Community Forest Management Plan
Village of Saranac Lake

2022

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ArborPro
URBAN FOREST MANAGEMENT

ArborPro Management Software

In 2019 the Village of Saranac Lake applied for and was awarded a grant to conduct a tree inventory and create a tree management plan from the Department of Environmental Conservation Division of Lands and Forests' Urban and Community Forestry Program. The Urban and Community Forestry Program works to increase public awareness of the importance of trees and help communities develop and implement comprehensive tree management plans to create healthy forests while enhancing quality of life".

The Village would like to thank all the various people and departments involved in putting together the information to secure the grant for the project.

Tree Committee Members

Stephen Langdon
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Village Board Members

Clyde Rabideau, Mayor
Kelly Brunette, Trustee
Tom Catillaz, Trustee
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NEW YORK STATE | Department of Environmental Conservation

THE VILLAGE OF SARANAC LAKE
THE CAPITAL OF THE ADIRONDACKS

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Community Profile

The Village of Saranac Lake is 2.78 square miles in size and with a population of 5,400 year-round residents it is the largest community in the Adirondacks. The village has a distinct urban core positioned within one of the largest and most ecologically intact regions of temperate northern hardwood forests around the globe. Urban tree management plans in Adirondack communities must therefore be compatible with regional forest resources that enhance economic and aesthetic values. Several community plans recognize the value of maintaining and enhancing the community forest and the recently awarded Downtown Revitalization Initiative will provide funding to increase the number of street trees within the downtown. An Urban Forest Management Plan for the Village was completed in 1999, however the inventory has changed a great deal and many of the management goals and actions require updating. A number of trees, especially street trees, are in poor health. Village staff have struggled to maintain trees and identify suitable species to plant in an urban setting with harsh winters that require the use of sand and salt on roads and sidewalks. In an effort to address some of these concerns the Village established a Tree Committee in 2019. Members of the Tree Committee include volunteers with a background in forestry who are able to assist the Village in identifying tree maintenance needs and prioritizing projects. This was one of the actions that led to the Village being recognized as a Tree City USA. These initiatives also helped Saranac Lake become a Bronze Certified Climate Smart Community. The combination of these factors prompted the Village to apply for, and subsequently receive, a 2019 Urban and Community Forestry Grant to complete a tree inventory and community forest management plan.

The overall goal of the project is to determine the types, quantities, location and health of the community forest, and to develop a management plan that will assist the Village in expanding its urban forest, addressing forest health issues and threats, creating an action plan for maintenance of the forest, and to secure community involvement in protecting and enhancing the village's forest resources.

This Community Forest Management Plan will directly benefit the people that use the village parks and spend time in the downtown, which includes both residents and visitors. The parks and downtown streets draw people for a variety of events, including the largest Farmers Market in the Adirondacks, a weekly summer concert series, fun runs, summer Art Walks, several parades throughout the year, and an array of Winter Carnival events. There will also be overall community benefits that will result from assessing the health of the community's trees, increasing the tree canopy, diversifying the tree species, and better maintaining the community forest. Better air quality benefits everyone, as does reducing the heat index, providing relief from humidity, sequestering carbon (a key goal for the Climate Smart Communities initiative), reducing noise, filtering storm water, increasing property values, making streets more walkable, and visually enhancing our streets and parks.

Saranac Lake has worked closely with the urban forestry consulting group, ArborPro Inc., and community leaders in the forestry community that make up the Village Tree Committee, to complete a tree inventory for the downtown streetscape, all village parks, and the village's recreational ski hill, and then draft a comprehensive community forest management plan. The plan helps to accurately identify management needs, step up invasive species preparedness and response planning, and look at overall community health as it relates to tree type and condition. The scope of the plan is limited to the trees located within village parks and tree lawns, but there are many more trees on village-owned forested lands around Mt. Pisgah, the wastewater treatment facility and reserve water tank. The combined area of these lands is over 300 acres, most of which is forested. That means the environmental benefits of trees reported in this plan is significantly understated since the calculations only considered the 523 trees that were included in the inventory.

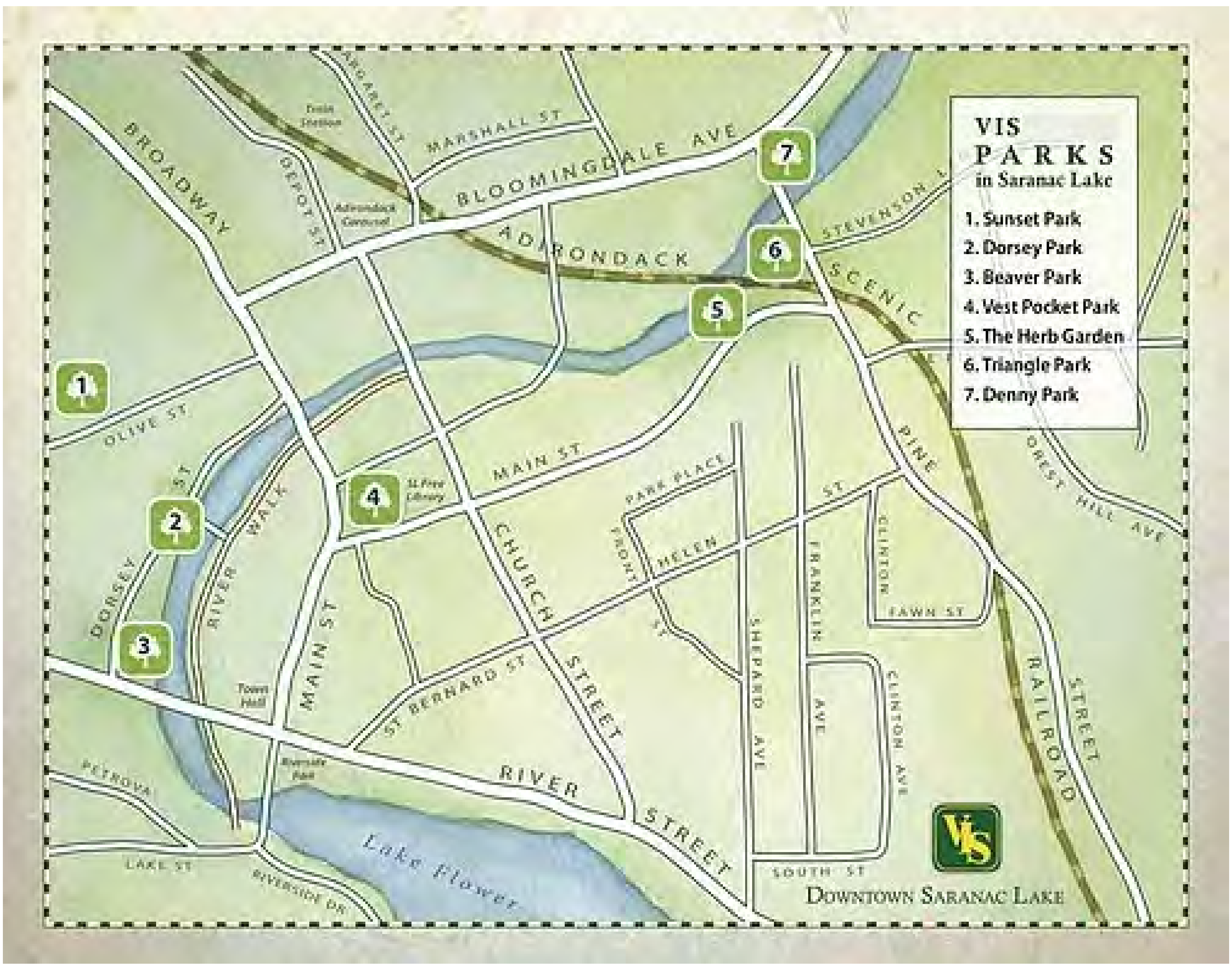
Saranac Lake is a small community with lots of big plans. The key to implementing most of these plans has been and continues to be an engaged community. The capacity of the Village is greatly expanded through volunteers and implementation of this plan will depend on the continued involvement of dedicated community members, especially the members of the Tree Committee. Other key partners include the staff and students in forestry programs, including the BOCES Natural Resources Science Program who have provided general tree maintenance and several special projects as well as staff and students from the Paul Smiths' College Forestry program who most recently provided tree services along the Riverwalk. Additional support comes from the Parks and Trails Advisory Board, Downtown Advisory Board, and Village Improvement Society. All of these partners will help the Village achieve the lofty goals of this plan, which include bolstering the quality of life for all residents, improving streetscape aesthetics, creating more shade for walking, improving soil health and air quality, and mitigating the impacts of climate change.

BOCES Partnership

The Village of Saranac Lake and the BOCES Natural Resources Science Program have had a long-term partnership that began around 2002. The Natural Resources students needed a space to practice skills. The large tract of mostly forested land around the village's wastewater treatment plant happens to be located across the street from the Adirondack Educational Center where the students attend class. The Village agreed to allow the students and staff to use these lands as a training area for students to practice land management and other skills needed to earn multiple safety certifications. The partnership eventually evolved to where students do projects on other village-owned lands. Recent projects have included tree and trail maintenance at Mt. Pisgah Recreation Center, clearing of land around the wastewater treatment plant for a new sand mine/gravel pit, and tree clearing for a new structure behind the DPW garage.

BOCES student Wyatt Martin practicing skills on forested lands adjacent to the village wastewater treatment plant.

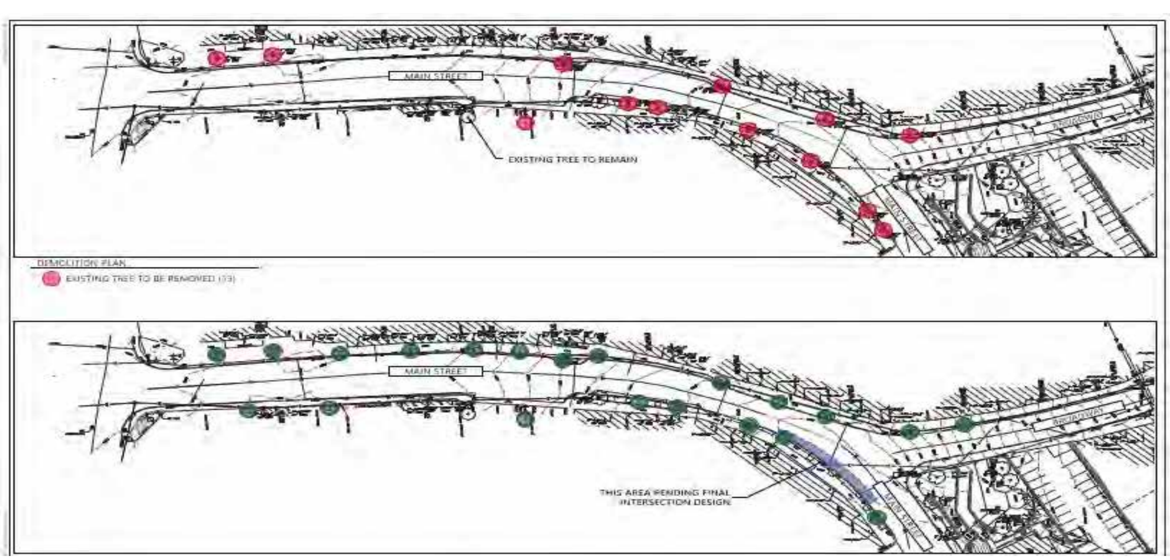
Village Improvement Society Parks In 1907, the newly formed Village Board of Trade, a precursor to the Chamber of Commerce, hired the Olmsted Brothers, of New York's Central Park fame, to draft a plan for a Saranac Lake Park system, but in 1909 the village board rejected the plan for being too expensive. On April 10, 1910, a group of local women formed the Village Improvement Society (VIS) to promote and initiate the park aspect of the "Olmsted Plan." The Olmsted Plan was originally drafted in an attempt to plan for the rapidly sprouting turn of the century community and to preserve the unique elements of the lake and river in Saranac Lake. The VIS continues this work today with a number of parks under their ownership and other parks deeded to the village but under their care. Parks under VIS ownership includes Beaver Park, Denny Park, Dorsey Street Park, Sunset Park & Arboretum, Triangle Park/Herb Garden, and Vest Pocket Park.



Downtown Revitalization Projects

The Village of Saranac Lake was awarded $4.3 million through the NYS Downtown Revitalization Initiative (DRI) to implement seven public projects throughout the downtown area. Several of the planned projects involve planting new trees with an emphasis on native species and removing damaged trees. The DRI projects are all expected to be complete by 2024.

- *Broadway and Main Urban Forestry Project*. The Broadway and Main Street corridors serve as the principal retail corridors within the village but lack presence of resilient street trees. Over the years the trees that have been installed have not thrived due to the absence of root space and nutrients. The existing sidewalk will be removed, and new structural soil will be installed below the sidewalk to allow for expanded root growth. The new trees will be surrounded by porous material that will provide a maintenance-free traversable surface that allows for water and nutrients to feed the tree. The project involves removing 13 trees and planting 21 new trees.
- *Church Street Streetscape Improvements*. Landscape improvements include the installation of street trees to create a continuous natural viewshed within the downtown. Up to 11 trees will be planted along the back side of the sidewalks from Bloomingdale Avenue to Woodruff Street. The addition of trees in the Church Street and Broadway/Main Street corridors will create a consistent urban tree canopy in downtown and expand the variety of street trees.
- *Ward Plumadore Park*. The improvements will transform the space by creating two plazas and providing foundations for new public art installations. The landscaping will be redesigned around the new plazas. Several trees will be removed during construction of the plazas but many new trees, shrubs and grasses will be planted.
- *William Morris Park*. The entrance of the park will be redesigned. Several trees will be removed so accommodate the new amenities, but most of those existing trees are in conflict with overhead utilities and susceptible to mortality from invasive insects. The trees will be replaced with new varieties that have a shorter maximum height and therefore are less likely to be in conflict with utilities.



Proposed tree locations

Executive Summary

ArborPro, Inc. developed this plan for the Village of Saranac Lake, New York with a focus on the current and future maintenance needs of trees inventoried in the summer of 2021. ArborPro completed the tree inventory to better understand the current state of the urban forest and to create a framework for future tree care and maintenance planning. This Tree Management Plan was developed by analyzing tree inventory data in relation to the Village's current and future urban forestry goals. In addition to maintenance and planning needs, this report addresses the economic, environmental, and social benefits that trees provide to the Village of Saranac Lake.

Please keep in mind that the tree inventory and management plan are limited to trees in parks owned by the Village and trees in Village right of ways.

Significant Findings from the Inventory

The Summer 2021 tree inventory included trees and stumps and vacant planting sites at the assigned locations. A total of 711 sites were recorded during the inventory which included 523 trees (73.8%), 50 stumps & snags (tall stump) (6.8%), and 138 vacant sites (19.4%).

The three most common species found in Saranac Lake are: American arborvitae (91 trees: 12.8%); green ash (65 trees: 9.14); and paper birch (43 trees: 6.0%).

1. The three most common young trees under 6" Diameter at Breast Height[1] (DBH) are: American arborvitae (91 trees); green ash (65 trees); and paper birch (43 trees).
2. The three most common mature trees (over 20" DBH) are: white pine (5 trees), green ash (4 trees) and sugar maple (4 trees).
3. A total of 49 distinct species of trees were recorded during the inventory.
4. 67.0% of Saranac Lake's tree population is in "fair" or better condition.
5. Trees provide approximately $1,500 in annual environmental benefits.
6. Environmental Benefits of the 523 trees inventoried,
    - Pollution Removal 125.2 pounds per year ($662.00/year).
    - Stormwater interception: valued at 8,000 cubic feet/year ($540.00/year).
    - Carbon sequestration: valued at 1.6 tons/year (280.00/year).
    - Oxygen Production: 4.3 tons/year.
    - Carbon Storage 7,500 tons ($12,8000).
7. Total replacement cost for all trees is $466,000.
8. The Village's juvenile tree class (DBH <6") accounts for 42% of the urban forest and is in line with the goal of achieving an ideal target of 40% juvenile trees.

[1] Commonly shortened to DBH the tree diameter is measured 54" above grade.

Tree Maintenance Needs

Maintenance recommendations recorded during the tree inventory were removal (4.0%), pruning (69.8%), stump removal (6.8%), and planting (19.4%).

While tree maintenance can be very costly and time consuming, the benefits that trees provide justify the expense. Proper pruning and regular maintenance help ensure that trees are providing maximum benefits throughout their life span. In addition to maximizing benefits, regular maintenance mitigates tree-related risk by removing hazardous limbs; reducing future storm damage clean-up; removing limb conflicts on sidewalks and roadways; improving the overall appearance of urban trees; and promoting proper growth patterns in young trees. Trees in the Priority 1 removal and Priority 1 prune category should be addressed first to properly mitigate risk and prioritize maintenance. After all Priority 1 maintenance has been completed, the Priority 2 prunes and removals should be addressed.

As part of the risk rating 6 trees were identified as being "high" risk and as such have been recommended for Priority 1 pruning (3 trees) or Priority 1 removal (3 trees). These should be pruned or removed as soon as possible to mitigate the risk.

Riverside Park

In addition to high priority maintenance and risk mitigation, the Village of Saranac Lake would greatly benefit from a routine pruning cycle. The length of this cycle will vary depending on budget and tree maintenance needs, and a five-year cycle is recommended for established trees. For young trees, a three-year, young tree training cycle is recommended to improve the structure, health, and longevity of newly planted trees. Improving longevity results in a longer lifespan for trees much closer to their typical lifetimes of 40 to 100 years. Neglected trees are frequently replaced at a much younger age, for example 20 years. The Village maintains trees in street ROWs and Parks. All information pertaining to priority and routine maintenance are recommendations that can be used to determine the cost and feasibility of completing the prescribed work. See section 3 for Tree Management recommendations.

Maintaining a proactive pruning and small tree training cycle means that young trees are tended to every three years while established trees are pruned every five years, if necessary. Saranac Lake has a considerable number of small/young trees that would benefit greatly from a tree training cycle. Proper tree training will reduce structural defects and maintenance needs as trees mature and become established. Investing the time and money to address these issues while trees are young will reduce future pruning costs and help ensure the longevity of newly planted trees. This report will later discuss long-term planning and maintenance cycles.

In addition to regular maintenance, tree planting is an important part of a comprehensive tree management plan. Adding new trees to the landscape is necessary to promote canopy growth, offset loss of trees due to natural mortality and other causes, and to increase biodiversity.

Tree removal at Riverside Park

PSC students on the Riverwalk

Removal of a damaged tree at Riverside Park

Introduction

The Village of Saranac Lake is home to more than 5,000 full-time residents. The Village is responsible for maintaining trees in parks, public spaces, and along street Rights-of-Way. The Village of Saranac Lake is rich in both cultural and natural resources. Saranac Lake is dedicated to preserving and improving its urban forest. Funding for these projects is provided by the State's Environmental Protection Fund (EPF) and is administered by the Urban Forest Community Forest Program in DEC's Division of Land and Forests.

Approach to Tree Management

The best approach to successfully managing an urban forest is to implement a proactive, organized program that sets goals and monitors progress. The first steps in this process are to complete a tree inventory and prioritize maintenance to guide short and long-term planning. The Village can utilize these tools to establish tree care priorities; generate strategic planting plans; draft cost-effective budgets based on projected needs; and ultimately reduce to a minimum, the need for costly, reactive solutions to emergency situations.

In the summer of 2021, Saranac Lake worked with ArborPro to conduct a comprehensive tree inventory and develop a Tree Management Plan. This plan considers the size characteristics, condition, and species distribution of the inventoried trees and provides a prioritized system for maintaining all trees within the survey area. The following tasks were completed:

- Inventory of trees, stumps, and vacant sites along street ROWs and in public parks.
- Analysis of tree inventory data.
- Development of a plan that prioritizes the recommended tree maintenance.

Tree Management Plan addresses:

- **Results of the inventory.**
- **Benefits of a healthy urban forest.**
- **Prioritization of tree maintenance.**
- **Short- and long-term goals.**

Trees are an important part of a community's green infrastructure — as essential as roads, bridges, or sewer mains. But trees, unlike other types of infrastructure, perform better and gain value over time. They are the only infrastructure that improves with age. A tree management plan, like a stormwater, street, or sewer management plan, protects important infrastructure on which the Village depends. The Tree Management Plan outlines how Saranac Lake will protect and care for one component of its green infrastructure — its trees. The management plan is divided into four sections:

- Section 1: Highlights and Results of Inventory Data
- Section 2: Benefits of a Healthy Urban Forest
- Section 3: Tree Management
- Section 4: Emerald Ash Borer Management
- Section 5: Asian Longhorn Beetle Management
- Section 6: Salt Damage Management

Section 1: Highlights and Results of Inventory Data

In the summer of 2021, ArborPro, Inc. assigned an Inventory Arborist to inventory tree sites and vacant planting sites along Village street rights-of-way and in public parks. A total of 711 sites were collected within the Village of Saranac Lake, which includes trees (73.8%), 50 stumps/snags (6.8%), and 138 vacant sites (19.4%). Table 1 shows a breakdown of sites collected by area.

Location	Count	%
Ampersand Park	25	3.52%
Baldwin Park	66	9.28%
Berkeley Green	20	2.81%
Main & Broadway Corridor	15	2.11%
Mt. Pisgah	59	8.30%
Park Ave	34	4.78%
Prescott Park	74	10.41%
Riverfront Park	59	8.30%
Riverside Park	46	6.47%
Riverwalk/Hydro Point Park	180	25.32%
Skate Park	15	2.11%
Ward Plumadore Park	30	4.22%
William Morris Park/Carousel	46	6.47%
William Wallace Park/Lake Colby Beach	42	5.91%
Total Tree Sites	711	100.00%

Table 1: Sites collected by area

Methods of Data Collection

Tree inventory data were collected using ArborPro's proprietary software. The software, ArborPro version 3.5.1, is loaded on pen-based tablets, equipped with geographic information systems (GIS), and uses both aerial imagery and global positioning system (GPS). The following data fields were collected at each tree location:

- address
- condition
- hardscape damage
- mapping coordinates
- notes
- observations
- tree diameter
- clearance
- parkway type
- parkway size
- recommended maintenance
- side
- site number
- species

Assessment of Tree Inventory Data

Professional judgment based on experience and industry standards is used to determine maintenance recommendations. Data analysis is then used to summarize the state of the inventoried urban forest. The summary helps identify trends in the tree population. Understanding and recognizing these trends will help guide short and long-term management planning. This section of the management plan summarizes the following criteria of the inventoried tree population:

- Size characteristics
- Tree condition
- Species and genus distribution

Winter Tree

Size Characteristics

A tree's general size provides insight into its age and value as well as the overall age of the urban forest. One industry-wide recognized size characteristic is diameter at breast height. Diameter at breast height (DBH) is determined by the diameter of the tree at 4.5 feet above grade. DBH range distribution can be used to analyze the relative age distribution of an urban forest. This allows the adjustment of planting plans to ensure that there are enough young trees to replace aging and over-mature trees. It is important that all age classes are adequately represented throughout the urban forest to ensure a healthy, vibrant tree canopy for future generations.

Figure 1 illustrates the distribution of the Village of Saranac Lake's trees by diameter class.

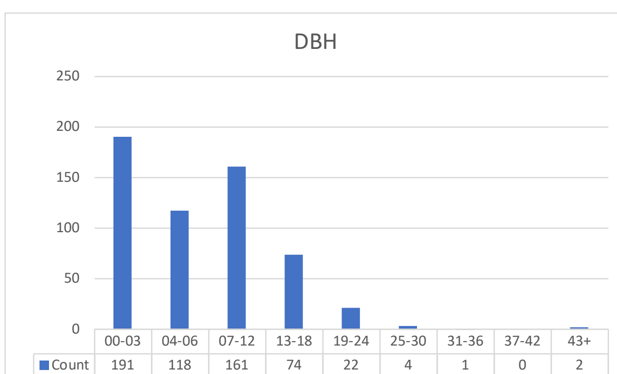


Figure 1: Diameter class distribution

Discussion

As the above graphs show, Saranac Lake has a distribution of size classes skewed towards the juvenile. An ideal size class distribution by diameter is typically considered to be 40% of trees at less than 8" (juvenile size class), 30% in the 8-16" range (semi-mature size class), 16 to 24" should be 20% (mature size class) and no more than 10% of trees should exceed 24" (senescent size class). (Leff, "The Sustainable Urban Forest" 2016.) An analysis of the exact DBH of the tree reveals the juvenile population (311) is 54.3% well above the ideal of 40%. The semi-mature trees (189) account for 32.8%. Mature and senescent size class trees (44) are 7.7%. This analysis leads to the conclusion that new tree plantings will increase the juvenile class. This is not an undesirable development; however, it does demonstrate the trees should be maintained so that they can grow into the older size classes. As the current population grows into new size classes newly planted trees will take their place in the distribution.

DBH range distribution can be used as a proxy to analyze the relative age distribution of an urban forest. Due to the lack of data regarding the DBH growth rate of various species in any given location, utilizing DBH as proxy for age is one approach. It is understood that while the age/diameter relationship is generally consistent within a species the relationship is not the same for all species. There are many factors affecting DBH growth rate and while not ideal, it is a metric from which age can be inferred.

Tree Condition

Not necessarily about desirability, tree condition is a subjective, qualitative representation of overall health, vigor, and structure. Likewise, appearance is not a complete indication of overall condition. Table 2 and Figure 2 show the number of trees recorded in each condition as well as the percentage of the total population that they represent.

Condition	Count	Percentage
Good	100	14.06%
Fair	370	52.04%
Poor	44	6.19%
Dead	11	1.55%
Stump	48	6.75%
Vacancy	138	19.41%
Totals	711	100.00%

Good – The tree has no major structural problems; no significant damage from diseases or pests; no significant mechanical damage; a full, balanced crown; and normal twig condition and vigor for its species. Trees in this category are 80-90% healthy.

Fair – The tree may exhibit the following characteristics: minor structural problems and/or mechanical damage; significant damage from non-fatal or disfiguring diseases; minor crown imbalance or thin crown; minor structural imbalance; or stunted growth compared to adjacent trees. Trees in this category are 60-80% healthy.

Poor – A tree can appear healthy but may have structural defects. This classification also includes healthy trees that have unbalanced structures or have been topped. Trees in this category may also have severe mechanical damage, decay, severe crown dieback or poor vigor/failure to thrive. Trees in this category are 40-60% healthy.

Dead – This category refers only to trees that are completely dead. Trees in advanced states of decline that are still alive are generally recorded as poor or critical, not dead.

Stump – Stumps included interfere with pedestrian traffic or pose a tripping hazard. Stumps are not included in dead tree count.

Vacancy – These are sites where a tree can be planted.

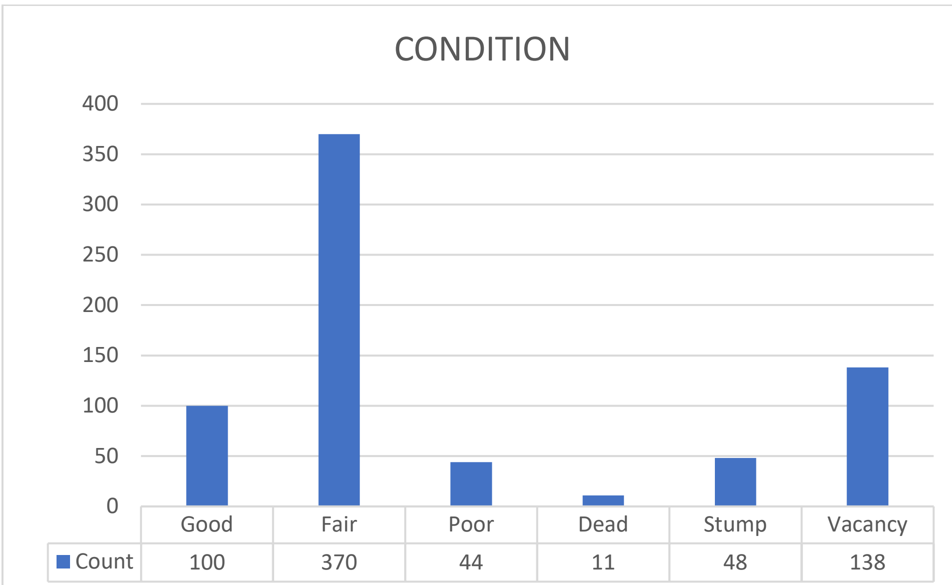


Figure 2: Tree condition by count

Discussion

Most trees in Saranac Lake (67.0%) were observed to be in Fair or better condition at the time of the inventory. This number excludes stumps and vacant sites and is used only to compare the condition of trees recorded in the inventory. Therefore, the overall health and condition of the Village's trees would be rated as Good. However, approximately 6.1% of the Village's trees are in poor condition; another 1.5% are dead. Figure 3 shows the maintenance recommendations by condition.

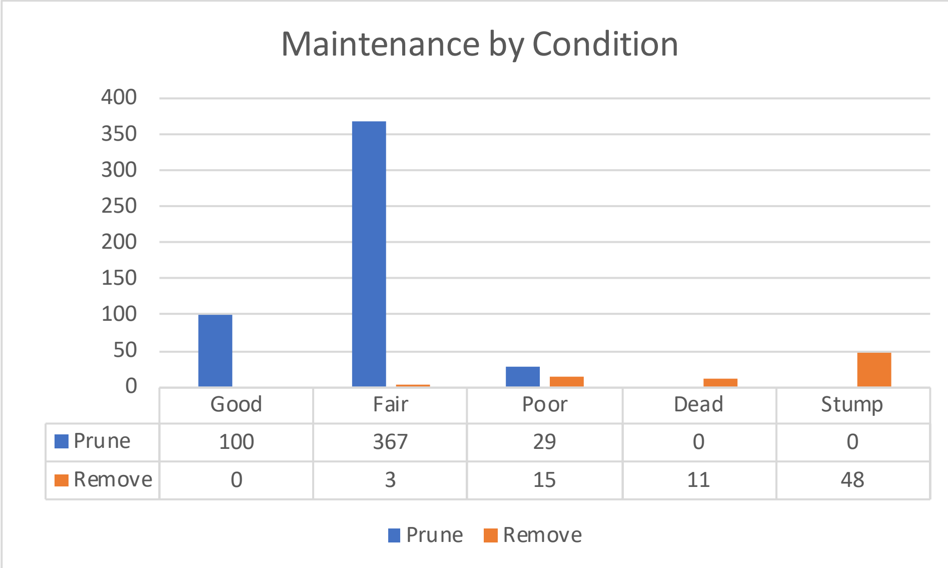


Figure 3: Maintenance recommendations by condition

Species and Genus Distribution

Understanding species and genus distribution is important when determining which species should be planted and which ones are currently overrepresented in the urban forest. Biodiversity is extremely important to the overall health and longevity of a tree population. The accepted guideline for urban biodiversity is the 10-20-30 rule. This means that no species should represent more than 10%, no genus should represent more than 20%, and no family should represent more than 30% of the total tree population. Figure 4 shows the distribution of species representing 2% or more of the total tree population.

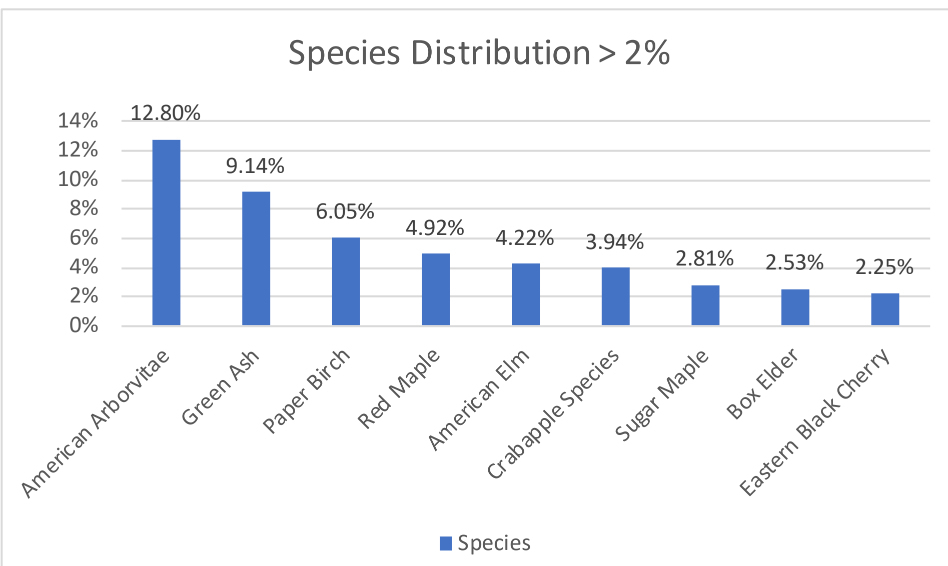


Figure 4: Species distribution by count and percentage over 2%

Table 3 contains the top 10 species of trees recorded in Saranac Lake by count and percentage of the total tree population. A full species frequency report can be found in Appendix A.

Rank	Species	Count	%
1	American Arborvitae	91	12.80%
2	Green Ash	65	9.14%
3	Paper Birch	43	6.05%
4	Red Maple	35	4.92%
5	American Elm	30	4.22%
6	Crabapple Species	28	3.94%
7	Sugar Maple	20	2.81%
8	Box Elder	18	2.53%
9	Eastern Black Cherry	16	2.25%
10	Freeman Maple	14	1.97%

Table 2: Ten most common species by percentage of total population

Discussion

The Village of Saranac Lake maintains 49 distinct species of urban trees. The distribution of these trees across species is in the desirable ranges, the largest percentage, American arborvitae comprising 12% of the population. It should also be noted that almost 50% of the American arborvitae are in the juvenile size class. ArborPro recommends the Village discontinue the planting of American arborvitae as they exceed the recommended 10% threshold for a particular species. Additionally, the genus *Acer* (maples) is close to the optimal percentage throughout the Village. Maples make up 18.7% of the total tree population, which is slightly under the recommended 20% threshold for a particular genus. This suggests that maples should be a limited planting choice. The potential threat from the invasive pest the Asian long-horned borer is further cause for concern as the maples are susceptible and a serious infestation could result in high tree mortality. This risk can be mitigated by analyzing the current list of species being planted by the Village and focusing on species that do well in the area while actively promoting biodiversity in the landscape. A list of recommended tree species for future plantings can be found in Appendix F.

Native and Exotic Species

An analysis of native versus exotic trees (non-native) was performed by a tree committee member with the following results. Approximately 10% of the inventory is comprised of exotic trees. Thirty eight of the fifty exotic trees are in less than good condition. This would indicate a trend of exotics being poor candidates for use in Saranac Lake. It can be a strategy to remove the poor performing exotics and replace them with a tree that is expected to perform better.

Climate change will be an important consideration when choosing trees suitable for planting. An analysis of the trees native to the area was also performed and they seem to be better suited for the current climate, how they will fare as temperatures increase in the area only time will tell.

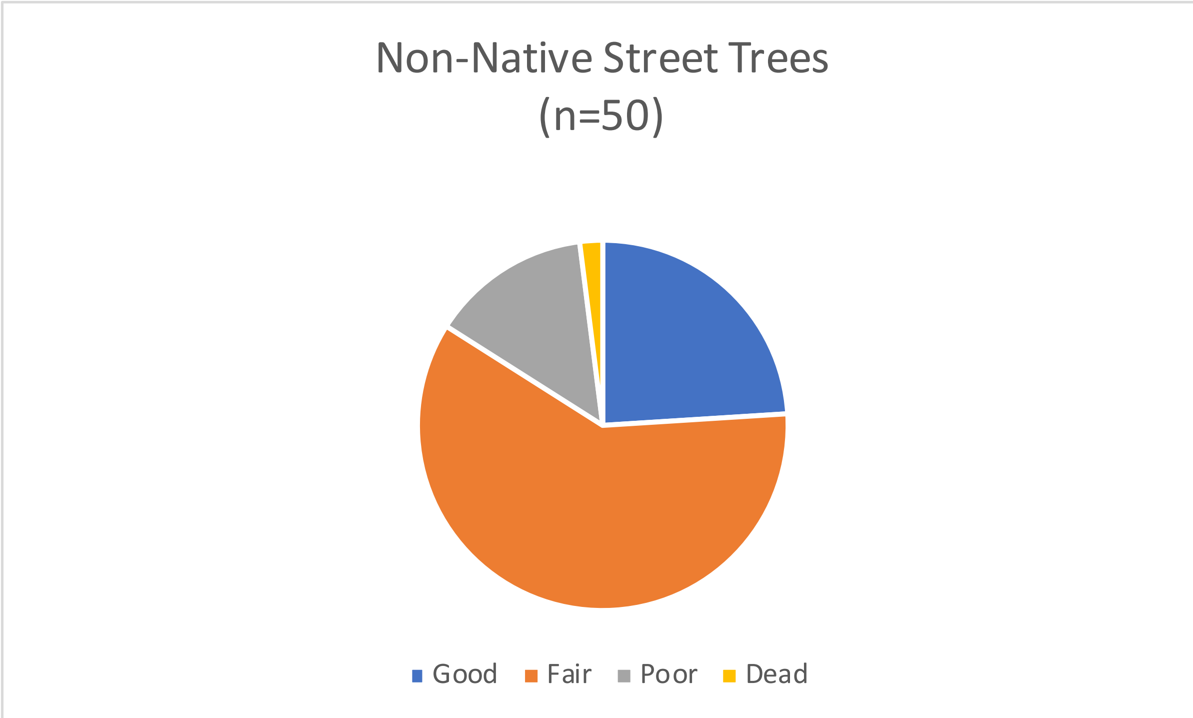


Figure 5: Exotic tree condition

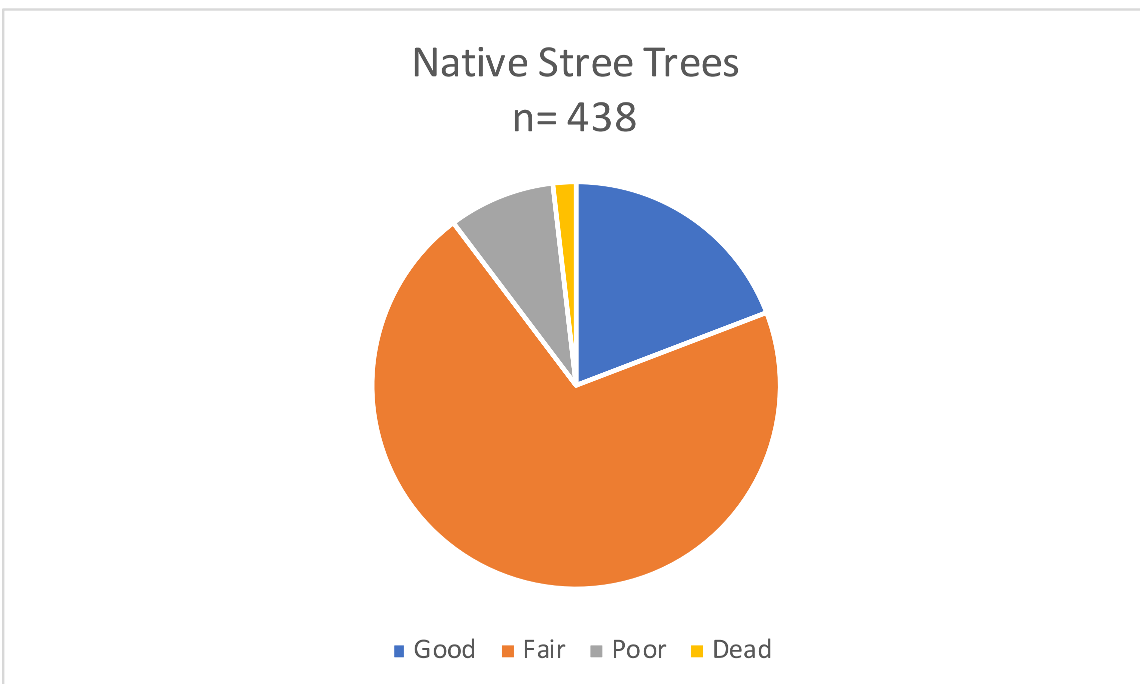


Figure 6: Native Tree Condition

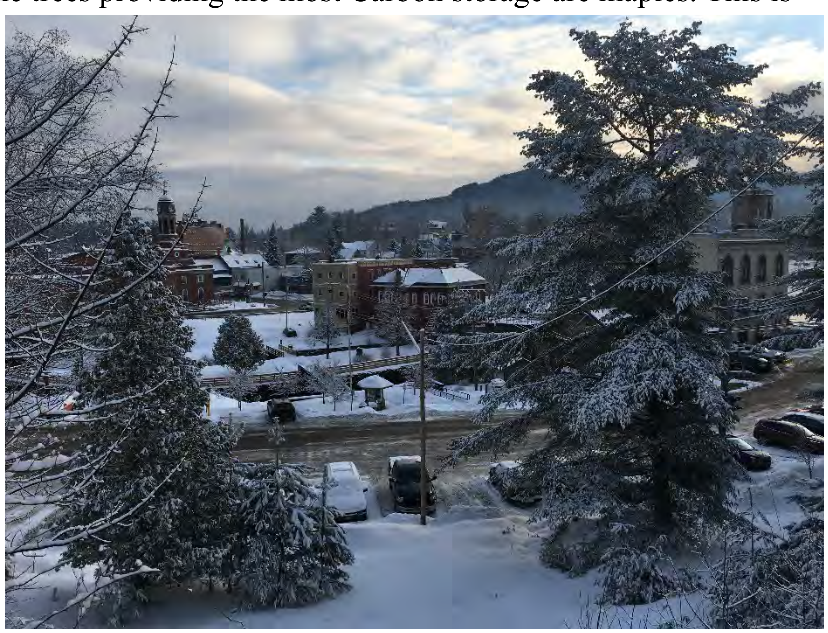
Section 2: Benefits of a Healthy Urban Forest

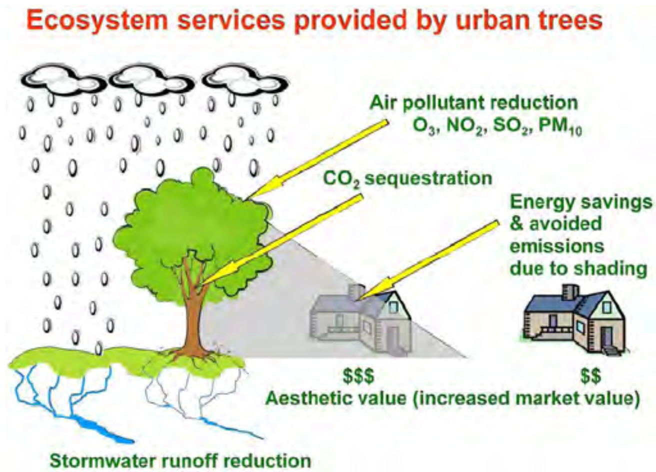
The benefits calculated in this section are based on the trees included in the 2021 survey which were trees in the village right of ways and in village owned parks. The village has trees on several acres of property that are forested and not included in the inventory. The eco benefits associated with these trees would significantly contribute to the total eco benefits provided by trees under village ownership. The properties these trees are on are referenced in the introduction provided by the village. As such an additional Canopy Coverage report was suggested by DEC Environmental Program Specialist Michelle Higgins This report is available from the iTree suite of tools and was run for the Village and can be found in Appendix G. The main takeaway from the report is Saranac Lake's trees sequester $244,000 worth of carbon annually and currently have about $6,100,000 worth of carbon stored in its trees.

Trees provide a host of environmental, social, and economic benefits in urban areas. When properly maintained, trees can reduce pollution, divert stormwater runoff, and lower energy costs. The benefits trees provide can offset the cost associated with tree maintenance. A properly implemented tree maintenance program will maximize tree benefits in the urban setting, allowing trees to provide benefits that meet or exceed the time and money invested in maintenance activities.

The i-Tree Eco application was used to quantify the benefits provided by Saranac Lake's trees. This application uses growth and benefit models designed around predominant urban trees to calculate the specific benefits that trees provide in dollar amounts. The benefits calculated by i-Tree Eco include, air quality improvements, carbon dioxide (CO_2) sequestration and storage, stormwater control, and the i-Tree annual benefit reports demonstrate the value urban trees provide to the surrounding community.

In the tables below notice that the trees providing the most Carbon storage are maples. This is due to their size. The canopy spread and tree height along with their larger diameters are the reason the maples are providing the most benefits. As these trees age-out they should be replaced with trees that have the potential to be at least as large if not larger at maturity so the eco-benefits from the urban forest can be maintained and even increased for future generations.





Benefit Summary by Trees

Trees contribute to many benefits to Saranac Lake. The following tables contain calculations of some of those benefits. Table 4 is the total benefits for the entire inventoried population for three categories. Carbon sequestration. pollution removal and avoided run-off from rain. Carbon storage can be found in table 5 as well as the structural value by species which is an estimated replacement cost. Please note table 5 is sorted by value highest to lowest.

Benefits	Total $ (USD)	$ (USD)/tree	$ (USD)/cap
Gross Carbon Sequestration	279.83	0.54	0.05
Pollution Removal	661.70	1.27	0.12
Avoided Runoff	539.60	1.04	0.10
Total Benefits	**1481.12**	**2.85**	**0.27**

Table 3- Total Benefits

Relaxing in the Park

Species	Trees	Carbon Storage		Gross Carbon Sequestration		Avoided Runoff		Pollution Removal		Structural Value
	Number	(ton)	($)	(ton/yr)	($/yr)	(ft^3/yr)	($/yr)	(ton/yr)	($/yr)	($)
Green ash	65	10.95	1867.87	0.23	39.24	1937.25	129.50	0.02	158.80	85,634.72
Northern white cedar	91	11.18	1906.02	0.18	30.16	826.38	55.24	0.01	67.74	71,045.70
Eastern white pine	13	6.92	1180.52	0.10	17.13	863.46	57.72	0.01	70.78	54,541.40
Red maple	35	9.36	1596.02	0.25	42.82	751.39	50.23	0.01	61.59	48,373.39
Sugar maple	20	8.61	1469.10	0.10	16.92	658.66	44.03	0.01	53.99	41,111.48
Paper birch	43	3.73	635.94	0.15	25.73	568.59	38.01	0.00	46.61	26,178.41
Black cherry	16	6.53	1113.40	0.13	22.83	346.72	23.18	0.00	28.42	21,794.38
White spruce	14	0.98	166.87	0.02	3.19	160.78	10.75	0.00	13.18	10,395.32
Littleleaf linden	4	1.44	245.56	0.03	4.42	185.39	12.39	0.00	15.20	10,117.25
Blue spruce	4	1.87	318.25	0.02	2.83	196.64	13.14	0.00	16.12	9,724.55
apple spp	28	0.97	165.04	0.04	7.58	91.81	6.14	0.00	7.53	9,314.26
Norway maple	9	2.12	362.33	0.05	9.00	162.31	10.85	0.00	13.30	9,177.00
Scots pine	8	1.25	212.69	0.02	3.93	144.13	9.63	0.00	11.81	9,165.71
American elm	30	0.86	147.16	0.04	7.66	168.59	11.27	0.00	13.82	8,914.19
Boxelder	18	2.58	439.24	0.07	11.10	272.92	18.24	0.00	22.37	7,301.30
American basswood	3	0.52	88.49	0.01	1.85	116.26	7.77	0.00	9.53	5,143.44
Balsam fir	7	0.37	62.79	0.01	1.40	37.99	2.54	0.00	3.11	4,440.03
Douglas fir	2	0.29	49.57	0.00	0.77	63.38	4.24	0.00	5.20	4,375.44
Quaking aspen	11	0.68	116.14	0.02	4.26	50.71	3.39	0.00	4.16	3,641.37
Limber pine	4	0.25	42.28	0.00	0.59	37.81	2.53	0.00	3.10	2,440.33
Thornless honeylocust	5	0.23	39.93	0.01	1.66	27.90	1.86	0.00	2.29	2,291.34
White willow	3	0.71	120.38	0.02	2.79	95.31	6.37	0.00	7.81	2,179.82
Yellow birch	1	0.59	100.20	0.01	1.13	35.23	2.35	0.00	2.89	2,166.10
Eastern service berry	9	0.14	23.70	0.01	1.55	13.26	0.89	0.00	1.09	1,518.73
Canada red chokecherry	8	0.12	20.56	0.01	1.62	6.86	0.46	0.00	0.56	1,462.29
River birch	4	0.19	33.17	0.01	1.47	37.72	2.52	0.00	3.09	1,381.78
Freeman maple	14	0.19	32.45	0.03	4.62	29.01	1.94	0.00	2.38	1,355.74
Slippery elm	1	0.23	39.53	0.01	1.15	33.89	2.27	0.00	2.78	1,243.65
Common lilac	11	0.11	19.29	0.01	1.97	12.91	0.86	0.00	1.06	1,204.80
European cranberry bush	5	0.13	22.39	0.00	0.80	6.80	0.45	0.00	0.56	1,087.11
Red pine	1	0.11	18.86	0.00	0.65	11.11	0.74	0.00	0.91	1,030.33
Bur oak	1	0.10	16.25	0.00	0.39	17.25	1.15	0.00	1.41	976.14
Eastern cottonwood	1	0.39	66.16	0.01	1.70	52.20	3.49	0.00	4.28	920.79
Staghorn sumac	1	0.05	7.84	0.00	0.25	6.15	0.41	0.00	0.50	842.83
Eastern hemlock	1	0.07	11.58	0.00	0.25	8.72	0.58	0.00	0.71	837.77
Japanese tree lilac	4	0.06	9.55	0.00	0.82	5.87	0.39	0.00	0.48	539.06
Cherry plum	2	0.02	4.12	0.00	0.38	3.79	0.25	0.00	0.31	341.34
Gray birch	1	0.02	3.01	0.00	0.28	5.60	0.37	0.00	0.46	309.73
Snow Pear	1	0.02	3.67	0.00	0.33	2.12	0.14	0.00	0.17	308.03
American mountain ash	1	0.04	6.11	0.00	0.42	2.66	0.18	0.00	0.22	308.03
Tatar maple	1	0.05	7.83	0.00	0.34	3.94	0.26	0.00	0.32	303.41
viburnum spp	4	0.02	3.78	0.00	0.50	3.74	0.25	0.00	0.31	280.71
Common chokecherry	4	0.01	2.17	0.00	0.47	3.27	0.22	0.00	0.27	249.58
Common ninebark	4	0.00	0.83	0.00	0.24	1.59	0.11	0.00	0.13	198.73
Common plum	2	0.00	0.34	0.00	0.10	0.93	0.06	0.00	0.08	97.88
Alternateleaf dogwood	1	0.01	1.25	0.00	0.17	0.85	0.06	0.00	0.07	77.01
Purple wisteria	1	0.01	0.96	0.00	0.11	0.74	0.05	0.00	0.06	77.01
willow spp	2	0.01	1.42	0.00	0.24	1.63	0.11	0.00	0.13	41.60
Total	**519.00**	**75.07**	**12,802.62**	**1.64**	**279.83**	**8,072.23**	**539.60**	**0.06**	**661.70**	**466,460.97**

Table 4- Benefits by Species

Carbon Storage

It is well known that trees absorb carbon dioxide and release oxygen into the atmosphere as a product of photosynthesis. Carbon absorbed during this process is ultimately stored in the wood of trees. The amount of carbon sequestered by the inventoried tree population is 1.64 tons annually. Once sequestered the Carbon is stored in the trees. Below is a chart with the top carbon storing trees.

Species	Tons of C Stored	(%)	CO2 Equivalent
Northern white cedar	11.20	14.9%	41.00
Green ash	11.00	14.6%	40.20
Red maple	9.40	12.5%	34.30
Sugar maple	8.60	11.5%	31.60
Eastern white pine	6.90	9.2%	25.40
Black cherry	6.50	8.7%	23.90

Table 5- Top Carbon Storing Trees

Stormwater Control

Trees reduce the costs associated with diverting stormwater by intercepting rainfall before it hits the ground and enters the storm runoff system. This greatly reduces the strain placed on public stormwater runoff systems. This can represent a significant amount of savings in the infrastructure needed to divert stormwater throughout the Village. The estimated savings for the Village in the management of stormwater runoff is $600.00 annually.

Species Name	Number of Trees	Leaf Area (ac)	Water Intercepted (ft^3/yr)	Avoided Runoff (ft^3/yr)	Avoided Runoff Value ($/yr)
Green ash	65	3.79	9018.96	1937.25	129.50
Eastern white pine	13	1.69	4019.88	863.46	57.72
Northern white cedar	91	1.61	3847.26	826.38	55.24
Red maple	35	1.47	3498.14	751.39	50.23
Sugar maple	20	1.29	3066.43	658.66	44.03
Paper birch	43	1.11	2647.11	568.59	38.01
Black cherry	16	0.68	1614.16	346.72	23.18
Boxelder	18	0.53	1270.58	272.92	18.24
Blue spruce	4	0.38	915.47	196.64	13.14
Littleleaf linden	4	0.36	863.10	185.39	12.39
American elm	30	0.33	784.89	168.59	11.27

Table 6- Avoided Runoff

Total Replacement Value

In addition to environmental benefits, the Village can consider the total replacement value for its urban forest. Total replacement value is the amount of money it would take to completely replace the existing urban forest with trees of the same size. While this is a scenario that will likely never happen, it gives the Village the specific dollar value of its trees in their current state. Replacement value differs from environmental benefits in that it shows how much the trees are worth instead of the dollar values that they provide in benefits. According to i-Tree Streets, the total replacement cost for Saranac Lake's trees is $466,461. Table 8 shows the breakdown of replacement value by diameter class.

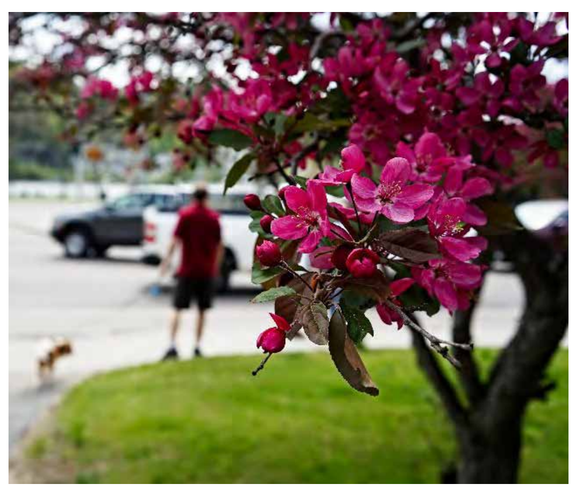
DBH Class	Replacement Value
0-03"	$17,610.00
04-06"	$54,729.00
07-12"	$144,706.00
13-18"	$138,950.00
19-24"	$78,521.00
25-32"	$31,945.00
Total	$466,461.00

Table 7: Replacement value by diameter class

Section 3: Tree Management

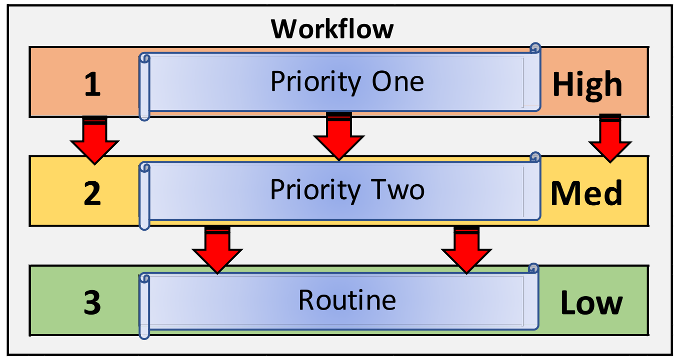
The purpose of this tree management plan is to provide a framework for the short and long-term maintenance of Saranac Lake's urban trees. The Village currently manages its trees and it is important to understand the cost and scope of the work that needs to be done. This section of the management plan will detail the maintenance recommendations from the inventory. The information contained within this section can be used to secure funding, work with homeowners to complete the work, and to understand the general needs of Saranac Lake's trees.

It is also important to recognize that the tree inventory data provides a snapshot of Saranac Lake's trees' current condition (Summer 2021). Prioritized tree maintenance will help reduce the overall risk of tree related catastrophes. However, because conditions can change drastically, routine maintenance should be coupled with the identification and monitoring of trees that may become hazardous in the future. The focus of this report is to identify and mitigate the trees that were deemed maintenance prioritizations at the time of the inventory while planning for the future through proactive maintenance.



Spring blossom

Recommended Maintenance and Tree Risk



A description and summary of the maintenance recommendations for the entire inventory follows below. As the names imply, Priority 1 pruning and removals pose the highest risk and should be dealt with first. Priority 2 pruning and removals should be considered after all Priority 1 pruning and removals have been completed. The remaining trees will be assigned to either routine pruning or young tree training activities, i.e. proactively pruned on a five-year and three-year basis respectively. The following more thoroughly describes each maintenance recommendation.

Priority 1 Prune – Trees that require Priority 1 pruning are recommended for trimming to remove hazardous deadwood, hangers, or broken branches. These trees have broken or hanging limbs; hazardous deadwood; and dead, dying, or diseased limbs or leaders greater than four inches in diameter.

Priority 1 Removal – Trees designated for removal have defects, which cannot be cost-effectively or practically treated. A majority of trees in this category have a large percentage of dead crown and pose an elevated level of risk for failure. Any hazards that cannot be mitigated with pruning could be seen as potential dangers to persons or property. Large dead and dying trees that are high liability risks are included in this category.

Maintenance	Count	Percentage
Priority 1 Removal	16	2.25%
Priority 1 Prune	11	1.55%
Priority 2 Removal	13	1.83%
Priority 2 Prune	14	1.97%
Routine Prune	258	36.29%
Training Prune	213	29.96%
Plant Tree	138	19.41%
Stump Removal	48	6.75%
Total	711	100.00%

Table 8: Recommended maintenance by tree count

Priority 2 Prune – Trees that require Priority 2 pruning are recommended for trimming to remove deadwood, correct structural problems, or resolve clearance issues. These trees do not pose as much risk as "Priority 1" trees.

Priority 2 Removal – Trees that should be removed but do not pose a liability as great as the first priority will be identified here. This category would need attention as soon as "Priority 1" trees are removed.

Routine Prune – These trees require routine horticultural pruning to correct structural problems or growth patterns, which would eventually obstruct traffic or interfere with utility wires or buildings. Trees in this category are large enough to require bucket truck access or manual climbing.

Training Prune – Small, young trees, up to 12 feet in height, that will grow to be large trees must be pruned to correct or eliminate weak, interfering, or objectionable branches in order to minimize future maintenance requirements. A person standing on the ground can prune these trees with a pole-pruner.

Stump Removal – Typically located in high use areas, stumps that interfere with pedestrian traffic and pose a tripping hazard should be removed.

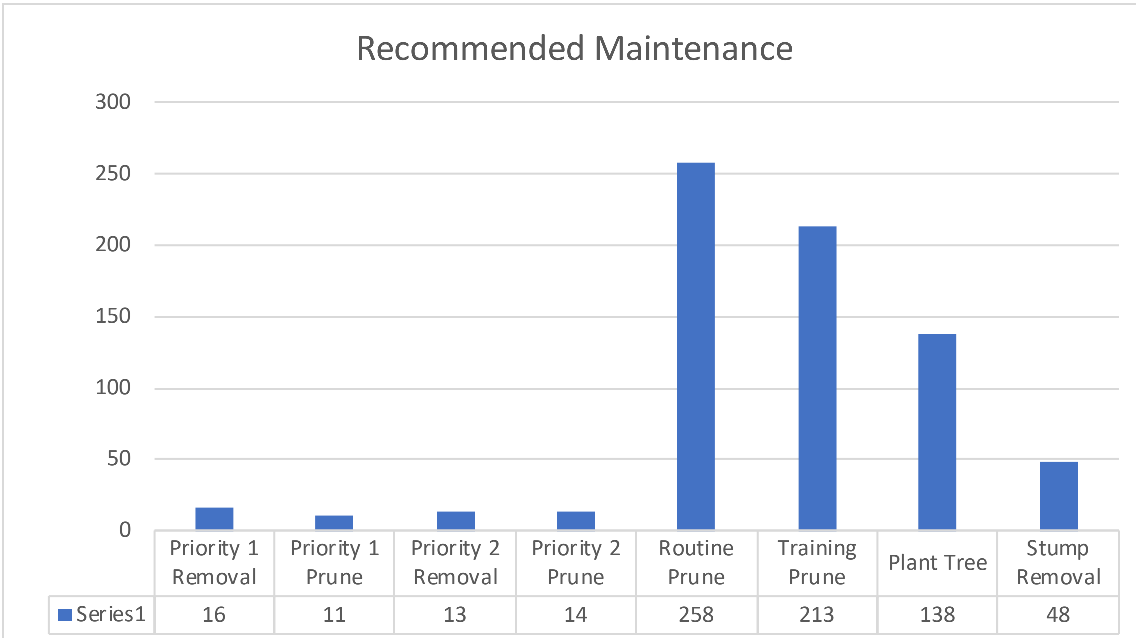


Figure 9: Recommended maintenance

Priority and Proactive Maintenance

Not all communities are able to implement a proactive maintenance schedule. Often, they simply rely on an on-demand response to hazardous or urgent situations. **However, a proactive program systematically reduces risk while improving the overall health of urban trees**. A proactive program will also help stabilize maintenance budgets and improve long-term planning.

In this plan, we chose to use a five-year cycle for routine tree trimming and a three-year cycle for young tree training. As previously explained, this involves pruning each tree every five years while conducting structural pruning on young trees every three years. These activities are considered proactive maintenance while trees in the Priority 1 and 2 categories are priority maintenance.

Priority Maintenance

Prioritizing maintenance is one of the tree inventory's main objectives. It allows tree work to be assigned based on observed risk over multiple years. Once prioritized, the work can be approached systematically to mitigate risk by addressing the highest priority trees first. In this plan, all trees designated as Priority 1 prunes and removals will be considered first. Priority 2 prunes and removals will be considered after all Priority 1 trees have been addressed. Trees in the Routine Prune and Training Prune category will be entered into the proactive maintenance schedule.

Priority Removals

While tree removal is often a last resort, in some situations it cannot be avoided. In parks and other high-use areas, creating a safe environment is more important than preserving hazardous trees that may have a social or cultural significance. Priority removals include Priority 1 and Priority 2 removals identified during the inventory. Figure 5 shows the trees and their respective diameter classes for these two categories.

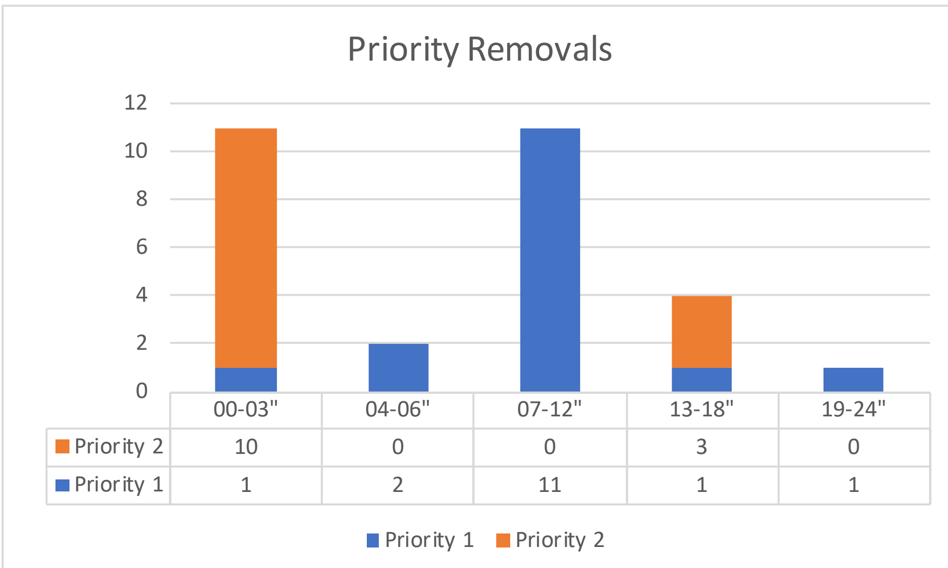


Figure 7 - Priority Removals by DBH Class

Trees in the Priority 1 Removal category pose a risk that cannot be mitigated through pruning. ArborPro recommends removing these trees in the first year of the five-year maintenance plan. The inventory found a total of 16 trees that were assessed to be Priority 1 Removals. Figure 12 shows a breakdown of the number of Priority 1 removals by diameter class.

Unhealthy tree to be removed

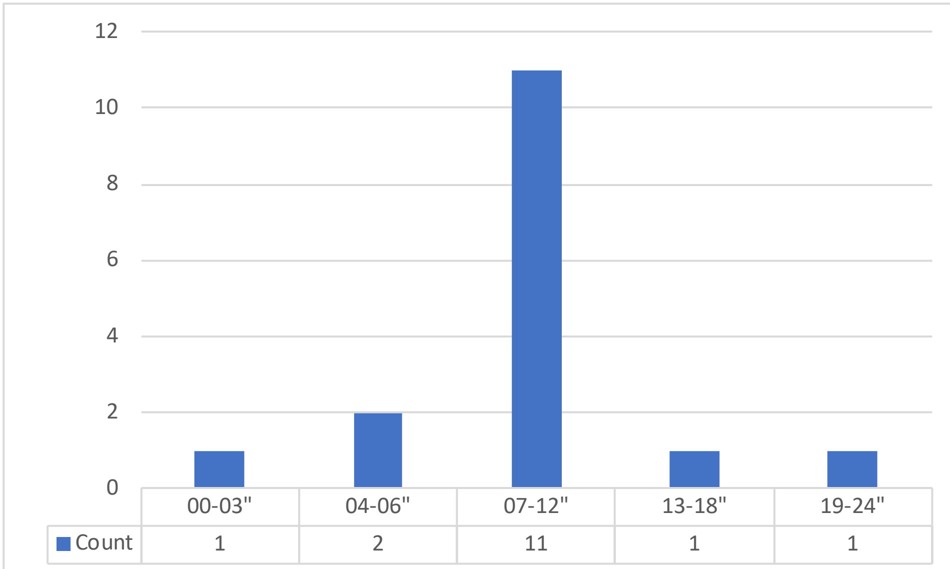


Figure 8: Priority 1 removals by diameter class

Priority 2 Removals do not pose significant risk to people or property and should not be addressed until all Priority 1 Removals have been completed. ArborPro recommends removing these trees in the second year of the five-year maintenance plan. The inventory found a total of 13 Priority 2 Removals. Figure 7 shows a breakdown of Priority 2 removals by count and diameter class.

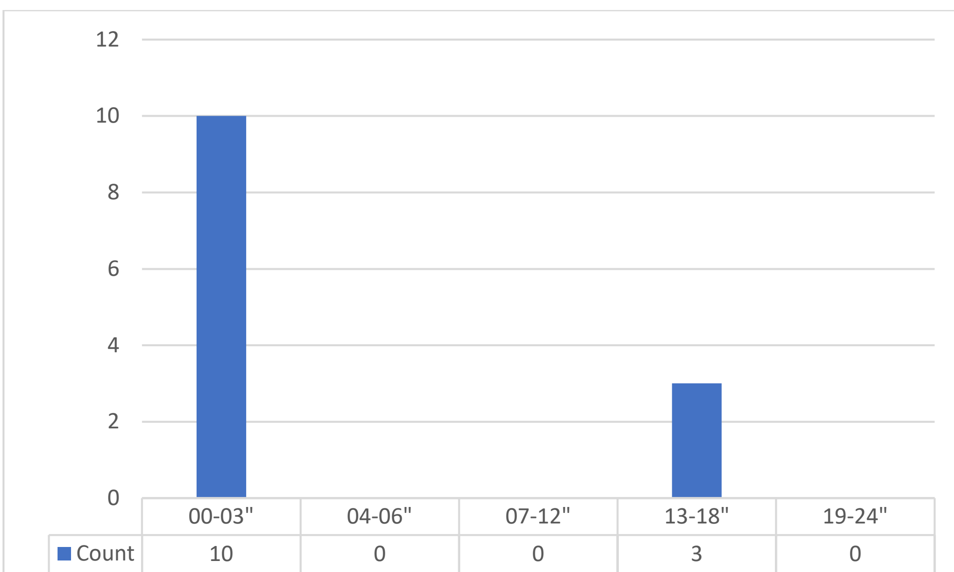


Figure 9: Priority 2 Removals by diameter class

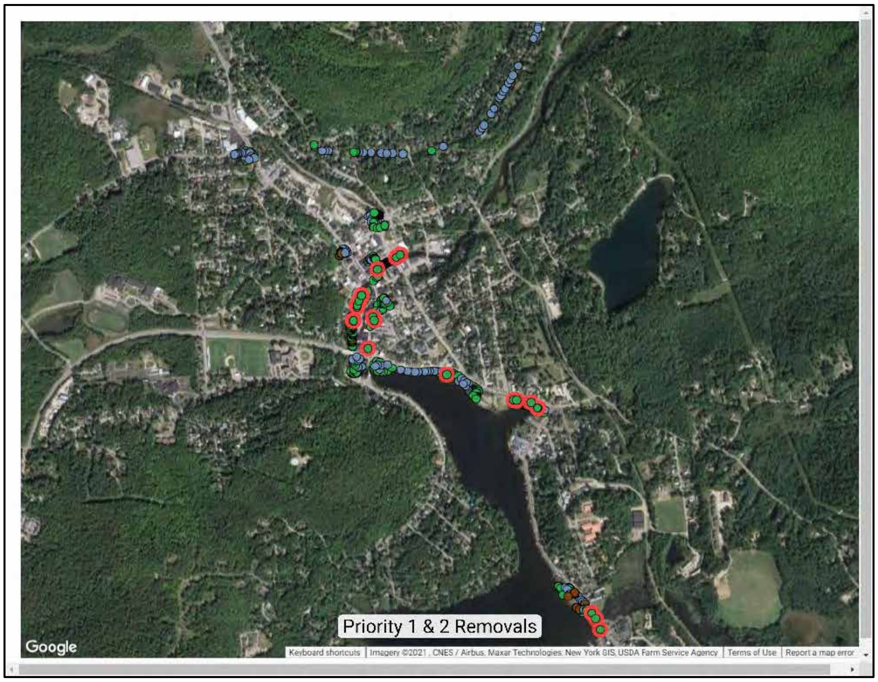


Figure 10: Location of priority removals

Priority Pruning

Priority pruning includes trees in the Priority 1 and Priority 2 category that need to be pruned to mitigate risk and remove obstructions to sidewalks, roads, etc.

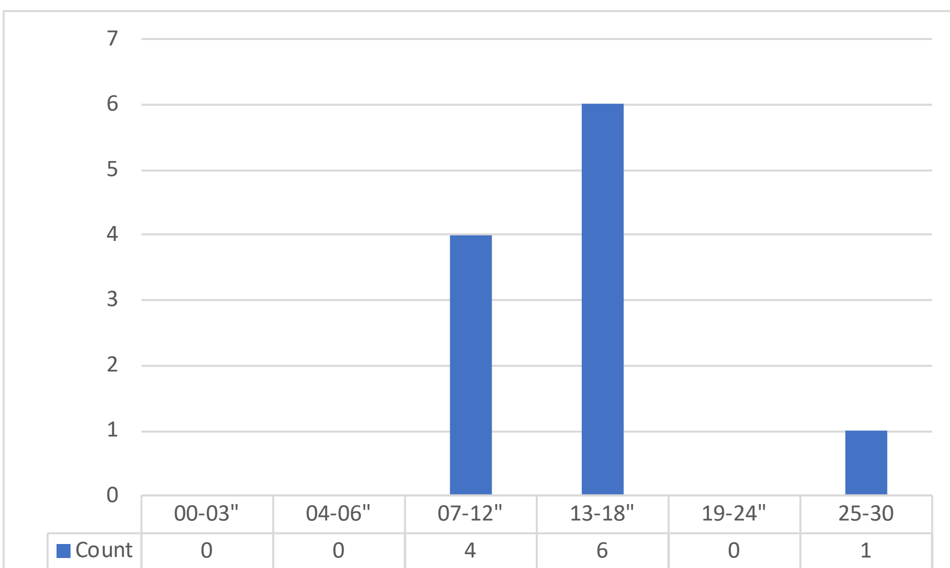


Figure 11 Priority 1 Prunes by Diameter Class

Trees in the Priority 1 Prune category pose a high risk to public safety that can be mitigated through pruning. ArborPro recommends pruning these trees in the first year of the five-year maintenance plan. The inventory found a total of 11 Priority 1 Prunes. Figure 9 shows a breakdown of Priority 1 Prunes by diameter class and count.

Trees in the Priority 2 Prune category pose a limited risk to public safety that can be mitigated through pruning. ArborPro recommends pruning these trees in the second and third year of the five-year maintenance plan. The inventory found a total of 14 Priority 2 Prunes. Figure 10 shows a breakdown of the number of Priority 2 Prunes by diameter class.

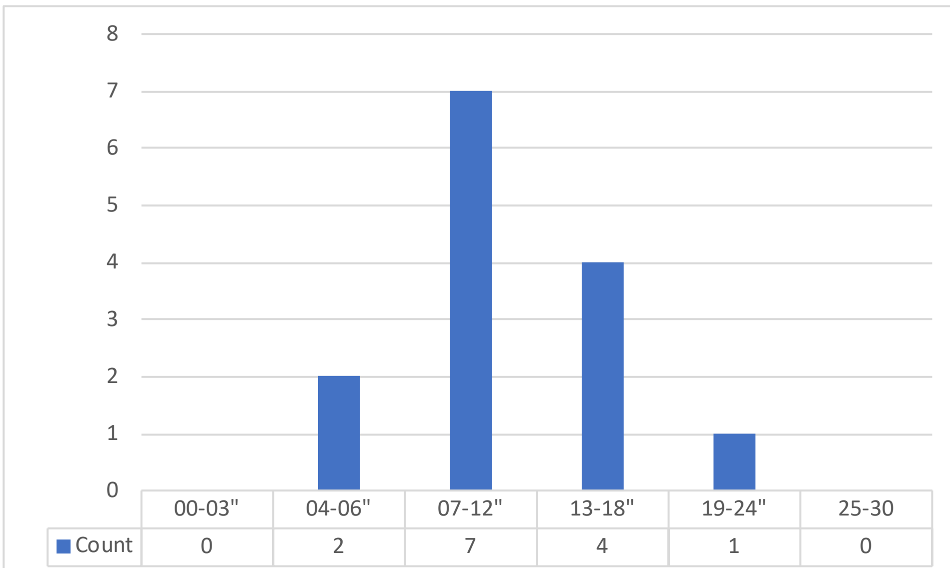


Figure 12- Priority 2 Prunes by Diameter Class

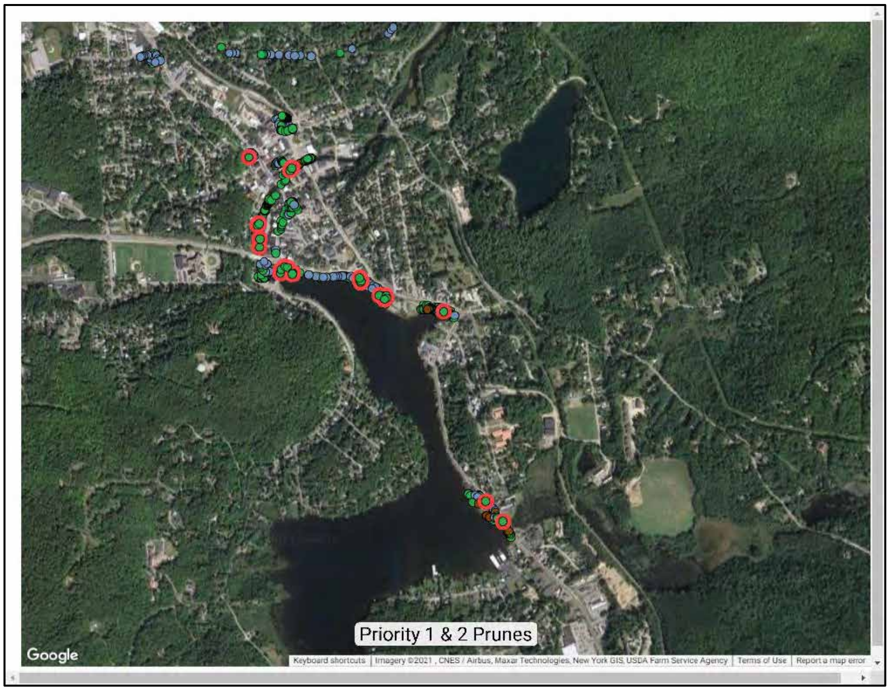
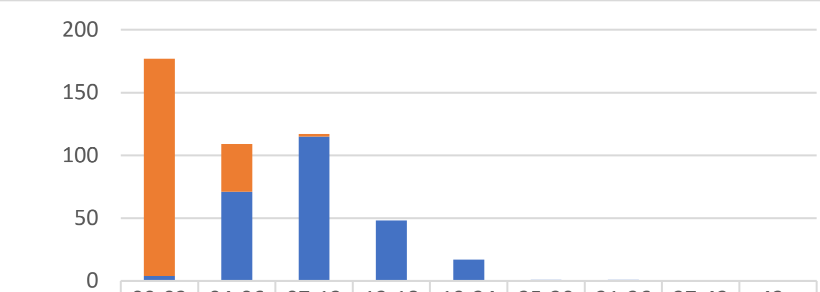


Figure 13: Location of Priority Prunes

Proactive Maintenance

Proactive tree maintenance requires that trees are systematically managed over time. To accomplish this, trees are placed in a pruning cycle that routinely addresses tree health and form. While it may be costly to implement a routine pruning cycle, it will reduce both risk and maintenance costs over time. Maintaining a routine pruning cycle will allow the Village to address minor maintenance needs on a regular basis. Over time, this will reduce the number of emergency situations and will allow the Village to regularly monitor potential problem trees.



	00-03	04-06	07-12	13-18	19-24	25-30	31-36	37-42	43+
Training	173	38	2	0	0	0	0	0	0
Routine	4	71	115	48	17	1	1	0	0

Figure 14: Proactive maintenance by diameter class

Routine Pruning Cycle

The routine pruning cycle includes all trees entered as a Routine Prune during the inventory. These trees pose little to no risk but could benefit from regular pruning to mitigate tree-related risk. By removing hazardous limbs, the Village can reduce future storm damage clean-up; remove limb conflicts on sidewalks and roadways; improve the overall appearance of urban trees; and promote proper growth patterns in young trees.

The length of a routine pruning cycle depends on the size of the tree population. ArborPro recommends a five-year cycle for the trees included in this inventory, i.e. prune approximately one-fifth of the tree population each year. This number will fluctuate as the Village removes trees and completes priority maintenance, and as young trees grow into maturity. This report and five-year maintenance plan will only consider trees in the Routine Prune category at the time of the inventory for the routine pruning cycle.

The 2021 tree inventory found a total of 258 trees that would benefit from routine pruning. Therefore, approximately 52 trees (one-fifth of the total population) will need to be pruned each year, starting in year four of the five-year maintenance plan. Figure 13 shows a breakdown of Routine Prunes by diameter class and count.

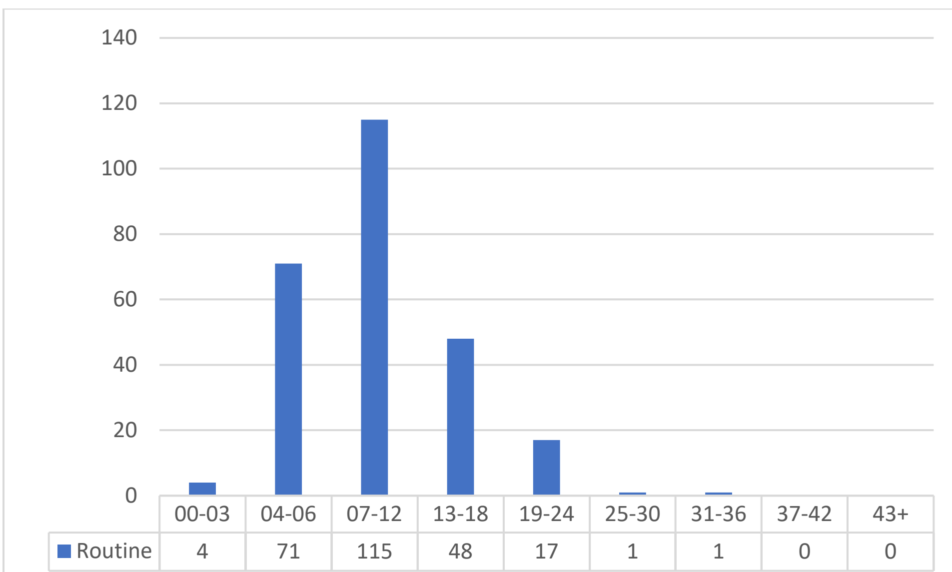


Figure 15: Routine Prunes by diameter class

Young Tree Training Cycle

> Planting trees is necessary to increase canopy cover and to replace trees lost to natural causes (expected to be 1–3% per year).

The Village of Saranac Lake has a large number of trees that fall into the Training prune category. Planting additional trees will increase this pruning class and help promote a healthy urban forest for years to come. It is also important to remember that older, more mature trees provide the most benefits to the community due to their canopy spreads and diameters. The Village must promote tree preservation and proactive tree care to ensure older trees survive as long as possible. One of Saranac Lake's objectives is to have an uneven-aged distribution of trees to ensure a sustainable tree population. It is recommended to implement a maintenance program to ensure that young, healthy trees are in place to replace the tree canopy that will be lost as older trees are removed. Tree planting and tree care will facilitate a more desirable age and species distribution over time.

The students of BOCES Natural Resource Science program can facilitate the young tree training. This will help the village keep pruning cots under control and provide valuable filed experience to the students.

Trees included in the Young Tree Training Cycle are typically less than 8 inches DBH and will benefit from structural pruning. Young trees tend to have higher growth rate and therefore require a shorter pruning cycle than mature trees. For this reason, ArborPro recommends a three-year cycle for young tree training.

Investing time and money to properly prune these trees will greatly reduce future structural problems and maintenance issues. Figure 14 illustrates the number of trees that would benefit from young tree training.

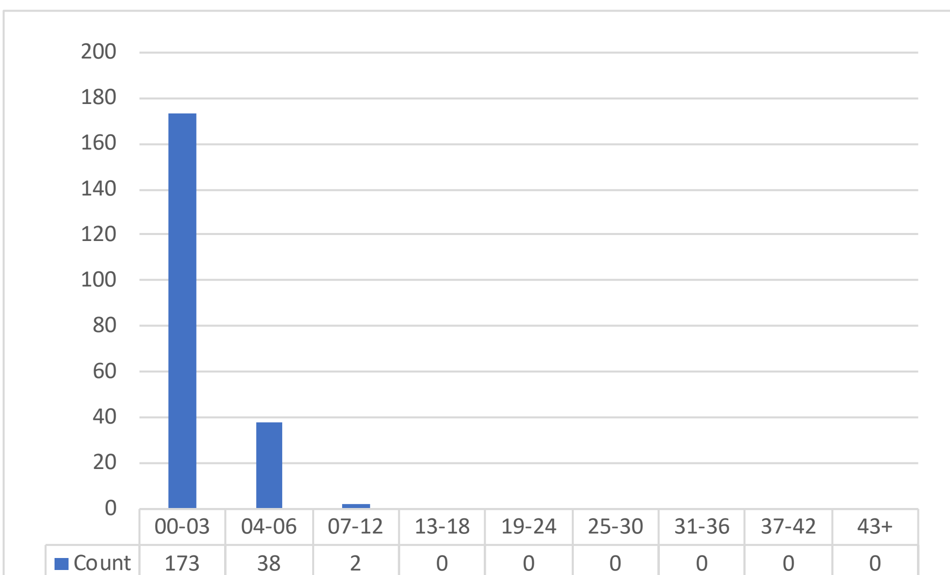


Figure 16: Number of Trees in the Young Tree Cycle

The three-year Young Tree Training Cycle should begin on year four of the maintenance plan. For the sake of this management plan, it will only include existing young trees. One-third of young trees should be structurally pruned each year. In reality, the number of trees in the training cycle will fluctuate as new trees are planted and as older plantings become established and no longer require training. Therefore, the amount of money spent and the number of trees in the training cycle will not remain constant.

The inventory found a total of 213 trees under 8 inches DBH that would benefit from structural pruning. Therefore, approximately 65 trees (one-third of the total population) should be trained each year beginning in year three of the five-year maintenance plan. However, if budget allows, the Young Tree Training Cycle could be moved to year one to benefit all of the recently planted trees.

Relatively inexpensive, young tree training can easily be done by Village staff or volunteers. Training young trees helps to reduce future maintenance costs by improving the structure and health of young trees. Since it can be done from the ground with little equipment, ArborPro recommends that the Village of Saranac Lake implement a young tree training program as soon as possible. This program will also present a good opportunity to interact with homeowners and discuss the importance of tree maintenance.

While a three-year training cycle has been suggested a five-year cycle can be implemented. This will change the annual budget by reducing annual pruning expenses associated with young trees. If a five-year cycle is adopted, structural corrections should be made as early as possible in the cycle. For the purposes of this report a three-year schedule has been used for budgeting. To modify the budget for a five-year cycle for all trees a total of 42 trees should be added to the routine cycle and the training cycle eliminated. In either case the first three years should be used to address the high priority trees as outlined in the budget.

Importance of Updating Inventory Data

Trees are living organisms that change with time. Inventory data, however, is static and will not reflect the current state of an urban forest unless it is continually updated. Whenever a tree is removed, inspected, pruned, or planted it should be updated in the inventory. If inventory data is not properly maintained, it will quickly become obsolete and will ultimately be of little use. Significant time and money have been invested in surveying Saranac Lake's trees. The only way to protect this investment is to continually update the inventory. The inventory can be updated using a spreadsheet program. There are many features in spreadsheets that allow filtering by species, condition, or recommended maintenance. It is possible to add a column to track work dates etc. Using the spreadsheet will allow you to quickly find information about your trees. The inventory can also be updated using ArborPro's flagship software Enterprise 2.0. All of Saranac Lake's data is in the program and ready to be updated, assign work and print reports for distribution.

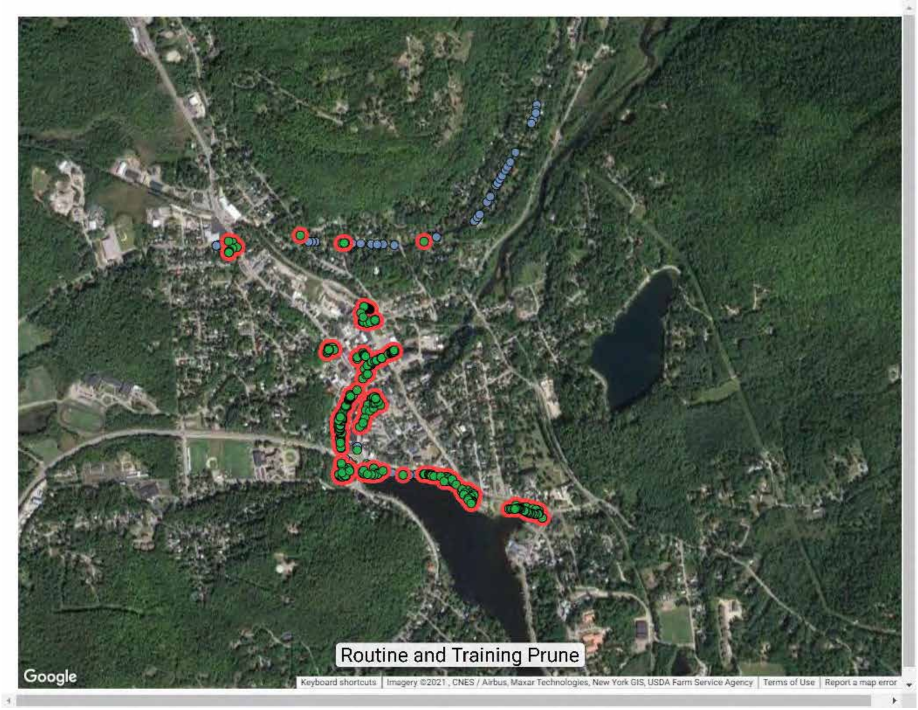


Figure 17:Location of Routine and Training Prunes

Importance of Tree Maintenance

Trees are naturally occurring, organic organisms. Often, they are treated as though they do not need human assistance to thrive. While this may be true in undisturbed forests, it is certainly not true for urban trees. Urban trees require regular maintenance to maximize the benefits they provide. When maintenance is neglected, trees can pose a serious risk to people and property. In addition, trees in urban environments are subject to many more stressors than trees in forests or rural areas. Urban trees grow in restricted spaces; are exposed to pollutants and road salt; are subject to soil compaction; and can be easily damaged by mowers or other maintenance activities.

Proactive pruning can greatly reduce the risk of tree failure and subsequent damage. In addition, proactive maintenance will prolong the life of a tree and reduce future maintenance costs. A well-maintained urban forest will be less susceptible to disease and disaster. Trees that are regularly pruned and maintained will not be as prone to disease as trees that have been neglected. When trees are pruned on a regular basis — or removed when they become diseased or hazardous — it eliminates some of the pathways for potential pests and diseases. Many of these pests and diseases attack stressed trees or enter through open wounds or dead branches. Therefore, a well-maintained urban forest will be less likely to succumb to pest infestations. In addition, species selection is an important part of maintaining a healthy urban forest. Careful species selection will increase biodiversity and reduce the risk of a catastrophic pest infestation. Most pests have preferred hosts (Emerald Ash Borer for example). Increasing biodiversity will limit the number of species that are susceptible to individual pests.

While it is impossible to predict when a natural disaster will strike, a level of disaster preparedness can be achieved through regular maintenance. Trees that have been pruned to remove dead or hanging limbs will be less likely to experience branch failure in high winds, thus reducing storm damage clean-up. Also, removing diseased or declining trees from the landscape will reduce the risk of whole tree failure in major storm events.

The importance of urban tree maintenance cannot be understated. A well-maintained urban forest will provide maximum benefits to the community while reducing the inherent risk of tree failure.

Vacant Sites and Tree Planting

During the inventory, a total of 138 vacant sites were recorded in areas that were suitable for planting new trees. Vacant sites were broken down into three categories based on the size of planting space. Vacant sites are classified by size to aid in the selection of appropriate species for those sites. For example, a large growing tree is not a good choice for a small site because of potential infrastructure conflicts and a smaller site with reduced rooting space will prevent a large tree from reaching its largest size. Conversely a small maturing tree planted in a space that would accommodate a large tree could be considered wasted space.

- Small Vacant Site – 4'to 6' planting space or any vacant site under electric utilities
- Medium Vacant Site – 6' to 8' planting space
- Large Vacant Site – 8'+ planting space

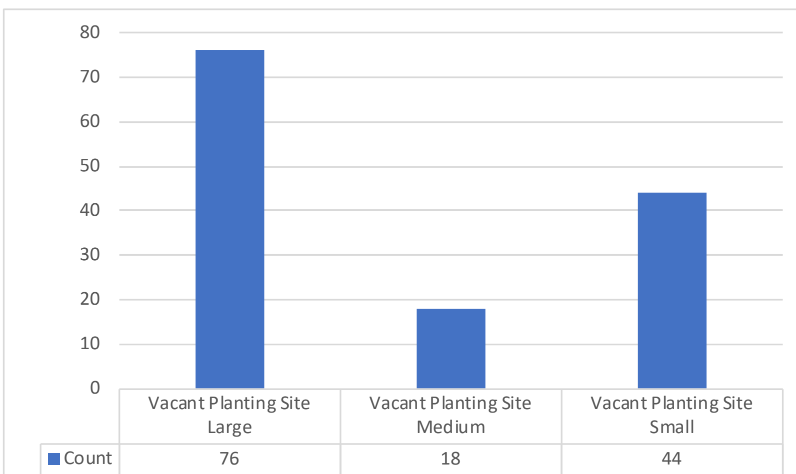


Figure 18:Vacant sites by size

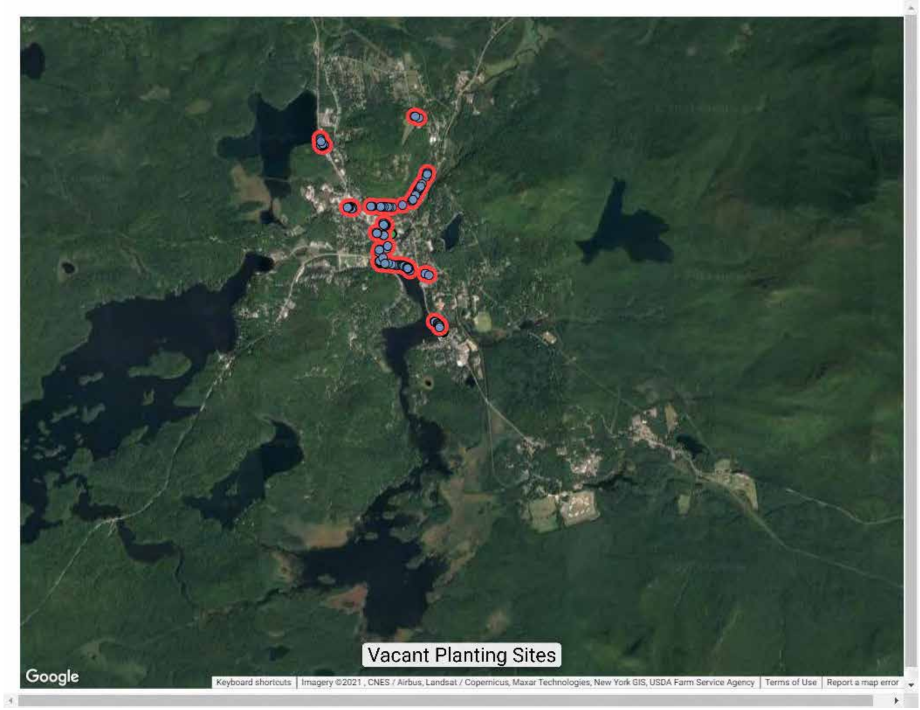


Figure 19: Vacant site locations

It is important that the Village of Saranac Lake implement and support a comprehensive planting plan.   Planting new trees would greatly benefit the Village.

The number of trees planted each year depends on budgeting and may vary from year to year. However, ArborPro recommends planting **at least 13 trees per year** to offset loss of trees due to natural mortality while gradually increasing canopy cover and biodiversity. In order to increase biodiversity, trees should be carefully selected and planted in areas suitable for that species. For example, planting a pin oak directly under power lines will only create problems in the future. As the trees grow into the power lines, they will require severe pruning or topping to prevent them from impacting the lines. The result will be a tree that is visually unappealing and in poor health.

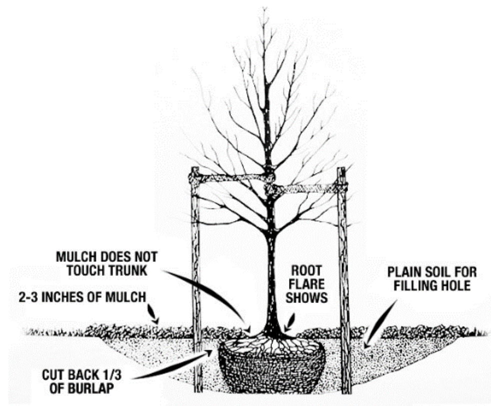
ArborPro recorded a total of 138 vacant sites during the inventory. This indicates that roughly 20% of Saranac Lake's tree sites can be planted. If 13 trees are planted each year, the Village will annually increase the total tree population by roughly 2%. At this rate, it will take approximately 10 years to fill all the vacant sites. The investment associated with planting new trees will depend on tree size and local labor costs. Using a $200.00 per site planting cost will require budgeting $2,000 per year for planting. In addition, each tree planted will increase the amount needed for annual maintenance. Five years after planting the budget will need to increase by $500.00 annually. Ten years after planting that amount will double and fifteen years after planting that amount triples. Planning for the budget increases is important so the trees can be properly maintained.

The village is fortunate to have forged a relationship with the BOCES Natural Resources Science program. The program and village have forged a mutually beneficial relationship with he village benefitting from tree planting and the students gaining valuable field experience by participating in the village urban forest program.

Tree Planting Procedures

Tree planting is an important part of maintaining and cultivating a healthy urban forest. Newly planted trees will become the foundation of the urban tree canopy as older trees start to die and are removed from the landscape. However, tree planting is only a worthwhile activity when trees are properly selected, properly planted, and properly cared for as they become established. If trees are not properly planted and cared for, they will become a future problem and not provide the benefits associated with healthy, mature trees.

When planting new trees:



- Consider the purpose of the tree that is being planted.
- Plant species with the longest anticipated service life to maximize benefits
- Assess the site conditions. Note any growth limitations or space requirements e.g., overhead utilities, proximity to buildings, existing tree canopy, etc.
- Select the best species for the site conditions such as choosing the largest growing tree for the site again to maximize benefits based on the available space.
- Ensure that the tree is properly planted and have a plan in place for follow-up tree care. Pay particular attention to planting depth (see sketch above right). Often trees are planted too deep and this adversely affects the service life. (They die sooner than they should).
- Monitor and record how newly planted species react to the site conditions. Incorporate this information into future planting plans.

Tips for Planting Trees

To ensure that newly planted trees will survive the planting process:

- Handle trees with care during transportation. Avoid damaging the trunks or branches when loading and unloading.
- Avoid storing trees for lengthy periods before planting. Make sure the root ball is kept moist if they are not being immediately planted.
- Dig the hole 2 to 3 times the size of the root ball using hand tools when possible. When augers are used, the sides of the hole can become compacted, which negatively affects root growth.

- Fill the hole with native soil when possible. If the native soil is undesirable, add soil amendments to improve soil structure. Gently tamp down the soil. Add water to promote a proper mixture of air, water, and soil.
- Stake trees for the first year of growth to both protect against wind and provide a barrier against mechanical damage from mowing.
- Add a thin layer of mulch. Make sure not to let mulch build up around the trunk. Over mulching is extremely common and will do irreversible damage in the long run.

Newly Planted Tree Maintenance

Proper young tree maintenance is just as important as proper planting techniques. If trees are not cared for after planting, they have little chance of surviving and becoming established. Newly planted trees will require maintenance for several years after planting.

Water

Watering newly planted trees is the most important key to their survival. Typically, it takes at least two months of watering for a new tree to become established. The time of year and tree species will dictate how much water should be applied after this period. The general rule is to keep soil moist to promote root growth. Consider using tree water bags which minimize run-off and evaporation while providing large amounts of water to the trees.

Mulching

Applying mulch to newly planted trees has many benefits. Mulch will help retain soil moisture and regulate temperatures around the root ball. Because over-mulching will have devastating effects on the long-term health of a tree, it is extremely important to avoid piling mulch around the trunk. Spread 3 to 4 inches of mulch around newly planted trees while ensuring the root flare is visible and mulch is not touching the trunk. Avoid over-mulching with a thicker than recommended layer which can impede water flow into the root zone. Also to be avoided is “volcano mulching” which is creating a volcano shape pile of mulch that is in contact with the trunk. This can lead to disease issues at the base of the tree as it impedes the natural exchange of gases at that location.

Tree Stakes

Tree stakes may be necessary for the first year after planting. It is important to remove tree stakes as soon as possible and no more than 1 year after planting. Leaving stakes too long can cause damage to the tree trunk, girdling from the tree tie if it’s left to long and stakes left too long also interfere with the formation of wood so the tree can stand on its own.

Caring for Established Young Trees

After planting, trees will take a few years to become established. The general rule: trees take one year for each inch in caliper when planted to become established. (Caliper is the trunk diameter at 6 inches above ground.) For example, if you are planting a 2-inch caliper tree, it will take 2 years for the roots to become fully established. Established trees still require regular watering and will need structural pruning as they begin to grow. Structural pruning establishes a central leader; removes dead or diseased branches; removes crossing limbs; and creates an overall structure that will benefit the tree into maturity.

Maintenance Cycle

Utilizing data from the 2021 tree inventory, ArborPro developed an annual maintenance schedule detailing the number and types of tasks to be completed each year. Budget projections were made using average cost of tree work based on diameter class. These costs are not specific to the Village of Saranac Lake; they only represent average costs based on industry knowledge and experience.

Maintenance Plan

This summary will include tree data collected within the Village limits during the inventory. It represents the total cost of priority maintenance and the recurring cost of proactive maintenance. A summary of the maintenance schedule is presented here. The complete table of estimated costs for this five-year plan can be found in Appendix E. The costs used in the creation of the five year plan are based on general costs in New York State. Local conditions and costs may be different.

In addition to the five-year maintenance plan, it is important to understand the total cost of priority maintenance and the recurring cost of proactive maintenance. It may not be possible to implement a five-year maintenance plan, but it is very important to understand what it would cost to maintain all of Saranac Lake's trees. Priority maintenance is the one-time cost of pruning or removing all the Priority 1 and Priority 2 trees. Proactive maintenance is the recurring cost of routine pruning and young tree training.

The breakdown of cost for all priority maintenance is:

Maintenance	Cost
Priority 1 Removal	$3,535
Priority 1 Prune	$1,190
Priority 2 Removal	$565
Priority 2 Prune	$250
Total	**$5,540**

Table 9: Cost of priority maintenance

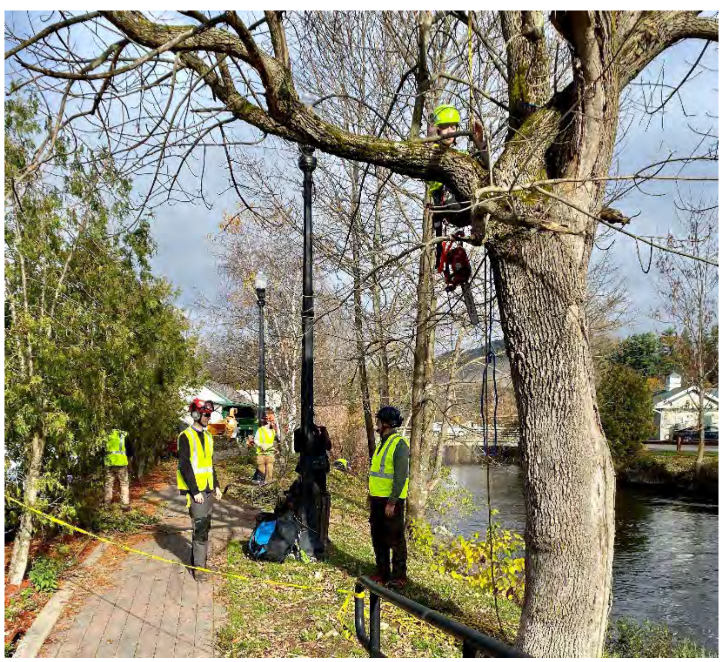
The recurring cost of proactive maintenance is:

Maintenance	Cost per Year
Routine Prune	$2,960
Young Tree Training	$1,090
Total	**$4,050**

Table 10: Recurring cost of proactive maintenance

While the Village may not be able to implement a proactive maintenance cycle immediately, it is an important goal to work towards. At the very least, the priority maintenance should be budgeted for and completed within the first three years. ArborPro recommends implementing the five-year maintenance plan as soon as possible.

Tree planting in Riverfront Park



Tree pruning on the Riverwalk

Section 4: Emerald Ash Borer Management Strategies

Emerald Ash Borer

Emerald ash borer is a small insect native to Asia. In the 1990s, it was introduced to the United States through solid wood packing materials near Detroit, Michigan. Since its introduction to North America, it has spread to 29 states, largely concentrating in the Midwest and Northeast. EAB has been confirmed in New York and surrounding states so will eventually necessitate a management strategy in Saranac Lake. EAB attacks all species of ash trees by boring into the tree and disrupting nutrient flow, ultimately causing the tree to die. The insect is responsible for killing hundreds of millions of North American trees and is constantly moving to new areas. The following image shows the distribution of EAB infestations by state.

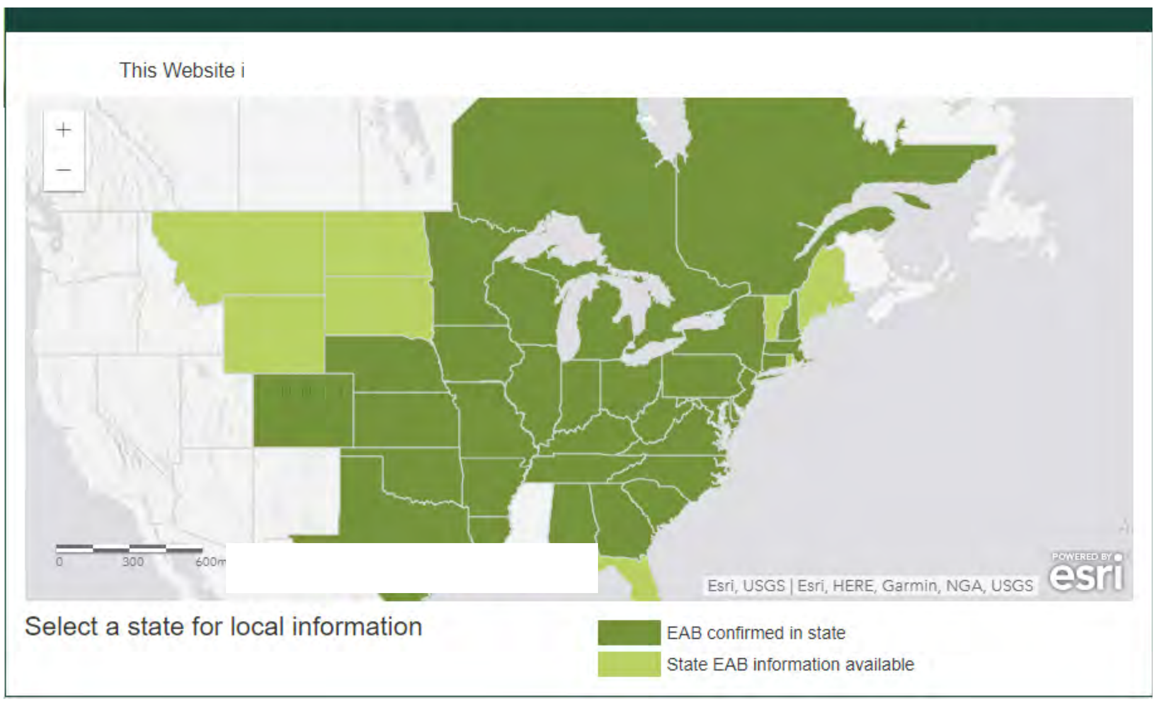


Figure 208: Emerald ash borer infestations by state

Identification

EAB Gallery
Photograph courtesy of Missouri Department of Conservation

Metallic green in color, the adult beetle is 3/8- to 5/8-inches long. The adult beetles are visible from late May to early August when they emerge from the trees to feed on leaves. Leaf feeding does not significantly damage the trees but is an important part of the insect's life-cycle. The female beetles then lay eggs in the branches and trunks of ash trees. The eggs hatch into larvae that bore into the wood beneath the bark. Larvae are white and can only be seen by removing the bark to expose galleries beneath the bark. The larvae feed on the inner bark and phloem tissue, disrupt the flow of nutrients to the tree, and inflict the most significant damage done throughout the insect's life-cycle.

Because the insect spends a majority of its life-cycle inside the tree, EAB is very difficult to detect and often goes unnoticed for years before the infestations are confirmed. Early warning signs of an infestation are: yellowing/thinning of the foliage; canopy dieback; drooping branches in the upper canopy; woodpecker damage to the bark; and the presence of epicormic shoots at the tree base or in branches. The most easily identifiable sign of an infestation are the D-shaped exit holes left by the beetles when they emerge from the tree as adults. However, during early phases of infestation, these exit holes are often high up in the canopy and not easily identifiable by the naked eye. Once a tree is infested, it will often die within two years if not treated with insecticide.

Ash Population

There are 65 green ash (Fraxinus pennsylvanica) in the village. They range in size from 00-03" to 19-24". This represents a little more than 12% of the tree population. The Emerald ash borer has not been reported in Essex County as of 2021. It has however, been reported in Franklin County. This means that the pest will most likely at some point attack the village's ash trees.

Once the pest has been confirmed to be within 15 miles of the village a decision will need to be made on treatment. Treatments for emerald ash borer are available and may be advisable for the largest trees so they can be retained in the population for a longer time to realize the benefits these trees provide to the community. Treatments of Village owned trees should be done by a plant pest and disease specialist. The costs associated with the treatments vary by region and are beyond the scope of this plan. (created 2021).

The treatments will need to take place annually. As such the expense associated with the treatments will need to be weighed against the tree condition. Only one tree at the time of the inventory was in poor condition and the remaining are in fair or good condition. Ash trees that become too poor to treat economically should be replaced with other species from the recommended species list.

DBH	Count
00-03	8
04-06	12
07-12	28
13-18	13
19-24	4
25-30	0
31-36	0
37-42	0
43+	0

Table 11:Green Ash by DBH

Trees are living organisms that change with time. Inventory data, however, is static and will not reflect the current state of an urban forest unless it is continually updated. Whenever a tree is removed, inspected, pruned, or planted it should be updated in the inventory. If inventory data is not properly maintained, it will quickly become obsolete and will ultimately be of little use. Significant time and money have been invested in surveying Saranac Lake's trees. The only way to protect this investment is to continually update the inventory.

Section 5: Asian Long-horned Beetle Management Strategies

Asian Long-horned Beetle (ALB)

Asian Long-horned beetle (ALB) (*Anoplophora glabripennis)* is, like Emerald ash borer, an Asian pest that came to the US as infested lumber in a US port. The ALB was first found in North America in 1996 in Brooklyn, NY – soon followed by finds in the Bronx, Queens and out on Long Island. Subsequent infestations have also been found in Chicago (1998); Jersey City, NJ (2002); Carteret, NJ (2004); Ontario, Canada (2005) and various NYC locations, including Central Park in Manhattan and on Staten Island (2007). It has also been found in Ohio (2011) and in Central Long Island (2014). (https://portal.ct.gov/DEEP/Forestry/Forest-Protection/Asian-Longhorned-Beetle#history) Eradication efforts have been successful in many of these areas, but they've come at a huge price: wholesale removal of host trees, both infected ones and individuals that could harbor the pest, both on public and private properties.

Saranac Lake has both disadvantages as well as advantages if/when ALB arrives. The biggest disadvantage is that the surrounding forests, not necessarily under purview of any regional authorities, are home to many maples (Acer spp), the pest's favorite (though not only) host. If surrounding forests do become infested, it's likely that Village trees could become swept into an infestation. If such a predicament occurs, the Village will need to do its part to prevent further spread. Such efforts will likely be dictated by State and possibly Federal agencies. Presumably, trapping and monitoring efforts are already in place regionally to detect pests before they arrive in Saranac Lake.

Saranac Lake's chief advantage is its small size and diversity of its existing urban forest. Current counts include 67 maples in street ROWs and 93 in parks. These do represent a sizable percentage of the Village's trees, as until recently, they've been reliable performers in the region. Other species such as birch (Betula spp) and poplars (Populus spp) are also favored hosts for ALB and need to be included in the group of trees to monitor. A full list of favored species, subject to regional variation, can be found here. The Village can best be served by increasing diversity of species known to be resistant to the pest, both in vacant planting sites identified in the ArborPro inventory and in additional areas that could accept trees, including parks and potentially on private property, schools, etc. Encouraging the community to be proactive in planting resistant species can help make the potential removal of Village trees, should the need arise, less impactful.

Dead, diseased/infested, declining trees, even if not with ALB, should be removed and replanted with species from the recommended list of species as soon as practical within the Village's budget. Establishment of new, vigorous plantings will give the community a sense of security should the removal of trees for ALB become necessary at some point. New plantings of say, oaks (Quercus spp) could be planted in vicinity of older maples, poplars, birches where room and conditions allow. If removal of the vulnerable species becomes necessary, such removal will already have established replacements to fill gaps. Such replacements can also be suggested to private property owners to prepare for such potential impact. Encourage residents, landscape companies, tree care companies working in the Village to be vigilant for the presence of the pest and report sightings to Village staff and other authorities promptly. Excellent identification of signs are easily available online, such as here and here. Keeping citizens aware but not panicked is, of course, best practice.

Section 6: Salt Damage and Management

Salt damage to street trees and how to mitigate it are long standing issues in much of the northern US. The Village of Saranac Lake is no exception. Road salts (chiefly sodium chloride) are used to rapidly dissolve ice on roadways and sidewalks to keep them navigable for vehicles and pedestrians. Their leaching into root zones of urban trees create difficulty for most tree species.

This treatment not only increases the content of Cl and Na ions in the soil, but also causes a number of adverse soil changes that are unfavorable to trees, such as: alkalization, alteration of soil structure, decreased soil permeability and aeration, intensive erosion, and disturbance of mycorrhizae (Equiza et al. 2017; Ordóñez-Barona et al. 2018). Alternative deicing chemicals, such as potassium formate (KFo; KCOOH) and calcium magnesium acetate (CMA; $Ca_3Mg_7(CH_3COO)_{20}$), may have a less negative impact on the soil, but they are more expensive and may also have an adverse effect on plants (Hanslin 2011). (link)

Older, mature trees in restricted grow spaces (tree pits, narrow tree lawns) that are close to road edge and surrounded by large volumes of concrete are ones that tend to suffer most. They've often been root pruned to mitigate sidewalk damage. Their reduced root systems prevent uptake of needed water and air as is; the substitution of chloride ions from salts really exacerbate nutrient uptake. Where room allows, increasing surface area of the grow space, even if not in regular geometric shapes, can benefit large tree health. Use of semi-porous materials, such as brick-on-sand in lieu of concrete, can also greatly increase air and water flow to the root zone. Mulching, preferably with organic materials, but even with inorganic materials, can prevent compaction and increase air/water exchange. Trees that are in poor condition in restricted grow spaces should be considered as high priority for removal, replacement with salt-resistant species where possible.

Newer/younger trees are generally better able to handle salts, but protection from damage is still best practice. Where new plantings are to be installed, invest in site preparation to the extent budget allows. New York City's grow space preparation guidelines are considered among the best. Following these for new project construction can give new trees the best chance for survival.

Other mitigation practices include: covering the soil surface with heavy plastic to minimize salt accumulation (can be weighted with inorganic mulch); targeting salt applications (don't saturate entire sidewalk surface if not necessary), and use of other deicing materials (as indicated above). In spring, application of gypsum and other soil penetrants, combined with several flooding applications from water trucks or hoses, especially on trees in restrictive grow spaces, will push salts below the upper root zone. Smaller wells and tree lawns will likely require more watering applications, larger ones less.

Selection of species resistant to salts should be a factor in replacement or in new designs. These should be evaluated on a case-by-case basis based on the size of grow space, amount of salt needed on the site, and other factors, such as Asian Longhorned Beetle.

Conclusions

Properly managing urban trees requires planning, communication, public support, and adequate funding. For these reasons, it is complicated and can only be accomplished through a well-defined vision for the future. The combination of priority and proactive maintenance detailed in this Tree Management Plan will create a framework for short- and long-term management that will help ensure a healthy, vibrant tree canopy for future generations. Saranac Lake must balance the needs of its residents with a knowledge and understanding of tree management to create a safe, enjoyable environment for everyone.

Appendix A – Public Input

Public Input Summary

A Public Forum was held on November 17, 2021 to collect public feedback on the draft community forest management plan. 10 people participated in the virtual forum. Comments are summarized below:

- There is strong support for street trees in downtown and for expanding the number of street trees.
- There is a need to improve the tree pits for street trees.
- Sometimes non-native species are better suited for the harsh urban environment.
- Avoid planting invasive species.
- There are several trees damaged by beavers long the Riverwalk. Are they prioritized for replacement? Riparian zones should be prioritized because they provide shade and climate change benefits.
- Barberry and burning bush are banned form NYS nurseries. There is a need to remove barberry from riparian zones.
- EAB – is it worth saving any ash trees in the village? What would be the cost per tree?
- Tree Committee should be prepared to address hemlock wooly adelgid, Asian longhorn beetle and spotted lantern fly.

Appendix B – Species Distribution

Botanical Name	Common Name	Count	Percentage
Abies balsamea	Balsam Fir	7	0.98%
Acer negundo	Box Elder	18	2.53%
Acer platanoides	Norway Maple	9	1.27%
Acer rubrum	Red Maple	35	4.92%
Acer saccharum	Sugar Maple	20	2.81%
Acer tataricum	Tatarian Maple	1	0.14%
Acer x freemanii	Freeman Maple	14	1.97%
Amelanchier canadensis	Canadian Serviceberry	9	1.27%
Betula alleghaniensis	Yellow Birch	1	0.14%
Betula nigra	River Birch	4	0.56%
Betula papyrifera	Paper Birch	43	6.05%
Betula populifolia	Gray Birch	1	0.14%
Cornus alternifolia	Alternate-Leaf Dogwood	1	0.14%
Fraxinus pennsylvanica	Green Ash	65	9.14%
Gleditsia triacanthos f. inermis	Thornless Honey Locust	5	0.70%
Malus species	Crabapple Species	28	3.94%
Other Tree	Other Tree	4	0.56%
Physocarpus opulifolius 'Monlo'	Diablo Ninebark	4	0.56%
Picea glauca	White Spruce	14	1.97%
Picea pungens f. glauca	Colorado Blue Spruce	4	0.56%
Pinus flexilis	Limber Pine	4	0.56%
Pinus resinosa	Red Pine	1	0.14%
Pinus strobus	White Pine	13	1.83%
Pinus sylvestris	Scotch Pine	8	1.13%
Populus deltoides	Cottonwood	1	0.14%
Populus tremuloides	Quaking Aspen	11	1.55%

Botanical Name	Common Name	Count	Percentage
Prunus cerasifera	Purple-Leafed Plum	2	0.28%
Prunus domestica	Plum	2	0.28%
Prunus serotina	Eastern Black Cherry	16	2.25%
Prunus virginiana	Chokecherry	4	0.56%
Prunus virginiana 'Canada Red'	Canada Red Cherry	8	1.13%
Pseudotsuga menziesii	Douglas Fir	2	0.28%
Pyrus nivalis	Snow Pear	1	0.14%
Quercus macrocarpa	Bur Oak	1	0.14%
Rhus typhina	Staghorn Sumac	1	0.14%
Salix alba	White Willow	3	0.42%
Salix species	Willow Species	2	0.28%
Snag	Snag	2	0.28%
Sorbus americana	American Mountain Ash	1	0.14%
Stump	Stump	48	6.75%
Syringa reticulata	Japanese Tree Lilac	4	0.56%
Syringa vulgaris	Common Lilac	11	1.55%
Thuja occidentalis	American Arborvitae	91	12.80%
Tilia americana	American Linden	3	0.42%
Tilia cordata	Littleleaf Linden	4	0.56%
Tsuga canadensis	Eastern Hemlock	1	0.14%
Ulmus americana	American Elm	30	4.22%
Ulmus rubra	Slippery Elm	1	0.14%
Vacant Planting Site - Large	Vacant Planting Site - Large	76	10.69%
Vacant Planting Site - Medium	Vacant Planting Site - Medium	18	2.53%
Vacant Planting Site - Small	Vacant Planting Site - Small	44	6.19%
Viburnum opulus	European Cranberry Bush	5	0.70%
Viburnum species	Viburnum Species	4	0.56%

Botanical Name	Common Name	Count	Percentage
Wisteria sinensis	Chinese Wisteria	1	0.14%

Appendix C – Species List by Frequency

Botanical Name	Common Name	Count	Percentage
Thuja occidentalis	American Arborvitae	91	12.80%
Vacant Planting Site - Large	Vacant Planting Site - Large	76	10.69%
Fraxinus pennsylvanica	Green Ash	65	9.14%
Stump	Stump	48	6.75%
Vacant Planting Site - Small	Vacant Planting Site - Small	44	6.19%
Betula papyrifera	Paper Birch	43	6.05%
Acer rubrum	Red Maple	35	4.92%
Ulmus americana	American Elm	30	4.22%
Malus species	Crabapple Species	28	3.94%
Acer saccharum	Sugar Maple	20	2.81%
Acer negundo	Box Elder	18	2.53%
Vacant Planting Site - Medium	Vacant Planting Site - Medium	18	2.53%
Prunus serotina	Eastern Black Cherry	16	2.25%
Acer x freemanii	Freeman Maple	14	1.97%
Picea glauca	White Spruce	14	1.97%
Pinus strobus	White Pine	13	1.83%
Populus tremuloides	Quaking Aspen	11	1.55%
Syringa vulgaris	Common Lilac	11	1.55%
Acer platanoides	Norway Maple	9	1.27%
Amelanchier canadensis	Canadian Serviceberry	9	1.27%
Pinus sylvestris	Scotch Pine	8	1.13%
Prunus virginiana 'Canada Red'	Canada Red Cherry	8	1.13%
Abies balsamea	Balsam Fir	7	0.98%
Gleditsia triacanthos f. inermis	Thornless Honey Locust	5	0.70%
Viburnum opulus	European Cranberry Bush	5	0.70%
Betula nigra	River Birch	4	0.56%

Botanical Name	Common Name	Count	Percentage
Other Tree	Other Tree	4	0.56%
Physocarpus opulifolius 'Monlo'	Diablo Ninebark	4	0.56%
Picea pungens f. glauca	Colorado Blue Spruce	4	0.56%
Pinus flexilis	Limber Pine	4	0.56%
Prunus virginiana	Chokecherry	4	0.56%
Syringa reticulata	Japanese Tree Lilac	4	0.56%
Tilia cordata	Littleleaf Linden	4	0.56%
Viburnum species	Viburnum Species	4	0.56%
Salix alba	White Willow	3	0.42%
Tilia americana	American Linden	3	0.42%
Prunus cerasifera	Purple-Leafed Plum	2	0.28%
Prunus domestica	Plum	2	0.28%
Pseudotsuga menziesii	Douglas Fir	2	0.28%
Salix species	Willow Species	2	0.28%
Snag	Snag	2	0.28%
Acer tataricum	Tatarian Maple	1	0.14%
Betula alleghaniensis	Yellow Birch	1	0.14%
Betula populifolia	Gray Birch	1	0.14%
Cornus alternifolia	Alternate-Leaf Dogwood	1	0.14%
Pinus resinosa	Red Pine	1	0.14%
Populus deltoides	Cottonwood	1	0.14%
Pyrus nivalis	Snow Pear	1	0.14%
Quercus macrocarpa	Bur Oak	1	0.14%
Rhus typhina	Staghorn Sumac	1	0.14%
Sorbus americana	American Mountain Ash	1	0.14%
Tsuga canadensis	Eastern Hemlock	1	0.14%
Ulmus rubra	Slippery Elm	1	0.14%
Wisteria sinensis	Chinese Wisteria	1	0.14%

Appendix D – Park Species

Ampersand Park		
Species	Common Name	Count
Acer rubrum	Red Maple	1
Betula papyrifera	Paper Birch	1
Fraxinus pennsylvanica	Green Ash	1
Picea pungens f. glauca	Colorado Blue Spruce	1
Prunus serotina	Eastern Black Cherry	2
Stump	Stump	2
Syringa reticulata	Japanese Tree Lilac	1
Vacant Planting Site - Large	Vacant Planting Site - Large	10
Vacant Planting Site - Medium	Vacant Planting Site - Medium	3
Vacant Planting Site - Small	Vacant Planting Site - Small	3
Baldwin Park		
Species	Common Name	Count
Abies balsamea	Balsam Fir	1
Acer rubrum	Red Maple	4
Betula papyrifera	Paper Birch	2
Other Tree	Other Tree	4
Picea glauca	White Spruce	3
Pinus resinosa	Red Pine	1
Pinus strobus	White Pine	1
Pinus sylvestris	Scotch Pine	3
Pyrus nivalis	Snow Pear	1
Salix alba	White Willow	1
Stump	Stump	13
Syringa vulgaris	Common Lilac	5
Thuja occidentalis	American Arborvitae	12
Ulmus americana	American Elm	4
Vacant Planting Site - Large	Vacant Planting Site - Large	4
Vacant Planting Site - Small	Vacant Planting Site - Small	7
Berkeley Green		
Species	Common Name	Count
Acer plantanoides	Norway Maple	2
Acer saccharum	Sugar Maple	1
Malus species	Crabapple Species	4

Physocarpus opulifolius 'Monlo'	Diablo Ninebark	4
Syringa reticulata	Japanese Tree Lilac	2
Thuja occidentalis	American Arborvitae	6
Vacant Planting Site - Small	Vacant Planting Site - Small	1
Mt. Pisgah		
Species	Common Name	Count
Acer rubrum	Red Maple	3
Acer saccharum	Sugar Maple	4
Betula papyrifera	Paper Birch	6
Fraxinus pennsylvanica	Green Ash	4
Malus species	Crabapple Species	1
Picea glauca	White Spruce	7
Picea pungens f. glauca	Colorado Blue Spruce	1
Populus tremuloides	Quaking Aspen	3
Prunus serotina	Eastern Black Cherry	10
Rhus typhina	Staghorn Sumac	1
Salix species	Willow Species	2
Snag	Snag	1
Thuja occidentalis	American Arborvitae	4
Tilia americana	American Linden	3
Ulmus americana	American Elm	6
Vacant Planting Site - Large	Vacant Planting Site - Large	3
Prescott Park		
Species	Common Name	Count
Acer plantanoides	Norway Maple	2
Acer saccharum	Sugar Maple	7
Acer x freemanii	Freeman Maple	10
Amelanchier canadensis	Canadian Serviceberry	2
Betula papyrifera	Paper Birch	14
Fraxinus pennsylvanica	Green Ash	6
Picea glauca	White Spruce	3
Pinus sylvestris	Scotch Pine	5
Populus deltoides	Cottonwood	1
Populus tremuloides	Quaking Aspen	1
Prunus domestica	Plum	1
Prunus virginiana	Chokecherry	3
Salix alba	White Willow	1

Stump	Stump	3
Thuja occidentalis	American Arborvitae	7
Ulmus americana	American Elm	5
Vacant Planting Site - Large	Vacant Planting Site - Large	3
Riverfront Park		
Species	Common Name	Count
Acer rubrum	Red Maple	3
Acer saccharum	Sugar Maple	1
Acer x freemanii	Freeman Maple	2
Fraxinus pennsylvanica	Green Ash	24
Pinus strobus	White Pine	6
Prunus domestica	Plum	1
Prunus serotina	Eastern Black Cherry	1
Stump	Stump	1
Syringa reticulata	Japanese Tree Lilac	1
Thuja occidentalis	American Arborvitae	4
Ulmus rubra	Slippery Elm	1
Vacant Planting Site - Large	Vacant Planting Site - Large	13
Wisteria sinensis	Chinese Wisteria	1
Riverside Park		
Species	Common Name	Count
Acer plantanoides	Norway Maple	5
Acer rubrum	Red Maple	4
Acer saccharum	Sugar Maple	2
Betula papyrifera	Paper Birch	1
Fraxinus pennsylvanica	Green Ash	8
Malus species	Crabapple Species	1
Picea glauca	White Spruce	1
Pinus strobus	White Pine	6
Salix alba	White Willow	1
Thuja occidentalis	American Arborvitae	3
Ulmus americana	American Elm	1
Vacant Planting Site - Large	Vacant Planting Site - Large	12
Vacant Planting Site - Medium	Vacant Planting Site - Medium	1

Riverwalk/Hydro Point Park		
Species	Common Name	Count
Abies balsamea	Balsam Fir	6
Acer negundo	Box Elder	18
Acer rubrum	Red Maple	8
Acer saccharum	Sugar Maple	1
Amelanchier canadensis	Canadian Serviceberry	4
Betula alleghaniensis	Yellow Birch	1
Betula nigra	River Birch	4
Betula papyrifera	Paper Birch	10
Betula populifolia	Gray Birch	1
Fraxinus pennsylvanica	Green Ash	13
Malus species	Crabapple Species	15
Picea pungens f. glauca	Colorado Blue Spruce	1
Pinus flexilis	Limber Pine	4
Populus tremuloides	Quaking Aspen	1
Prunus virginiana 'Canada Red'	Canada Red Cherry	8
Quercus macrocarpa	Bur Oak	1
Snag	Snag	1
Sorbus americana	American Mountain Ash	1
Stump	Stump	21
Thuja occidentalis	American Arborvitae	31
Tilia cordata	Littleleaf Linden	2
Tsuga canadensis	Eastern Hemlock	1
Ulmus americana	American Elm	8
Vacant Planting Site - Large	Vacant Planting Site - Large	5
Vacant Planting Site - Medium	Vacant Planting Site - Medium	5
Viburnum opulus	European Cranberry Bush	5
Viburnum species	Viburnum Species	4
Skate Park		
Species	Common Name	Count
Acer rubrum	Red Maple	2
Cornus alternifolia	Alternate-Leaf Dogwood	1
Malus species	Crabapple Species	2
Prunus serotina	Eastern Black Cherry	1
Prunus virginiana	Chokecherry	1
Ulmus americana	American Elm	3
Vacant Planting Site - Small	Vacant Planting Site - Small	5

Ward Plumadore Park		
Species	Common Name	Count
Acer saccharum	Sugar Maple	1
Betula papyrifera	Paper Birch	1
Fraxinus pennsylvanica	Green Ash	4
Malus species	Crabapple Species	4
Picea pungens f. glauca	Colorado Blue Spruce	1
Populus tremuloides	Quaking Aspen	3
Stump	Stump	3
Syringa vulgaris	Common Lilac	6
Ulmus americana	American Elm	2
Vacant Planting Site - Large	Vacant Planting Site - Large	1
Vacant Planting Site - Medium	Vacant Planting Site - Medium	2
Vacant Planting Site - Small	Vacant Planting Site - Small	2
William Morris Park/Carousel		
Species	Common Name	Count
Acer rubrum	Red Maple	4
Acer x freemanii	Freeman Maple	2
Fraxinus pennsylvanica	Green Ash	2
Malus species	Crabapple Species	1
Prunus serotina	Eastern Black Cherry	1
Pseudotsuga menziesii	Douglas Fir	2
Thuja occidentalis	American Arborvitae	24
Vacant Planting Site - Large	Vacant Planting Site - Large	8
Vacant Planting Site - Small	Vacant Planting Site - Small	2
William Wallace Park/Lake Colby Beach		
Species	Common Name	Count
Acer rubrum	Red Maple	6
Betula papyrifera	Paper Birch	7
Fraxinus pennsylvanica	Green Ash	3
Populus tremuloides	Quaking Aspen	3
Stump	Stump	5
Ulmus americana	American Elm	1
Vacant Planting Site - Large	Vacant Planting Site - Large	17

Appendix E – Street Species

Main & Broadway Corridor		
Species	Common Name	Count
Acer tataricum	Tatarian Maple	1
Amelanchier canadensis	Canadian Serviceberry	3
Gleditsia triacanthos f. inermis	Thornless Honey Locust	5
Prunus cerasifera	Purple-Leafed Plum	2
Tilia cordata	Littleleaf Linden	2
Vacant Planting Site - Medium	Vacant Planting Site - Medium	2
Park Ave		
Species	Common Name	Count
Acer saccharum	Sugar Maple	3
Betula papyrifera	Paper Birch	1
Prunus serotina	Eastern Black Cherry	1
Vacant Planting Site - Medium	Vacant Planting Site - Medium	5
Vacant Planting Site - Small	Vacant Planting Site - Small	24

Appendix F – Five-year Budget

Year			2022		2023		2024		2025		2026		Five-Year Cost
Activity	DBH	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Priority 1 Removal	00"-03"	$25	1	$25	0	$0	0	$0	0	$0	0	$0	$25
	04"-06"	$105	2	$210	0	$0	0	$0	0	$0	0	$0	$210
	07"-12"	$220	11	$2,420	0	$0	0	$0	0	$0	0	$0	$2,420
	13"-18"	$355	1	$355	0	$0	0	$0	0	$0	0	$0	$355
	19"-24"	$525	1	$525	0	$0	0	$0	0	$0	0	$0	$525
	25"-30"	$845	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31"-36"	$1,140	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37"-42"	$1,470	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$1,850	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**16**	**$3,535**	**0**	**$0**	**0**	**$0**	**$0**	**$0**	**0**	**$0**	**$3,535**
Priority 2 Removal	00"-03"	$25	10	$250	0	$0	0	$0	0	$0	0	$0	$250
	04"-06"	$105	3	$315	0	$0	0	$0	0	$0	0	$0	$315
	07"-12"	$220	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13"-18"	$355	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	19"-24"	$525	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	25"-30"	$845	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31"-36"	$1,140	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37"-42"	$1,470	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$1,850	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**13**	**$565**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$565**
Stump Removal	00"-03"	$25	3	$75	0	$0	0	$0	0	$0	0	$0	$75
	04"-06"	$25	5	$125	0	$0	0	$0	0	$0	0	$0	$125
	07"-12"	$25	22	$550	0	$0	0	$0	0	$0	0	$0	$550
	13"-18"	$40	12	$480	0	$0	0	$0	0	$0	0	$0	$480
	19"-24"	$60	3	$180	0	$0	0	$0	0	$0	0	$0	$180
	25"-30"	$85	1	$85	0	$0	0	$0	0	$0	0	$0	$85
	31"-36"	$110	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37"-42"	$130	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$160	2	$320	0	$0	0	$0	0	$0	0	$0	$320
Total			**48**	**$1,815**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$1,815**
Priority 1 Prune	00"-03"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	04"-06"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	07"-12"	$75	4	$300	0	$0	0	$0	0	$0	0	$0	$300
	13"-18"	$120	6	$720	0	$0	0	$0	0	$0	0	$0	$720
	19"-24"	$170	1	$170	0	$0	0	$0	0	$0	0	$0	$170
	25"-30"	$225	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31"-36"	$305	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37"-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$590	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**11**	**$1,190**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$1,190**
Priority 2 Prune	00"-03"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	04"-06"	$30	2	$60	0	$0	0	$0	0	$0	0	$0	$60
	07"-12"	$75	7	$525	0	$0	0	$0	0	$0	0	$0	$525
	13"-18"	$120	4	$480	0	$0	0	$0	0	$0	0	$0	$480
	19"-24"	$170	1	$170	0	$0	0	$0	0	$0	0	$0	$170
	25"-30"	$225	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31"-36"	$305	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37"-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$590	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**14**	**$1,235**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$1,235**
Routine Prune	00"-03"	$20	0	$0	0	$0	0	$0	4	$80	0	$0	$80
	04"-06"	$30	0	$0	0	$0	0	$0	36	$1,080	35	$1,050	$2,130
	07"-12"	$75	0	$0	0	$0	0	$0	58	$4,350	57	$4,275	$8,625
	13"-18"	$120	0	$0	0	$0	0	$0	24	$2,880	24	$2,880	$5,760
	19"-24"	$170	0	$0	0	$0	0	$0	9	$1,530	8	$1,360	$2,890
	25"-30"	$225	0	$0	0	$0	0	$0	2	$450	0	$0	$450
	31"-36"	$305	0	$0	0	$0	0	$0	1	$305	0	$0	$305
	37"-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$590	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**0**	**$0**	**0**	**$0**	**0**	**$0**	**134**	**$10,675**	**124**	**$9,565**	**$20,240**
Young Tree Training	00"-03"	$20	58	$1,160	58	$1,160	58	$1,160	58	$1,160	58	$1,160	$5,800
	04"-06"	$30	12	$360	12	$360	14	$420	12	$360	12	$360	$1,860
	07"-12"	$75	2	$150	0	$0	0	$0	0	$0	0	$0	$150
Total			**72**	**$1,670**	**70**	**$1,520**		**$1,580**	**70**	**$1,520**	**70**	**$1,520**	**$7,810**
Cost Grand Total				**$10,010**		**$1,520**		**$1,580**		**$12,195**		**$11,085**	**$36,390**

Appendix G – Recommended Species

Recommended Street Trees for the Village

Photos and descriptions for most of the listed trees can be found in Trees for Urban and Suburban Landscapes by Gilman. Photos and descriptions are also available online at the University of Connecticut Plant Database site.

(Note that starred * species should be used sparingly if Asian Longhorn Beetle (ALB) continues to spread regionally.)

Small Trees
(30 ft. or less in height)

Scientific name	Common name
Acer ginnala*	Amur Maple
Acer tatarica*	Tatarian Maple
Amelanchier spp. Preferred cultivars: Amelanchier ‘Cumulus’ Amelanchier ‘Autumn Brilliance’	Serviceberry (native)
Carpinus caroliniana	American Hornbeam (native)
Crataegus phaenopyrum	Washington Thorn (US native)
Halesia carolina	Carolina Silverbell (US native)
Maackia amurensis	Amur Maackia
Malus spp. Preferred crabapple cultivars: ‘Adams’ ‘Adirondack’ ‘Centurian’ ‘Indian Summer’ ‘Liset’ ‘Prairiefire’ ‘Red Jewel’ ‘Sentinel’	Crabapple
Prunus virginiana ‘Canada Red’	Canada Red chokecherry (cultivar of native)

Medium Size Trees
(30 ft. – 50 ft.)

Scientific name	Common name
Carpinus betulus 'Fastigiata'	Columnar European Hornbeam
Ginkgo biloba (male cultivars)	Maidenhair Tree
Gleditsia triacanthos var. inermis Preferred cultivars: 'Shademaster' 'Skyline' (most cold hardy) 'Halka'	Thornless Honeylocust (native)
Ostrya virginiana	Ironwood (native)
Quercus robur x bicolor 'Long'	Regal Prince Columnar Oak
Sorbus aucuparia	European Mountain Ash
Styphnolobium japonicum 'Regent'	Japanese Pagoda Tree
Tilia cordata Preferred cultivars: 'Greenspire' 'Corinthian' 'Olympic'	Littleleaf Linden
Tilia tomentosa	Silver Linden

Large Trees
(maturing to over 50 ft.)

Scientific name	Common name
Acer saccharum* Note: This species should only be used as a setback planting (set further off the road),	Sugar Maple (native)

Acer rubrum* Preferred cultivars: ‘Autumn Flame’ ‘October Glory’ ‘Red Sunset’	Red Maple (native)
Celtis occidentalis ‘Prairie Pride’	Hackberry (native)
Gymnocladus dioicus	Kentucky Coffee Tree (native)

Large Trees
(maturing to over 50 ft.)

Quercus alba	White Oak (native)
Quercus coccinea	Scarlet Oak (native)
Quercus macrocarpa	Bur Oak (native)
Quercus palustris	Pin Oak (native)
Quercus rubra	Red Oak (native)
Tilia americana ‘Redmond’	Basswood (native)
Ulmus americana hybrids Preferred cultivars: ‘Cathedral’ ‘Homestead’ ‘Valley Forge’	American Elm hybrids
Zelkova serrata	Japanese Zelkova

Recommended trees for downtown tree pit locations

The openings in paved areas (tree pits) provide an opportunity to plant small ornamental trees to enhance the aesthetics of the downtown area. These sites, however, are stressful so species selection and post-planting care are important for long-term survival.

The following trees would be good choices to plant in the pits as trees need to be replaced. It is important to pay attention to the recommended cultivars where listed because there can be great variation within a species and only certain cultivars may be suitable in some cases.

Scientific Name	Common Name
Acer ginnala (single stem form)	Amur maple
Acer rubrum (for larger pit openings)	Red maple (native)
Preferred cultivars:	
'Excelsior'	
'Red Rocket'	
Acer tataricum	Tatarian maple
Amelanchier spp.	Serviceberry (native)
Preferred cultivars:	
'Cumulus'	
'Autumn Brilliance'	
Carpinus caroliniana	American Hornbeam (native)
Preferred cultivar: 'Palisade'	
Gleditsia triacanthos var. inermis (for larger pit openings)	
Preferred cultivar: 'Skyline'	
Ostrya virginiana (single stem form)	Ironwood (native)
Prunus virginiana	Chokecherry (native)
Preferred cultivar: 'Canada Red'	

Crabapples are also a possibility but not where falling fruit could be deemed a liability. The following Crabapple cultivars are good choices due to good flower production and low incidence of disease.

Malus spp.
Preferred Crabapple Cultivars:
Malus 'Adams'
Malus 'Adirondack'
Malus 'Centurian'
Malus 'Prairi-fire'
Malus 'Red Jewel'

* Note: This tree can become invasive especially if planted near park or woods edges

Evergreens

Evergreen trees have been omitted from the recommended street tree list since they generally do not make good street trees (dense foliage limits visibility). However, the following trees should perform well as setback plantings (off the road and set on private property) or as park trees:

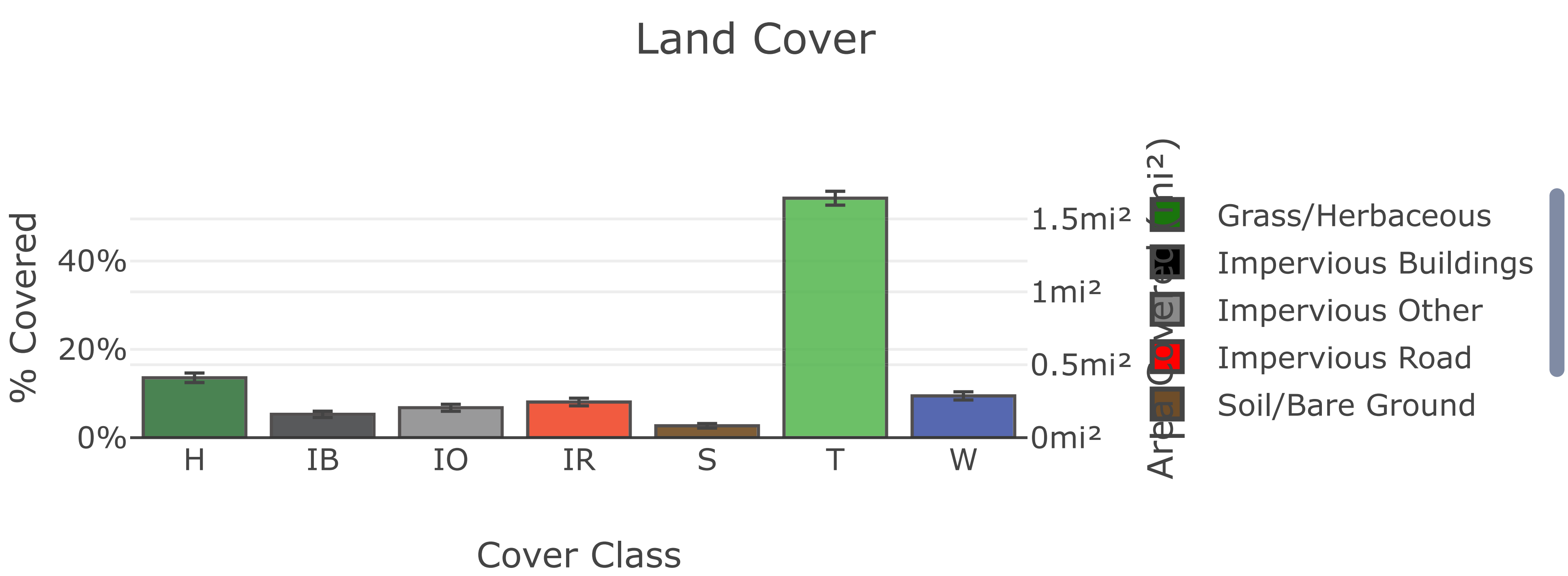
Balsam fir, European larch, White spruce, Blue spruce, White fir, White pine, Austrian pine, White cedar, and Eastern Hemlock.

Appendix H
iTree Canopy Cover Report

i-Tree Canopy v7.1

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 1/4/2022



Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (mi²) ± SE
H	Grass/Herbaceous		136	13.55 ± 1.08	0.41 ± 0.03
IB	Impervious Buildings		53	5.28 ± 0.71	0.16 ± 0.02
IO	Impervious Other		68	6.77 ± 0.79	0.21 ± 0.02
IR	Impervious Road		81	8.07 ± 0.86	0.24 ± 0.03
S	Soil/Bare Ground		27	2.69 ± 0.51	0.08 ± 0.02
T	Tree/Shrub		544	54.18 ± 1.57	1.64 ± 0.05
W	Water		95	9.46 ± 0.92	0.29 ± 0.03
Total			**1004**	**100.00**	**3.03**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (kT)	±SE	CO_2 Equiv. (kT)	±SE	Value (USD)	±SE
Sequestered annually in trees	1.43	±0.04	5.26	±0.15	$244,461	±7,095
Stored in trees (Note: this benefit is not an annual rate)	36.00	±1.04	131.99	±3.83	$6,139,337	±178,170

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 0.874 kT of Carbon, or 3.203 kT of CO_2, per mi²/yr and rounded. Amount stored is based on 21.940 kT of Carbon, or 80.446 kT of CO_2, per mi² and rounded. Value (USD) is based on $170,550.73/kT of Carbon, or $46,513.84/kT of CO_2 and rounded. (English units: kT = kilotons (1,000 tons), mi² = square miles)

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	946.83	±27.48	$40	±1
NO2	Nitrogen Dioxide removed annually	5,162.83	±149.83	$69	±2
O3	Ozone removed annually	51,419.52	±1,492.25	$3,611	±105
SO2	Sulfur Dioxide removed annually	3,253.49	±94.42	$12	±0
PM2.5	Particulate Matter less than 2.5 microns removed annually	2,498.56	±72.51	$7,465	±217
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	17,223.63	±499.85	$2,622	±76
Total		**80,504.86**	**±2,336.33**	**$13,820**	**±401**

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in lb/mi²/yr @ $/lb/yr and rounded:
CO 577.084 @ $0.04 | NO2 3,146.698 @ $0.01 | O3 31,339.728 @ $0.07 | SO2 1,982.970 @ $0.00 | PM2.5 1,522.851 @ $2.99 | PM10* 10,497.643 @ $0.15 (English units: lb = pounds, mi² = square miles)

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (gal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	542.99	±15.76	$5	±0
E	Evaporation	44,830.82	±1,301.04	N/A	N/A
I	Interception	45,081.71	±1,308.32	N/A	N/A
T	Transpiration	60,663.01	±1,760.50	N/A	N/A
PE	Potential Evaporation	339,702.79	±9,858.52	N/A	N/A
PET	Potential Evapotranspiration	277,169.06	±8,043.73	N/A	N/A

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in gal/mi²/yr @ $/gal/yr and rounded:
AVRO 330.949 @ $0.01 | E 27,323.972 @ N/A | I 27,476.886 @ N/A | T 36,973.547 @ N/A | PE 207,045.729 @ N/A | PET 168,931.995 @ N/A (English units: gal = gallons, mi² = square miles)

About i-Tree Canopy

The concept and prototype of this program were developed by David J. Nowak, Jeffery T. Walton, and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company)

Limitations of i-Tree Canopy

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate.

DAVEY Arbor Day Foundation SMA ISA Casey Trees

Additional support provided by:

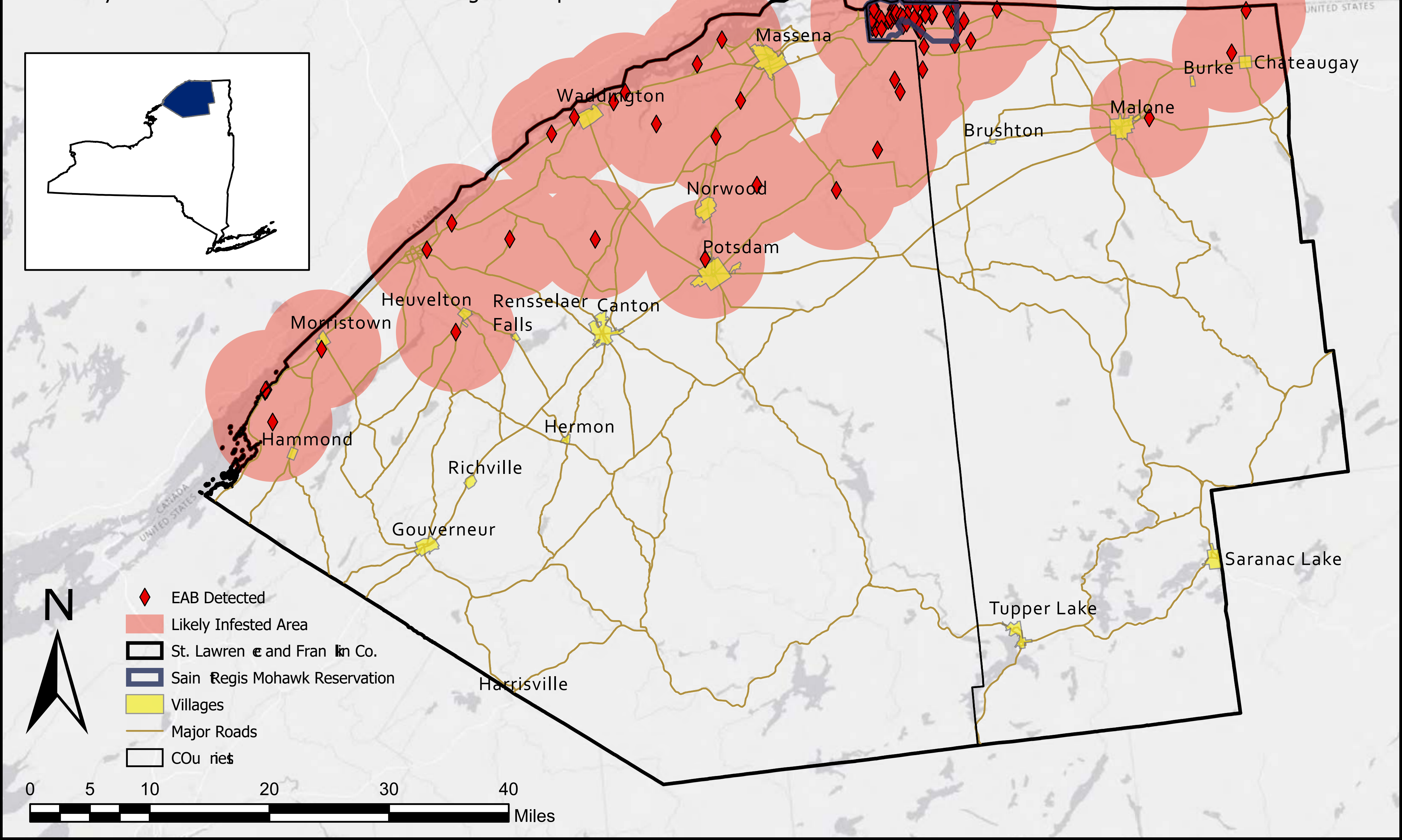
Treeconomics WOODLAND TRUST

Use of this tool indicates acceptance of the EULA

Appendix I
Emerald Ash Borer Infestations
St. Lawrence and Franklin Counties
March 2022

Known EAB Infestations in St. Lawrence and Franklin Counties

Locations of known emerald ash borer (EAB) detections as of March 2022 in St. Lawrence and Franklin counties collected from iMapInvasives observations and other monitoring and detection surveys. The 8-km (5-mi) buffer surrounding each detection point represents areas with a high likelihood of being infested presently or in 1-2 years. The high number of detections on the Saint Regis Mohawk Tribe reservation represent ongoing efforts by tribal authorities to delimit and manage the impact of EAB.



Appendix J
iTree Ecosystem Analysis

October 2021

i-Tree Ecosystem Analysis

Saranac Lake, NY

Urban Forest Effects and Values
October 2021

Summary

Understanding an urban forest's structure, function and value can promote management decisions that will improve human health and environmental quality. An assessment of the vegetation structure, function, and value of the Saranac Lake, NY urban forest was conducted during 2021. Data from 519 trees located throughout Saranac Lake, NY were analyzed using the i-Tree Eco model developed by the U.S. Forest Service, Northern Research Station.

- Number of trees: 519
- Tree Cover: 2.772 acres
- Most common species of trees: Northern white cedar, Green ash, Paper birch
- Percentage of trees less than 6" (15.2 cm) diameter: 57.2%
- Pollution Removal: 125.2 pounds/year ($662/year)
- Carbon Storage: 75.07 tons ($12.8 thousand)
- Carbon Sequestration: 1.641 tons ($280/year)
- Oxygen Production: 4.375 tons/year
- Avoided Runoff: 8.072 thousand cubic feet/year ($540/year)
- Building energy savings: N/A – data not collected
- Avoided carbon emissions: N/A – data not collected
- Structural values: $466 thousand

Ton: short ton (U.S.) (2,000 lbs)
Monetary values $ are reported in US Dollars throughout the report except where noted.
Ecosystem service estimates are reported for trees.

For an overview of i-Tree Eco methodology, see Appendix I. Data collection quality is determined by the local data collectors, over which i-Tree has no control.

Table of Contents

I. Tree Characteristics of the Urban Forest

The urban forest of Saranac Lake, NY has 519 trees with a tree cover of Northern white cedar. The three most common species are Northern white cedar (17.5 percent), Green ash (12.5 percent), and Paper birch (8.3 percent).

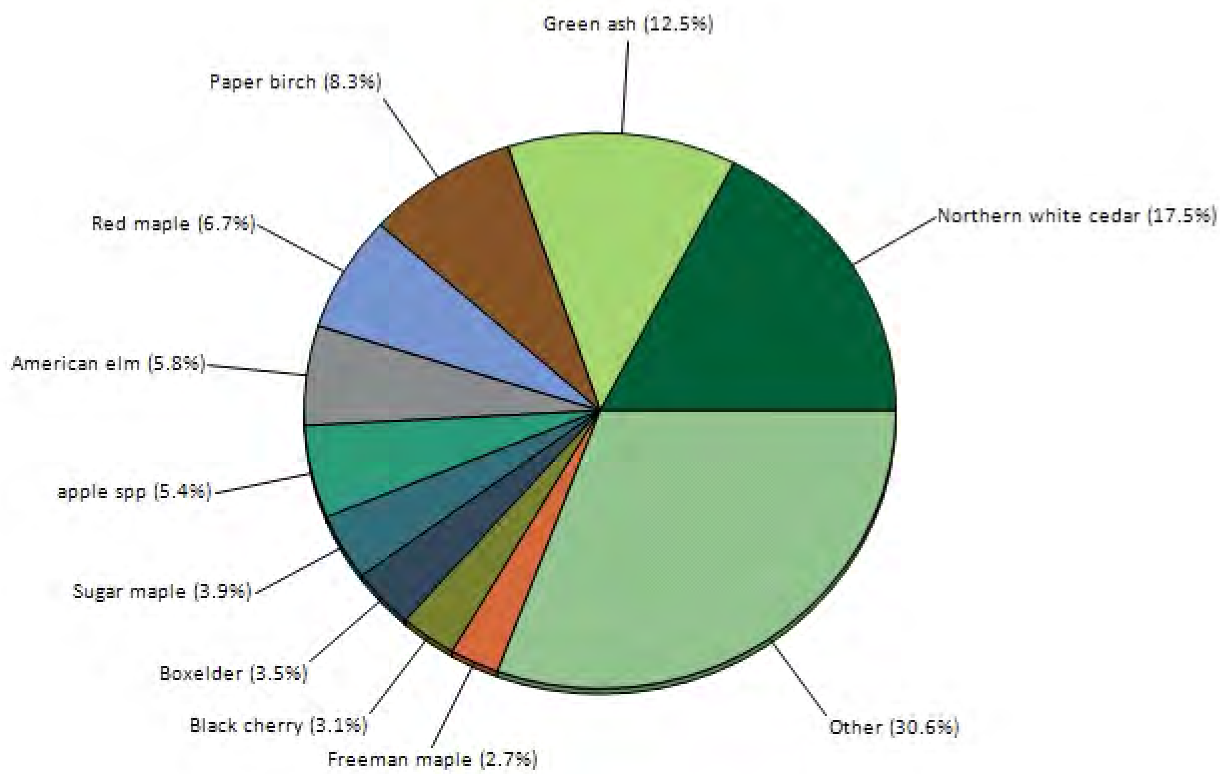


Figure 1. Tree species composition in Saranac Lake, NY

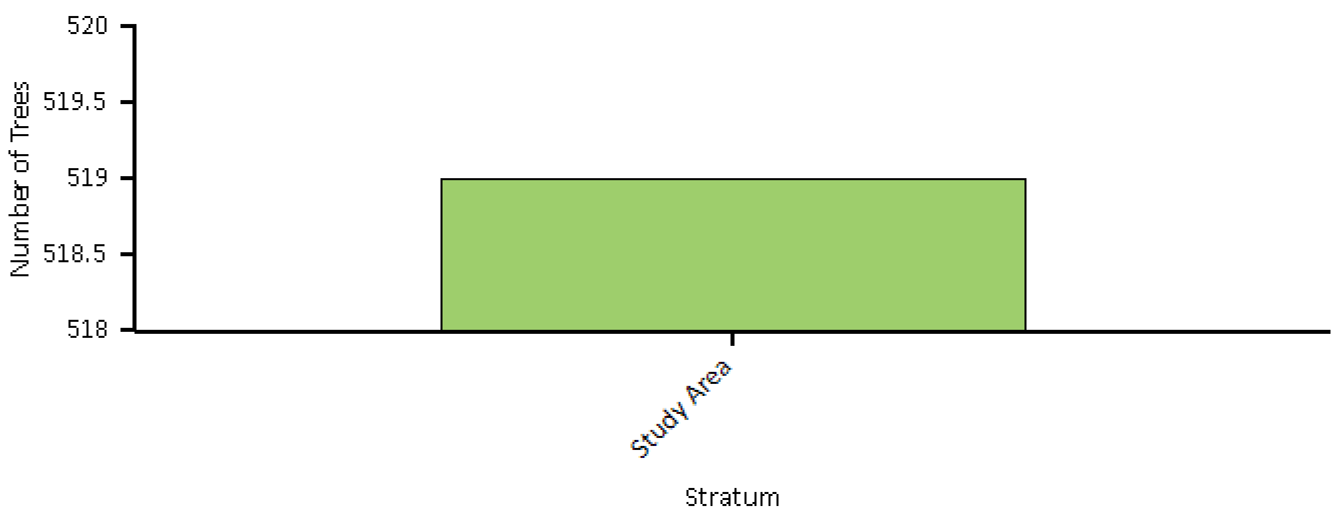


Figure 2. Number of trees in Saranac Lake, NY by stratum

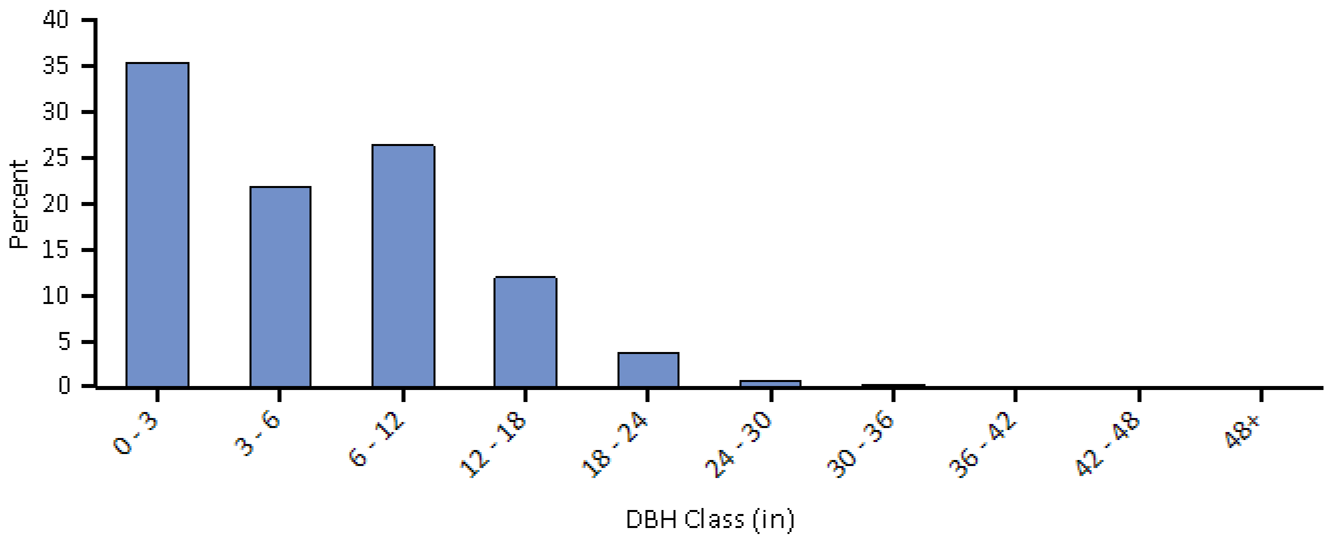


Figure 3. Percent of tree population by diameter class (DBH - stem diameter at 4.5 feet)

Urban forests are composed of a mix of native and exotic tree species. Thus, urban forests often have a tree diversity that is higher than surrounding native landscapes. Increased tree diversity can minimize the overall impact or destruction by a species-specific insect or disease, but it can also pose a risk to native plants if some of the exotic species are invasive plants that can potentially out-compete and displace native species. In Saranac Lake, NY, about 81 percent of the trees are species native to North America, while 76 percent are native to New York. Species exotic to North America make up 19 percent of the population. Most exotic tree species have an origin from North America + (7 percent of the species).

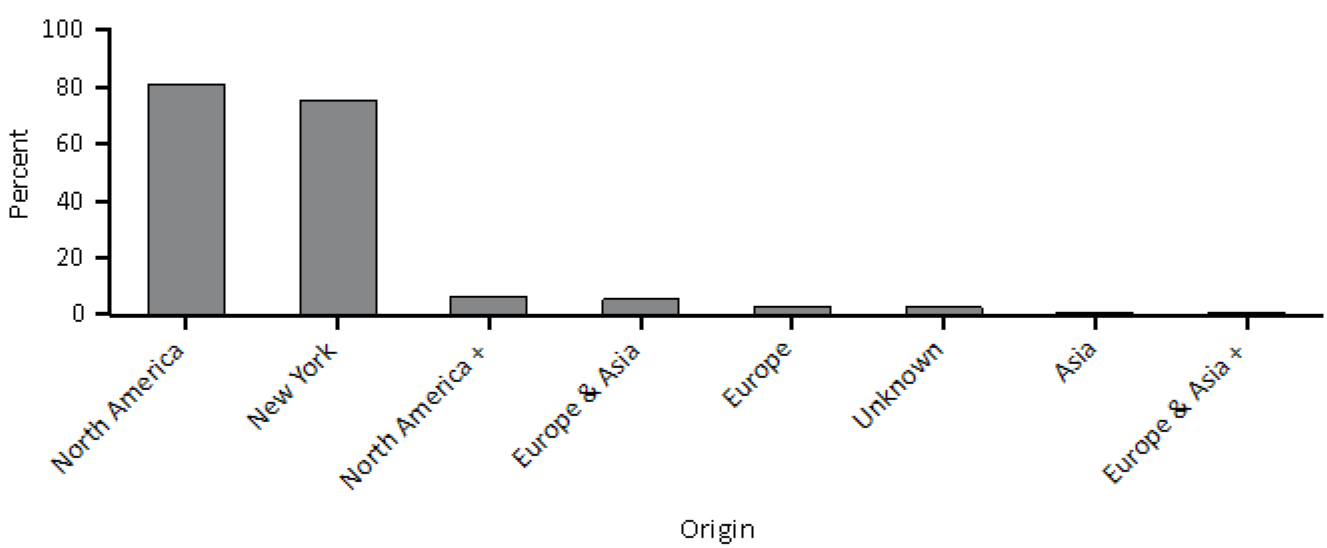


Figure 4. Percent of live tree population by area of native origin, Saranac Lake, NY

The plus sign (+) indicates the tree species is native to another continent other than the ones listed in the grouping.

Invasive plant species are often characterized by their vigor, ability to adapt, reproductive capacity, and general lack of natural enemies. These abilities enable them to displace native plants and make them a threat to natural areas. One of the 48 tree species in Saranac Lake, NY are identified as invasive on the state invasive species list (). This invasive species (Norway maple) comprises 1.7 percent of the tree population though it may only cause a minimal level of impact (see Appendix V for a complete list of invasive species).

II. Urban Forest Cover and Leaf Area

Many tree benefits equate directly to the amount of healthy leaf surface area of the plant. Trees cover about 2.772 acres of Saranac Lake, NY and provide 15.77 acres of leaf area.

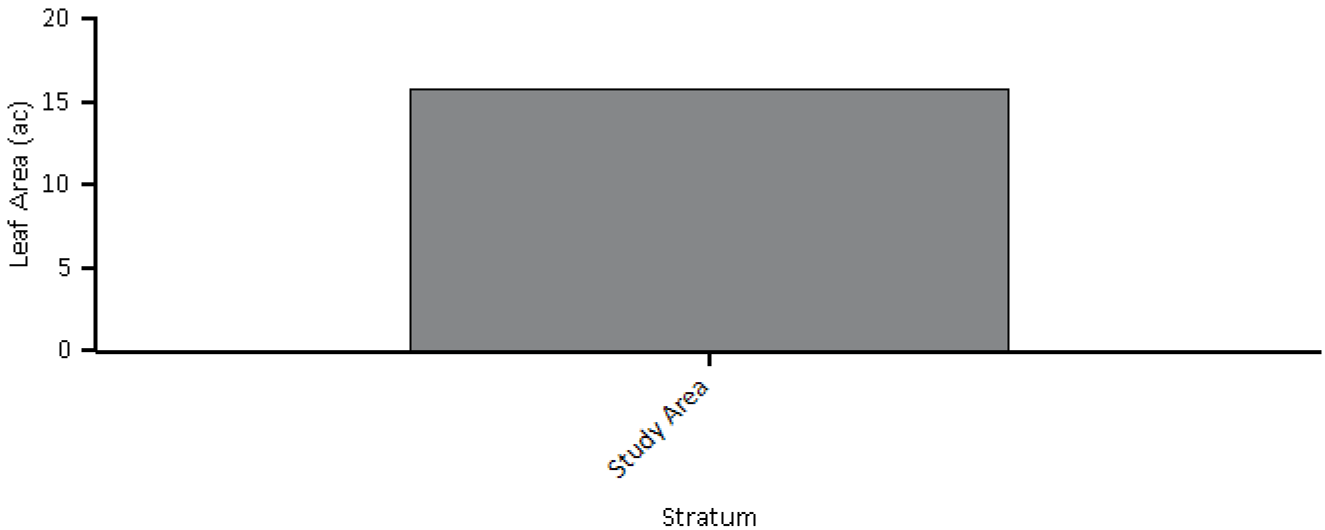


Figure 5. Leaf area by stratum, Saranac Lake, NY

In Saranac Lake, NY, the most dominant species in terms of leaf area are Green ash, Eastern white pine, and Northern white cedar. The 10 species with the greatest importance values are listed in Table 1. Importance values (IV) are calculated as the sum of percent population and percent leaf area. High importance values do not mean that these trees should necessarily be encouraged in the future; rather these species currently dominate the urban forest structure.

Table 1. Most important species in Saranac Lake, NY

Species Name	*Percent Population*	*Percent Leaf Area*	*IV*
Green ash	12.5	24.0	36.5
Northern white cedar	17.5	10.2	27.8
Red maple	6.7	9.3	16.1
Paper birch	8.3	7.0	15.3
Eastern white pine	2.5	10.7	13.2
Sugar maple	3.9	8.2	12.0
American elm	5.8	2.1	7.9
Black cherry	3.1	4.3	7.4
Boxelder	3.5	3.4	6.8
apple spp	5.4	1.1	6.5

Common ground cover classes (including cover types beneath trees and shrubs) in Saranac Lake, NY are not available since they are configured not to be collected.

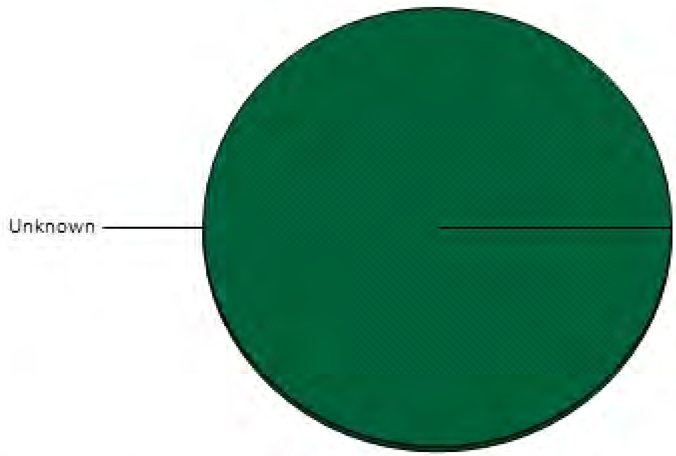


Figure 6. Percent of land by ground cover classes, Saranac Lake, NY

III. Air Pollution Removal by Urban Trees

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape materials and ecosystem processes, and reduced visibility. The urban forest can help improve air quality by reducing air temperature, directly removing pollutants from the air, and reducing energy consumption in buildings, which consequently reduces air pollutant emissions from the power sources. Trees also emit volatile organic compounds that can contribute to ozone formation. However, integrative studies have revealed that an increase in tree cover leads to reduced ozone formation (Nowak and Dwyer 2000).

Pollution removal[1] by trees in Saranac Lake, NY was estimated using field data and recent available pollution and weather data available. Pollution removal was greatest for ozone (Figure 7). It is estimated that trees remove 125.2 pounds of air pollution (ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 2.5 microns (PM2.5)[2], and sulfur dioxide (SO2)) per year with an associated value of $662 (see Appendix I for more details).

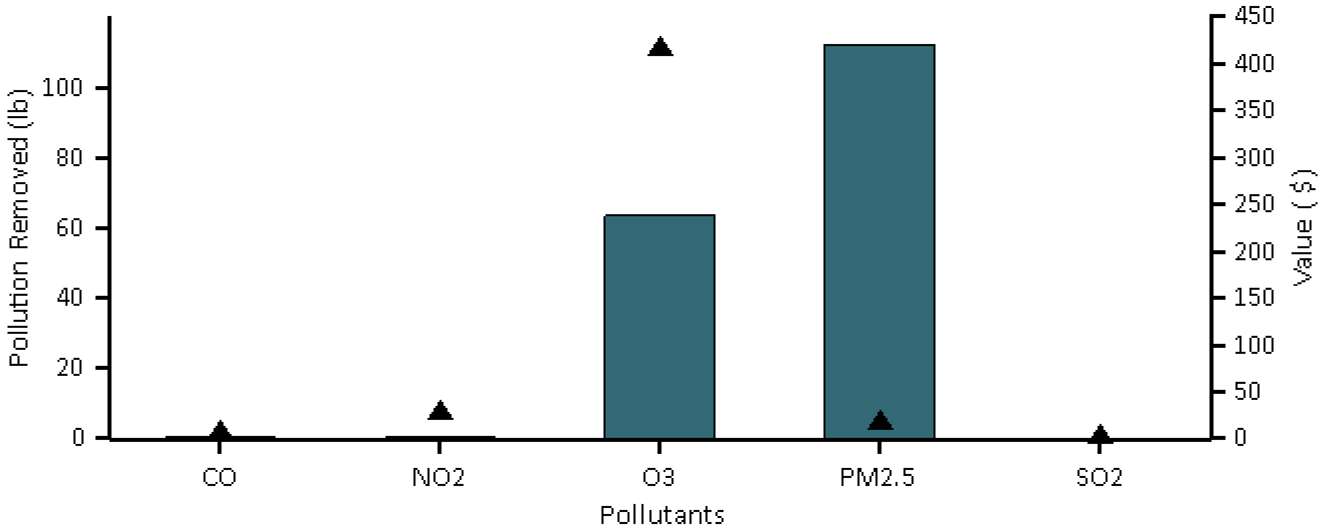


Figure 7. Annual pollution removal (points) and value (bars) by urban trees, Saranac Lake, NY

[1] Particulate matter less than 10 microns is a significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

[2] Trees remove PM2.5 when particulate matter is deposited on leaf surfaces. This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors (see Appendix I for more details).

In 2021, trees in Saranac Lake, NY emitted an estimated 27.72 pounds of volatile organic compounds (VOCs) (6.25 pounds of isoprene and 21.47 pounds of monoterpenes). Emissions vary among species based on species characteristics (e.g. some genera such as oaks are high isoprene emitters) and amount of leaf biomass. Thirty- seven percent of the urban forest's VOC emissions were from Eastern white pine and Blue spruce. These VOCs are precursor chemicals to ozone formation.[3]

General recommendations for improving air quality with trees are given in Appendix VIII.

[3] Some economic studies have estimated VOC emission costs. These costs are not included here as there is a tendency to add positive dollar estimates of ozone removal effects with negative dollar values of VOC emission effects to determine whether tree effects are positive or negative in relation to ozone. This combining of dollar values to determine tree effects should not be done, rather estimates of VOC effects on ozone formation (e.g., via photochemical models) should be conducted and directly contrasted with ozone removal by trees (i.e., ozone effects should be directly compared, not dollar estimates). In addition, air temperature reductions by trees have been shown to significantly reduce ozone concentrations (Cardelino and Chameides 1990; Nowak et al 2000), but are not considered in this analysis. Photochemical modeling that integrates tree effects on air temperature, pollution removal, VOC emissions, and emissions from power plants can be used to determine the overall effect of trees on ozone concentrations.

IV. Carbon Storage and Sequestration

Climate change is an issue of global concern. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power sources (Abdollahi et al 2000).

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of Saranac Lake, NY trees is about 1.641 tons of carbon per year with an associated value of $280. See Appendix I for more details on methods.

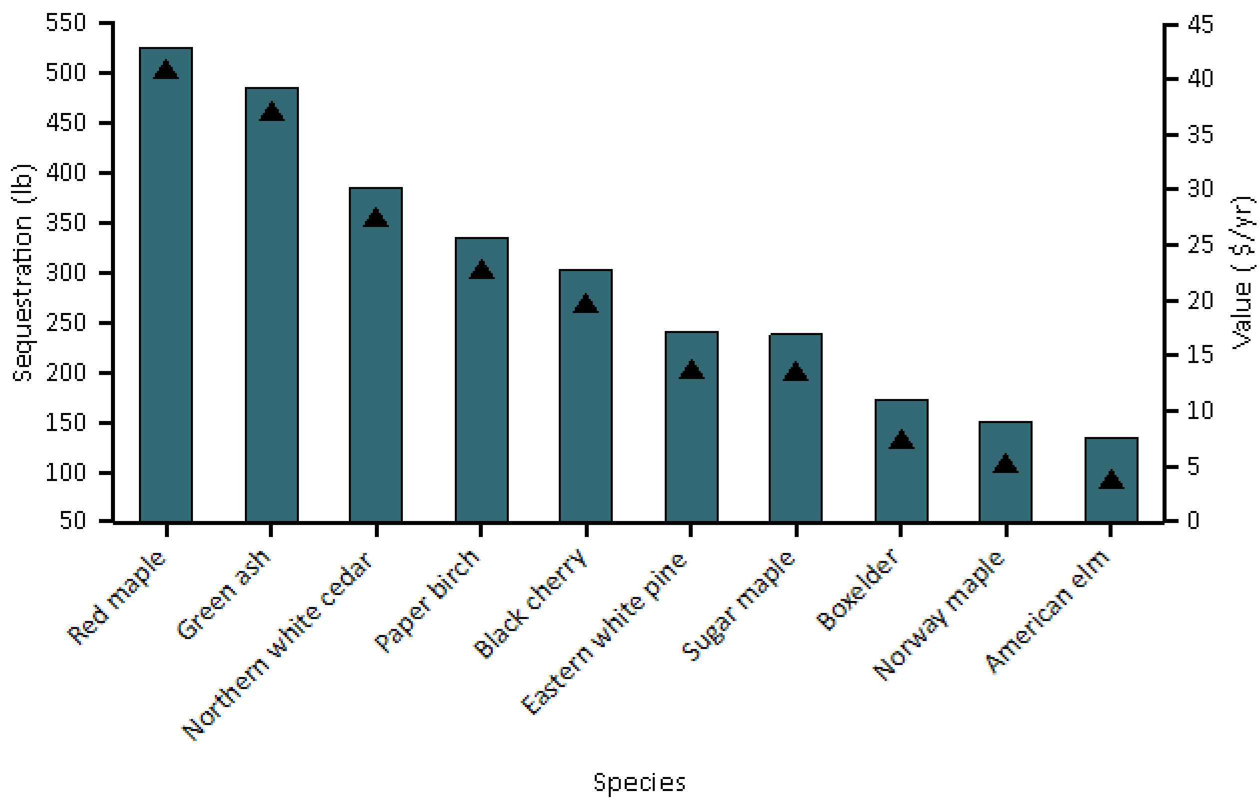


Figure 8. Estimated annual gross carbon sequestration (points) and value (bars) for urban tree species with the greatest sequestration, Saranac Lake, NY

Carbon storage is another way trees can influence global climate change. As a tree grows, it stores more carbon by holding it in its accumulated tissue. As a tree dies and decays, it releases much of the stored carbon back into the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose. Maintaining healthy trees will keep the carbon stored in trees, but tree maintenance can contribute to carbon emissions (Nowak et al 2002c). When a tree dies, using the wood in long-term wood products, to heat buildings, or to produce energy will help reduce carbon emissions from wood decomposition or from fossil-fuel or wood-based power plants.

Trees in Saranac Lake, NY are estimated to store 75.1 tons of carbon ($12.8 thousand). Of the species sampled, Northern white cedar stores the most carbon (approximately 14.9% of the total carbon stored) and Red maple sequesters the most (approximately 15.3% of all sequestered carbon.)

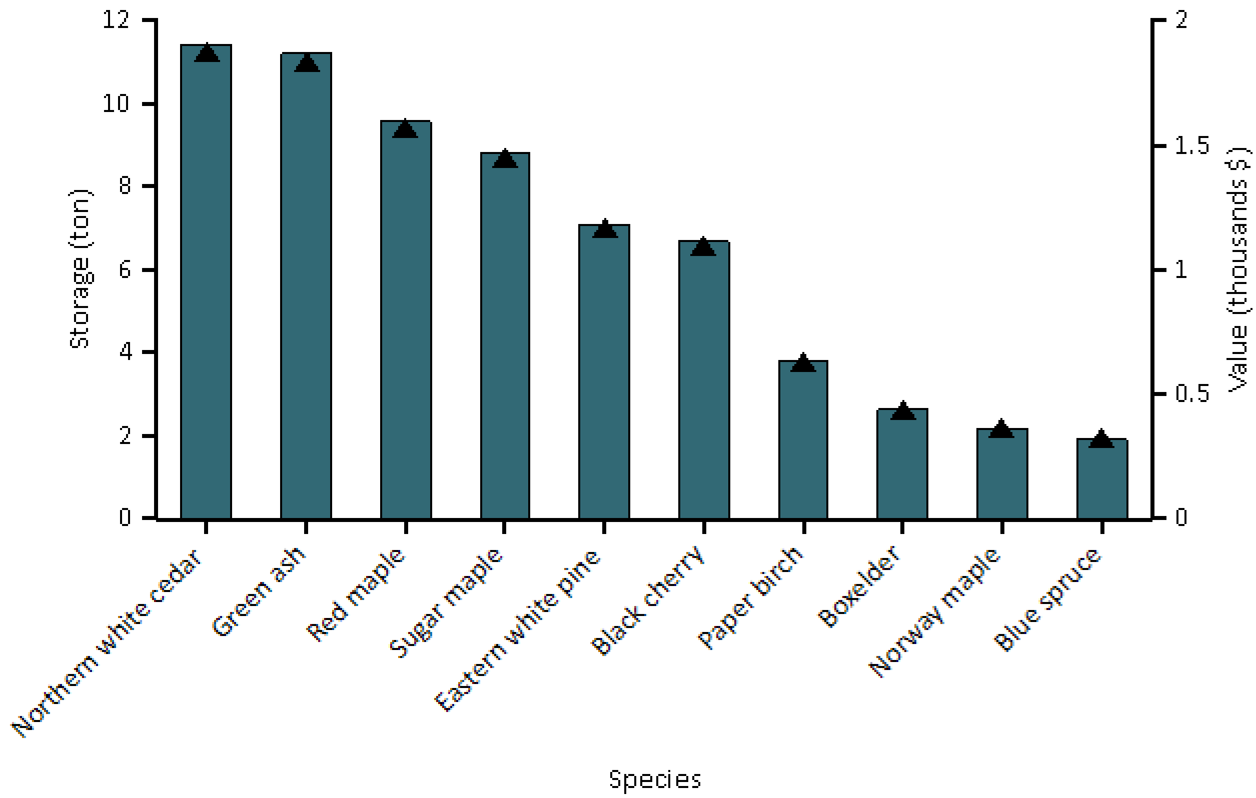


Figure 9. Estimated carbon storage (points) and values (bars) for urban tree species with the greatest storage, Saranac Lake, NY

V. Oxygen Production

Oxygen production is one of the most commonly cited benefits of urban trees. The annual oxygen production of a tree is directly related to the amount of carbon sequestered by the tree, which is tied to the accumulation of tree biomass.

Trees in Saranac Lake, NY are estimated to produce 4.375 tons of oxygen per year.[4] However, this tree benefit is relatively insignificant because of the large and relatively stable amount of oxygen in the atmosphere and extensive production by aquatic systems. Our atmosphere has an enormous reserve of oxygen. If all fossil fuel reserves, all trees, and all organic matter in soils were burned, atmospheric oxygen would only drop a few percent (Broecker 1970).

Table 2. The top 20 oxygen production species.

Species	*Oxygen (pound)*	*Gross Carbon Sequestration (pound/yr)*	*Number of Trees*	*Leaf Area (acre)*
Red maple	1,339.10	502.16	35	1.47
Green ash	1,227.24	460.21	65	3.79
Northern white cedar	943.07	353.65	91	1.61
Paper birch	804.76	301.78	43	1.11
Black cherry	714.05	267.77	16	0.68
Eastern white pine	535.68	200.88	13	1.69
Sugar maple	529.20	198.45	20	1.29
Boxelder	347.18	130.19	18	0.53
Norway maple	281.45	105.54	9	0.32
American elm	239.58	89.84	30	0.33
apple spp	236.91	88.84	28	0.18
Freeman maple	144.52	54.19	14	0.06
Littleleaf linden	138.27	51.85	4	0.36
Quaking aspen	133.26	49.97	11	0.10
Scots pine	122.83	46.06	8	0.28
White spruce	99.86	37.45	14	0.31
Blue spruce	88.40	33.15	4	0.38
White willow	87.28	32.73	3	0.19
Common lilac	61.46	23.05	11	0.03
American basswood	57.76	21.66	3	0.23

VI. Avoided Runoff

Surface runoff can be a cause for concern in many urban areas as it can contribute pollution to streams, wetlands, rivers, lakes, and oceans. During precipitation events, some portion of the precipitation is intercepted by vegetation (trees and shrubs) while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff (Hirabayashi 2012). In urban areas, the large extent of impervious surfaces increases the amount of surface runoff.

Urban trees and shrubs, however, are beneficial in reducing surface runoff. Trees and shrubs intercept precipitation, while their root systems promote infiltration and storage in the soil. The trees and shrubs of Saranac Lake, NY help to reduce runoff by an estimated 8.07 thousand cubic feet a year with an associated value of $540 (see Appendix I for more details). Avoided runoff is estimated based on local weather from the user-designated weather station. In Saranac Lake, NY, the total annual precipitation in 2016 was 35.0 inches.

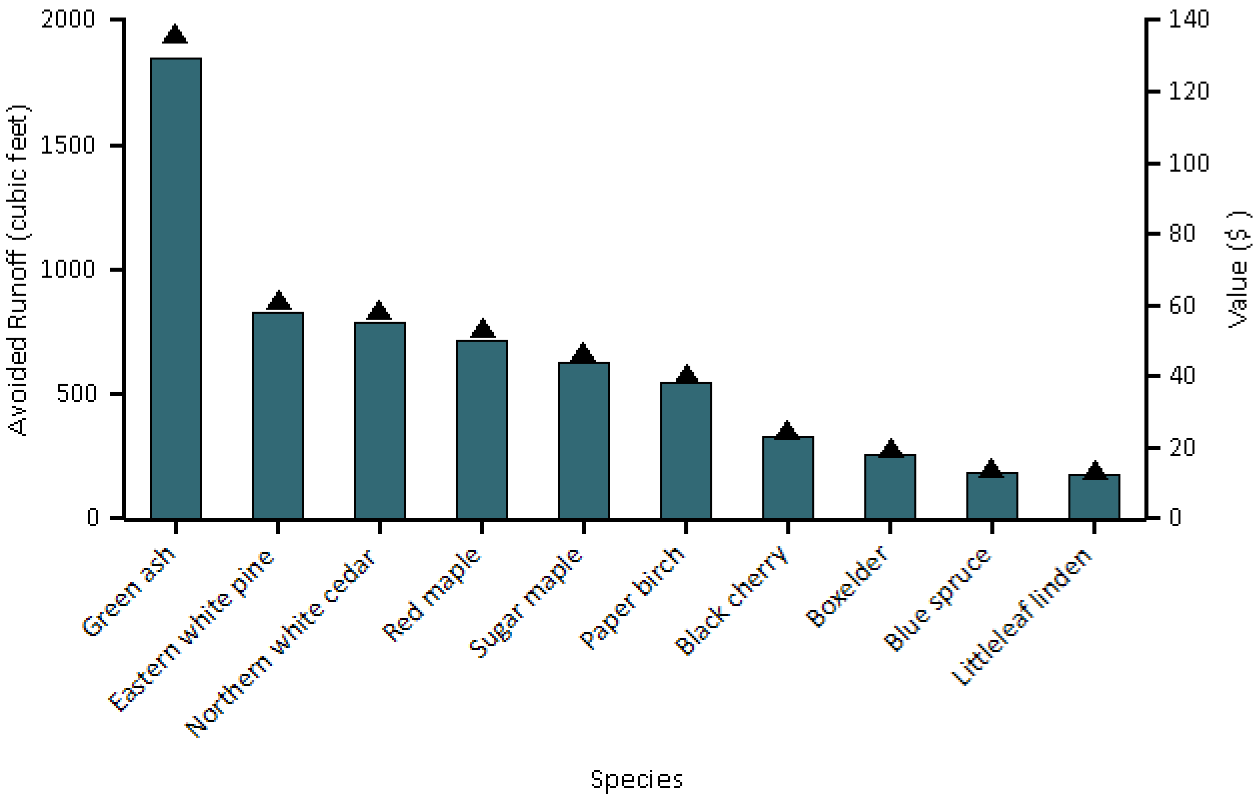


Figure 10. Avoided runoff (points) and value (bars) for species with greatest overall impact on runoff, Saranac Lake, NY

VII. Trees and Building Energy Use

Trees affect energy consumption by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months and can either increase or decrease building energy use in the winter months, depending on the location of trees around the building. Estimates of tree effects on energy use are based on field measurements of tree distance and direction to space conditioned residential buildings (McPherson and Simpson 1999).

Because energy-related data were not collected, energy savings and carbon avoided cannot be calculated.

Table 3. Annual energy savings due to trees near residential buildings, Saranac Lake, NY

	Heating	*Cooling*	*Total*
MBTU[a]	0	N/A	0
MWH[b]	0	0	0
Carbon Avoided (pounds)	0	0	0

[a]MBTU - one million British Thermal Units

[b]MWH - megawatt-hour

Table 4. Annual savings [a]($) in residential energy expenditure during heating and cooling seasons, Saranac Lake, NY

	Heating	*Cooling*	*Total*
MBTU[b]	0	N/A	0
MWH[c]	0	0	0
Carbon Avoided	0	0	0

[b]Based on the prices of $173.3 per MWH and $12.8256800359033 per MBTU (see Appendix I for more details)

[c]MBTU - one million British Thermal Units

[c]MWH - megawatt-hour

[5] Trees modify climate, produce shade, and reduce wind speeds. Increased energy use or costs are likely due to these tree-building interactions creating a cooling effect during the winter season. For example, a tree (particularly evergreen species) located on the southern side of a residential building may produce a shading effect that causes increases in heating requirements.

VIII. Structural and Functional Values

Urban forests have a structural value based on the trees themselves (e.g., the cost of having to replace a tree with a similar tree); they also have functional values (either positive or negative) based on the functions the trees perform.

The structural value of an urban forest tends to increase with a rise in the number and size of healthy trees (Nowak et al 2002a). Annual functional values also tend to increase with increased number and size of healthy trees. Through proper management, urban forest values can be increased; however, the values and benefits also can decrease as the amount of healthy tree cover declines.

Urban trees in Saranac Lake, NY have the following structural values:

- Structural value: $466 thousand
- Carbon storage: $12.8 thousand

Urban trees in Saranac Lake, NY have the following annual functional values:

- Carbon sequestration: $280
- Avoided runoff: $540
- Pollution removal: $662
- Energy costs and carbon emission values: $0

(Note: negative value indicates increased energy cost and carbon emission value)

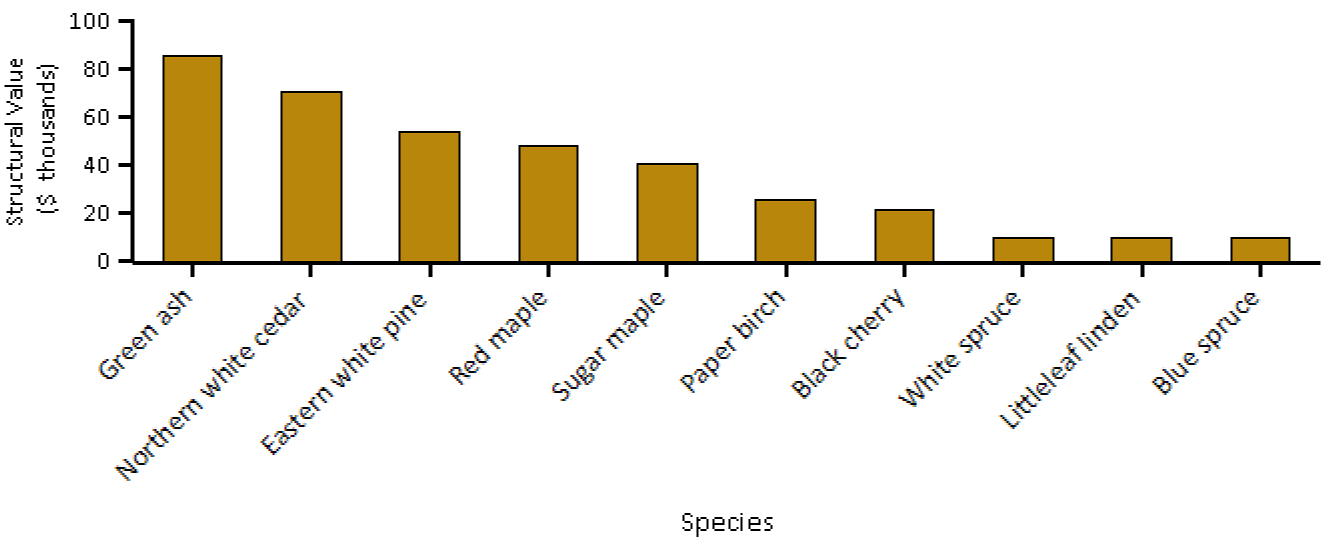


Figure 11. Tree species with the greatest structural value, Saranac Lake, NY

IX. Potential Pest Impacts

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, structural value and sustainability of the urban forest. As pests tend to have differing tree hosts, the potential damage or risk of each pest will differ among cities.Thirty-six pests were analyzed for their potential impact and compared with pest range maps (Forest Health Technology Enterprise Team 2014) for the conterminous United States to determine their proximity to Essex County. Twelve of the thirty-six pests analyzed are located within the county. For a complete analysis of all pests, see Appendix VII.

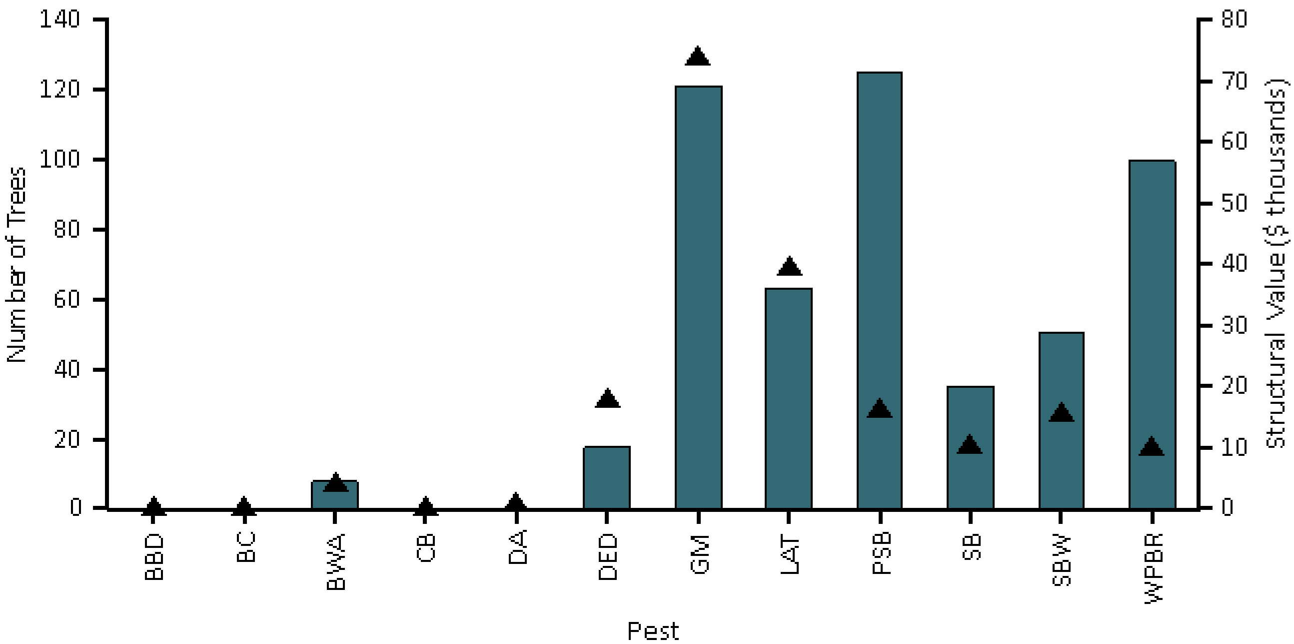


Figure 12. Number of trees at risk (points) and associated compensatory value (bars) for most threatening pests located in the county, Saranac Lake, NY

Beech bark disease (BBD) (Houston and O'Brien 1983) is an insect-disease complex that primarily impacts American beech. This disease threatens 0.0 percent of the population, which represents a potential loss of $0 in structural value.

Butternut canker (BC) (Ostry et al 1996) is caused by a fungus that infects butternut trees. The disease has since caused significant declines in butternut populations in the United States. Potential loss of trees from BC is 0.0 percent ($0 in structural value).

Balsam woolly adelgid (BWA) (Ragenovich and Mitchell 2006) is an insect that has caused significant damage to the true firs of North America. Saranac Lake, NY could possibly lose 1.3 percent of its trees to this pest ($4.44 thousand in structural value).

The most common hosts of the fungus that cause chestnut blight (CB) (Diller 1965) are American and European chestnut. CB has the potential to affect 0.0 percent of the population ($0 in structural value).

Dogwood anthracnose (DA) (Mielke and Daughtrey) is a disease that affects dogwood species, specifically flowering and Pacific dogwood. This disease threatens 0.2 percent of the population, which represents a potential loss of $77 in structural value.

American elm, one of the most important street trees in the twentieth century, has been devastated by the Dutch elm disease (DED) (Northeastern Area State and Private Forestry 1998). Since first reported in the 1930s, it has killed over 50 percent of the native elm population in the United States. Although some elm species have shown varying degrees of resistance, Saranac Lake, NY could possibly lose 6.0 percent of its trees to this pest ($10.2 thousand in structural value).

The gypsy moth (GM) (Northeastern Area State and Private Forestry 2005) is a defoliator that feeds on many species causing widespread defoliation and tree death if outbreak conditions last several years. This pest threatens 24.9 percent of the population, which represents a potential loss of $69.3 thousand in structural value.

Quaking aspen is a principal host for the defoliator, large aspen tortrix (LAT) (Ciesla and Kruse 2009). LAT poses a threat to 13.3 percent of the Saranac Lake, NY urban forest, which represents a potential loss of $36.1 thousand in structural value.

The pine shoot beetle (PSB) (Ciesla 2001) is a wood borer that attacks various pine species, though Scotch pine is the preferred host in North America. PSB has the potential to affect 5.4 percent of the population ($71.6 thousand in structural value).

Spruce beetle (SB) (Holsten et al 1999) is a bark beetle that causes significant mortality to spruce species within its range. Potential loss of trees from SB is 3.5 percent ($20.1 thousand in structural value).

Spruce budworm (SBW) (Kucera and Orr 1981) is an insect that causes severe damage to balsam fir. SBW poses a threat to 5.2 percent of the Saranac Lake, NY urban forest, which represents a potential loss of $28.9 thousand in structural value.

Since its introduction to the United States in 1900, white pine blister rust (Eastern U.S.) (WPBR) (Nicholls and Anderson 1977) has had a detrimental effect on white pines, particularly in the Lake States. WPBR has the potential to affect 3.3 percent of the population ($57 thousand in structural value).

Appendix I. i-Tree Eco Model and Field Measurements

i-Tree Eco is designed to use standardized field data and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects (Nowak and Crane 2000), including:

- Urban forest structure (e.g., species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year.
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power sources.
- Structural value of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by pests, such as Asian longhorned beetle, emerald ash borer, gypsy moth, and Dutch elm disease.

Typically, all field data are collected during the leaf-on season to properly assess tree canopies. Typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings (Nowak et al 2005; Nowak et al 2008).

During data collection, trees are identified to the most specific taxonomic classification possible. Trees that are not classified to the species level may be classified by genus (e.g., ash) or species groups (e.g., hardwood). In this report, tree species, genera, or species groups are collectively referred to as tree species.

<u>Tree Characteristics:</u>

Leaf area of trees was assessed using measurements of crown dimensions and percentage of crown canopy missing. In the event that these data variables were not collected, they are estimated by the model.

An analysis of invasive species is not available for studies outside of the United States. For the U.S., invasive species are identified using an invasive species list ()for the state in which the urban forest is located. These lists are not exhaustive and they cover invasive species of varying degrees of invasiveness and distribution. In instances where a state did not have an invasive species list, a list was created based on the lists of the adjacent states. Tree species that are identified as invasive by the state invasive species list are cross-referenced with native range data. This helps eliminate species that are on the state invasive species list, but are native to the study area.

<u>Air Pollution Removal:</u>

Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter less than 2.5 microns. Particulate matter less than 10 microns (PM10) is another significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models (Baldocchi 1988; Baldocchi et al 1987). As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature (Bidwell and Fraser 1972; Lovett 1994) that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere (Zinke 1967). Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values (Hirabayashi et al 2011; Hirabayashi et al 2012; Hirabayashi 2011).

Trees remove PM2.5 when particulate matter is deposited on leaf surfaces (Nowak et al 2013). This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors. Generally, PM2.5 removal is positive with positive benefits. However, there are some cases when net removal is negative or resuspended particles lead to increased pollution concentrations and negative values. During some months (e.g., with no rain), trees resuspend more particles than they remove. Resuspension can also lead to increased overall PM2.5 concentrations if the boundary layer conditions are lower during net resuspension periods than during net removal periods. Since the pollution removal value is based on the change in pollution concentration, it is possible to have situations when trees remove PM2.5 but increase concentrations and thus have negative values during periods of positive overall removal. These events are not common, but can happen.

For reports in the United States, default air pollution removal value is calculated based on local incidence of adverse health effects and national median externality costs. The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and particulate matter less than 2.5 microns using data from the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BenMAP) (Nowak et al 2014). The model uses a damage-function approach that is based on the local change in pollution concentration and population. National median externality costs were used to calculate the value of carbon monoxide removal (Murray et al 1994).

For international reports, user-defined local pollution values are used. For international reports that do not have local values, estimates are based on either European median externality values (van Essen et al 2011) or BenMAP regression equations (Nowak et al 2014) that incorporate user-defined population estimates. Values are then converted to local currency with user-defined exchange rates.

For this analysis, pollution removal value is calculated based on the prices of $1,327 per ton (carbon monoxide), $4,314 per ton (ozone), $325 per ton (nitrogen dioxide), $118 per ton (sulfur dioxide), $180,477 per ton (particulate matter less than 2.5 microns).

Carbon Storage and Sequestration:

Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation. To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations (Nowak 1994). To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

Carbon sequestration is the removal of carbon dioxide from the air by plants. To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year x) to estimate tree diameter and carbon storage in year x+1.

Carbon storage and carbon sequestration values are based on estimated or customized local carbon values. For international reports that do not have local values, estimates are based on the carbon value for the United States (U.S. Environmental Protection Agency 2015, Interagency Working Group on Social Cost of Carbon 2015) and converted to local currency with user-defined exchange rates.

For this analysis, carbon storage and carbon sequestration values are calculated based on $171 per ton.

Oxygen Production:

The amount of oxygen produced is estimated from carbon sequestration based on atomic weights: net O2 release (kg/yr) = net C sequestration (kg/yr) × 32/12. To estimate the net carbon sequestration rate, the amount of carbon sequestered as a result of tree growth is reduced by the amount lost resulting from tree mortality. Thus, net carbon sequestration and net annual oxygen production of the urban forest account for decomposition (Nowak et al 2007). For complete inventory projects, oxygen production is estimated from gross carbon sequestration and does not account for decomposition.

Avoided Runoff:

Annual avoided surface runoff is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis.

The value of avoided runoff is based on estimated or user-defined local values. For international reports that do not have local values, the national average value for the United States is utilized and converted to local currency with user-defined exchange rates. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series (McPherson et al 1999; 2000; 2001; 2002; 2003; 2004; 2006a; 2006b; 2006c; 2007; 2010; Peper et al 2009; 2010; Vargas et al 2007a; 2007b; 2008).

For this analysis, avoided runoff value is calculated based on the price of $0.07 per ft³.

Building Energy Use:

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature (McPherson and Simpson 1999) using distance and direction of trees from residential structures, tree height and tree condition data. To calculate the monetary value of energy savings, local or custom prices per MWH or MBTU are utilized.

For this analysis, energy saving value is calculated based on the prices of $173.30 per MWH and $12.83 per MBTU.

Structural Values:

Structural value is the value of a tree based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree). Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information (Nowak et al 2002a; 2002b). Structural value may not be included for international projects if there is insufficient local data to complete the valuation procedures.

Potential Pest Impacts:

The complete potential pest risk analysis is not available for studies outside of the United States. The number of trees at risk to the pests analyzed is reported, though the list of pests is based on known insects and disease in the United States.

For the U.S., potential pest risk is based on pest range maps and the known pest host species that are likely to experience mortality. Pest range maps for 2012 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team 2014) were used to determine the proximity of each pest to the county in which the urban forest is located. For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively (Eastern Forest Environmental Threat Assessment Center; Worrall 2007).

<u>Relative Tree Effects:</u>

The relative value of tree benefits reported in Appendix II is calculated to show what carbon storage and sequestration, and air pollutant removal equate to in amounts of municipal carbon emissions, passenger automobile emissions, and house emissions.

Municipal carbon emissions are based on 2010 U.S. per capita carbon emissions (Carbon Dioxide Information Analysis Center 2010). Per capita emissions were multiplied by city population to estimate total city carbon emissions.

Light duty vehicle emission rates (g/mi) for CO, NOx, VOCs, PM10, SO2 for 2010 (Bureau of Transportation Statistics 2010; Heirigs et al 2004), PM2.5 for 2011-2015 (California Air Resources Board 2013), and CO2 for 2011 (U.S. Environmental Protection Agency 2010) were multiplied by average miles driven per vehicle in 2011 (Federal Highway Administration 2013) to determine average emissions per vehicle.

Household emissions are based on average electricity kWh usage, natural gas Btu usage, fuel oil Btu usage, kerosene Btu usage, LPG Btu usage, and wood Btu usage per household in 2009 (Energy Information Administration 2013; Energy Information Administration 2014)

- CO2, SO2, and NOx power plant emission per KWh are from Leonardo Academy 2011. CO emission per kWh assumes 1/3 of one percent of C emissions is CO based on Energy Information Administration 1994. PM10 emission per kWh from Layton 2004.
- CO2, NOx, SO2, and CO emission per Btu for natural gas, propane and butane (average used to represent LPG), Fuel #4 and #6 (average used to represent fuel oil and kerosene) from Leonardo Academy 2011.
- CO2 emissions per Btu of wood from Energy Information Administration 2014.
- CO, NOx and SOx emission per Btu based on total emissions and wood burning (tons) from (British Columbia Ministry 2005; Georgia Forestry Commission 2009).

Appendix II. Relative Tree Effects

The urban forest in Saranac Lake, NY provides benefits that include carbon storage and sequestration, and air pollutant removal. To estimate the relative value of these benefits, tree benefits were compared to estimates of average municipal carbon emissions, average passenger automobile emissions, and average household emissions. See Appendix I for methodology.

<u>Carbon storage is equivalent to:</u>

- Amount of carbon emitted in Saranac Lake, NY in 1 days
- Annual carbon (C) emissions from 53 automobiles
- Annual C emissions from 22 single-family houses

<u>Carbon monoxide removal is equivalent to:</u>

- Annual carbon monoxide emissions from 0 automobiles
- Annual carbon monoxide emissions from 0 single-family houses

<u>Nitrogen dioxide removal is equivalent to:</u>

- Annual nitrogen dioxide emissions from 1 automobiles
- Annual nitrogen dioxide emissions from 0 single-family houses

<u>Sulfur dioxide removal is equivalent to:</u>

- Annual sulfur dioxide emissions from 4 automobiles
- Annual sulfur dioxide emissions from 0 single-family houses

<u>Annual carbon sequestration is equivalent to:</u>

- Amount of carbon emitted in Saranac Lake, NY in 0.0 days
- Annual C emissions from 0 automobiles
- Annual C emissions from 0 single-family houses

Appendix III. Comparison of Urban Forests

A common question asked is, "How does this city compare to other cities?" Although comparison among cities should be made with caution as there are many attributes of a city that affect urban forest structure and functions, summary data are provided from other cities analyzed using the i-Tree Eco model.

I. City totals for trees

City	*% Tree Cover*	*Number of Trees*	*Carbon Storage (tons)*	*Carbon Sequestration (tons/yr)*	*Pollution Removal (tons/yr)*
Toronto, ON, Canada	26.6	10,220,000	1,221,000	51,500	2,099
Atlanta, GA	36.7	9,415,000	1,344,000	46,400	1,663
Los Angeles, CA	11.1	5,993,000	1,269,000	77,000	1,975
New York, NY	20.9	5,212,000	1,350,000	42,300	1,676
London, ON, Canada	24.7	4,376,000	396,000	13,700	408
Chicago, IL	17.2	3,585,000	716,000	25,200	888
Phoenix, AZ	9.0	3,166,000	315,000	32,800	563
Baltimore, MD	21.0	2,479,000	570,000	18,400	430
Philadelphia, PA	15.7	2,113,000	530,000	16,100	575
Washington, DC	28.6	1,928,000	525,000	16,200	418
Oakville, ON , Canada	29.1	1,908,000	147,000	6,600	190
Albuquerque, NM	14.3	1,846,000	332,000	10,600	248
Boston, MA	22.3	1,183,000	319,000	10,500	283
Syracuse, NY	26.9	1,088,000	183,000	5,900	109
Woodbridge, NJ	29.5	986,000	160,000	5,600	210
Minneapolis, MN	26.4	979,000	250,000	8,900	305
San Francisco, CA	11.9	668,000	194,000	5,100	141
Morgantown, WV	35.5	658,000	93,000	2,900	72
Moorestown, NJ	28.0	583,000	117,000	3,800	118
Hartford, CT	25.9	568,000	143,000	4,300	58
Jersey City, NJ	11.5	136,000	21,000	890	41
Casper, WY	8.9	123,000	37,000	1,200	37
Freehold, NJ	34.4	48,000	20,000	540	22

II. Totals per acre of land area

City	*Number of Trees/ac*	*Carbon Storage (tons/ac)*	*Carbon Sequestration (tons/ac/yr)*	*Pollution Removal (lb/ac/yr)*
Toronto, ON, Canada	64.9	7.8	0.33	26.7
Atlanta, GA	111.6	15.9	0.55	39.4
Los Angeles, CA	19.6	4.2	0.16	13.1
New York, NY	26.4	6.8	0.21	17.0
London, ON, Canada	75.1	6.8	0.24	14.0
Chicago, IL	24.2	4.8	0.17	12.0
Phoenix, AZ	12.9	1.3	0.13	4.6
Baltimore, MD	48.0	11.1	0.36	16.6
Philadelphia, PA	25.1	6.3	0.19	13.6
Washington, DC	49.0	13.3	0.41	21.2
Oakville, ON , Canada	78.1	6.0	0.27	11.0
Albuquerque, NM	21.8	3.9	0.12	5.9
Boston, MA	33.5	9.1	0.30	16.1
Syracuse, NY	67.7	10.3	0.34	13.6
Woodbridge, NJ	66.5	10.8	0.38	28.4
Minneapolis, MN	26.2	6.7	0.24	16.3
San Francisco, CA	22.5	6.6	0.17	9.5
Morgantown, WV	119.2	16.8	0.52	26.0
Moorestown, NJ	62.1	12.4	0.40	25.1
Hartford, CT	50.4	12.7	0.38	10.2
Jersey City, NJ	14.4	2.2	0.09	8.6
Casper, WY	9.1	2.8	0.09	5.5
Freehold, NJ	38.3	16.0	0.44	35.3

Appendix IV. General Recommendations for Air Quality Improvement

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmosphere environment. Four main ways that urban trees affect air quality are (Nowak 1995):

- Temperature reduction and other microclimate effects
- Removal of air pollutants
- Emission of volatile organic compounds (VOC) and tree maintenance emissions
- Energy effects on buildings

The cumulative and interactive effects of trees on climate, pollution removal, and VOC and power plant emissions determine the impact of trees on air pollution. Cumulative studies involving urban tree impacts on ozone have revealed that increased urban canopy cover, particularly with low VOC emitting species, leads to reduced ozone concentrations in cities (Nowak 2000). Local urban management decisions also can help improve air quality.

Urban forest management strategies to help improve air quality include (Nowak 2000):

Strategy	*Result*
Increase the number of healthy trees	Increase pollution removal
Sustain existing tree cover	Maintain pollution removal levels
Maximize use of low VOC-emitting trees	Reduces ozone and carbon monoxide formation
Sustain large, healthy trees	Large trees have greatest per-tree effects
Use long-lived trees	Reduce long-term pollutant emissions from planting and removal
Use low maintenance trees	Reduce pollutants emissions from maintenance activities
Reduce fossil fuel use in maintaining vegetation	Reduce pollutant emissions
Plant trees in energy conserving locations	Reduce pollutant emissions from power plants
Plant trees to shade parked cars	Reduce vehicular VOC emissions
Supply ample water to vegetation	Enhance pollution removal and temperature reduction
Plant trees in polluted or heavily populated areas	Maximizes tree air quality benefits
Avoid pollutant-sensitive species	Improve tree health
Utilize evergreen trees for particulate matter	Year-round removal of particles

Appendix V. Invasive Species of the Urban Forest

The following inventoried tree species were listed as invasive on the New York invasive species list ():

Species Name[a]	*Number of Trees*	*% of Trees*	*Leaf Area (ac)*	*Percent Leaf Area*
Norway maple	9	1.7	0.3	2.0
Total	**9**	**1.73**	**0.32**	**2.01**

[a]Species are determined to be invasive if they are listed on the state's invasive species list

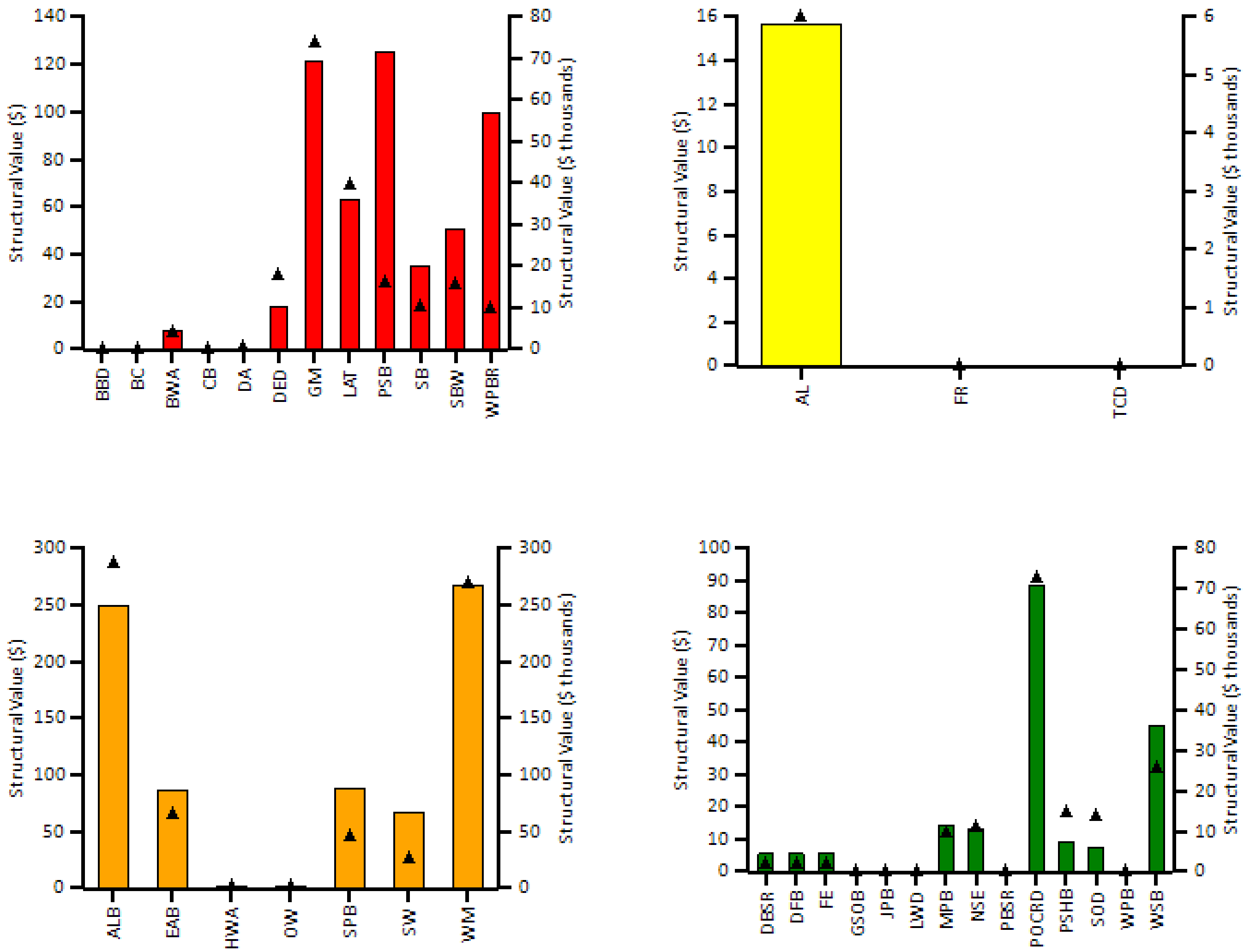
Appendix VI. Potential Risk of Pests

Thirty-six insects and diseases were analyzed to quantify their potential impact on the urban forest. As each insect/ disease is likely to attack different host tree species, the implications for {0} will vary. The number of trees at risk reflects only the known host species that are likely to experience mortality.

Code	Scientific Name	Common Name	Trees at Risk (#)	Value ($ thousands)
AL	Phyllocnistis populiella	Aspen Leafminer	16	5.86
ALB	Anoplophora glabripennis	Asian Longhorned Beetle	287	249.55
BBD	Neonectria faginata	Beech Bark Disease	0	0.00
BC	Sirococcus clavigignenti juglandacearum	Butternut Canker	0	0.00
BWA	Adelges piceae	Balsam Woolly Adelgid	7	4.44
CB	Cryphonectria parasitica	Chestnut Blight	0	0.00
DA	Discula destructiva	Dogwood Anthracnose	1	0.08
DBSR	Leptographium wageneri var. pseudotsugae	Douglas-fir Black Stain Root Disease	2	4.38
DED	Ophiostoma novo-ulmi	Dutch Elm Disease	31	10.16
DFB	Dendroctonus pseudotsugae	Douglas-Fir Beetle	2	4.38
EAB	Agrilus planipennis	Emerald Ash Borer	65	85.63
FE	Scolytus ventralis	Fir Engraver	2	4.38
FR	Cronartium quercuum f. sp. Fusiforme	Fusiform Rust	0	0.00
GM	Lymantria dispar	Gypsy Moth	129	69.25
GSOB	Agrilus auroguttatus	Goldspotted Oak Borer	0	0.00
HWA	Adelges tsugae	Hemlock Woolly Adelgid	1	0.84
JPB	Dendroctonus jeffreyi	Jeffrey Pine Beetle	0	0.00
LAT	Choristoneura conflictana	Large Aspen Tortrix	69	36.15
LWD	Raffaelea lauricola	Laurel Wilt	0	0.00
MPB	Dendroctonus ponderosae	Mountain Pine Beetle	12	11.61
NSE	Ips perturbatus	Northern Spruce Engraver	14	10.40
OW	Ceratocystis fagacearum	Oak Wilt	1	0.98
PBSR	Leptographium wageneri var. ponderosum	Pine Black Stain Root Disease	0	0.00
POCRD	Phytophthora lateralis	Port-Orford-Cedar Root Disease	91	71.05
PSB	Tomicus piniperda	Pine Shoot Beetle	28	71.55
PSHB	Euwallacea nov. sp.	Polyphagous Shot Hole Borer	18	7.30
SB	Dendroctonus rufipennis	Spruce Beetle	18	20.12
SBW	Choristoneura fumiferana	Spruce Budworm	27	28.94
SOD	Phytophthora ramorum	Sudden Oak Death	17	5.86
SPB	Dendroctonus frontalis	Southern Pine Beetle	45	88.14
SW	Sirex noctilio	Sirex Wood Wasp	26	67.18
TCD	Geosmithia morbida	Thousand Canker Disease	0	0.00
WM	Operophtera brumata	Winter Moth	269	267.10
WPB	Dendroctonus brevicomis	Western Pine Beetle	0	0.00
WPBR	Cronartium ribicola	White Pine Blister Rust	17	56.98

Code	Scientific Name	Common Name	Trees at Risk (#)	Value ($ thousands)
WSB	Choristoneura occidentalis	Western Spruce Budworm	32	36.10

In the following graph, the pests are color coded according to the county's proximity to the pest occurrence in the United States. Red indicates that the pest is within the county; orange indicates that the pest is within 250 miles of the county; yellow indicates that the pest is within 750 miles of the county; and green indicates that the pest is outside of these ranges.



Note: points - Number of trees, bars - Structural value

Based on the host tree species for each pest and the current range of the pest (Forest Health Technology Enterprise Team 2014), it is possible to determine what the risk is that each tree species in the urban forest could be attacked by an insect or disease.

Spp. Risk	Risk Weight	Species Name	AL	ALB	BBD	BC	BWA	CB	DA	DBSR	DED	DFB	EAB	FE	FR	GM	GSOB	HWA	JPB	LAT	LWD	MPB	NSE	OW	PBSR	POCRD	PSB	PSHB	SB	SBW	SOD	SPB	SW	TCD	WM	WPB	WPBR	WSB
	16	Quaking aspen																																				
	16	Limber pine																																				
	16	White willow																																				
	14	Paper birch																																				
	14	Eastern white pine																																				
	14	River birch																																				
	14	Gray birch																																				
	13	White spruce																																				
	13	willow spp																																				
	13	Douglas fir																																				
	12	Scots pine																																				
	12	Blue spruce																																				
	11	Boxelder																																				
	10	American elm																																				
	10	Bur oak																																				
	10	Slippery elm																																				
	10	Red pine																																				
	10	Yellow birch																																				
	9	Green ash																																				
	8	Balsam fir																																				
	7	apple spp																																				
	7	Common chokecherry																																				
	7	American basswood																																				
	7	American mountain ash																																				
	6	Red maple																																				
	6	Sugar maple																																				
	6	Norway maple																																				
	6	Eastern hemlock																																				
	6	Eastern cottonwood																																				
	4	Eastern service berry																																				
	4	Littleleaf linden																																				
	4	Staghorn sumac																																				
	4	Alternateleaf dogwood																																				

	3	Black cherry
	3	Freeman maple
	3	Common plum
	3	Tatar maple
	1	Northern white cedar
	1	Common lilac
	1	viburnum spp

Note:

Species that are not listed in the matrix are not known to be hosts to any of the pests analyzed.

Species Risk:

- Red indicates that tree species is at risk to at least one pest within county
- Orange indicates that tree species has no risk to pests in county, but has a risk to at least one pest within 250 miles from the county
- Yellow indicates that tree species has no risk to pests within 250 miles of county, but has a risk to at least one pest that is 250 and 750 miles from the county
- Green indicates that tree species has no risk to pests within 750 miles of county, but has a risk to at least one pest that is greater than 750 miles from the county

Risk Weight:

Numerical scoring system based on sum of points assigned to pest risks for species. Each pest that could attack tree species is scored as 4 points if red, 3 points if orange, 2 points if yellow and 1 point if green.

Pest Color Codes:

- Red indicates pest is within Essex county
- Red indicates pest is within 250 miles county
- Yellow indicates pest is within 750 miles of Essex county
- Green indicates pest is outside of these ranges

References

Abdollahi, K.K.; Ning, Z.H.; Appeaning, A., eds. 2000. Global climate change and the urban forest. Baton Rouge, LA: GCRCC and Franklin Press. 77 p.

Baldocchi, D. 1988. A multi-layer model for estimating sulfur dioxide deposition to a deciduous oak forest canopy. Atmospheric Environment. 22: 869-884.

Baldocchi, D.D.; Hicks, B.B.; Camara, P. 1987. A canopy stomatal resistance model for gaseous deposition to vegetated surfaces. Atmospheric Environment. 21: 91-101.

Bidwell, R.G.S.; Fraser, D.E. 1972. Carbon monoxide uptake and metabolism by leaves. Canadian Journal of Botany. 50: 1435-1439.

British Columbia Ministry of Water, Land, and Air Protection. 2005. Residential wood burning emissions in British Columbia. British Columbia.

Broecker, W.S. 1970. Man's oxygen reserve. Science 168(3939): 1537-1538.

Bureau of Transportation Statistics. 2010. Estimated National Average Vehicle Emissions Rates per Vehicle by Vehicle Type using Gasoline and Diesel. Washington, DC: Burea of Transportation Statistics, U.S. Department of Transportation. Table 4-43.

California Air Resources Board. 2013. Methods to Find the Cost-Effectiveness of Funding Air Quality Projects. Table 3 Average Auto Emission Factors. CA: California Environmental Protection Agency, Air Resources Board.

Carbon Dioxide Information Analysis Center. 2010. CO2 Emissions (metric tons per capita). Washington, DC: The World Bank.

Cardelino, C.A.; Chameides, W.L. 1990. Natural hydrocarbons, urbanization, and urban ozone. Journal of Geophysical Research. 95(D9): 13,971-13,979.

Ciesla, W. M. 2001. Tomicus piniperda. North American Forest Commission. Exotic Forest Pest Information System for North America (EXFOR).

Ciesla, W. M.; Kruse, J. J. 2009. Large Aspen Tortrix. Forest Insect & Disease Leaflet 139. Washington, DC: U. S. Department of Agriculture, Forest Service. 8 p.

Diller, J. D. 1965. Chestnut Blight. Forest Pest Leaflet 94. Washington, DC: U. S. Department of Agriculture, Forest Service. 7 p.

Eastern Forest Environmental Threat Assessment Center. Dutch Elm Disease. http://threatsummary.forestthreats.org/threats/threatSummaryViewer.cfm?threatID=43

Energy Information Administration. 1994. Energy Use and Carbon Emissions: Non-OECD Countries. Washington, DC: Energy Information Administration, U.S. Department of Energy.

Energy Information Administration. 2013. CE2.1 Fuel consumption totals and averages, U.S. homes. Washington, DC: Energy Information Administration, U.S. Department of Energy.

Energy Information Administration. 2014. CE5.2 Household wood consumption. Washington, DC: Energy Information Administration, U.S. Department of Energy.

Federal Highway Administration. 2013. Highway Statistics 2011.Washington, DC: Federal Highway Administration, U.S. Department of Transportation. Table VM-1.

Forest Health Technology Enterprise Team. 2014. 2012 National Insect & Disease Risk Maps/Data. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. http://www.fs.fed.us/foresthealth/technology/nidrm2012.shtml

Georgia Forestry Commission. 2009. Biomass Energy Conversion for Electricity and Pellets Worksheet. Dry Branch, GA: Georgia Forestry Commission.

Heirigs, P.L.; Delaney, S.S.; Dulla, R.G. 2004. Evaluation of MOBILE Models: MOBILE6.1 (PM), MOBILE6.2 (Toxics), and MOBILE6/CNG. Sacramento, CA: National Cooperative Highway Research Program, Transportation Research Board.

Hirabayashi, S. 2011. Urban Forest Effects-Dry Deposition (UFORE-D) Model Enhancements, http://www.itreetools.org/eco/resources/UFORE-D enhancements.pdf

Hirabayashi, S. 2012. i-Tree Eco Precipitation Interception Model Descriptions, http://www.itreetools.org/eco/resources/iTree_Eco_Precipitation_Interception_Model_Descriptions_V1_2.pdf

Hirabayashi, S.; Kroll, C.; Nowak, D. 2011. Component-based development and sensitivity analyses of an air pollutant dry deposition model. Environmental Modeling and Software. 26(6): 804-816.

Hirabayashi, S.; Kroll, C.; Nowak, D. 2012. i-Tree Eco Dry Deposition Model Descriptions V 1.0

Holsten, E.H.; Thier, R.W.; Munson, A.S.; Gibson, K.E. 1999. The Spruce Beetle. Forest Insect & Disease Leaflet 127. Washington, DC: U.S. Department of Agriculture, Forest Service. 12 p.

Houston, D. R.; O'Brien, J. T. 1983. Beech Bark Disease. Forest Insect & Disease Leaflet 75. Washington, DC: U. S. Department of Agriculture, Forest Service. 8 p.

Interagency Working Group on Social Cost of Carbon, United States Government. 2015. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. http://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf

Kucera, D. R.; Orr, P. W. 1981. Spruce Budworm in the Eastern United States. Forest Pest Leaflet 160. Washington, DC: U.S. Department of Agriculture, Forest Service. 8 p.

Layton, M. 2004. 2005 Electricity Environmental Performance Report: Electricity Generation and Air Emissions. CA: California Energy Commission.

Leonardo Academy. 2011. Leonardo Academy's Guide to Calculating Emissions Including Emission Factors and Energy Prices. Madison, WI: Leonardo Academy Inc.

Lovett, G.M. 1994. Atmospheric deposition of nutrients and pollutants in North America: an ecological perspective.

Ecological Applications. 4: 629-650.

McPherson, E.G.; Maco, S.E.; Simpson, J.R.; Peper, P.J.; Xiao, Q.; VanDerZanden, A.M.; Bell, N. 2002. Western Washington and Oregon Community Tree Guide: Benefits, Costs, and Strategic Planting. International Society of Arboriculture, Pacific Northwest, Silverton, OR.

McPherson, E.G.; Simpson, J.R. 1999. Carbon dioxide reduction through urban forestry: guidelines for professional and volunteer tree planters. Gen. Tech. Rep. PSW-171. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 237 p.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Crowell, A.M.N.; Xiao, Q. 2010. Northern California coast community tree guide: benefits, costs, and strategic planting. PSW-GTR-228. Gen. Tech. Rep. PSW-GTR-228. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Vargas, K.E.; Maco, S.E.; Xiao, Q. 2006a. Coastal Plain Community Tree Guide: Benefits, Costs, and Strategic Planting PSW-GTR-201. USDA Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Vargas, K.E.; Xiao, Q. 2007. Northeast community tree guide: benefits, costs, and strategic planting.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Gardner, S.L.; Cozad, S.K.; Xiao, Q. 2006b. Midwest Community Tree Guide: Benefits, Costs and Strategic Planting PSW-GTR-199. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Gardner, S.L.; Vargas, K.E.; Xiao, Q. 2006c. Piedmont Community Tree Guide: Benefits, Costs, and Strategic Planting PSW-GTR 200. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Xiao Q.; Mulrean, E. 2004. Desert Southwest Community Tree Guide: Benefits, Costs and Strategic Planting. Phoenix, AZ: Arizona Community Tree Council, Inc. 81 :81.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Scott, K.I.; Xiao, Q. 2000. Tree Guidelines for Coastal Southern California Communities. Local Government Commission, Sacramento, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q. 1999. Tree Guidelines for San Joaquin Valley Communities. Local Government Commission, Sacramento, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q.; Maco, S.E.; Hoefer, P.J. 2003. Northern Mountain and Prairie Community Tree Guide: Benefits, Costs and Strategic Planting. Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station, Albany, CA.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q.; Pittenger, D.R.; Hodel, D.R. 2001. Tree Guidelines for Inland Empire Communities. Local Government Commission, Sacramento, CA.

Mielke, M. E.; Daughtrey, M. L. How to Identify and Control Dogwood Anthracnose. NA-GR-18. Broomall, PA: U. S. Department of Agriculture, Forest Service, Northeastern Area and Private Forestry.

Murray, F.J.; Marsh L.; Bradford, P.A. 1994. New York State Energy Plan, vol. II: issue reports. Albany, NY: New York State Energy Office.

National Invasive Species Information Center. 2011. Beltsville, MD: U.S. Department of Agriculture, National Invasive Species Information Center. http://www.invasivespeciesinfo.gov/plants/main.shtml

Nicholls, T. H.; Anderson, R. L. 1977. How to Identify White Pine Blister Rust and Remove Cankers. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry

Northeastern Area State and Private Forestry. 1998. How to identify and manage Dutch Elm Disease. NA-PR-07-98. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry.

Northeastern Area State and Private Forestry. 2005. Gypsy moth digest. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry.

Nowak, D.J. 1994. Atmospheric carbon dioxide reduction by Chicago's urban forest. In: McPherson, E.G.; Nowak, D.J.; Rowntree, R.A., eds. Chicago's urban forest ecosystem: results of the Chicago Urban Forest Climate Project. Gen. Tech. Rep. NE-186. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 83-94.

Nowak, D.J. 1995. Trees pollute? A "TREE" explains it all. In: Proceedings of the 7th National Urban Forestry Conference. Washington, DC: American Forests: 28-30.

Nowak, D.J. 2000. The interactions between urban forests and global climate change. In: Abdollahi, K.K.; Ning, Z.H.; Appeaning, A., eds. Global Climate Change and the Urban Forest. Baton Rouge, LA: GCRCC and Franklin Press: 31-44.

Nowak, D.J., Hirabayashi, S., Bodine, A., Greenfield, E. 2014. Tree and forest effects on air quality and human health in the United States. Environmental Pollution. 193:119-129.

Nowak, D.J., Hirabayashi, S., Bodine, A., Hoehn, R. 2013. Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. Environmental Pollution. 178: 395-402.

Nowak, D.J.; Civerolo, K.L.; Rao, S.T.; Sistla, S.; Luley, C.J.; Crane, D.E. 2000. A modeling study of the impact of urban trees on ozone. Atmospheric Environment. 34: 1601-1613.

Nowak, D.J.; Crane, D.E. 2000. The Urban Forest Effects (UFORE) Model: quantifying urban forest structure and functions. In: Hansen, M.; Burk, T., eds. Integrated tools for natural resources inventories in the 21st century. Proceedings of IUFRO conference. Gen. Tech. Rep. NC-212. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station: 714-720.

Nowak, D.J.; Crane, D.E.; Dwyer, J.F. 2002a. Compensatory value of urban trees in the United States. Journal of Arboriculture. 28(4): 194 - 199.

Nowak, D.J.; Crane, D.E.; Stevens, J.C.; Hoehn, R.E. 2005. The urban forest effects (UFORE) model: field data collection manual. V1b. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station, 34 p. http://www.fs.fed.us/ne/syracuse/Tools/downloads/UFORE_Manual.pdf

Nowak, D.J.; Crane, D.E.; Stevens, J.C.; Ibarra, M. 2002b. Brooklyn's urban forest. Gen. Tech. Rep. NE-290. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 107 p.

Nowak, D.J.; Dwyer, J.F. 2000. Understanding the benefits and costs of urban forest ecosystems. In: Kuser, John, ed.

Handbook of urban and community forestry in the northeast. New York, NY: Kluwer Academics/Plenum: 11-22.

Nowak, D.J.; Hoehn, R.; Crane, D. 2007. Oxygen production by urban trees in the United States. Arboriculture & Urban Forestry. 33(3):220-226.

Nowak, D.J.; Hoehn, R.E.; Crane, D.E.; Stevens, J.C.; Walton, J.T; Bond, J. 2008. A ground-based method of assessing urban forest structure and ecosystem services. Arboriculture and Urban Forestry. 34(6): 347-358.

Nowak, D.J.; Stevens, J.C.; Sisinni, S.M.; Luley, C.J. 2002c. Effects of urban tree management and species selection on atmospheric carbon dioxide. Journal of Arboriculture. 28(3): 113-122.

Ostry, M.E.; Mielke, M.E.; Anderson, R.L. 1996. How to Identify Butternut Canker and Manage Butternut Trees. U. S. Department of Agriculture, Forest Service, North Central Forest Experiment Station.

Peper, P.J.; McPherson, E.G.; Simpson, J.R.; Albers, S.N.; Xiao, Q. 2010. Central Florida community tree guide: benefits, costs, and strategic planting. Gen. Tech. Rep. PSW-GTR-230. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Peper, P.J.; McPherson, E.G.; Simpson, J.R.; Vargas, K.E.; Xiao Q. 2009. Lower Midwest community tree guide: benefits, costs, and strategic planting. PSW-GTR-219. Gen. Tech. Rep. PSW-GTR-219. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

U.S. Environmental Protection Agency. 2010. Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards. Washington, DC: U.S. Environmental Protection Agency. EPA-420-R-10-012a

U.S. Environmental Protection Agency. 2015. The social cost of carbon. http://www.epa.gov/climatechange/EPAactivities/economics/scc.html

van Essen, H.; Schroten, A.; Otten, M.; Sutter, D.; Schreyer, C.; Zandonella, R.; Maibach, M.; Doll, C. 2011. External Costs of Transport in Europe. Netherlands: CE Delft. 161 p.

Vargas, K.E.; McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Xiao, Q. 2007a. Interior West Tree Guide.

Vargas, K.E.; McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Xiao, Q. 2007b. Temperate Interior West Community Tree Guide: Benefits, Costs, and Strategic Planting.

Vargas, K.E.; McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Xiao, Q. 2008. Tropical community tree guide: benefits, costs, and strategic planting. PSW-GTR-216. Gen. Tech. Rep. PSW-GTR-216. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Worrall, J.J. 2007. Chestnut Blight. Forest and Shade Tree Pathology.
http://www.forestpathology.org/dis_chestnut.html

Zinke, P.J. 1967. Forest interception studies in the United States. In: Sopper, W.E.; Lull, H.W., eds. Forest Hydrology. Oxford, UK: Pergamon Press: 137-161.