

ANALYSIS OF THE INCREASE IN THE DIVERSITY OF TREE SPECIES IN
THE URBAN FOREST OF THUNDER BAY

By

Param Joshi

1130037



Faculty of Natural Resources Management

Lakehead University

April 2024

**ANALYSIS OF THE INCREASE IN THE DIVERSITY OF TREE SPECIES IN
THE URBAN FOREST OF THUNDER BAY**

by

Param Joshi

1130037

**An undergraduate thesis submitted in partial fulfillment of the requirements for
the Degree of Honours Bachelor of Environmental Management**

Faculty of Natural Resources Management

Lakehead University

April 2024

Dr. Leonard Hutchison
Supervisor

Daniel Corbett
Second Reader

LIBRARY RIGHTS STATEMENT

In presenting this thesis in partial fulfillment of the requirements of the HBEM degree at Lakehead University in Thunder Bay, I agree that the University will make it freely available for inspection.

This thesis is made available by my authority solely for the purpose of private study and research and may not be copied or reproduced in whole or in part (except as permitted by the Copyright Laws) without my written authority.

Signature: _____ Date: 05/03/2024

A CAUTION TO THE READER

This HBEM thesis has been through a semi-formal process of review and comment by at least two faculty members. It is made available for loan by the Faculty of Natural Resources Management for the purpose of advancing the practice of professional and scientific forestry.

The reader should be aware that the opinions and conclusions expressed in this document are those of the student and do not necessarily reflect the opinions of the thesis supervisor, the faculty or Lakehead University.

ABSTRACT

JOSHI. P.K. 2024. Analysis of the increase in the diversity of tree species in the Urban Forest of Thunder Bay, Ontario.

Keywords: urban forestry, monoculture, Thunder Bay, diversity, tree species

The City of Thunder Bay has set a target of planting 100,000 trees within the municipal boundary by 2050. To take a step in this direction, the City of Thunder Bay planted 4300 trees in the last six years, but the challenge is planting trees that are of different species to promote diversity and reduce the risk of mortality due to diseases and pests. Traditionally, importance was given to monoculture due to the aesthetic look of planting a single species of tree along a road but with the introduction of DED and EAB, importance was shifted to polyculture. Thirty different genera of trees were planted in the last six years from 2018-2023. Green Ash, which constituted around 24% of the total number of trees in the urban forest of the city has not been planted once due to EAB and the remaining are being injected by TreeAzin or cut down. *Acer* and *Tilia* are still in the top five genera planted along with *Ulmus* and *Malus*. With the limitation of the short growing season, it is demanding to find various tree species that can survive other than the ones that already exist here. Although hybrids and different varieties of tree species are available that can tolerate the climate in Thunder Bay, there is still a long way to go.

CONTENTS

ABSTRACT	v
ACKNOWLEDGMENTS	vii
LIST OF TABLES	viii
LIST OF FIGURES	ix
INTRODUCTION	1
LITERATURE REVIEW	3
URBAN FORESTRY	3
URBAN FORESTRY IN THUNDER BAY	4
BENEFITS OF URBAN TREES	6
DISEASES, INSECTS AND PESTS OF URBAN TREES	8
MATERIALS AND METHODS	10
RESULTS	12
DISCUSSION	19
CONCLUSION	24
LITERATURE CITED	25
APPENDIX	28

ACKNOWLEDGEMENTS

I would like to thank and acknowledge the following individuals for their contributions and assistance in the completion of this undergraduate thesis.

My thesis supervisor, Dr. Leonard Hutchison, who guided me through his course on ‘Urban Forestry’ and the knowledge he possesses of urban forestry to pursue this topic in particular that made me more interested in urban forestry and also for the support all along the thesis.

Daniel Corbett, Urban Forester for the City of Thunder Bay and also my manager during a co-op work term with the city as an Urban Forester Student, for sharing the knowledge and training to understand urban forestry in detail during my work term and also for providing data for the thesis and agreeing to be the second reader.

TABLES

Table	Page
1. Number of trees, percentage composition and common names of the top 10 tree species found in Thunder Bay	6
2. List of common names of the trees planted	14
3. Top 10 genera of trees planted over the last 5 years	15

FIGURES

Figure	Page
1. Map of the trees planted in 2018-2023 and Thunder Bay urban limit	11
2. Column chart of the number of trees planted per year from 2018 to 2023	12
3. Pie Chart of the percentage of genera planted over 6 years from 2018-2023.	13
4. Column chart of the genera of trees planted in 2023.	16
5. Column chart of the genera of trees planted in 2022.	17
6. Column chart of the genera of trees planted in 2021.	18

INTRODUCTION

Thunder Bay is a medium-sized city with a population of 123,258 according to the 2021 Canadian Census, located on the north shore of Lake Superior. The Canadian plant hardiness zone of Thunder Bay is 3A which limits the number of species available for planting. The city is unique in that it is surrounded by forests, which provide important economic benefits for the city. The urban forest is a major infrastructure asset for the city and a key component of the city's commitment to sustainability. Urban forests play an important role in beautifying urban landscapes, improving living conditions, absorbing urban pollutants, mitigating urban heat island effects, purifying atmospheric environments, and reducing noise, making urban forests a key component of urban ecosystems (Berland *et al.* 2017).

“Urban Forestry”, this term was first published in 1894 by George R. Cook and he recommended that only one species of tree should be planted along a street at uniform distances (Kenney 2010). The first definition that undoubtedly described the term ‘urban forestry’ was created by Jorgensen in 1970 and it stated that, ‘*Urban forestry is a specialized branch of forestry and has as its objectives the cultivation and management of trees for their present and potential contribution to the physiological, sociological and economic well-being of urban society. The contributions include the overall ameliorating effect of trees on their environment, as well as their recreational and general amenity value.*’ Since then, numerous definitions of the term ‘urban forestry’ have been published with the development of the profession.

Humans have introduced monocultures. The natural forest is diverse with a diversity of trees and shrub species that make them more resistant and less likely to surrender to a single pathogen. For a long time, monocultures of American elms were planted on the streets because of their dense canopy and vase-shaped form until Dutch Elm Disease (DED) came and wiped out all the elms from the streets (Griffin and Jacobi 2018) leaving them uncovered. Green ash was chosen as the replacement for American elm because of its fast-growing capability and tolerance to a variety of soil types, compaction, temperatures and moisture conditions. But even green ash saw the same fate as American elm when Emerald Ash Borer (EAB) arrived and started killing millions of ash trees.

After the deadly attacks of DED and EAB, cities began to understand that planting the same species of trees for aesthetic appeal cannot outweigh the cost of millions of urban trees dying due to diseases and the concept of planting different species of trees instead of only one species began to take off. Polyculture can decrease the risk of trees on a street being completely wiped out due to some invasive pathogen. Increasing the diversity of urban trees can also benefit the wildlife of the city. Polycultures might not be as lovely and eye-catching as monocultures but if they are artfully planned, they can offer a continuous display of various tree heights, canopy structures, bark textures and colors of flowers and foliage.

OBJECTIVES

The main objective of this thesis is to find out the diversity of the urban forest of Thunder Bay and how it has been changing for the last five years by analyzing the data provided by the City of Thunder Bay on the trees planted in the last five years. The subsidiary objective was to look at the benefits of polyculture.

NULL HYPOTHESIS

The diversity of the urban forest of the City of Thunder Bay has not increased and the City of Thunder Bay is still planting monocultures. The aim is to reject the null hypothesis.

LITERATURE REVIEW

Urban Forestry

A specialized branch of forestry which has the cultivation and management of trees for their present and future contribution to the physiological, sociological and economic well-being of urban society in its objectives is defined as the term urban forestry (Jorgensen 1974). These contributions include the overall improving effect of trees on their environment, as well as their recreational and general value. In 1993, Deneke contributed to the term and added that “Urban forestry is the sustained planning, planting, protection, maintenance, and care of trees, forests, greenspace and related resources in and around cities and communities for economic, environmental, social, and public health benefits for people. The definition includes retaining trees and forest cover as urban populations expand into surrounding rural areas and restoring critical parts of the urban environment after construction. Expansion of the urban/rural interface raises environmental and public health safety concerns, as well as opportunities to create educational and environmental links between urban people and nature. In addition, urban and community forestry includes the development of citizen involvement and support for investments in long-term on-going tree planting, protection, and care programs.”

Numerous different definitions of urban forestry have been provided throughout the years, but the one thing common in all of them is that they all acknowledge that the urban forest does not end at the city lines. Urban forestry encompasses the management of trees as well as the associated biotic and abiotic components. If the traditional

perspective of forestry concentrates on the sustained production of forest products and ecological services in a wildland context, urban forestry focuses on the provision of a diverse range of economic, environmental, and social services to urban society. Urban forests and urban forestry as defined by the 2019-2024 Canadian Urban Forest Strategy (CUFS), is “trees, forests, greenspace and related abiotic, biotic and cultural components in areas extending from the urban core to the urban-rural fringe” and “the sustained planning, planting, protection, maintenance, management and care of trees, forests, greenspace along with related resources in and around cities as well as communities for economic, environmental, social, and public health benefits for people.” This definition of urban forestry includes “techniques associated with retaining trees in the context of densification; forest cover in the context of urban expansion into surrounding rural areas, and greening critical parts of the urban environment after development and urbanization.”

Urban Forestry in Thunder Bay

Many historical records describe how, even in the late 19th century, before the word "urban forestry" was even coined, Port Arthur and Fort William—which together established Thunder Bay—greened their communities with trees. Records from 1886 stated that Waverly Park had 100 Gilead poplars planted as part of a massive tree-planting initiative. To provide each species with the appropriate amount of growth area, the Fort William Parks Board pruned trees in Vickers and Dease Parks in 1935. Approximately 450 Laurel Leaf willows were planted in 1926 along Memorial

Boulevard in remembrance of the soldiers who died in WWI. Despite the absence of such historical records throughout the previous 130 years, it was evident that the urban forest had a significant role in Thunder Bay's history. The first urban forester, Shelley Vescio was hired in 2001 and the first street tree inventory was done between the years 2000 and 2001. The street tree inventory revealed that there were 18,270 street trees and around 10,000 available plating spots. In 2011, an Urban Forest Management Plan was developed for the City of Thunder Bay by Davey Resource Group and the street tree inventory from 2001 was analyzed to assess the structure of Thunder Bay's managed tree population. There were 64 species which represented 29 genera, in which *Fraxinus* and *Acer* were the dominant genera. The top 10 species populations evaluated in the Urban Forest Management Plan are listed in Table 1.

Table 1. shows the number of trees, percentage composition and common names of the top 10 tree species found in Thunder Bay (Urban Forest Management Plan 2011).

Common Name	Number of Trees	Percentage Composition
Green ash	4,661	26%
Silver maple	3,245	18%
American basswood	1,440	8%
Paper birch	1,406	8%
Linden species	1,197	7%
White spruce	772	4%
Crabapple species	732	4%
Black ash	537	3%
Manitoba maple	502	3%
American elm	383	2%
Total	14,875	81%

Benefits of Urban Trees

Maintaining and restoring forest functionality in urban ecosystems may help reduce stormwater runoff and improve water quality (Boggs and Sun 2011). As a result, urban areas require fewer storm drains, reducing municipal expenses for erosion control, stormwater management, and pollutant treatment. The presence of urban trees both prevents warming through shading and cools building and pavement surfaces through transpiration and evaporative cooling, mitigating the urban heat island effect that can

expand and intensify as a city grows (Akbari *et al.* 2001). According to McPherson *et al.* (2005), the presence of urban trees and other vegetation near buildings can reduce summertime indoor air temperatures by up to 3 °C when compared to parts of the same building that are not shaded by vegetation. Additionally, by serving as windbreaks, these plants can act as windbreaks and reduce wind speed, which can reduce air infiltration into buildings by up to 50% and result in potential annual heating savings of up to 25%. Urban forests also serve as important sinks for carbon dioxide, directly separating CO₂ to form woody and foliar biomass (Nowak *et al.* 2006). Finally, urban trees increase the attractiveness of communities, reduce noise, improve wildlife habitat, and provide recreational opportunities (McPherson *et al.* 2005). The higher sale prices commanded by houses close to trees and parkland can be used to measure the value buyers place on the benefits associated with proximity to treed properties (Peper *et al.* 2007).

Statistics about the advantages of urban trees are provided in the Urban Forest Management Plan (2011). At an average annual savings of \$25 per tree, the City of Thunder Bay saves \$455,908 annually and the population of silver maples provides the greatest total benefit, accounting for 30.8 percent (\$140,312) of all energy savings. Furthermore, American elms provide the largest benefit per tree (\$44) in energy savings, while silver maple delivers the second-highest value (\$43) per tree. After accounting for the \$700,000 cost of upkeep, city-owned trees contribute roughly \$851,000 to the economy annually in terms of net value. Additionally, they cut carbon dioxide levels by 2.5 million kilograms, retain 78,606 cubic meters of stormwater runoff from city sewers, and remove 13,525 kg of contaminants from the air annually (Dunick 2012).

Diseases, Insects and Pests of Urban Trees

The city had a significant number of American elms, planted as street trees (approximately 1400) and found naturally as riverbank trees along the Kaministiquia River (approximately 13,500) before the arrival of Dutch elm disease around 1977 (Betts 1984). Since it lacked any organized sanitation program, Thunder Bay very quickly lost most of its urban elm population (Betts 1984). The elms have since been replaced by other species, and currently, American elm constitutes a very small and insignificant fraction of the approximately 20,000 street trees in Thunder Bay (Wilson 2006). Another significant threat to the health and sustainability of urban forests is the introduction of pests from other countries. Emerald ash borer (EAB) is one such example that has killed millions of ash trees in Canada and the northern U.S. EAB has the potential to kill all boulevard ash trees. In 2000, ash comprised 4,750 trees (25 percent) of the street tree inventory. The number of ash trees in parks and on private lands is unknown.

Moreover, extended periods of drought, increased wind events, and deadly attacks by insects and diseases all conspire to threaten tree health. As an example, the effects of climate change have been witnessed in Thunder Bay for several years through the decline of both mature and immature white birch trees. Hundreds of trees on municipal property and an unknown number on private lands have succumbed to the stress of drought and were subsequently attacked by the bronze birch borer, which may result in the elimination of this species from the landscape.

MATERIALS AND METHODS

A feature layer of all the trees planted from 2018 to 2023 by the City of Thunder Bay was provided by the Urban Forestry Department of the City of Thunder Bay. The feature layer had all the trees planted in the last 6 years as feature points inside the urban limits of the City of Thunder Bay. The attribute table contained various information but only the scientific name, common name, address, and the year of planting were assessed.

The attribute table and the feature layer were analyzed using ArcGIS Pro by ESRI. The trees planted between 2018 -2023, and the urban limit of the City of Thunder Bay are shown in Figure 1 with the trees planted as red dots and the urban limit marked clearly with a black thick outline. Summarized tables of the different genera of trees planted and when they were planted were created. Comparison of the diversity of trees recently planted with the street tree inventory done by the City of Thunder Bay in 2001.

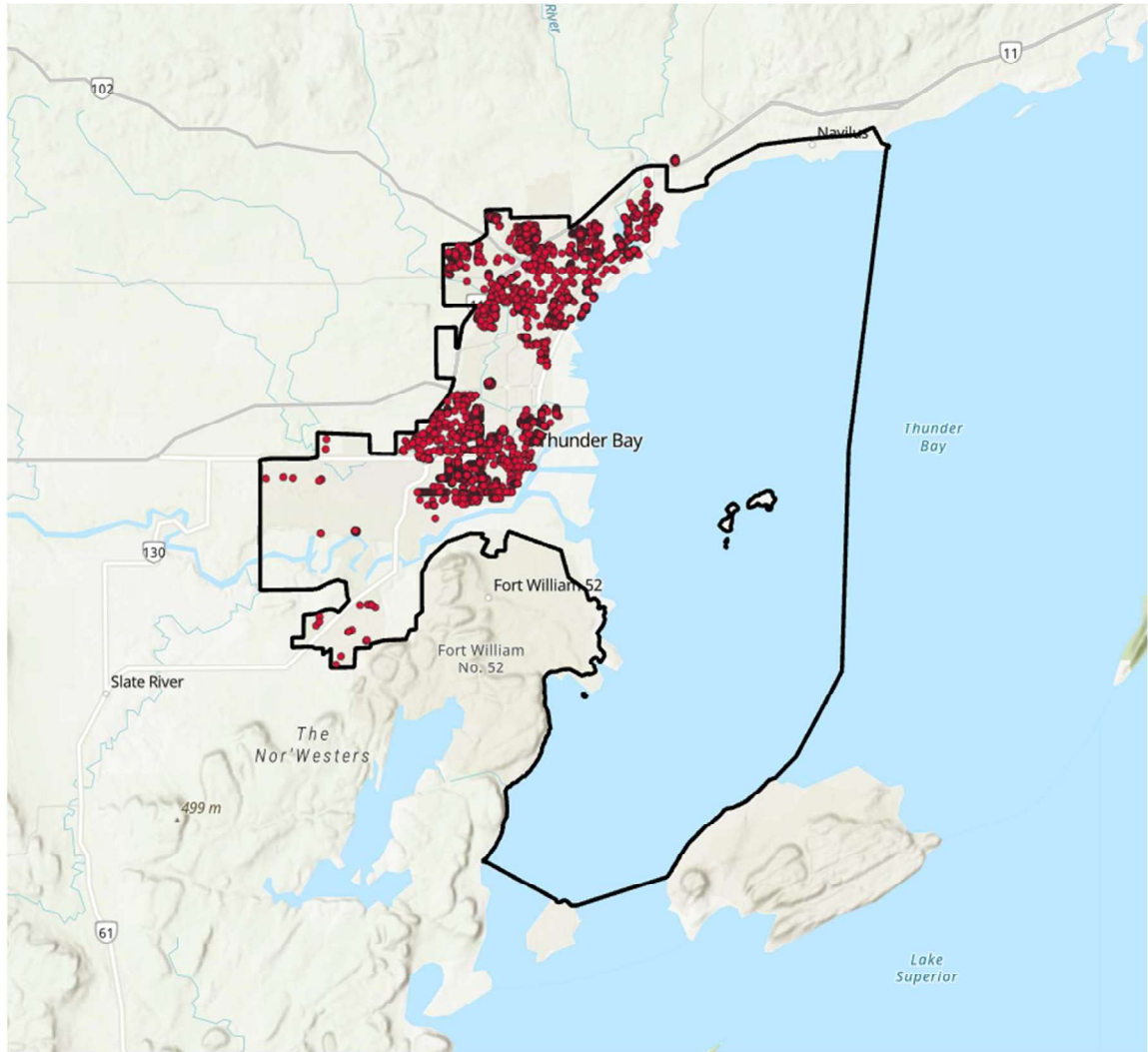


Figure 1. The map of the trees planted in 2018-2023 and Thunder Bay urban limit in ArcGIS Pro.

RESULTS

TREES PLANTED IN THE LAST 6 YEARS

Since 2019, a total of 4300 trees have been planted throughout the city. There were 4336 records in the data but only 4300 of them were trees, the rest 34 were stumps and 2 of them were retired. The highest number of trees were planted in 2021 which was 1,113 and the lowest number of trees were planted in 2018 which was 239. The number of Trees planted per year is shown in Figure 2 below and it shows the columns between the years which illustrates the trees planted between the years 2018-2019 and so on.

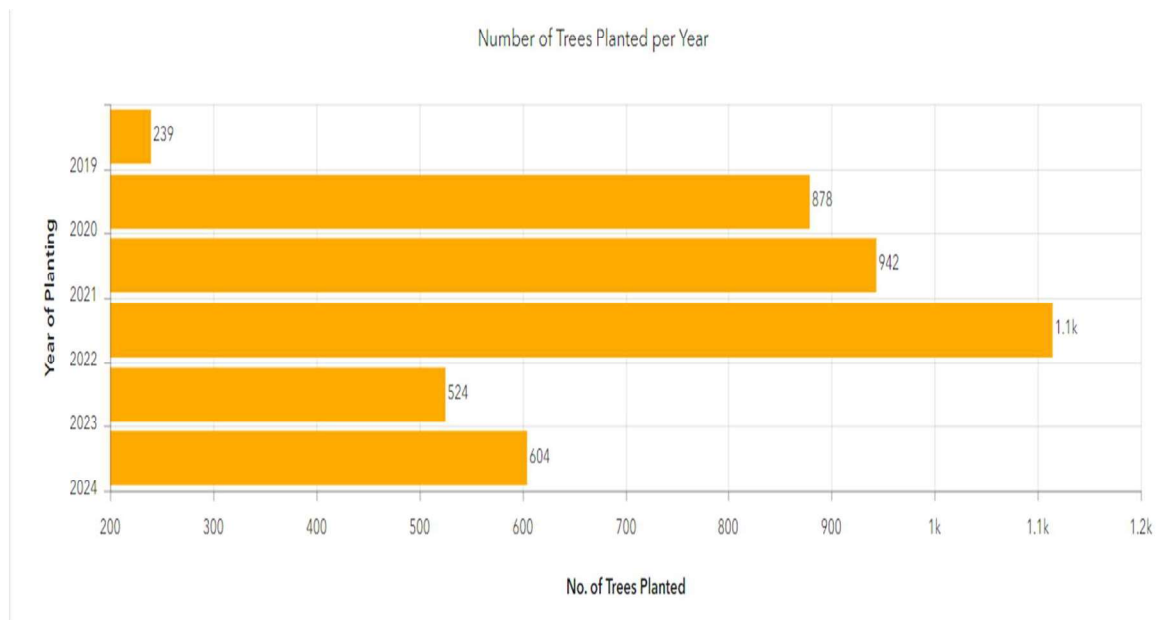


Figure 2. Number of Trees Planted Per year from 2018 to 2023.

PERCENTAGE OF TREE SPECIES PLANTED IN THE LAST 6 YEARS

A total of 30 known genera of trees were planted and there was an unknown genus that was not identified in the data which consisted of 0.26% of the total trees planted. Out of the 30 identified genera, *Malus* spp. was the most planted and it contributed 15% of the total trees planted, followed by *Acer* spp. (14.63%) and *Ulmus* spp. (12.4%) which are shown in Figure 3 along with all other genera planted.

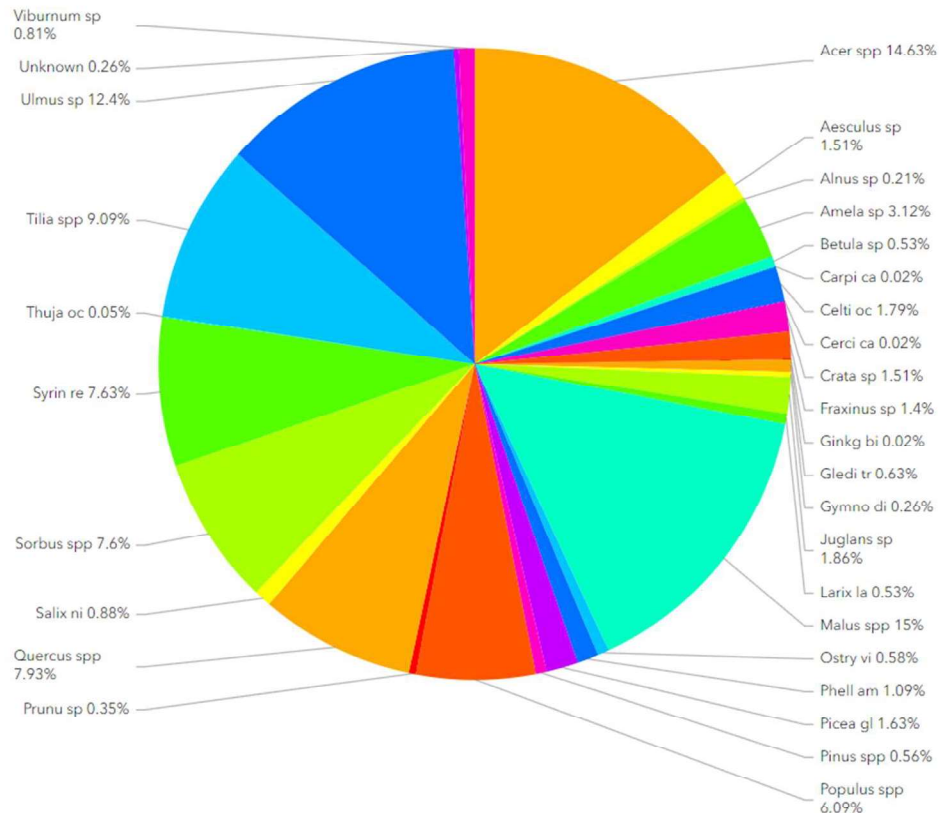


Figure 3. displays the percentage of genera planted over 6 years from 2018-2023.

Table 2. List of common names of the trees planted.

List of Common Names of the Trees planted over the last 5 years		
ALDER	DROP MORE LINDEN	NORTHWOOD MAPLE
AMERICAN ELM	EASTERN WHITE CEDAR	OHIO BUCKEYE
AMERICAN LINDEN	EASTERN WHITE PINE	PAPER BIRCH
AMUR CHOKECHERRY	ELM PRAIRIE EXPEDITION	PIN OAK
ASH WHITE	FORT MCNAIR HORSECHESNUT	SCOTS PINE
AUTUMN SPLENDOR BUCKEYE	FREEMAN MAPLE	SERVICEBERRY
BALSAM POPLAR	GALA APPLE	SILVER CLOUD MAPLE
	GLADIATOR CRABAPPLE	SNOWBIRD HAWTHORN
BLACK GUM, NYSSA SP.	GLENLEVEN LINDEN	STARLIGHT CRABAPPLE
BLACK MAPLE	GOLDSBUR CHERRY	SUNDANCE POPLAR
BLACK WALNUT	GREEN ASH	SWEDISH UPRIGHT POPLAR
BLACK WILLOW	HACKBERRY	RED MAPLE
BLUE BEECH	IRONWOOD	RED OAK
BURR OAK	IVORY SILK TREE LILAC	TARTARIAN MAPLE
BUTTERNUT	KENTUCKY COFFEE TREE	THORNLESS COCKSPUR HAWTHORN
CARDINAL ROYAL MOUNTAIN ASH	MAJESTIC SKIES OAK	THORNLESS HONEY LOCUST
CAROLINA POPLAR	MANITOBA MAPLE	TRIUMPH ELM
COMMON HACKBERRY	MOUNTAIN ASH RUSSIAN	UNITY SUGAR MAPLE
COTTONWOOD	NANNY BERRY	WHITE SPRUCE

Fifty six different types of trees were planted from 30 genera identified and are shown in Table 2. Most of them are hybrids or varieties produced by nurseries which are adapted and tolerant to the urban environment of Thunder Bay. Trees such as American linden, white birch, green ash, silver maple, sugar maple and species of poplar are present in the urban forest of Thunder Bay.

Table 3. The top 10 genera of trees planted over the last 6 years.

Genera	No. of Trees
<i>Malus</i>	645
<i>Acer</i>	629
<i>Ulmus</i>	533
<i>Tilia</i>	391
<i>Quercus</i>	341
<i>Syringa</i>	328
<i>Sorbus</i>	327
<i>Populus</i>	262
<i>Amelanchier</i>	134
<i>Juglans</i>	80
Total	3670

Out of 4300 trees planted, 3670 (~85%) are the genera listed in Table 3. *Malus* was the most planted genera with 645 trees planted which included gladiator crabapple, starlight crabapple and gala apple. *Acer* was the second most planted with 629 trees that included varieties such as black maple, freeman maple, silver cloud maple, red maple, Tartarian maple and unity sugar maple. *Ulmus* came in third with 533 trees and included varieties of American elm, prairie expedition elm and triumph elm. A combined 391 trees of American linden, drop more linden and glenleven linden were planted. *Quercus*, *Syringa*, *Sorbus* and *Populus* had 341, 328, 327 and 262 trees planted respectively. *Amelanchier* and *Juglans* were the least planted genera with 134 and 80 trees.

GENERA OF TREES PLANTED IN THE LAST 3 YEARS

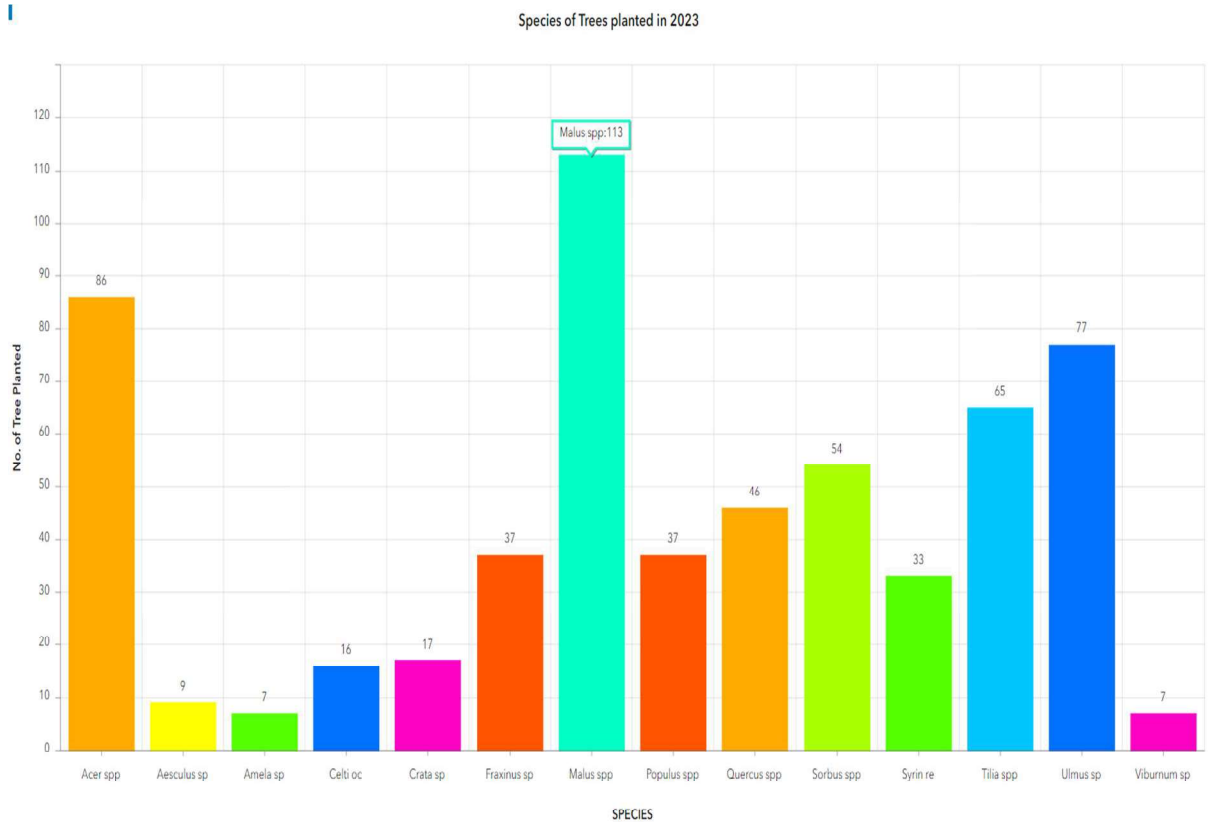


Figure 4. Genera of trees planted in 2023.

A total of 604 trees were planted in 2023 which are shown in Figure 4. One Hundred and thirteen trees of *Malus* spp. were planted in 2023 which was the highest out of 14 genera planted in 2023. *Acer*, *Ulmus*, *Tilia* and *Sorbus* were among the top 5 highest planted trees after *Malus* with 86, 77, 65 and 54 trees respectively. Less than 10 trees of *Aesculus* spp., *Amelanchier* spp. and *Viburnum* sp. were planted. There were other genera such as *Celtis* spp., *Crataegus* spp., *Populus* spp., *Quercus* spp. and *Syringa* sp. that had a noticeable number of trees planted. No ash trees were planted although the data shows 37 ash trees.

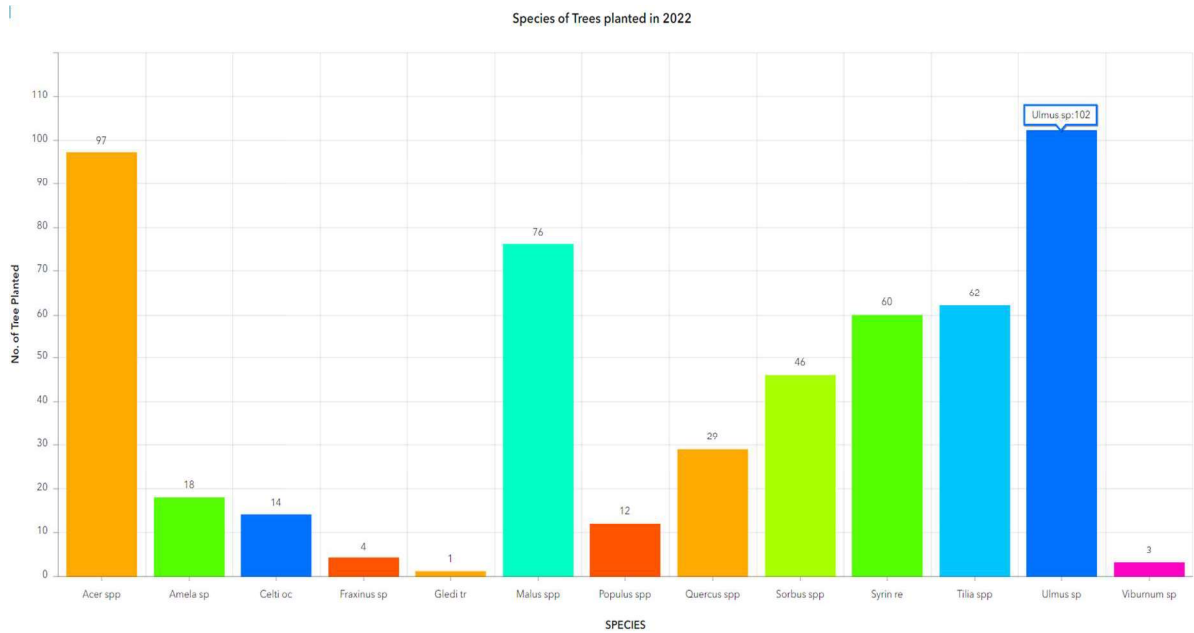


Figure 5. Genera of trees planted in 2022.

A total of 524 trees were planted in 2022 (Figure 5) and out of that 102 trees of *Ulmus* spp. were planted in 2023 which was the highest out of 13 genera that were planted in 2023. *Acer*, *Malus*, *Tilia* and *Syringa* were among the top 5 highest planted trees after *Ulmus* with 97, 76, 62 and 60 trees respectively. Less than 20 trees of *Amelanchier* spp., *Celtis* sp., *Populus* spp., *Fraxinus* sp. and *Viburnum* sp. were planted. There were other genera such as *Quercus* spp. and *Sorbus* spp. that had a significant number of trees planted. Surprisingly, there was 1 *Gleditsia triacanthos* (honey locust) planted in 2022.

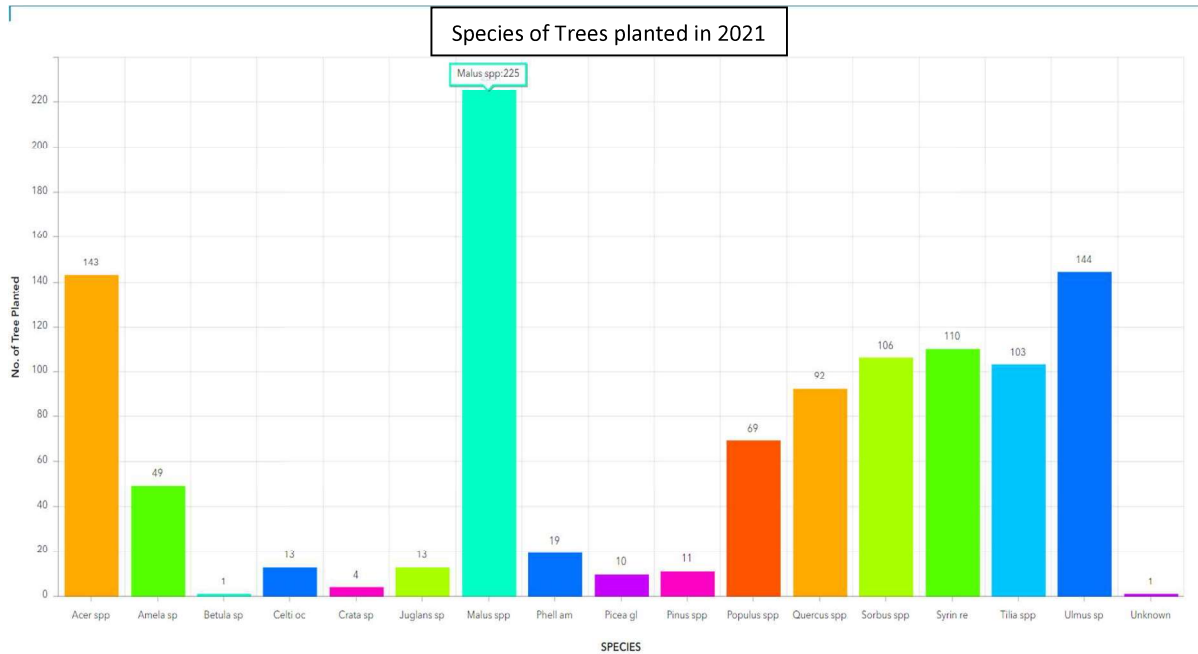


Figure 6. Genera of trees planted in 2021.

The greatest number of trees within the last 6 years were planted in 2021, with 1,113 trees of 16 genera and 1 unknown genus. A total of 225 trees of *Malus* spp. were planted followed by *Ulmus*, *Acer*, *Syringa*, *Sorbus* and *Tilia*, which were all greater than 100 trees. Thirteen and nineteen trees of genera *Juglans* sp. (Black Walnut) and *Phellodendron* sp. (Amur cork tree) which are not native to Thunder Bay were planted respectively. Remarkably, 11 white pine and 10 white spruces were also planted, mostly in parks. The city does not plant paper birch as a street tree but the data shows there is 1 that was planted.

DISCUSSION

Comparing Table 1 with the street tree inventory conducted in 2011 to Table. 3 which has the genera planted in the last 5 years, we see that the top 10 genera planted include *Acer*, *Tilia*, *Malus* and *Ulmus* which are also in the top 10 of the street tree inventory table but the percentage has changed significantly. There were only 732 crabapple trees in 2011 but in the last 6 years, 645 of them have been planted. *Acer* is still being planted although 18% of the total street trees are maples, mainly because the *Acer* genus makes a significant contribution to the urban forest with its variety of aesthetic qualities and its potential to deliver ecosystem services such as the regulation of microclimate and mitigating the urban heat island effect (Deak Sjöman *et al.*, 2015). Because of DED, elms had been wiped out in the city before the street tree inventory was done in 2011 and there were only 383 trees left. Five Hundred and thirty three hybrids and varieties of elms such as triumph elm and prairie expedition elm have been planted in the last six years which are more resistant to DED. All the other genera like oaks, lilacs, mountain ash, aspen, serviceberry and walnuts contributed less than 2% to the street tree inventory done in 2011 but they are being planted more and are among the top 10 genera planted in the last six years.

Trees with similar genetic characteristics are similarly vulnerable to biotic and abiotic stress damage. In urban forests, diversity—both genetic diversity within a species and species diversity as a whole—is essential because it lowers the risk of catastrophic tree loss and the ecosystem services it provides, should too many closely related trees in a given area fall ill at the same time (Lohr, 2013). A well-known example

of this is the destruction of several urban forests in North America and Europe due to Dutch elm disease (Wilson, 1975). Elm trees were a common street tree in many cities on these two continents because of its high aesthetic value, quick growth, and tolerance to urban environments. Between the middle of the 20th century, Dutch elm disease began to spread, and a significant percentage of the trees died as a result, resulting in disastrous losses. Ash trees, which in certain places can make up more than 35% of the urban forest, are currently dying off rapidly in North America due to the Emerald Ash Borer (Ball *et al.*, 2007). These losses have ramifications that extend beyond the urban forest and may have significant ripple effects.

The importance of diversity in urban forests is becoming more widely acknowledged. Diversity offers some defence against climatic changes like those brought on by climate change, as well as against pests and diseases like Dutch elm disease and chestnut blight (Sanders, 1984). The relative abundance of the most prevalent species has been used as a proxy for variety in a number of benchmarks that have been put forth to help manage the diversity in urban forests. To avoid repetitive landscapes using cheap and readily available species, Barker (1975) recommended that no more than 5% of a given tree inventory be planted using any one species. The impact of Dutch elm disease and other pest or diseases specific to certain species, genera or families led to greater interest in increasing diversity in the urban forest to reduce its vulnerability (Sanders, 1981). Critical examination of the 5% benchmark as unlikely to be achievable led to higher benchmarks for the relative abundance of the most common species (mostly 10–15%). To manage and improve diversity, there has been wide-spread acceptance of the 10/20/30 rule proposed by Santamour (2003), which states that

municipal forests should comprise no more than 10% of any particular species, 20% of any one genus or 30% of any single family.

Applying the 10/20/30 rule to the street tree inventory done in 2011, we find that the genus *Fraxinus* contributed 29% to the urban forest of Thunder Bay which is 9% greater than the proposed rule and green ash alone contributed 25% to the urban forest which is 15% greater than the proposed rule and as a result due to the invasion of EAB, that 25% of the urban forest is under risk and the city might lose most of it. Another species that was greater than the 10% rule was silver maple at 18%. *Tilia* contributed 15% of the urban forest and was under the proposed rule.

With the increase in the number of trees in the urban forest of Thunder Bay, the percentage of a species or genus contributing will either increase if they are planted more or decrease if they are not planted at all and decline due to various reasons. For example, the percentage of green ash in the urban forest thriving would be significantly low compared to the percentage in 2011, mainly due to the infestation of EAB. The results found from the data of the last six years might not be ideal to use the 10/20/30 rule as it is at a much smaller scale, nevertheless the rule is applied but the comparison should only be marginally considered for further tree planting. In the last six years, the genus *Malus* has been planted the most at 15% and it is nearing the 20% limit of a single genus but there were very few trees of *Malus* in the 2011 street tree inventory, it accounted to only 4%. Although it might be 1st in our results, with the increase in the total number of trees in the urban forest, the contribution of *Malus* would still be low.

Similarly, *Ulmus* contributed to 12.4% of the total trees planted in our data but because of DED, most of the previous elms died and the recently planted elms would only contribute to a small percentage of the total street tree inventory. Silver maple was already over the proposed rule of 10% at 18%, *Acer* contributed to 14.63% of the trees planted in the last six years and it included silver maple, sugar maple, Tartarian maple and freeman maple. The 20% rule for the genus is not yet reached but the 10% for species was already reached in 2011 by silver maple, so planting silver maple might not be ideal and other species of *Acer* should be planted more.

Malus has been increasingly planted in the urban forest of Thunder Bay.

Gladiator flowering crabapple was one of the cultivars of *Malus* that was planted, and it has a narrow oval shape with single medium pink flowers in spring, purplish summer foliage, deep purple fall foliage, and small purple-red crabapples. More upright than most crabapples, it has high disease resistance and is well suited to any landscape with limited space (Williams 2018) and it is approved by the City of Thunder Bay to be planted under power lines as it is a small to medium tree. Attractive pink or white blooms, fruits that are edible and act as a source of food for urban wildlife and approval for planting under powerlines make it one of the top choices of the city as well as the citizens. There are still lots of old neighbourhoods in Thunder Bay that have overhead power lines and, in the past, large trees were planted underneath them which posed a risk of power failure and had to be trimmed and maintained which is expensive. Planting a small tree such as a crabapple eliminates the risk of power failure and also is less costly to maintain.

The American elm, once abundant in US and Canadian cities, faced devastation with the arrival of Dutch elm disease (DED) around 1930, likely introduced via imported European elm logs. The pathogen, *Ophiostoma ulmi*, spread rapidly aided by the European bark beetle. By 1960, over 40 million elms succumbed to death (Dunn 2000), marking a profound shift in urban forestry. DED's impact reshaped attitudes towards monoculture planting and street tree management (Watson 2012), highlighting the vulnerability of urban ecosystems. This event stands as a pivotal moment in the history of urban forestry, prompting new approaches to tree diversity and disease management. Since then, breeding programs have been developed to grow varieties of American elm trees that are resistant to DED. Two of the varieties have been planted in Thunder Bay and they are Triumph™ elm and Prairie Expedition® elm. The triumph™ elm has very good resistance to Dutch elm disease (DED) and to elm yellows. Moreover, it also has good resistance to elm leaf beetle and it is easily transplanted, quick to establish, and adaptable to most soil types (The Morton Arboretum). Southwest of Fargo in North Dakota, North Dakota State University discovered a lone survivor in a stand of American elm trees (Johnson 2014) and cloned it. Introduced in 2004, it was named 'Lewis and Clark' and marketed as Prairie Expedition®. It is cold hardy to USDA Hardiness Zone 3 and is DED resistant (NDSU Research Foundation).

CONCLUSION

Although 4300 trees have been planted in the last six years and they include 30 genera, many trees have also been removed due to pests, diseases, poor pruning practices and old age. The total number of trees has not increased significantly, and the diversity has also not changed remarkably. The target of planting 100,000 trees by 2050 by the City of Thunder Bay is achievable if the planting is prioritized with a goal of diversity in mind. EAB has put 25% of the street trees under risk and if they have to be removed, then the total number of street trees would decrease notably.

The increase in diversity of tree species, not only protects the trees of the urban forest of Thunder Bay from threats such as EAB and DED which have had a deadly impact on the trees, it also promotes biodiversity, habitats and food for urban and migrating wildlife and it seems aesthetic with different sizes and types of trees on a street covering different parts of the canopy.

LITERATURE CITED

- Akbari, H., Pomerantz, M., and Taha, H. 2001. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. *Solar Energy*, 70(3), 295–310.
- Ball, J., Mason, S., Kiesz, A., McCormick, D., & Brown, C. 2007. Assessing the hazard of emerald ash borer and other exotic stressors to community forests. *Arboriculture & Urban Forestry*, 33(5), 350-359.
- Barker, Philip A. 1975. Ordinance control of street trees. *Journal of Arboriculture*, 212-215.
- Berland, A., Shiflett, S. A., Shuster, W. D., Garmestani, A. S., Goddard, H. C., Herrmann, D. L., and Hopton, M. E. 2017. The role of trees in urban stormwater management. *Landscape and Urban Planning*, 162, 167–177.
- Betts, P. W. 1984. Incidence of Dutch elm disease in the city of Thunder Bay and surrounding area. B.Sc.F. thesis, Lakehead University, Thunder Bay, Ont.
- Boggs, J. L., and Sun, G. 2011. Urbanization alters watershed hydrology in the piedmont of North Carolina. *Ecohydrology*, 4, 256–264.
- Davey Resource Group. 2011. Urban Forest Management Plan City of Thunder Bay. 210 pp.
- Deak Sjöman, J., Hirons, A., and Sjöman, H. 2015. Branch area index of solitaire trees—Its use for designing with regulating ecosystem services. *Journal of Environmental Quality*, 45(1), 175-187.

- Deneke, F. 1993. Urban Forestry in North America: Towards a Global Ecosystem Perspective. Pp 4-8 in: G. Blouin and R. Comeau (Eds.). Proceedings of the First Canadian Urban Forests Conference, May 30 – June 2, 1992. Winnipeg, Manitoba. 151pp.
- Dunick., L. 2012. Thunder Bay Recognizes the Importance of Urban Forest. Ontario Urban Forest Council.
- Dunn, C.P. 2000. The Elms: Breeding, Conservation, and Disease Management. Kluwer Academic Publishers, Boston, Massachusetts, U.S. 361pp
- Griffin, J.J. and Jacobi, W. 2018. Ten-year performance of elms in the National Elm Trial. *Acta Hortic.* 1191, 31-36.
- Johnson, B. 2014. Dutch elm disease resistant tree introduced. Fergus Falls Daily Journal 22 December 2014. 2pp
- Jorgensen, E. 1974. Towards an urban forestry concept. Proceedings of the 10th Commonwealth Forestry Conference. Ottawa, Canada; Forestry Service.
- Lohr, V. I. 2013. Diversity in landscape plantings: Broader understanding and more teaching needed. *HortTechnology* 23.1: 126-129.
- McPherson, G., Simpson, J., Peper, P., Maco, S., & Xiao, Q. 2005. Municipal forest benefits and costs in five US cities. *Journal of Forestry*, 103, 411–416.
- NDSU Research Foundation. PRAIRIE EXPEDITION® American Elm - *Ulmus Americana* 'LEWIS & CLARK' (RFM-37).

https://www.ndsuresearchfoundation.org/prairie_expedition. Accessed 1 April 2024.

Nowak, D. J., Crane, D. E., and Stevens, J. C. 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening*, 4(3), 115–123.

Peper, P.J.; McPherson, E.G., Simpson, J.R., Gardner, S.L., Vargas, K.E., and Xiao, Q. 2007. New York City, New York Municipal Forest Resource Analysis. Technical Report. U.S. Department of Agriculture Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research. 65 p.

Statistics Canada. 2021 Census of Population geographic summary, Thunder Bay [Census metropolitan area], Ontario. <https://www12.statcan.gc.ca/census-recensement/2021/search-recherche/productresults-resultatsproduits-eng.cfm?LANG=E&GEOCODE=2021S0503595>.

Sanders, Ralph A. 1984. Some determinants of urban forest structure. *Urban Ecology* 8.1-2, 13-27.

Sanders, Ralph A. 1981 "Diversity in the street trees of Syracuse, New York." *Urban Ecology* 5.1, 33-43.

Santamour, F.S., Jr. 2003. Trees for urban planting: diversity, uniformity, and common sense. *Overstory* #126.

- Tree Canada. (n.d.). Canadian Urban Forest Strategy: 2019-2024. Retrieved from <https://treecanada.ca/wp-content/uploads/2018/10/TC-CUFS-2019-2024-Eng-1.pdf>
- The Morton Arboretum. TRIUMPH™ elm. <https://mortonarb.org/plant-and-protect/trees-and-plants/triumph-elm/>. Accessed 1 April 2024.
- Watson, B.G. 2012. Dutch elm disease: Then and now. *Arbor Age* 32(4):18–19
- Williams, Sara. “Gardening: Diversifying our urban forests – Part 2.” *Saskatoon StarPhoenix*, 24 August 2018.
- Wilson, J. 2006. Urban forestry in northern Ontario. *Ont. Arborist*, 34(5): 20-21.
- Wilson, C. L. 1975. Long Battle against Dutch elm disease. *Journal of Arboriculture* 1(6): 107-112.

APPENDIX

Appendix: Trees planted in 2023.

BOTANICAL	COMMON	PLANTING_D
Quercus spp	RED OAK	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Acer spp	FREEMAN MAPLE	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Ulmus sp	TRIUMPH ELM	7/17/2023
Malus spp	GLADIATOR CRABAPPLE	7/17/2023
Malus spp	STARLIGHT CRABAPPLE	7/17/2023
Malus spp	GLADIATOR CRABAPPLE	7/18/2023
Malus spp	GLADIATOR CRABAPPLE	7/18/2023
Malus spp	STARLIGHT CRABAPPLE	7/19/2023
Tilia spp	AMERICAN LINDEN	7/18/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/11/2023
Ulmus sp	TRIUMPH ELM	7/17/2023
Celti oc	HACKBERRY	7/17/2023
Ulmus sp	TRIUMPH ELM	7/19/2023
Acer spp	UNITY SUGAR MAPLE	7/19/2023
Tilia spp	DROP MORE LINDEN	7/19/2023
Acer spp	SILVER CLOUD MAPLE	7/19/2023
Crata sp	SNOWBIRD HAWTHORN	7/19/2023
Tilia spp	DROP MORE LINDEN	7/17/2023
Acer spp	SILVER CLOUD MAPLE	7/17/2023
Tilia spp	DROPMORE LINDEN	7/17/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/17/2023
Malus spp	GLADIATOR CRABAPPLE	7/17/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	7/17/2023
Acer spp	UNITY SUGAR MAPLE	7/19/2023
Tilia spp	AMERICAN LINDEN	7/19/2023
Tilia spp	AMERICAN LINDEN	7/19/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/19/2023
Acer spp	UNITY SUGAR MAPLE	7/19/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/17/2023
Quercus spp	RED OAK	7/11/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/11/2023
Acer spp	FREEMAN MAPLE	7/11/2023

Tilia spp	AMERICAN LINDEN	7/11/2023
Acer spp	UNITY SUGAR MAPLE	7/11/2023
Quercus spp	RED OAK	7/11/2023
Ulmus sp	TRIUMPH ELM	7/11/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/11/2023
Acer spp	SILVER CLOUD MAPLE	7/11/2023
Ulmus sp	TRIUMPH ELM	7/11/2023
Tilia spp	AMERICAN LINDEN	7/17/2023
Tilia spp	DROP MORE LINDEN	7/11/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/11/2023
Acer spp	SILVER CLOUD MAPLE	7/11/2023
Quercus spp	BURR OAK	7/11/2023
Celti oc	COMMON HACKBERRY	7/11/2023
Acer spp	SILVER CLOUD MAPLE	7/11/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/11/2023
Acer spp	SILVER CLOUD MAPLE	7/19/2023
Tilia spp	AMERICAN LINDEN	7/18/2023
Ulmus sp	TRIUMPH ELM	7/18/2023
Acer spp	SILVER CLOUD MAPLE	7/18/2023
Syrin re	IVORY SILK TREE LILAC	7/17/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/17/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/17/2023
Acer spp	FREEMAN MAPLE	7/6/2023
Tilia spp	DROP MORE LINDEN	7/6/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/6/2023
Malus spp	GLADIATOR CRABAPPLE	7/24/2023
Tilia spp	DROP MORE LINDEN	8/1/2023
Quercus spp	BURR OAK	8/17/2023
Acer spp	FREEMAN MAPLE	6/29/2023
Tilia spp	DROP MORE LINDEN	8/16/2023
Fraxinus sp	ASH WHITE	3/8/2023
Fraxinus sp	ASH	3/8/2023
Fraxinus sp	ASH GREEN	4/5/2023
Fraxinus sp	ASH GREEN	4/5/2023
Acer spp	MAPLE SILVER	4/21/2023
Fraxinus sp	ASH GREEN	5/9/2023
Acer spp	UNKNOWN SPECIES	5/9/2023
Tilia spp	AMERICAN LINDEN	6/21/2023

Acer spp	SILVER CLOUD MAPLE	6/21/2023
Acer spp	SILVER CLOUD MAPLE	6/21/2023
Syrin re	IVORY SILK TREE LILAC	6/21/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	6/21/2023
Ulmus sp	TRIUMPH ELM	6/21/2023
Malus spp	STARLIGHT CRABAPPLE	6/21/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	6/21/2023
Celti oc	HACKBERRY	6/21/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	6/21/2023
Fraxinus sp	ASH GREEN	4/5/2023
Syrin re	IVORY SILK TREE LILAC	6/21/2023
Acer spp	UNITY SUGAR MAPLE	6/29/2023
Ulmus sp	TRIUMPH ELM	6/29/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	6/29/2023
Malus spp	GLADIATOR CRABAPPLE	6/29/2023
Syrin re	IVORY SILK TREE LILAC	6/29/2023
Quercus spp	BURR OAK	6/29/2023
Syrin re	IVORY SILK TREE LILAC	6/29/2023
Quercus spp	RED OAK	6/29/2023
Malus spp	GLADIATOR CRABAPPLE	6/29/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	6/30/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Malus spp	STARLIGHT CRABAPPLE	6/30/2023
Acer spp	UNITY SUGAR MAPLE	6/30/2023
Acer spp	UNITY SUGAR MAPLE	6/30/2023
Acer spp	UNITY SUGAR MAPLE	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Quercus spp	RED OAK	6/30/2023
Acer spp	UNITY SUGAR MAPLE	6/30/2023
Malus spp	GLADIATOR CRABAPPLE	6/30/2023
Malus spp	STARLIGHT CRABAPPLE	6/30/2023
Malus spp	GLADIATOR CRABAPPLE	6/30/2023
Malus spp	STARLIGHT CRABAPPLE	6/30/2023

Acer spp	UNITY SUGAR MAPLE	6/30/2023
Populus spp	SUNDANCE POPLAR	6/30/2023
Malus spp	STARLIGHT CRABAPPLE	6/30/2023
Quercus spp	RED OAK	6/30/2023
Quercus spp	BURR OAK	6/30/2023
Quercus spp	BURR OAK	6/30/2023
Ulmus sp	TRIUMPH ELM	6/9/2023
Quercus spp	RED OAK	7/6/2023
Quercus spp	BURR OAK	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Quercus spp	RED OAK	7/6/2023
Quercus spp	RED OAK	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Syrin re	IVORY SILK TREE LILAC	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Quercus spp	BURR OAK	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/6/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/6/2023
Malus spp	GLADIATOR CRABAPPLE	7/6/2023
Tilia spp	AMERICAN LINDEN	7/6/2023
Malus spp	GLADIATOR CRABAPPLE	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/6/2023
Tilia spp	AMERICAN LINDEN	7/6/2023
Acer spp	FREEMAN MAPLE	7/6/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Acer spp	SILVER CLOUD MAPLE	7/6/2023
Malus spp	GLADIATOR CRABAPPLE	7/11/2023
Syrin re	IVORY SILK TREE LILAC	7/11/2023
Malus spp	UNKNOWN SPECIES	7/11/2023
Malus spp	STARLITE CRABAPPLE	7/11/2023
Acer spp	SILVER CLOUD MAPLE	7/11/2023
Malus spp	GLADIATOR CRABAPPLE	7/11/2023
Celti oc	COMMON HACKBERRY	7/11/2023
Ulmus sp	TRIUMPH ELM	7/6/2023
Malus spp	STARLIGHT CRABAPPLE	7/17/2023
Malus spp	GLADIATOR CRABAPPLE	7/17/2023
Malus spp	STARLITE CRABAPPLE	7/17/2023
Malus spp	STARLIGHT CRABAPPLE	7/18/2023

Sorbus spp	RUSSIAN MOUNTAIN ASH	7/18/2023
Malus spp	STARLIGHT CRABAPPLE	7/18/2023
Malus spp	GLADIATOR CRABAPPLE	7/18/2023
Malus spp	STARLIGHT CRABAPPLE	7/18/2023
Quercus spp	BURR OAK	7/18/2023
Ulmus sp	TRIUMPH ELM	7/18/2023
Tilia spp	DROPMORE LINDEN	7/18/2023
Malus spp	GLADIATOR CRABAPPLE	7/17/2023
Acer spp	SILVER CLOUD MAPLE	7/18/2023
Syrin re	IVORY SILK TREE LILAC	7/19/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/19/2023
Malus spp	STARLIGHT CRABAPPLE	7/19/2023
Ulmus sp	TRIUMPH ELM	7/19/2023
Malus spp	STARLIGHT CRABAPPLE	7/19/2023
Amela sp	SERVICE BERRY	7/19/2023
Ulmus sp	TRIUMPH ELM	7/24/2023
Acer spp	UNITY SUGAR MAPLE	7/24/2023
Tilia spp	DROPMORE LINDEN	7/24/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/24/2023
Celti oc	COMMON HACKBERRY	7/24/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/24/2023
Syrin re	IVORY SILK TREE LILAC	7/24/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/24/2023
Tilia spp	AMERICAN LINDEN	7/24/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/24/2023
Malus spp	STARLIGHT CRABAPPLE	7/24/2023
Acer spp	SILVER CLOUD MAPLE	7/24/2023
Tilia spp	AMERICAN LINDEN	7/24/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/24/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/24/2023
Acer spp	SILVER CLOUD MAPLE	7/24/2023
Tilia spp	DROP MORE LINDEN	7/24/2023
Acer spp	UNITY SUGAR MAPLE	7/24/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/24/2023
Tilia spp	AMERICAN LINDEN	7/24/2023
Acer spp	FREEMAN MAPLE	7/31/2023
Populus spp	CAROLINA POPLAR	7/31/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	7/31/2023
Malus spp	GLADIATOR CRABAPPLE	7/31/2023
Malus spp	STARLITE CRABAPPLE	7/31/2023

Malus spp	STARLITE CRABAPPLE	7/31/2023
Malus spp	GLADIATOR CRABAPPLE	7/31/2023
Ulmus sp	TRIUMPH ELM	7/31/2023
Tilia spp	DROP MORE LINDEN	7/31/2023
Acer spp	SILVER CLOUD MAPLE	7/31/2023
Tilia spp	DROP MORE LINDEN	7/31/2023
Syrin re	IVORY SILK TREE LILAC	7/31/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/1/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/1/2023
Malus spp	STARLITE CRABAPPLE	8/1/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/1/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/1/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/1/2023
Malus spp	GLADIATOR CRABAPPLE	8/1/2023
Tilia spp	AMERICAN LINDEN	8/1/2023
Syrin re	IVORY SILK TREE LILAC	8/1/2023
Viburnum sp	NANNYBERRY VIBURNUM	8/1/2023
Tilia spp	AMERICAN LINDEN	8/1/2023
Malus spp	GLADIATOR CRABAPPLE	8/1/2023
Malus spp	GLADIATOR CRABAPPLE	8/1/2023
Malus spp	GLADIATOR CRABAPPLE	8/1/2023
Syrin re	IVORY SILK TREE LILAC	8/1/2023
Syrin re	IVORY SILK TREE LILAC	8/1/2023
Acer spp	UNITY SUGAR MAPLE	8/1/2023
Malus spp	STARLITE CRABAPPLE	8/1/2023
Malus spp	STARLITE CRABAPPLE	8/1/2023
Acer spp	UNITY SUGAR MAPLE	8/1/2023
Malus spp	STARLITE CRABAPPLE	8/1/2023
Fraxinus sp	UNKNOWN SPECIES	8/2/2023
Fraxinus sp	UNKNOWN SPECIES	8/2/2023
Fraxinus sp	UNKNOWN SPECIES	8/2/2023
Ulmus sp	UNKNOWN SPECIES	8/2/2023
Tilia spp	AMERICAN LINDEN	8/3/2023
Populus spp	CAROLINA POPLAR	8/3/2023
Malus spp	GLADIATOR CRABAPPLE	8/3/2023
Malus spp	STARLITE CRABAPPLE	8/3/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/3/2023
Acer spp	SILVER CLOUD MAPLE	8/3/2023
Ulmus sp	TRIUMPH ELM	8/3/2023
Malus spp	GLADIATOR CRABAPPLE	8/3/2023

Malus spp	STARLITE CRABAPPLE	8/3/2023
Malus spp	GLADIATOR CRABAPPLE	8/3/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/3/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/3/2023
Viburnum sp	NANNYBERRY VIBURNUM	8/3/2023
Amela sp	SERVICE BERRY	8/3/2023
Syrin re	IVORY SILK TREE LILAC	8/3/2023
Acer spp	SILVER CLOUD MAPLE	8/3/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/3/2023
Tilia spp	DROP MORE LINDEN	7/24/2023
Acer spp	UNITY SUGAR MAPLE	7/24/2023
Tilia spp	AMERICAN LINDEN	7/31/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	7/31/2023
Tilia spp	DROP MORE LINDEN	8/8/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/8/2023
Malus spp	GLADIATOR CRABAPPLE	8/8/2023
Malus spp	STARLITE CRABAPPLE	8/8/2023
Acer spp	SILVER CLOUD MAPLE	8/8/2023
Tilia spp	DROP MORE LINDEN	8/8/2023
Malus spp	GLADIATOR CRAB	8/8/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/8/2023
Malus spp	STARLITE CRABAPPLE	8/8/2023
Acer spp	SILVER CLOUD MAPLE	8/8/2023
Tilia spp	AMERICAN LINDEN	8/8/2023
Tilia spp	AMERICAN LINDEN	8/8/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/8/2023
Tilia spp	AMERICAN LINDEN	8/8/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/8/2023
Tilia spp	AMERICAN LINDEN	8/8/2023
Malus spp	GLADIATOR CRABAPPLE	8/8/2023
Malus spp	STARLITE CRABAPPLE	8/8/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/8/2023
Crata sp	SNOWBIRD HAWTHORN	8/8/2023
Tilia spp	DROP MORE LINDEN	8/8/2023
Acer spp	FREEMAN MAPLE	8/8/2023
Malus spp	GLADIATOR CRABAPPLE	8/8/2023
Tilia spp	DROP MORE LINDEN	8/9/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/9/2023
Tilia spp	DROP MORE LINDEN	8/9/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/9/2023

Viburnum sp	NANNYBERRY VIBURNUM	8/9/2023
Quercus spp	BURR OAK	8/9/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/9/2023
Syrin re	IVORY SILK TREE LILAC	8/9/2023
Acer spp	SILVER CLOUD MAPLE	8/9/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/9/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/9/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/9/2023
Tilia spp	AMERICAN LINDEN	8/9/2023
Viburnum sp	NANNYBERRY VIBURNUM	8/9/2023
Acer spp	SILVER CLOUD MAPLE	8/9/2023
Tilia spp	DROPMORE LINDEN	8/9/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/9/2023
Acer spp	UNITY SUGAR MAPLE	8/9/2023
Malus spp	GLADIATOR CRABAPPLE	8/9/2023
Tilia spp	DROPMORE LINDEN	8/9/2023
Acer spp	FREEMAN MAPLE	8/9/2023
Acer spp	SILVER CLOUD MAPLE	8/9/2023
Tilia spp	AMERICAN LINDEN	8/9/2023
Quercus spp	BURR OAK	8/9/2023
Ulmus sp	TRIUMPH ELM	8/9/2023
Acer spp	SILVER CLOUD MAPLE	8/9/2023
Celti oc	HACKBERRY	8/9/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/9/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/10/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/10/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/10/2023
Viburnum sp	NANNYBERRY VIBURNUM	8/10/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/10/2023
Acer spp	SILVER CLOUD MAPLE	8/10/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/10/2023
Acer spp	UNITY SUGAR MAPLE	8/10/2023
Malus spp	STARLITE CRABAPPLE	8/10/2023
Tilia spp	AMERICAN LINDEN	8/10/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/10/2023
Malus spp	GLADIATOR CRABAPPLE	8/10/2023
Malus spp	GLADIATOR CRABAPPLE	8/10/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/10/2023
Quercus spp	RED OAK	8/10/2023
Populus spp	CAROLINA POPLAR	8/10/2023

Quercus spp	BURR OAK	8/10/2023
Quercus spp	RED OAK	8/10/2023
Populus spp	CAROLINA POPLAR	8/10/2023
Quercus spp	BURR OAK	8/10/2023
Malus spp	GLADIATOR CRABAPPLE	8/10/2023
Malus spp	STARLITE CRABAPPLE	8/10/2023
Malus spp	GLADIATOR CRABAPPLE	8/10/2023
Tilia spp	AMERICAN LINDEN	8/10/2023
Populus spp	CAROLINA POPLAR	8/10/2023
Fraxinus sp	UNKNOWN SPECIES	8/11/2023
Fraxinus sp	UNKNOWN SPECIES	8/11/2023
Fraxinus sp	UNKNOWN SPECIES	8/11/2023
Fraxinus sp	UNKNOWN SPECIES	8/11/2023
Celti oc	HACKBERRY	8/14/2023
Acer spp	SILVER CLOUD MAPLE	8/14/2023
Acer spp	SILVER CLOUD MAPLE	8/14/2023
Celti oc	HACKBERRY	8/14/2023
Malus spp	GLADIATOR CRABAPPLE	8/14/2023
Malus spp	STARLITE CRABAPPLE	8/14/2023
Malus spp	GLADIATOR CRABAPPLE	8/14/2023
Tilia spp	DROP MORE LINDEN	8/14/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/14/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/14/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/14/2023
Malus spp	GLADIATOR CRABAPPLE	8/14/2023
Malus spp	STARLITE CRABAPPLE	8/14/2023
Malus spp	GLADIATOR CRABAPPLE	8/14/2023
Acer spp	SILVER CLOUD MAPLE	8/14/2023
Malus spp	STARLITE CRABAPPLE	8/14/2023
Amela sp	SERVICEBERRY	8/14/2023
Malus spp	GLADIATOR CRABAPPLE	8/14/2023
Tilia spp	DROPMORE LINDEN	8/14/2023
Syrin re	IVORY SILK TREE LILAC	8/14/2023
Syrin re	IVORY SILK TREE LILAC	8/14/2023
Tilia spp	AMERICAN LINDEN	8/14/2023
Acer spp	FREEMAN MAPLE	8/14/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/14/2023
Crata sp	SNOWBIRD HAWTHORN	8/14/2023
Fraxinus sp	UNKNOWN SPECIES	8/15/2023
Populus spp	CAROLINA POPLAR	8/15/2023

Populus spp	CAROLINA POPLAR	8/15/2023
Populus spp	SUNDANCE POPLAR	8/15/2023
Populus spp	CAROLINA POPLAR	8/15/2023
Populus spp	CAROLINA POPLAR	8/15/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/15/2023
Celti oc	COMMON HACKBERRY	8/15/2023
Celti oc	COMMON HACKBERRY	8/15/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/15/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/15/2023
Viburnum sp	NANNY BERRY	8/15/2023
Crata sp	THORNLESS COCKSPUR HAWTHORN	8/15/2023
Aesculus sp	OHIO BUCKEYE	8/15/2023
Celti oc	HACKBERRY	8/15/2023
Aesculus sp	OHIO BUCKEYE	8/15/2023
Aesculus sp	OHIO BUCKEYE	8/15/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/16/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/16/2023
Syrin re	IVORY SILK TREE LILAC	8/16/2023
Syrin re	IVORY SILK TREE LILAC	8/16/2023
Tilia spp	DROPMORE LINDEN	8/17/2023
Acer spp	FREEMAN MAPLE	8/17/2023
Acer spp	UNITY SUGAR MAPLE	8/17/2023
Acer spp	SILVER CLOUD MAPLE	8/17/2023
Syrin re	IVORY SILK TREE LILAC	8/17/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/17/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/17/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/17/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/17/2023
Malus spp	STARLITE CRABAPPLE	8/17/2023
Tilia spp	AMERICAN LINDEN	8/17/2023
Malus spp	GLADIATOR CRABAPPLE	8/17/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/17/2023
Acer spp	SILVER CLOUD MAPLE	8/17/2023
Populus spp	CAROLINA POPLAR	8/15/2023
Acer spp	SILVER CLOUD MAPLE	8/17/2023
Populus spp	EASTERN COTTONWOOD	8/22/2023
Tilia spp	DROPMORE LINDEN	8/22/2023
Acer spp	SILVER CLOUD MAPLE	8/22/2023
Quercus spp	BURR OAK	8/22/2023
Populus spp	EASTERN COTTONWOOD	8/22/2023

Malus spp	GLADIATOR CRABAPPLE	8/22/2023
Tilia spp	AMERICAN LINDEN	8/22/2023
Quercus spp	RED OAK	8/22/2023
Ulmus sp	TRIUMPH ELM	8/22/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/22/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/10/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/21/2023
Ulmus sp	TRIUMPH ELM	8/21/2023
Acer spp	UNITY SUGAR MAPLE	8/21/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/21/2023
Acer spp	SILVER CLOUD MAPLE	8/21/2023
Ulmus sp	TRIUMPH ELM	8/21/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/21/2023
Acer spp	SILVER CLOUD MAPLE	8/21/2023
Tilia spp	DROPMORE LINDEN	8/21/2023
Ulmus sp	TRIUMPH ELM	8/21/2023
Acer spp	SILVER CLOUD MAPLE	8/21/2023
Ulmus sp	TRIUMPH ELM	8/22/2023
Acer spp	UNITY SUGAR MAPLE	8/22/2023
Acer spp	SILVER CLOUD MAPLE	8/22/2023
Tilia spp	DROPMORE LINDEN	8/22/2023
Tilia spp	AMERICAN LINDEN	8/22/2023
Acer spp	UNITY SUGAR MAPLE	8/22/2023
Acer spp	SILVER CLOUD MAPLE	8/22/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/22/2023
Malus spp	STARLIGHT CRABAPPLE	8/22/2023
Malus spp	GLADIATOR CRABAPPLE	8/22/2023
Quercus spp	RED OAK	8/22/2023
Malus spp	GLADIATOR CRABAPPLE	8/22/2023
Malus spp	GLADIATOR CRABAPPLE	8/22/2023
Quercus spp	BURR OAK	8/22/2023
Malus spp	GLADIATOR CRABAPPLE	8/22/2023
Malus spp	STARLIGHT CRABAPPLE	8/22/2023
Quercus spp	RED OAK	8/22/2023
Malus spp	STARLIGHT CRABAPPLE	8/22/2023
Crata sp	SNOWBIRD HAWTHORN	8/22/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/22/2023
Populus spp	EASTERN COTTONWOOD	8/22/2023
Populus spp	EASTERN COTTONWOOD	8/22/2023
Quercus spp	BURR OAK	8/23/2023

Syrin re	IVORY SILK TREE LILAC	8/23/2023
Quercus spp	IVORY SILK TREE LILAC	8/23/2023
Viburnum sp	NANNYBERRY VIBURNUM	8/23/2023
Syrin re	IVORY SILK TREE LILAC	8/23/2023
Acer spp	UNITY SUGAR MAPLE	8/23/2023
Quercus spp	RED OAK	8/23/2023
Syrin re	IVORY SILK TREE LILAC	8/23/2023
Acer spp	UNITY SUGAR MAPLE	8/23/2023
Syrin re	IVORY SILK TREE LILAC	8/23/2023
Celti oc	HACKBERRY	8/23/2023
Acer spp	UNITY SUGAR MAPLE	8/23/2023
Quercus spp	BURR OAK	8/23/2023
Syrin re	UNKNOWN SPECIES	8/23/2023
Ulmus sp	TRIUMPH ELM	8/22/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/22/2023
Syrin re	IVORY SILK TREE LILAC	8/23/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/24/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/24/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/24/2023
Crata sp	SNOWBIRD HAWTHORN	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Ulmus sp	TRIUMPH ELM	8/24/2023
Ulmus sp	TRIUMPH ELM	8/24/2023
Malus spp	GLADIATOR CRABAPPLE	8/24/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/24/2023
Malus spp	STARLITE CRABAPPLE	8/24/2023
Malus spp	GLADIATOR CRABAPPLE	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Malus spp	GLADIATOR CRABAPPLE	8/24/2023
Malus spp	STARLITE CRABAPPLE	8/24/2023
Tilia spp	AMERICAN LINDEN	8/24/2023
Malus spp	STARLITE CRABAPPLE	8/24/2023
Celti oc	HACKBERRY	8/24/2023
Populus spp	EASTERN COTTONWOOD	8/24/2023
Malus spp	STARLITE CRABAPPLE	8/24/2023

Malus spp	GLADIATOR CRABAPPLE	8/24/2023
Tilia spp	DROPMORE LINDEN	8/28/2023
Malus spp	STARLIGHT CRABAPPLE	8/28/2023
Malus spp	STARLIGHT CRABAPPLE	8/28/2023
Tilia spp	AMERICAN LINDEN	8/28/2023
Tilia spp	AMERICAN LINDEN	8/28/2023
Acer spp	MAPLE SILVER CLOUD	8/28/2023
Tilia spp	DROPMORE LINDEN	8/28/2023
Tilia spp	DROPMORE LINDEN	8/28/2023
Aesculus sp	OHIO BUCKEYE	8/28/2023
Populus spp	EASTERN COTTONWOOD	8/28/2023
Sorbus spp	MOUNTAIN ASH	8/28/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/28/2023
Malus spp	STARLIGHT CRABAPPLE	8/28/2023
Malus spp	GLADIATOR CRABAPPLE	8/28/2023
Malus spp	STARLIGHT CRABAPPLE	8/28/2023
Amela sp	SERVICEBERRY	8/28/2023
Acer spp	UNITY SUGAR MAPLE	8/28/2023
Syrin re	IVORY SILK LILAC	8/28/2023
Celti oc	COMMON HACKBERRY	8/28/2023
Aesculus sp	OHIO BUCKEYE	8/28/2023
Aesculus sp	OHIO BUCKEYE	8/28/2023
Aesculus sp	OHIO BUCKEYE	8/28/2023
Aesculus sp	OHIO BUCKEYE	8/28/2023
Ulmus sp	ELM PRAIRIE EXPEDITION	8/28/2023
Ulmus sp	TRIUMPH ELM	8/28/2023
Ulmus sp	ELM PRAIRIE EXPEDITION	8/28/2023
Malus spp	GLADIATOR CRABAPPLE	8/28/2023
Malus spp	STARLIGHT CRABAPPLE	8/28/2023
Malus spp	GLADIATOR CRABAPPLE	8/28/2023
Malus spp	STARLIGHT CRABAPPLE	8/28/2023
Acer spp	SILVER CLOUD MAPLE	8/28/2023
Acer spp	UNITY SUGAR MAPLE	8/28/2023
Ulmus sp	ELM PRAIRIE EXPEDITION	8/28/2023
Syrin re	IVORY SILK LILAC	8/28/2023
Sorbus spp	MOUNTAIN ASH	8/28/2023
Sorbus spp	MOUNTAIN ASH	8/28/2023
Syrin re	IVORY SILK LILAC	8/28/2023
Ulmus sp	ELM PRAIRIE EXPEDITION	8/28/2023
Acer spp	SILVER CLOUD MAPLE	8/28/2023

Quercus spp	BUR OAK	8/28/2023
Malus spp	GLADIATOR CRABAPPLE	8/30/2023
Malus spp	STARLIGHT CRABAPPLE	8/30/2023
Syrin re	IVORY SILK LILAC	8/30/2023
Populus spp	EASTERN COTTONWOOD	8/30/2023
Quercus spp	RED OAK	8/30/2023
Quercus spp	BUR OAK	8/30/2023
Quercus spp	BUR OAK	8/30/2023
Quercus spp	RED OAK	8/30/2023
Tilia spp	DROPMORE LINDEN	8/30/2023
Syrin re	IVORY SILK LILAC	8/30/2023
Acer spp	SILVER CLOUD MAPLE	8/30/2023
Crata sp	SNOWBIRD HAWTHORN	8/30/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/30/2023
Syrin re	IVORY SILK LILAC	8/30/2023
Tilia spp	AMERICAN LINDEN	8/30/2023
Malus spp	STARLIGHT CRABAPPLE	8/30/2023
Malus spp	GLADIATOR CRABAPPLE	8/30/2023
Malus spp	STARLIGHT CRABAPPLE	8/30/2023
Acer spp	UNITY SUGAR MAPLE	8/30/2023
Malus spp	STARLIGHT CRABAPPLE	8/30/2023
Acer spp	SILVER CLOUD MAPLE	8/30/2023
Ulmus sp	PRAIRIE EXPEDITION ELM	8/30/2023
Tilia spp	AMERICAN LINDEN	8/30/2023
Malus spp	STARLIGHT CRABAPPLE	8/30/2023
Acer spp	UNITY SUGAR MAPLE	8/30/2023
Malus spp	GLADIATOR CRABAPPLE	8/30/2023
Ulmus sp	TRIUMPH ELM	8/30/2023
Quercus spp	RED OAK	8/30/2023
Syrin re	IVORY SILK LILAC	8/30/2023
Quercus spp	BUR OAK	8/30/2023
Malus spp	STARLIGHT CRABAPPLE	8/30/2023
Sorbus spp	RUSSIAN MOUNTAIN ASH	8/30/2023
Acer spp	SILVER CLOUD MAPLE	8/30/2023
Malus spp	STARLIGHT CRABAPPLE	8/30/2023
Malus spp	GLADIATOR CRABAPPLE	8/30/2023
Quercus spp	BUR OAK	8/30/2023
Amela sp	SERVICEBERRY	8/30/2023
Acer spp	UNITY SUGAR MAPLE	8/30/2023
Malus spp	GLADIATOR CRABAPPLE	8/30/2023

Ulmus sp	PRAIRIE EXPEDITION ELM	8/30/2023
Sorbus spp	MOUNTAIN ASH	8/28/2023
Tilia spp	AMERICAN LINDEN	8/28/2023
Aesculus sp	OHIO BUCKEYE	8/28/2023
Crata sp	SNOWBIRD HAWTHORN	8/28/2023
Acer spp	UNITY SUGAR MAPLE	8/28/2023
Celti oc	COMMON HACKBERRY	8/28/2023
Amela sp	SERVICEBERRY	8/28/2023
Ulmus sp	ELM TRIUMPH	8/28/2023
Quercus spp	BUR OAK	8/28/2023
Quercus spp	RED OAK	8/28/2023
Quercus spp	RED OAK	8/28/2023
Quercus spp	RED OAK	8/28/2023
Quercus spp	RED OAK	8/28/2023
Quercus spp	BUR OAK	8/28/2023
Malus spp	STARLITE CRABAPPLE	8/28/2023
Acer spp	SILVER CLOUD MAPLE	8/28/2023
Populus spp	EASTERN COTTONWOOD	8/28/2023
Populus spp	EASTERN COTTONWOOD	8/28/2023
Sorbus spp	MOUNTAIN ASH	8/28/2023
Celti oc	COMMON HACKBERRY	8/28/2023
Populus spp	EASTERN COTTONWOOD	8/28/2023
Acer spp	SILVER CLOUD MAPLE	8/30/2023
Amela sp	SERVICEBERRY	8/30/2023
Malus spp	GLADIATOR CRABAPPLE	8/30/2023
Tilia spp	AMERICAN LINDEN	8/30/2023
Ulmus sp	TRIUMPH ELM	8/30/2023
Fraxinus sp	ASH	9/7/2023
Fraxinus sp	GREEN ASH	9/20/2023