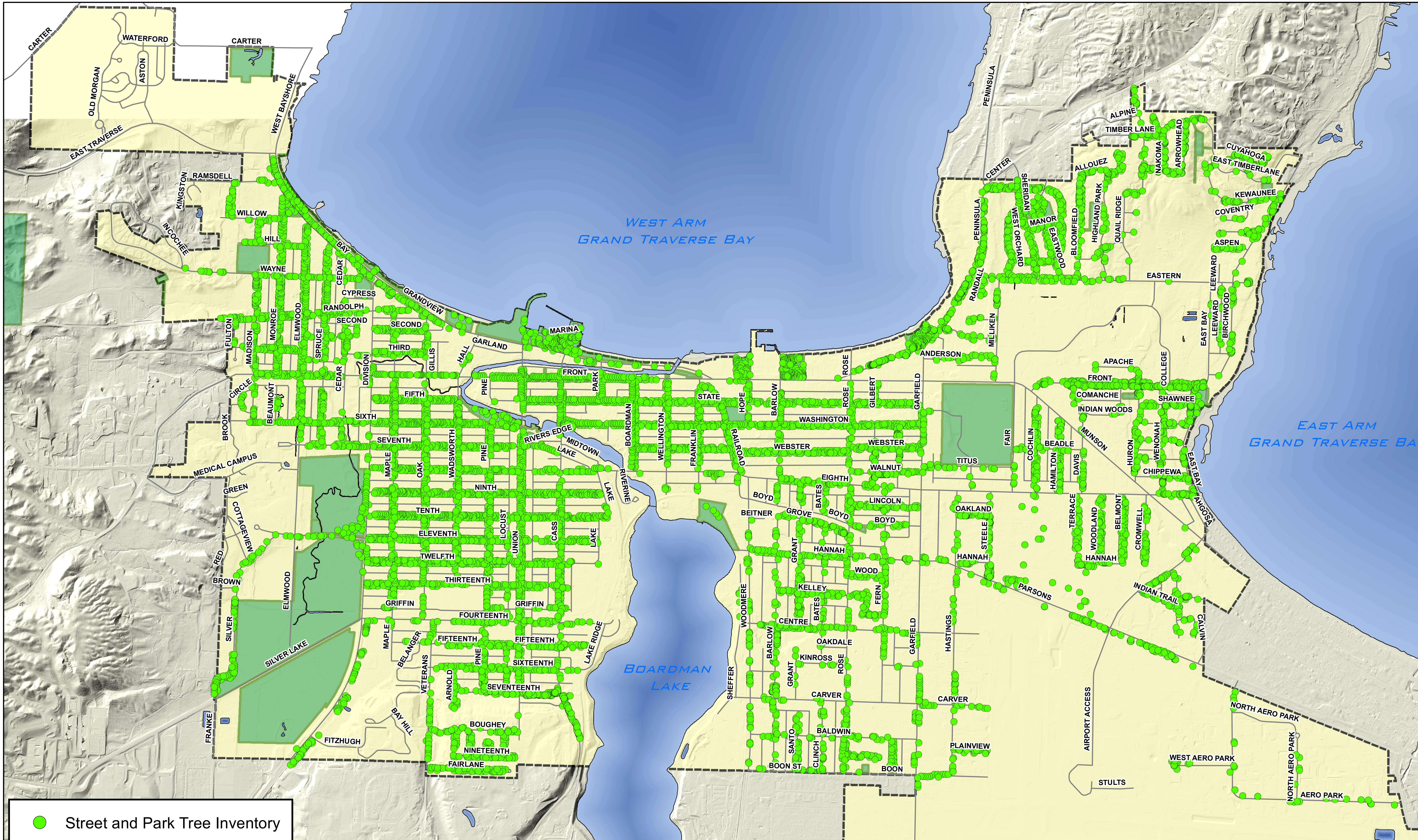
TREE COVERAGE COMPARISON
2000 to 2010

City of Traverse City, Michigan

1 inch = 2,500 feet
9/13/2018 NBS



City of TRAVERSE CITY

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Document Path: G:\GIS\GIS Requests\TreeStudy_09042018\Trees_NewRemoved20132018.mxd

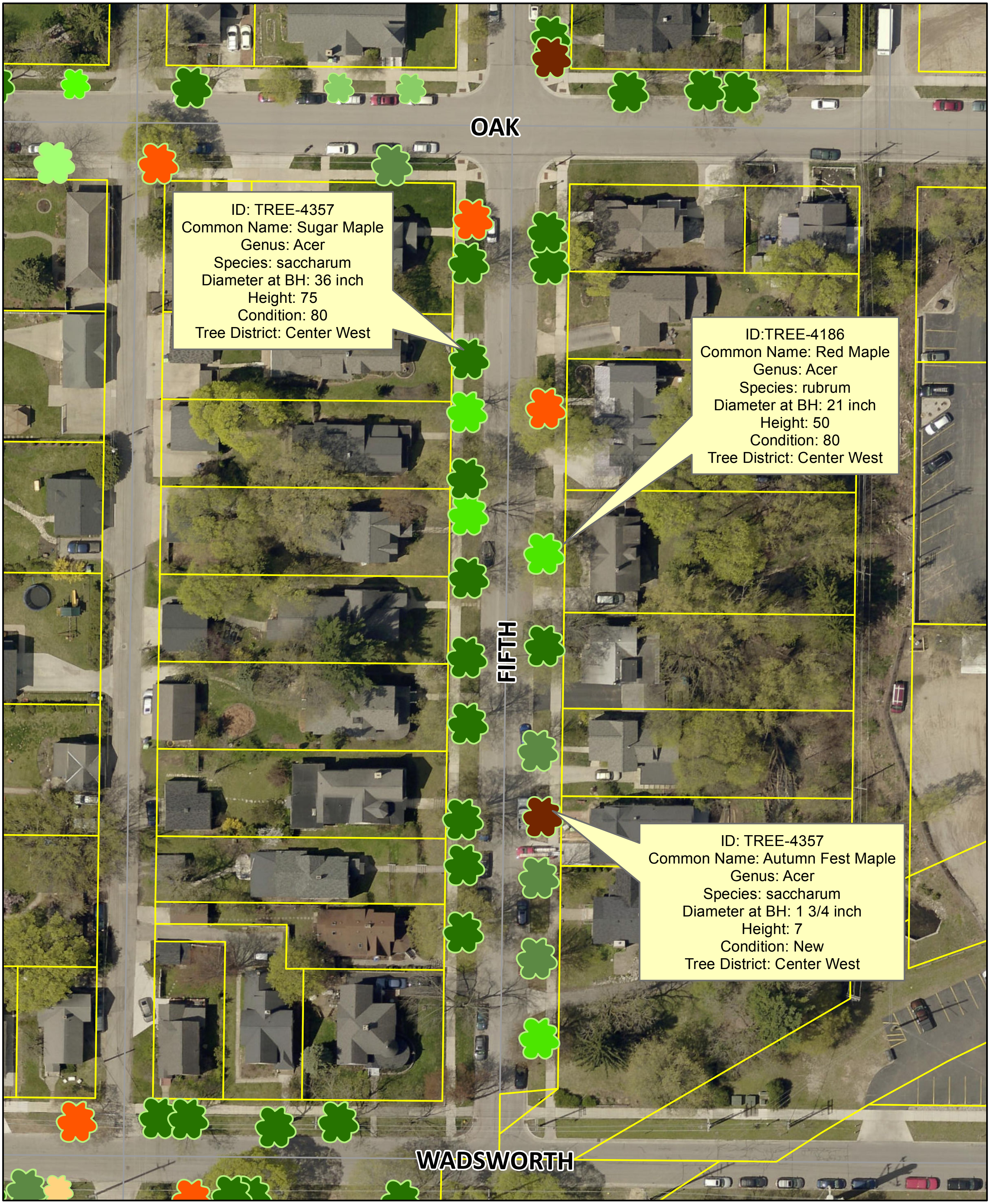
Street and Park Tree Inventory

City of Traverse City, Michigan

N

1 inch = 1,600 feet

10/30/2018 GWS



City of
TRAVERSE CITY
GEOGRAPHIC INFORMATION SYSTEMS

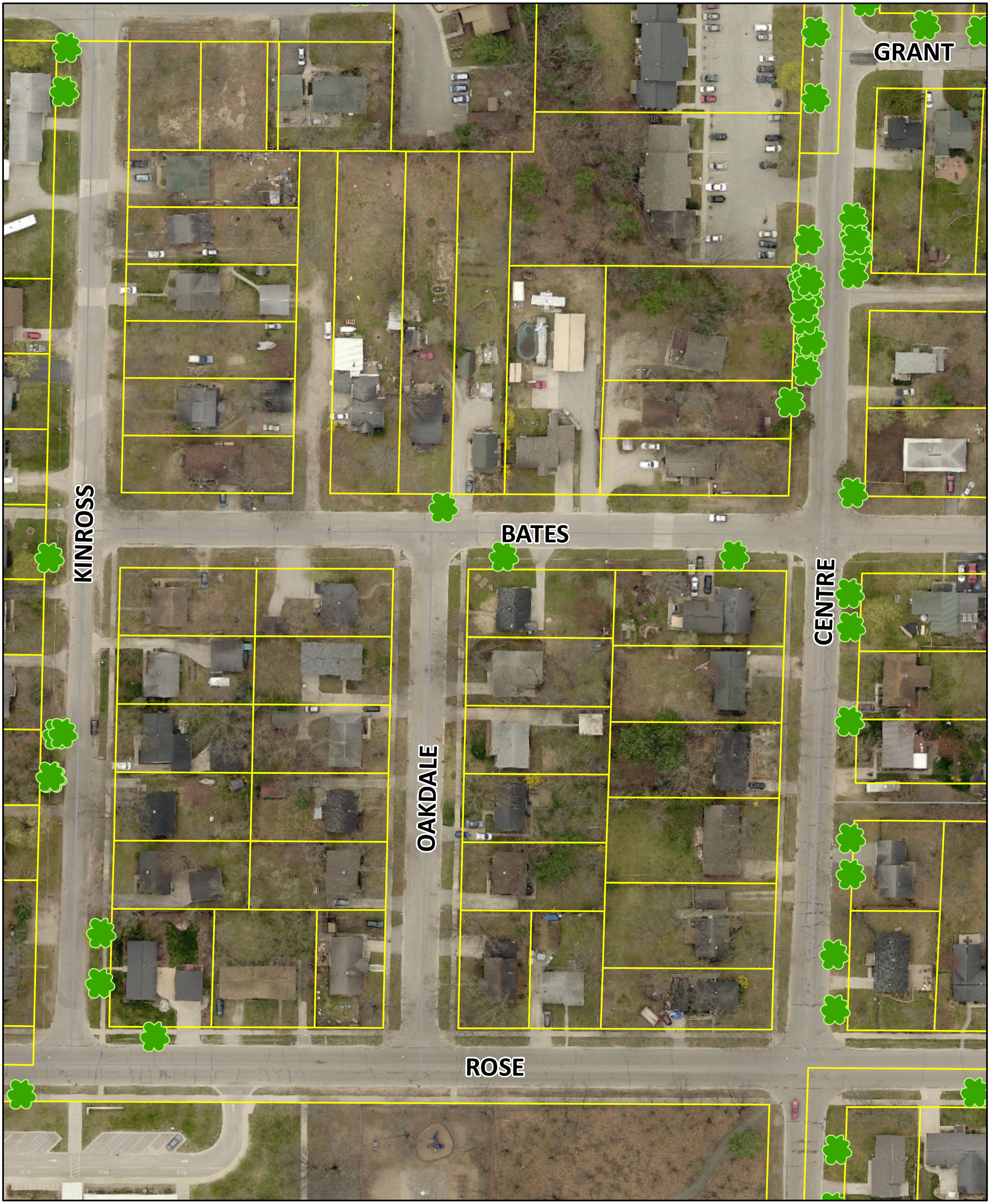
1 inch = 70 feet

Document Path: G:\GIS\GIS Requests\TreeStudy_09042018\TreeNeighborhood1.mxd

Tree Inventory

Fith Street between Oak and Wadsworth

12/17/2018 GWS



City of
TRAVERSE CITY
GEOGRAPHIC INFORMATION SYSTEMS

Tree Inventory Planning

Bates St Between Centre and Kinross

1 inch = 107 feet

Document Path: G:\GIS\GIS Requests\TreeStudy_09042018\TreeNeighborhood2.mxd

12/18/2018 GWS