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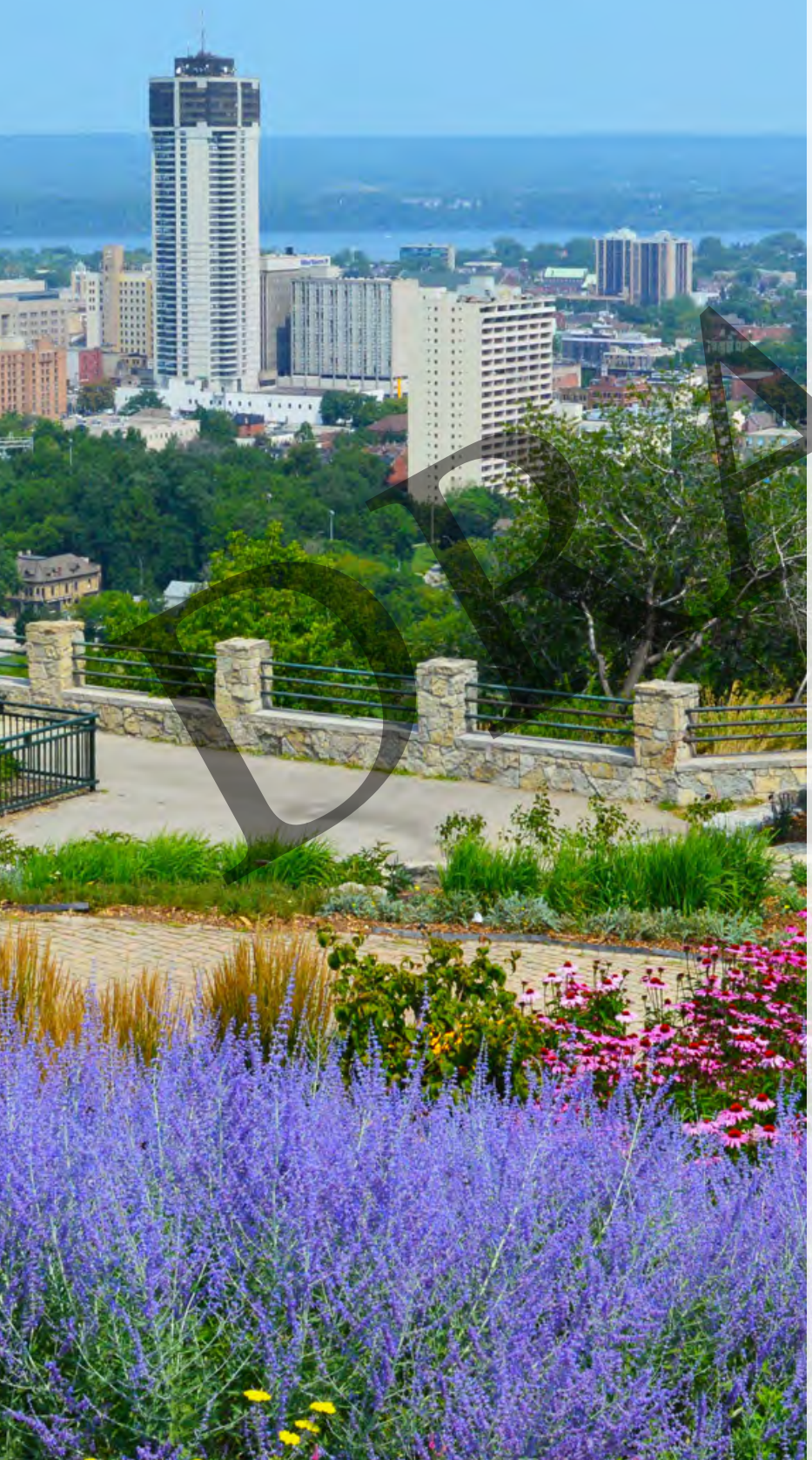

DRAFT

2020

City of Hamilton

URBAN FOREST STRATEGY

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Executive Summary

The City of Hamilton's urban forest includes all trees, forests and natural landscape features found in the urban area of Hamilton, on both public and private lands. Research shows that trees and forests in the urban area provide many environmental, economic and health benefits to urban residents. However, pressures on Hamilton's urban forest are growing, with stresses like climate change, urban development and invasive species creating significant challenges to forest management. Today, the City faces a slow and subtle loss in tree canopy cover as a result of these pressures. This means that Hamilton must proactively manage its urban forest. The need for an Urban Forest Strategy for the City of Hamilton was first identified in the 2014 Urban Woodland Conservation By-law Staff Report.[1]

The purpose of the Strategy is to guide the protection, care and planting of the City's trees and forests on public and privately-owned land in the urban area. A bold strategy for Hamilton's urban forest is also needed to help the City meet its urban forestry goals as set out in the Urban Hamilton Official Plan.

URBAN FOREST STRATEGY VISION STATEMENT:

Hamilton's urban forest is resilient, contributes to the well-being of all neighbourhoods, and is valued as a shared asset.

The Strategy is guided by the following vision statement, which was developed with input from stakeholders, including community representatives and the people who manage Hamilton's urban forest. A study of Hamilton's urban forest was completed in the summer of 2018 using an approach developed by the United States Department of Agriculture Forest Service.[2] This approach has been used in cities across North America and produced information about the City's urban forest and the economic value of the ecosystem services it provides. The information from the study, along with a review of Hamilton's urban forest policies and programs and input from two rounds of stakeholder engagement and public consultation, resulted in a set of five themes and guiding principles that set the direction for Hamilton's first Urban Forest Strategy (refer to Appendix A: UFS Themes and Actions).

Grouped under these five themes are 25 actions to improve urban forest management in Hamilton. Implementing these actions will be an ongoing and collaborative effort between the many City departments, the public and the business community whose activities all affect the urban forest. The 25 actions link to a set of monitoring indicators that will be used to report on the state of the forest moving forward.

[1] *A Woodland Conservation By-law for Private Property Within the Urban Area (PD02229(f)) (City Wide), 2014.*
[2] *USDA Forest Service i-Tree tools.*

Introduction

Hamilton's urban forest is unique. The Niagara Escarpment winds through the urban area, separating it into downtown and "Hamilton Mountain" areas. Cootes Paradise, Dundas Valley, and Red Hill Valley form major natural corridors connecting the escarpment to Lake Ontario. Throughout the city, there are greenspaces and trees that provide habitat for native plants and animals, maintain watershed function, support public health, and make Hamilton a beautiful place to live.

Tree Canada broadly defines the urban forest as *"trees, forests, greenspace and related abiotic, biotic and cultural components in areas extending from the urban core to the urban-rural fringe."*[3] More simply, Hamilton's urban forest can be defined as all trees, whether single trees, groups or woodlands found on public and private land within the urban boundary. As a system, it also includes all the species that live within it.

WHAT IS THE URBAN FOREST?

Hamilton's urban forest includes all of the publicly and privately-owned trees and supporting vegetation in the urban area. The urban forest includes more than Hamilton's natural areas.

Individual trees and groups of trees along streets, in backyards, parks, and commercial areas in Hamilton's urban boundary are also part of the urban forest.

The City's Strategic Plan lays out a clear vision: *"To be the best place to raise a child and age successfully."* Research shows that the urban forest improves the health and well being of residents at all ages. Hamilton's urban forest not only contributes to the City's vision of a healthy community but provides many other environmental and economic benefits to government and the business community (Figure 1).[4]

ENVIRONMENTAL

Improved local air and water quality

Biodiversity conservation

Reduced flooding

Mitigate urban heat island effect

Carbon sequestration and storage

ECONOMIC

Reduced pressure on stormwater infrastructure

Extended pavement life

Increased residential property values

Improved visitor perception

Lower energy costs for heating and cooling

Improved climate resiliency

SOCIAL

Mental health benefits

Shade and cooling

Increased physical activity

Better walking environments

Noise reduction

Solace and a sense of place

Cultural and heritage values

Figure 1. Environmental, economic and health benefits of urban trees (Source: Tree Canada, Benefits of Urban Trees)

[3] *Canadian Urban Forest Strategy 2019-2024. Tree Canada.*
[4] *See Tree Canada – Compendium of Best Urban Forest Management Practices, Chapter 3: Benefits of Urban Trees with literature cited.*

In a time where climate change is expected to have serious impacts on the livability and infrastructure of cities, urban forests are even more important to counteract some of the effects. Public health officials are also increasingly interested in how infrastructure improvements can be integrated with efforts to improve human health and wellness. In this respect, the urban forest is an important part of a city's 'green' infrastructure.[5]

Green infrastructure (GI) is defined as the *"natural vegetative systems and green technologies that together provide a multitude of economic, environmental and social benefits."*[6] It includes the soils that can sustain vegetation (including trees) and absorb water, as well as other stormwater infiltration and retention technologies like porous pavement, bioswales, rain barrels and cisterns. All of these mimic natural ecosystem services. The urban forest is an important part of Hamilton's GI and contributes to the services it provides in a number of ways:

- Trees reduce stormwater runoff by capturing and storing rainfall in their canopy and releasing water into the atmosphere;
- Trees draw moisture from the soil ground surface, thereby increasing soil water storage potential;
- Tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil as well as reduce erosion and sedimentation;
- Trees help slow down and temporarily store runoff and reduce pollutants by taking up nutrients and other pollutants from soils and water through their roots; and,
- Urban forest canopy lowers air temperatures and reduces the urban heat island effect through shading and evapotranspiration, which improves energy efficiency in the buildings.

Hamilton's First Urban Forest Strategy

Purpose and Scope

Hamilton is fortunate to have many natural areas like Cootes Paradise, Dundas Valley and the Niagara Escarpment, all of which contribute to a beautiful and healthier urban environment. There are also many trees growing in parks, backyards and along streets and private properties throughout the City that provide many benefits to residents of Hamilton. However, pressures on trees in the urban area are increasing. Stresses include:

- Invasive non-native tree species which compete with native trees and reduce native biodiversity;
- Pests and diseases (emerald ash borer, gypsy moth, butternut canker, oak wilt, Dutch elm disease);
- Impacts of climate change (drought, flooding, storm damage), which increase environmental stress on trees;
- Difficult growing conditions in the urban area (poor soil, soil compaction, road salt and other pollutants, and limited space to plant); and,
- Urban development, which reduces available space for trees and can increase conflicts with other infrastructure.

Without intervention, the City may see a slow and steady loss of its urban tree canopy, conversion of existing forest cover to less-desirable invasive tree species and further loss of native biodiversity. The purpose of the Urban Forest Strategy (UFS) is to help guide the protection, care and planting of the City's

[5] *Nearby Nature—A Cost-Effective Prescription for Better Community Health? 2018. USDA Forest Service Pacific Northwest Research Station, Science Findings.*
[6] *Green Infrastructure Ontario.*

trees and forests on public and privately-owned land in the urban area. A bold strategy for Hamilton's urban forest is also needed to help the City meet its urban forestry goals as set out in the Urban Hamilton Official Plan (UHOP).

The scope of the UFS is focused within the City's urban boundary, where forest and tree cover have been most affected by ongoing urbanization (Figure 2).

Figure 2. Map of Urban Forest Strategy scope – Hamilton urban boundary.

The UFS is guided by the following vision statement, which was developed with input from the community and the many people who manage Hamilton's urban forest.

Hamilton's urban forest is resilient, contributes to the well-being of all neighbourhoods, and is valued as a shared asset.

Data collection, background information review, and consultation resulted in the following five themes and principles to guide Hamilton's first UFS:

1. **Inspire:** A bold vision for Hamilton's urban forest will engage and inspire the community.
2. **Act:** Goals are good. Actions are better.[7]
3. **Protect:** Trees are a valued city asset and an essential part of Hamilton's infrastructure.
4. **Grow:** Regular tree planting and maintenance programs will maximize long-term benefits and reduce risk to people, property and the health of the urban forest.
5. **Adapt:** Management decisions are evidence-based and responsive to change.

Grouped under these five themes are 25 actions to improve urban forest management in Hamilton (refer to Appendix X: UFS Themes and Actions). Implementing these actions will be an ongoing and collaborative effort between City departments, the public and the community whose activities affect the urban forest. The actions link to a set of monitoring indicators that will be used to report on the state of the forest in future plans.

[7] *Vibrant Cities Lab. URL: https://www.vibrantcitieslab.com/toolkit/plan-the-total-program/.*

Urban Forest Strategy Approach and Methodologies

The UFS was developed in several stages, which included: an urban forest assessment with field data collection, a background scan of existing programs, policy, legislation and environmental context, interviews with a City UFS working group and two rounds of staff, stakeholder, and public engagement that included an online survey, public information centre, meetings and a series of workshops.

The 2018 urban forest assessment used the USDA Forest Service's suite of i-Tree tools to collect and analyze data about the urban forest. These tools include:

- i-Tree Eco
  - A sample-based inventory tool that used data collected from 212 randomly located field plots to provide a picture of the structure and composition of the urban forest, as well as the value of ecosystem services it provides to the City of Hamilton.
- i-Tree Streets
  - An analysis tool that uses street tree inventory data to quantify the economic value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO2 reduction, stormwater control, and property value increase.
- i-Tree Canopy
  - A point-based, random sampling tool that uses leaf-on aerial imagery to provide a description of current land cover[8] (including a tree canopy cover estimate) for the City of Hamilton.

More details about each assessment tool and the study approach can be found in Appendices B, C and D.

Context for the Urban Forest Strategy

The Natural Environment

Hamilton is located in Ontario's Deciduous (Carolinian) forest region, one of the most biologically diverse areas in Canada. Although it makes up only 1% of Canada's total land area, it is home to a larger number of species than any other forest region in Canada, many of which are rare. There are about 70 species of trees, 2,200 species of herbaceous plants, 64 species of ferns, 110 different grasses, and over 130 different sedge species found in the Carolinian forest. Oak, hickory, ash, chestnut, and walnut, as well as red and sugar maple, sassafras, tulip tree, and beech, are some of the tree species that make up the Carolinian forest canopy. Today, less than 15% of Ontario's Carolinian forest landscape still has natural canopy cover, a reduction from over 80% before European settlement and continued urbanization.

This region supports many different types of habitats including fens, swamps, bogs, tallgrass prairies, meadows, thickets, creek valleys, and the cliffs of the Niagara Escarpment. All of these ecosystems are considered part of the urban forest, which can be defined as all single trees, forests and natural landscape features found in the urban area of Hamilton, on both public and private lands.

Individual trees in urban areas, including the City's distinct population of street trees, can connect natural landscape features. These linkages are important for maintaining biodiversity, long-term forest health and supporting movement of wildlife and plants between habitats.

[8] *Land cover describes the physical surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other (Natural Resources Canada).*

Community Awareness and Appreciation of Urban Forest Value

"General Appreciation for Trees as a Community Resource" is identified and assessed as an indicator of a sustainable urban forest management program.[9] At the low end of performance, municipalities might experience *"general ambivalence or negative attitudes about trees, which are perceived as neutral at best or as the source of problems. Actions harmful to trees may be taken deliberately."* [9] In an optimal situation, the urban forest is *"recognized as vital to the community's environmental, social, and economic well-being…there is widespread public and political support and advocacy for trees, resulting in strong policies and plans that advance the viability and sustainability of the entire urban forest."* [9] A background scan carried out for the UFS in conjunction with stakeholder consultations suggest that Hamilton falls somewhere between 'low' and 'optimal'.

A 2018 online survey (refer to Appendix F: Summary of Consultation Activities) that was part of the study background showed that survey participants have a high level of appreciation of trees as a community resource. 96% of survey respondents said they *"appreciate the beauty of trees and woodlands."* However, current practices in Hamilton do not always reflect a high level of commitment to growing a sustainable urban forest and the state of the forest as observed through the UFS study reflects this. The UFS identifies gaps in the City's urban forest management program. For this reason, certain UFS actions are aimed at improving the general awareness and appreciation of Hamilton's urban forest resource as well as proper implementation of existing procedures to support the City's urban forest goals. The following examples highlight areas where positive and pro-active outreach and engagement with facts about the urban forest may assist in addressing the City's urban forest goals:

- Completing an evidence-based assessment of the costs and benefits of a private tree by-law for Hamilton.
    - The most recent efforts to improve private tree protection by-laws met with resistance and the proposed changes were not implemented. The City should base decisions on a review of evidence from other municipalities to have an accurate picture of the costs and benefits associated with implementing a comprehensive private tree by-law.
- Ensuring processes are in place to effectively implement tree protection and landscape plans (including tree planting) already required under site plan review.
- Giving staff better tools or providing incentives to protect mature trees in site plan review.
    - The arborist reports currently required in support of development applications do not provide any leverage for tree retention on site.
- Creating an interdepartmental working group to support UFS implementation.
    - Given the mandate for forest management across multiple City departments, create an inter-departmental working group to resolve challenging policy and operational issues around the protection and integration of trees in both City infrastructure as well as private sector projects and improve awareness/appreciation within government of trees as a municipal asset.
- Identifying possible social or values barriers to tree planting in Hamilton.
    - A 2019 outreach initiative by City staff to identify possible tree planting locations in City rights-of-way met with little positive uptake for street tree plantings. If the City is meeting with resistance to tree planting in public rights-of-way, the challenges for increasing tree canopy on private lands will be significant. This is important because private lands represent an area of opportunity for increasing canopy cover in Hamilton in the future.

One of the first priorities for Hamilton's UFS is to improve the general awareness and appreciation of the urban forest as a community resource and valuable municipal asset. However, all too often the effort required to implement and sustain an effective engagement strategy and develop new partnerships is

[9] *Criteria C6, Community Framework in The Sustainable Urban Forest: A step-by-step approach. Davey Institute/USDA Forest Service.*

underestimated. Because increasing awareness and appreciation has been identified as a priority, the UFS recommends a new staff position to support key aspects of UFS implementation. This position will support inter-departmental cooperation, education and outreach efforts and the development of partnerships with external agencies to support Hamilton's urban forestry goals.

ACTIONS:

- Create a new staff position dedicated solely to outreach, communications, education and partnership development.
- Develop and implement an inspiring urban forest communications strategy.
- Work directly with Hamilton's development community to improve awareness, identify urban forest allies, and recognize best practices.
- Carry out an annual evaluation of the effectiveness of stakeholder engagement strategies.

Climate Change

In early 2019, the City of Hamilton joined other municipalities across Canada in declaring a climate emergency. Climate change affects virtually all aspects of life in the city, from public health to infrastructure to transportation and energy systems to biodiversity. The City has been very engaged on climate initiatives. Some key examples include:

- Member of the Federation of Canadian Municipalities Partners for Climate Change Program (PCP) since 1994.
- Member of the Global Covenant of Members (formerly Compact of Mayors), which requires Hamilton to submit annual GHG emissions.
- City of Hamilton Board of Health (BOH) passed the Community Climate Change Action Plan.
- City of Hamilton have joined and worked with ICLEI Canada through the Building Adaptive and Resilient Communities (BARC).
- Some key City of Hamilton staff were trained on community climate vulnerability and adaptation facilitation.

A 2017 community risk assessment for the City of Hamilton[10] described some of the expected impacts of climate change. These include:

- More precipitation in the winter season;
- Increased heat waves;
- More frequent extreme storms; and,
- Warmer temperatures year-round.

All of these impacts have implications for the health and management of the urban forest. At the same time, the urban forest is a tool that can increase the resilience of cities to climate change. For example, planting large canopy trees where people walk and gather (e.g., streets, parking lots) provides shade and cooling in extreme summer temperatures. Trees can help improve local air quality by absorbing airborne particulate matter from engines. Strategic tree planting can reduce energy consumption and

[10] *Community Risk Assessment Workshop. December 2017. City of Hamilton.*

emissions from heating and cooling of buildings. Trees sequester and store carbon in the trunks, roots, branches and leaves. They help preserve the life of pavement by shading it from the sun and support stormwater management by intercepting rainfall and slowing surface runoff, reducing the burden on grey infrastructure. In short, the urban forest can be an important adaptation tool in urban areas.

Climate change will have negative impacts on the urban forest. Warmer temperatures can lead to new pest and disease introductions. The City will face increased damage to trees from extreme weather events and the changing climate can make growing conditions more stressful as a result of prolonged drought and/or wet conditions. Understanding the vulnerability of the urban forest to climate change will help the City of Hamilton reduce these impacts to the forest. In order to understand the best options for responding to anticipated climate change impacts, the City should carry out a detailed assessment of the vulnerability of natural heritage systems and green infrastructure, including the urban forest, to climate change. There is no 'one-size-fits-all' solution when it comes to expected climate change impacts. Decisions should be based on local context, expected impacts, political and socio-economic priorities and sound data. One example of using local context to develop appropriate adaptation strategies would be looking at the species that make up Hamilton's urban forest and understanding which of these will be most susceptible to increased temperatures and drought. Integrating climate change adaptation into decision-making is an opportunity to enhance resilience and reduce the long-term costs and impacts of climate change.[11]

ACTION:

Complete a climate change vulnerability assessment for Hamilton's natural systems, including the urban forest.

The Policy Environment

At the provincial level, several plans guide growth in Hamilton and enable the protection of natural heritage features, including the urban forest. These plans include:

- Provincial Policy Statement (PPS);
- Growth Plan for the Greater Golden Horseshoe;
- Greenbelt Plan ; and,
- Niagara Escarpment Plan.

The PPS requires that natural heritage features and the connections between them be protected. The PPS places certain restrictions on development, ranging from prohibiting development altogether to showing that there will be no negative impact on natural features or their ecological functions. The Greenbelt Plan, Growth Plan and the Niagara Escarpment Plan build on the existing policy framework established in the PPS to ensure that greater protection is applied in this part of Ontario.

Because they control land use at the local level, cities play an important part in protecting the urban forest and the benefits it provides. In Hamilton, urban forest management supports other City plans and initiatives that address a range of strategic objectives, including urban growth, stormwater management, climate change, public health, recreation and various environmental and natural heritage objectives for the City and surrounding region (Figure 3).

[11] *Natural Resources Canada, 2007.*

The Urban Forest Strategy supports other strategic objectives in the City of Hamilton

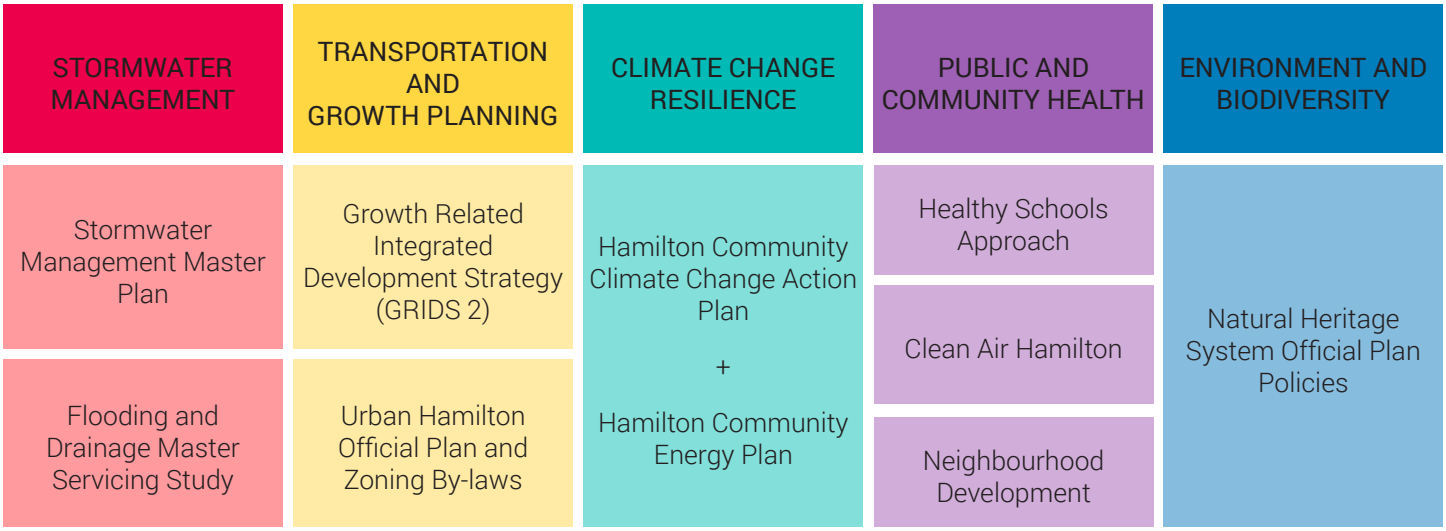


Figure 3. Urban Forest Strategy links to other City of Hamilton plans and objectives.

Over the years, the City of Hamilton has developed policies that support urban greening in principle, along with by-laws and guidelines to protect municipal trees and some private trees and woodlands in the City (Table 1).

Table 1. Plans, policies and guidelines that support the urban forest.

Urban Hamilton Official Plan, Volume 1, Section C.2.0 Natural Heritage System, C.2.11 Tree and Woodland Protection and Section B, 3.3. Urban Design Guidelines
City of Hamilton 2016-2025 Strategic Plan
Secondary Plans
Complete Livable Better (CLB) Streets policy and framework
Streetscape Master Plans
City-Wide Corridor Planning and Design Guidelines
The City of Hamilton Site Plan Guidelines
City of Hamilton Tree Protection Guidelines

These plans, policies, and guidelines provide opportunities to negotiate tree protection and planting through the plan of subdivision and/or site plan control process. However, staff are missing effective tools to turn high level policy goals (like 30% canopy cover) into trees in the ground during site planning and development and through the implementation of public works projects.

Staff need updated and detailed guidelines to:

a. Require the retention of existing trees on private property; and,
b. Implement minimum standards for tree planting and landscaping.

Other tools to support future tree establishment include the City's zoning by-laws. Unless adequate landscape strips are clearly required in zoning, they are very difficult to get or too narrow to support tree planting. Common urban design practices limit the future growth of the urban forest in new developments. For example:

- In both new residential and commercial developments, road allowances often do not provide adequate space and soil volumes to support street tree planting.
- Driveways and parking pads on narrow lots restrict front yard area and reduce potential growing space, thus limiting tree planting space on private land.

The City has developed a standard for new residential areas that requires a tree planted on every lot (three for corner lots). This will help improve the future livability of new residential areas, assuming these trees are planted properly and supported by adequate soil volumes and soil quality. However, without considering trees more comprehensively early on in the urban design process, other non-residential areas in Hamilton may lack trees to provide pedestrian comfort and character. This is contrary to Official Plan goals. Other cities have improved the integration of trees in planning by:

- Setting canopy cover targets to ensure trees are considered in site-level development and integrating these in urban design guidelines;
- Amending zoning by-laws to increase or require retention of plantable space suitable for trees; and,
- Having detailed requirements for creating suitable planting habitat, including minimum soil volumes and soil quality requirements at the development application level.

ACTIONS:

- Develop and apply minimum canopy cover targets to new development proposals.
- Review best practices and put forward a list of priority amendments to improve the integration of trees in applicable policies, plans and guidelines.

Hamilton's Tree By-Laws

Hamilton also has a suite of by-laws and policies that offer some protection to both public and private trees in the urban area (Table 2).

Table 2. Hamilton's tree by-laws and protection policies.

Public Tree Preservation and Sustainability Policy
Public Tree By-law (No. 15-125)
City of Hamilton Reforestation Policy (Municipal Lands)
Tree By-laws for Ancaster, Dundas, and Stoney Creek

Urban Woodlands By-law (2014)
Heritage Tree Protection
Tree Protection Guidelines

The City of Hamilton revised its private woodland tree by-law for urban areas in 2014. Recognizing that small urban woodlands have significant value, the new by-law regulates woodlands 0.2 hectares in size or larger. However, woodlands that don't meet the size criteria (less than 0.2 hectares) and individual private trees within the urban boundary are not protected.

The existing policies and by-laws have helped to prevent significant loss in the urban forest canopy over the last ten years despite loss of canopy cover to emerald ash borer and a severe ice storm in 2013 that caused widespread damage to Ontario's forests. However, Hamilton's current policies have not resulted in any expansion of the urban forest toward the City's 30% canopy target.

PRIVATE TREE BY-LAWS

In many cities, comprehensive private tree by-laws preserve and protect trees from both development impacts and private landowner removals. This is important because the growth of existing trees makes a significant contribution to increasing the urban tree canopy. By-laws and their associated permitting processes can also include provisions for tree replacement where canopy cover is lost due to tree removals. When carefully designed and properly enforced, by-laws provide an important tool for preserving municipal canopy cover through the protection of existing trees and requirements for replacements. They also provide an important education tool and help promote the value of trees in urban areas.

Some of the advantages of implementing a private tree by-law are as follows:

- It is an effective public education tool for elevating the value of trees;
- Offers protection for mature trees by setting a diameter limit for removals;
- Permit process for removal of protected trees provides the ability to impose conditions (e.g., tree replacement);
- Gives the ability to issue Orders and apply penalties for contraventions; and,
- Can provide a reasonable level of governance and regulation to a valued City asset.

On the other hand, the effectiveness of municipal tree by-laws can be limited if they are not properly resourced and consistently enforced. Basic requirements for appropriate by-law implementation include:

- Suitable data management systems to support permit functions, tracking and reporting;
- Proper controls for permit issuance and collection of payments and deposits, as well as follow-up to verify compliance with permit conditions;
- Adequate staff to administer a by-law/permitting system; and,
- Effective enforcement mechanisms for by-law contraventions.

When properly designed, resourced and implemented, private tree protection tree by-laws can have a positive effect in preserving trees in the urban environment.

Hamilton has recently declared a state of climate emergency. One outcome of this declaration was to establish a task force across City departments to find ways to achieve net zero carbon emissions

by 2050. Urban trees have a role to play in the effort to address climate change, and the protection of existing mature trees is part of the local solution. For this reason, Hamilton should revisit the utility of a comprehensive private tree protection by-law for supporting the UFS goals and actions as well as the City's climate change initiatives. Decisions about private tree protection by-laws should be evidence-based, including an assessment of the pros and cons and costs of implementing a comprehensive private tree by-law in Hamilton.

OTHER OPTIONS FOR PROTECTING AND PRESERVING TREES

In the absence of by-laws, there are other non-regulatory approaches that can help promote the protection and retention of trees. These may include:

- Working directly with developers and City project managers early in new development and infrastructure projects to design around existing trees;
- Educating homeowners about the value of tree preservation and alternatives to removal where appropriate;
- Reaching out to the arboricultural industry to promote best practices for urban tree maintenance and retention;
- Integrating canopy cover targets in site-level development through site plan and urban design guidelines;
- Providing incentives (e.g. bonus credits) and recognition for preserving existing trees on site in development applications;
- Implementing stormwater credit/fee programs; and/or,
- Offering special zoning exceptions, expedited permitting, or modified stormwater requirements during the permitting/approvals process to encourage the preservation of trees and use of other GI practices on private property.

ACTIONS:

- Identify options for increasing the preservation of healthy trees in Hamilton.
- Work directly with Hamilton's development community to improve awareness, identify urban forest allies, and recognize best practices and innovation.

Developing an appropriate suite of tree protection tools will be unique to the local context and should include input from all proponents whose activities affect trees.

Urban Forestry in Hamilton - Program Structure

In Hamilton, the responsibility for managing the urban forest is divided between several City divisions. The Forestry and Horticulture (F&H) department falls under the Environmental Services branch of the Public Works Division of the City. F&H oversee the management of street trees as well as trees in parks and cemeteries. The department is responsible for:

- Tree Planting - planting of trees on City property, including streets, parks and cemeteries. Tree planting involves site identification and inspection of proposed tree planting locations, planting trees and the inspection of trees after planting.

- Tree Maintenance - maintaining urban and rural trees, including customer requests, tree trimming, tree removal, forest health and emergency storm response.
- Development Review - Review of all development impacts to public trees, including administration of a tree by-law permitting process.
- Program Support - data management, health and safety, program development and coordination. Responding to public inquiries, educational materials and web content are also part of this service.

F&H has no mandate for natural areas management, aside from assisting with tree planting projects on public lands and removal of hazard trees along trails, as needed. Existing private tree by-laws for woodlots are enforced separately through Municipal Law Enforcement, which is part of the Planning and Economic Development Department. The management of natural areas falls mainly under the jurisdiction of Parks Operations and/or is done in partnership with local Conservation Authorities and other agencies or landowners. Currently, active management in City-owned natural areas is limited to some invasive species control (e.g., phragmites) as well as removal of hazardous trees along trails. With regard to hazard management, this is done in large part for street trees through the regular tree maintenance program and in woodlands by some pro-active trail maintenance but is otherwise reactive to calls from the public or reported hazard trees. Currently, there is no staff in place to support outreach to either partner agencies or private landowners, although private land represent a significant opportunity for increasing Hamilton's tree cover in the longer term.

The Planning and Economic Development Department is responsible for the review of private trees on properties that are under the development review process. This process offers some opportunities to negotiate the protection of existing trees and request the integration of trees through landscape plans. However, in practice this is usually limited to compensation for tree removals on site based on the City's Tree Protection Guidelines. Compensation requirements for private trees are currently 1:1, so a large tree can be removed and replaced with one small tree. This practice can result in significant short-term net loss in tree canopy, particularly where a large tree is removed. For this reason, some jurisdictions in Ontario have gone to a diameter-replacement approach (e.g., a replacement tree required for every 10cm of diameter removed).

The Growth Management Division of the Planning and Economic Development Department carries out final planting inspections to ensure developers have carried out the proper planting consistent with approved landscape plans. Forestry qualifications are currently not required for inspectors, who evaluate tree species, planting quality, and other factors that influence tree survival and urban forest health.

For development that is not under site plan control (such as building permits), there are limited tools for protecting private trees or encouraging their retention or replacement when removed.

CANOPY COVER

Canopy cover represents the amount of land area covered by forest canopy as seen from above. It is one of many ways to describe the urban forest. The term canopy cover includes all trees and shrubs that make up the urban forest.

Many cities are setting canopy cover targets because research shows that 30-40% cover is the minimum needed to support basic watershed function.

[12] *Environment Canada. 2013. How Much Habitat is Enough? Third Edition. Environment Canada, Toronto, Ontario.*

IMPLICATIONS OF CURRENT MANAGEMENT FRAMEWORK FOR CANOPY COVER IN HAMILTON

The Urban Hamilton Official Plan (UHOP) sets a target to increase canopy cover from its current 21.2% to 30% across the City. This is based in part on research that suggests that 30% forest (canopy) cover is the minimum needed to support native species persistence and a minimum level of aquatic ecosystem function.[12]

The last ten years have been a period of significant canopy loss due to the emerald ash borer infestation. In that context, the City's approach to urban forest management has maintained canopy cover over the last 10 years, but it has not resulted in any measurable increase. If anything, there has been a slight decrease in overall canopy cover as measured in this study (though not statistically significant at a confidence level of 95%). Future monitoring will help establish a clear trend. The following factors were identified as some of the barriers to achieving the 30% canopy cover target and a healthy, sustainable urban forest.

- Staff are lacking tools like updated site plan guidelines, tree protection plan guidelines, and canopy targets to translate high level policy goals at the site level and ensure the integration of trees and urban woodlands in development and construction.
- Protection for private trees (both individual trees and woodlands that do not meet size criteria) is limited under current tree by-laws with different regulations across the City.
- Forest management responsibilities are divided between several City departments, leading to inconsistencies in the implementation of similar management activities. For example, compensation requirements differ for the removal of public vs. private trees and oversight to ensure implementation of tree protection and landscape plans is not consistent.
- Even though natural areas are part of the urban forest, their management is outside the scope of the Forestry department and there is no formal co-ordination with Parks who have oversight of these areas. Furthermore, funding for active management of natural areas is currently limited to the management of specific invasive species (phragmites).

These represent some of the current implementation challenges identified through a background policy and program scan. Other issues have been identified through the study findings and public consultation. The following actions are included to address the identified challenges.

ACTIONS:

- Establish an inter-departmental working group to support UFS implementation.
- Improve implementation of Tree Protection/Management Plans and Landscape Plans.
- Develop a best practices manual for tree protection, planting and preservation to share with all City departments and utilities whose activities affect trees.
- Apply standardized tree planting details and specifications in all city tree planting projects.
- Develop service standards and emergency response plans for hazard trees and other forestry service requests as well as severe weather events.

Hamilton's Urban Forest Today

The following information from i-Tree studies and other data sources as cited provides a baseline picture of the state of Hamilton's urban forest, as assessed in 2018.[13]

HAMILTON'S URBAN FOREST

Canopy cover (2006): 22.1% (standard error 1.14%)

Canopy cover (2017): 21.2% (standard error 1.13%)

Land use with highest canopy cover: Open Space (54%)

Land use with lowest canopy cover: Industrial (2.3%)

Total number of trees: 5,212,000

Replacement value of trees: $2.13 billion

Number of different species sampled: 97

Top three species by number of trees: Eastern white cedar, white ash, European buckthorn (invasive)

Top three species by leaf area (m^2): Black walnut, Norway maple (invasive), Manitoba maple (invasive)

Native species: 67.3% of total leaf area is comprised of species native to southern Ontario

Invasive species: 29.2% of total leaf area is comprised of invasive species (the remaining 3.5% are non-native, non-invasive species)

Proportion of smallest trees (<15.2 cm diameter): 75.9% of total tree population

Proportion of largest trees: (>76 cm diameter): 0.5% of total tree population

Trees in good or excellent condition: 80.1%

Most significant threats (now and future): emerald ash borer, Asian longhorned beetle, gypsy moth, oak wilt

Increase in hard (impervious) surface in Hamilton (2006-2017): 4.1 percentage points

[13] *A detailed study report is found in Appendix B.*

Forest Structure, Diversity and Distribution

There are approximately 5.2 million trees in the City of Hamilton urban area. Approximately 58% of these are located on private property with the remaining 42% on public land.

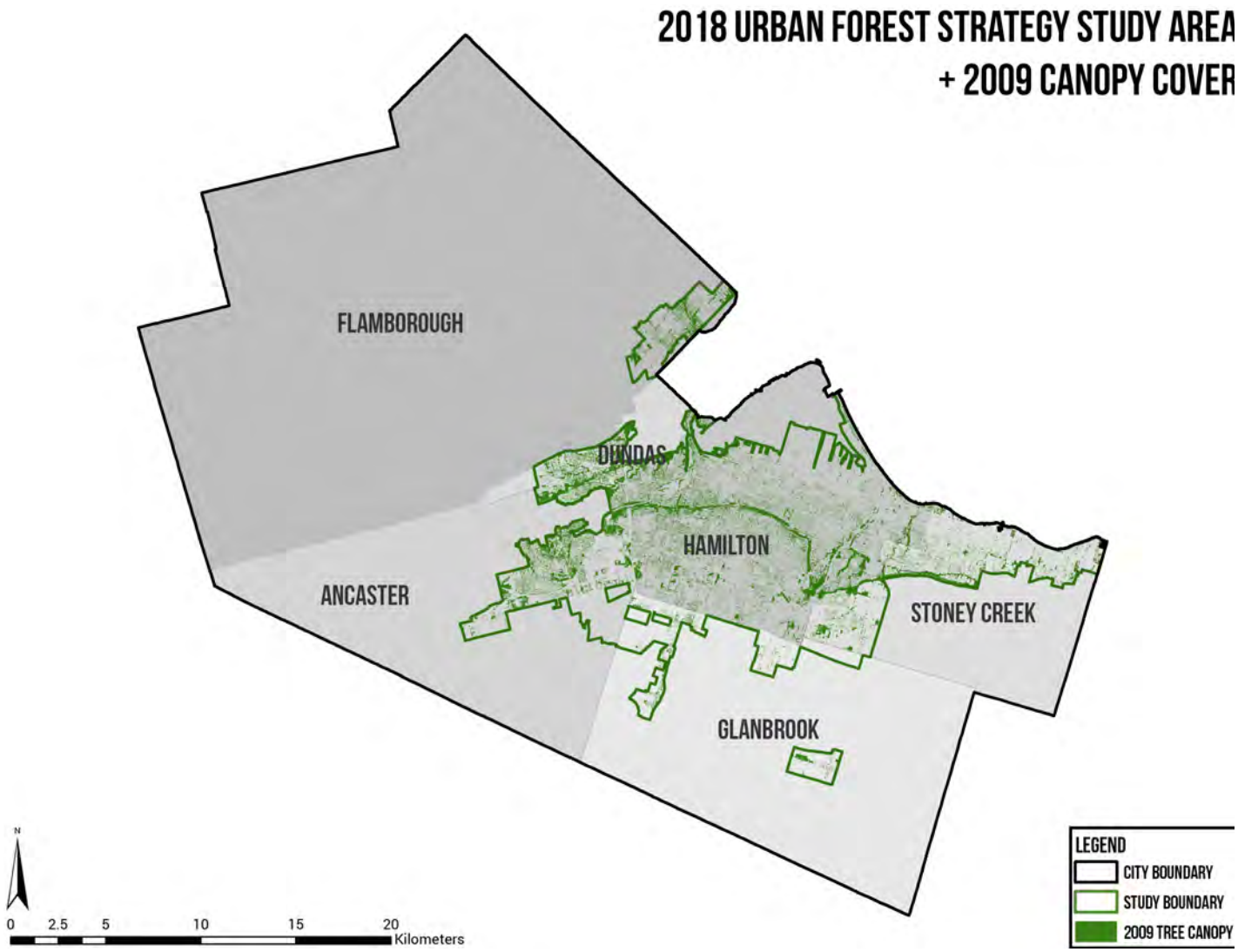


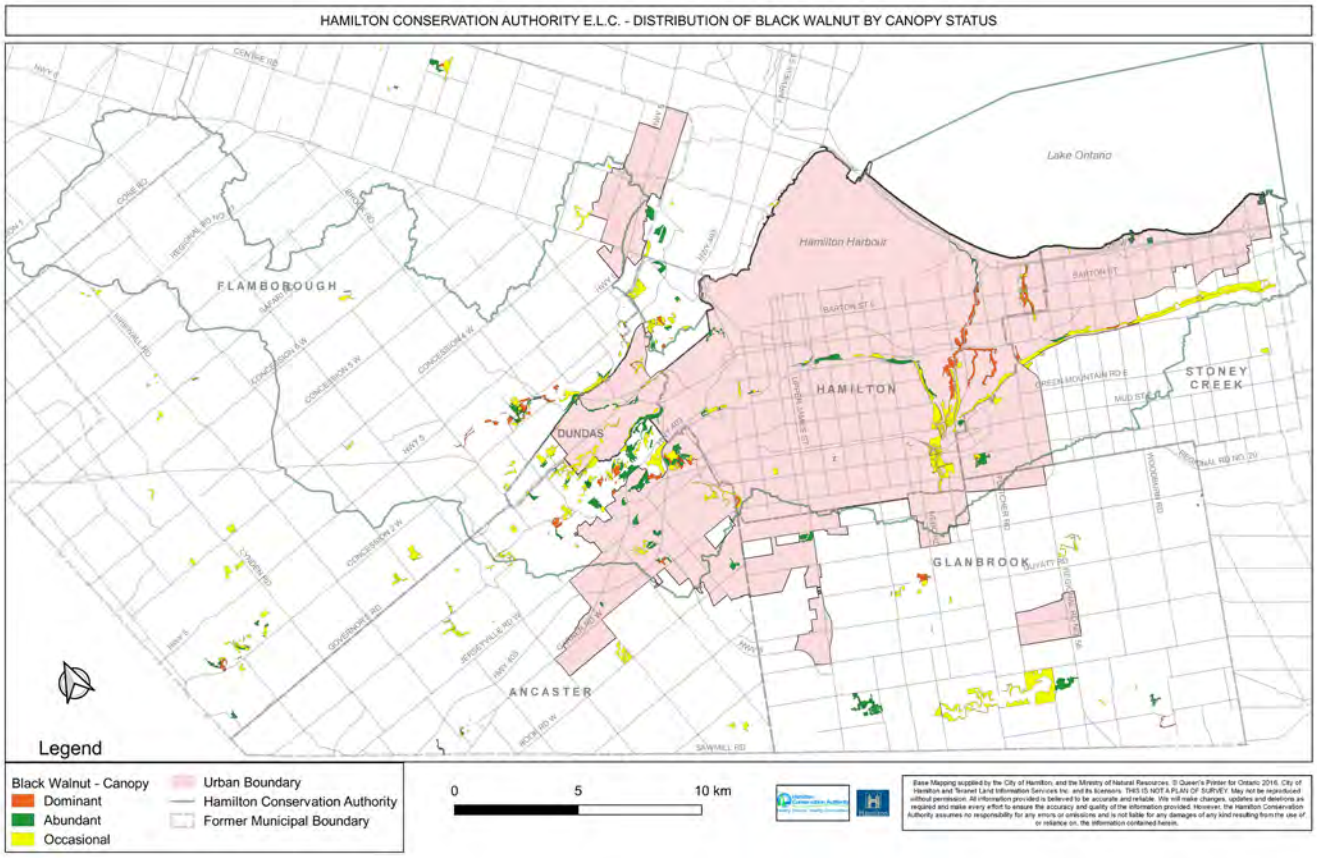
Figure 4. Distribution of canopy cover in Hamilton within urban boundary (Source: 2009 tree cover map, City of Hamilton).

Canopy cover[14] across the City of Hamilton is estimated at 21.2%.[15] This may represent a decrease from the 2006 canopy cover estimate of 22.1%. However, the change measured was not statistically significant.

Different land use classes tend to have different levels of tree cover, based on the intensity and type of development. In terms of canopy distribution, the Open Space land use category (including parks and natural areas) has the highest canopy cover relative to other land use classes at 54%. Industrial lands have the lowest amount of canopy cover at 2.3% (Figure 4).[16]

Black walnut, Norway maple and Manitoba maple represent the top three species in terms of leaf area.[17] The prevalence of black walnut in the field sample is supported by Hamilton Conservation Authority canopy and sub-canopy mapping for the species (Figure 5). Historic records also suggest that black walnut was well represented in the Carolinian forest region of Ontario.[18]

[14] Includes trees and shrub cover as these cannot be differentiated in canopy estimates using a point sampling methodology.
[15] Land and tree cover were assessed using the US Forest Service i-Tree Canopy tool using 2017 leaf-on imagery that was the most recent year available.
[16] Based on 2018 aerial point sampling using i-Tree Canopy tool and Google Earth imagery from 2017/2018.
[17] Represents total area coverage of the canopy in metres squared.
[18] What is a Carolinian Forest? https://caroliniancanada.ca/legacy/SpeciesHabitats_Forests.htm.



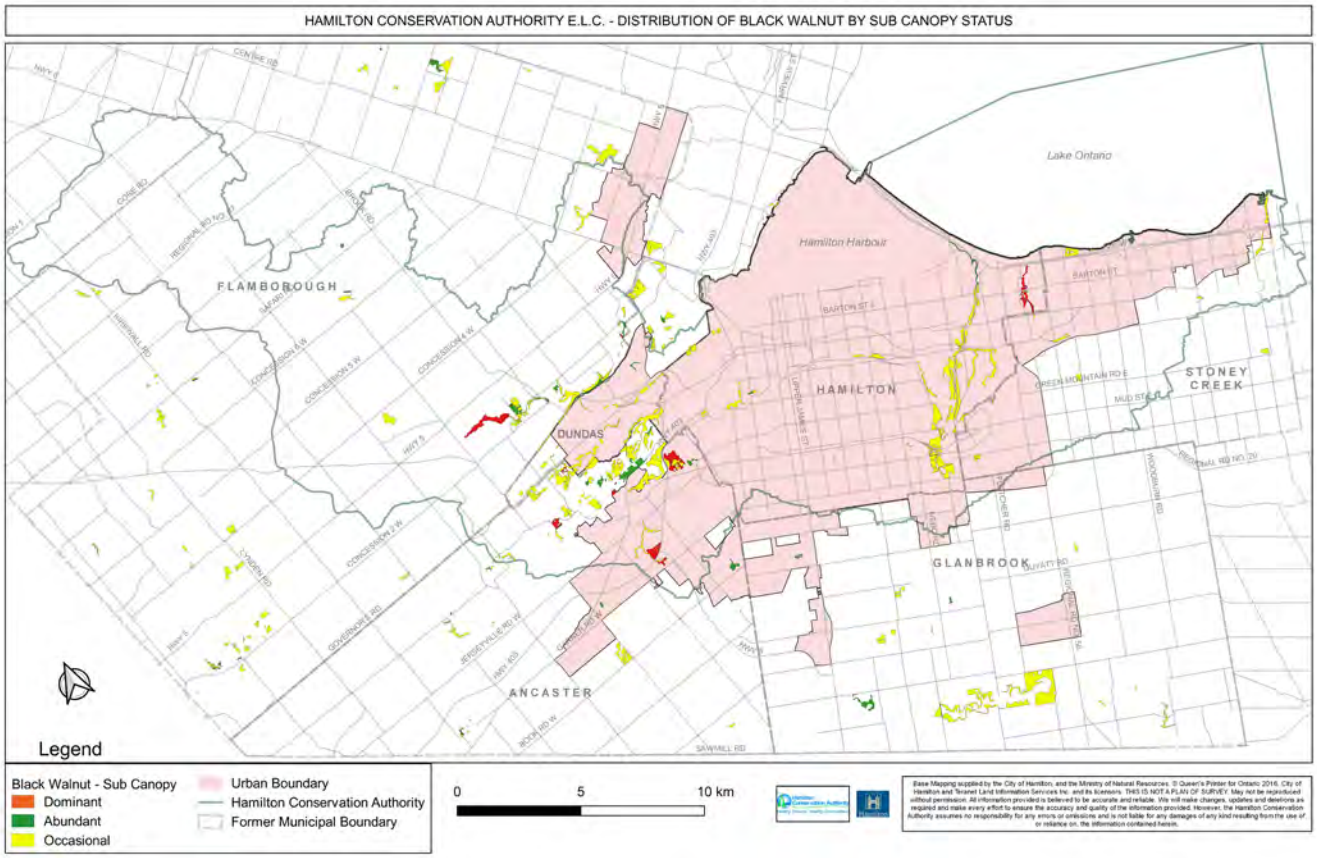


Figure 5. Change caption to "Distribution of black walnut in canopy (top) and sub-canopy (bottom) in Hamilton (Source: Hamilton Conservation Authority).

Norway and Manitoba maple are both classified as invasive species in Ontario.[19] In terms of total leaf area, almost 25% of Hamilton's urban forest consists of Category 1 and 2 invasive species (refer to footnote on Table 8). Invasive species are non-native plants, animals, and diseases that can cause harm to the economy, environment, and human health.

Some of these species, like Norway maple, were commonly planted in Hamilton because of their shade characteristics and ability to thrive in tough urban environments but later became invasive in natural areas. Now, forest managers develop tree planting lists for streets and natural areas that reflect the different management goals and growing conditions on these sites. Climate change is another factor that will affect tree species selection for the City of Hamilton.

The presence of these invasive species shows how dramatically Hamilton's forests have changed over time, with native species increasingly replaced by invasive trees and shrubs. Table 3 shows the top ten species in Hamilton by number of trees, total leaf area[20] in square metres and the importance value, which combines these two measurements and describes how dominant a species is in a given forest area.

Table 3. Top ten tree species in Hamilton by population, leaf area and importance value (Source: i-Tree Eco study data, 2018).

Species Name	% of Population	Leaf Area (m^2)	Importance Value (IV)
Black walnut	5.9	19.8	25.7
White ash	9.7	4.0	13.7
Eastern white cedar	10.9	2.2	13.0
*European buckthorn	9.4	1.5	10.8
**Norway maple	2.8	7.3	10.2
Hawthorn spp.	6.9	3.1	10.0
*Manitoba maple (boxelder)	3.7	4.8	8.5
Green ash	6.6	0.9	7.5
**Black locust	2.7	4.6	7.4
Sugar maple	2.8	4.3	7.2

*Category 1 invasive species: Species that exclude all other species and dominate sites indefinitely. Plants in this category are a threat to natural areas wherever they occur because they tend to disperse widely.

**Category 2 invasive species: Species that are highly invasive but tend to dominate only certain niches or do not spread rapidly from major concentrations. Most persist in dense populations for long periods.

The dominant shrub species in Hamilton's urban forest are gray dogwood (17.4%), honeysuckle (13.4%) and the invasive European buckthorn, comprising 7.3% of the total shrub layer leaf area. A significant proportion of Hamilton's total shrub leaf area (14.3%) is also comprised of invasive species.

Invasive species are a growing problem for most Ontario municipalities. Invasive plants reproduce and grow quickly, easily invading adjacent natural areas, woodlands and landscaped areas. They interfere with the growth of desirable plants, resulting in loss of native diversity. They degrade wildlife habitat and can interfere with recreational activities. Management costs can quickly escalate and cost cities millions of dollars where invasions are not detected and treated early.

[19] *Government of Ontario. URL: https://www.ontario.ca/page/invasive-species-ontario*
[20] *Leaf area is the total one-sided surface area contributed by all leaves on the tree. Leaf area is estimated using measurements of crown dimensions and percentage of crown canopy missing.*

Invasive insect pests like the emerald ash borer also pose a significant threat to the City's tree canopy, as well as the health of the urban forest. The cost of managing the effects of emerald ash borer have been significant across all Ontario municipalities, and represent a huge loss for urban forests across the province.

In the face of climate change and increasing movement of people, invasive species represent a growing management challenge for Hamilton. For this reason, the UFS includes a recommendation to develop and implement an invasive species management strategy.

ACTIONS:

- Develop and implement an Invasive Species Management Strategy.
- Fund regular, active management of natural areas in Hamilton to support native biodiversity and forest health.

Size Class Distribution

The size class of an urban forest reflects the history of management, natural disturbance history and age of urban development and may differ across neighbourhoods. Ideally, the urban forest should include a sustainable distribution of sizes, including trees in the largest size class. Overall, Hamilton's urban forest has a relatively sustainable size class distribution but falls somewhat short of suggested targets in the small and medium size classes (Figure 6). Because large trees provide more benefits, increasing the retention of mature trees (on both private and public land in Hamilton) has been identified as a priority in the UFS. There is a different trend for street trees, which is discussed in a later section of this report.

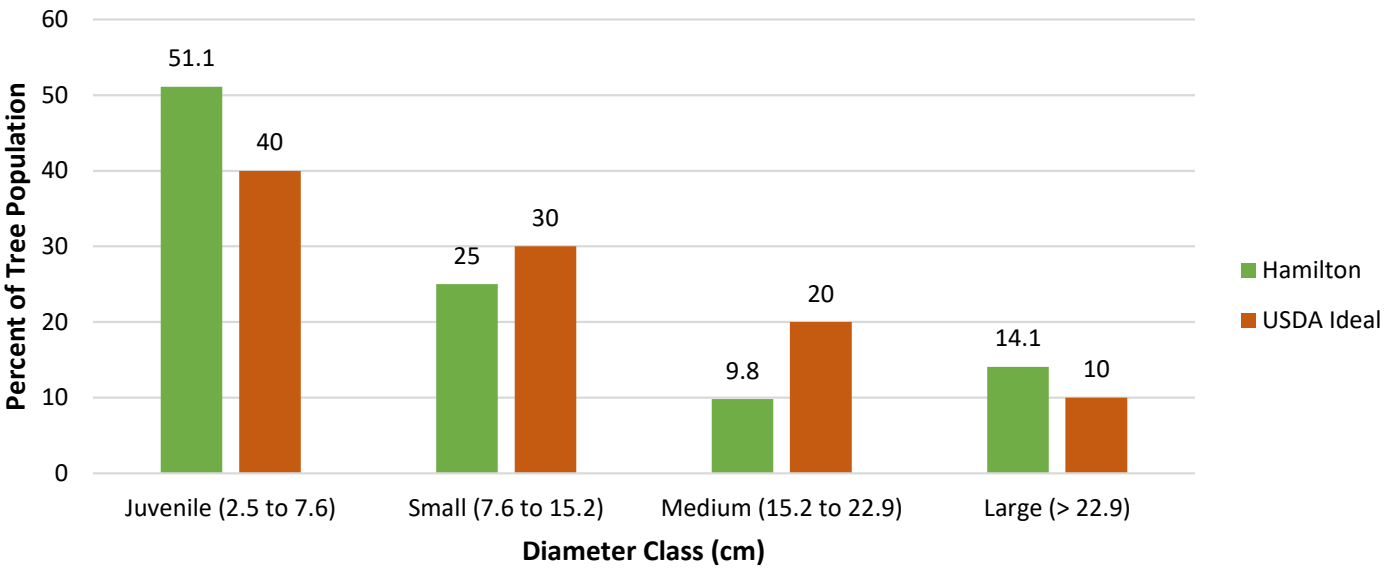


Figure 6. Overall size class distribution of the urban forest compared to the ideal, according to the USDA ideal distribution for an urban forest (Source: i-Tree Eco study data, 2018).

Forest Health

There are many insects and diseases that can potentially kill trees or threaten the health, structural value and sustainability of the urban forest. Major threats to Hamilton's forest currently include emerald ash borer, Asian longhorned beetle, gypsy moth and oak wilt. Although oaks represent a small portion of the City's tree population, they have a high relative structural value because of their large average size (Figure 7).

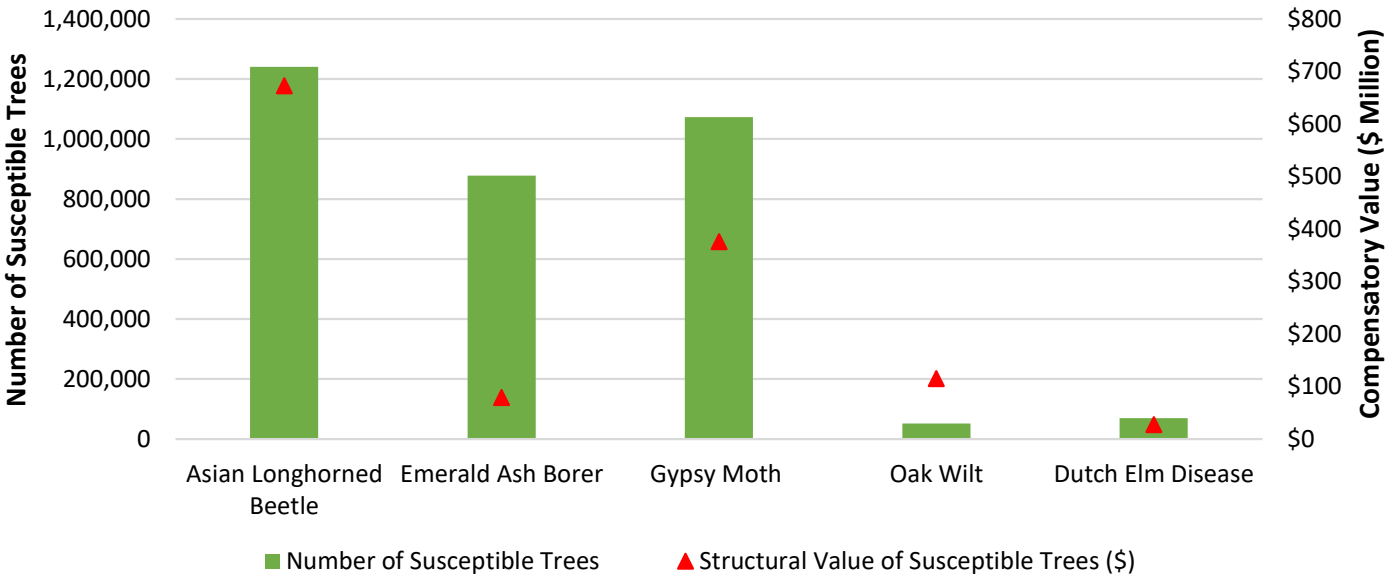


Figure 7. Susceptibility of Hamilton's trees to major invasive pests (Source: i-Tree Eco study data, 2018).

Some of these threats are preventable through early detection or treatable with appropriate management activities. For example, Asian longhorned beetle monitoring programs by municipal, provincial and federal agencies working together have prevented the spread of an infestation in west Toronto, which could affect about 32% of the total leaf area of the urban forest in Hamilton. Gypsy moth populations are also actively monitored by the City, and aerial spray programs are implemented when populations are high and threatening severe defoliation.

Recognition of the multiple value of urban forests through studies is resulting in increased public investment in trees in many North American cities. At the same time, systematic monitoring of the urban forest condition is infrequent. Monitoring is an important part of a program to sustain healthy community forests, to guide adaptive management and to ensure the long-term flows of net benefits from investments in trees. Interagency cooperation in Canada on Asian longhorned beetle monitoring and control, for example, contributed to declaring this pest eradicated from Ontario after it was first detected in 2003. Since then, it has been found again but constant monitoring and eradication efforts have kept the beetle under control in Ontario, resulting in avoided costs to municipalities in terms of large-scale tree removal and replacement programs.

ACTIONS: Implement a forest health monitoring program in Hamilton, including natural areas.

Ecosystem Services

The i-Tree assessments carried out as part of the UFS in 2018 used methods developed by the USDA Forest Service to determine the economic value of the ecosystem services and structural (replacement) value[24] of the City's urban forest. The study shows that Hamilton's urban forest provides ecosystem services worth approximately $8.2 million per year, including avoided runoff, oxygen production, pollution removal, carbon storage and sequestration and energy savings.

Surface runoff can be a cause for concern in many urban areas as it can contribute to water pollution in streams, wetlands and lakes. Urban vegetation, including trees and shrubs help slow surface runoff. Trees and shrubs intercept precipitation, while their root systems promote infiltration and storage in the soil. The trees and shrubs of Hamilton help to reduce surface runoff by an estimated 815,639 m³/year[25] a year, with an associated value of $1.9 million.

Trees in Hamilton are estimated to produce 13.46 thousand metric tonnes of oxygen per year, with some of the top contributors being black walnut, black locust, honeylocust and Norway maple.

Trees in Hamilton remove 256 tonnes of pollution from the air annually, including carbon monoxide, nitrogen dioxide, and sulfur dioxide, with an equivalent service value of $1.13 million.[26]

Climate Change Mitigation

Urban forests help mitigate climate change by sequestering atmospheric carbon in their leaves/branches/trunk and by altering energy use in buildings, consequently reducing carbon dioxide emissions from fossil-fuel based power sources[27].

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon sequestered increases with the size and health of the trees. The gross sequestration of Hamilton trees is about 13.41 thousand metric tonnes of carbon per year with an associated value of $1.54 million.

Carbon storage is another way that trees can influence global climate change. As a tree grows, it stores more carbon by holding it in its accumulated biomass until it decays and dies. Trees in Hamilton's urban area are estimated to store 395,000 metric tonnes of carbon, which is valued at

ECOSYSTEM SERVICES PROVIDED BY HAMILTON'S URBAN FOREST

Total value of annual benefits provided by Hamilton's urban forest:
$8.2 million

Structural (replacement) value of Hamilton's urban forest:
$2.134 billion ($409/tree)

Oxygen production:
13.46 thousand metric tonnes/year

Avoided runoff due to trees:
815,639 m³/year ($1.9 million)

Pollution removal:
256 tonnes/year ($1.13 million)

Gross carbon sequestration:
13,412 tonnes ($1.54 million)

Amount of carbon stored by Hamilton's urban forest:
395,000 metric tonnes (worth $45.4 million, based on the social cost of carbon)

Energy savings:
282,319 MBTUs/year ($3.63 million)

THE AMOUNT OF CARBON STORED BY THE CITY'S URBAN FOREST IS EQUIVALENT TO:

The amount of carbon emitted in Hamilton in 58 days

Annual carbon emissions from 308,000 cars

Annual carbon emissions from 126,000 single family houses

[24] Replacement value represents the cost of having to replace a tree with a similar tree (size and species).
[25] Avoided runoff is estimated based on local weather from the weather station at Hamilton International Airport, 2010.
[26] Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and particulate matter less than 2.5 microns.
[27] Abdollahi, K.K., Ning, Z.H., Appeaning, A., 2000. Global Climate Change and the Urban Forest. GCRCC and Franklin Press, Baton Rouge, pp. 31-44.

approximately $45.4 million[28] or $7.9 million[29] based on the social cost of carbon[30] and the market price of carbon, respectively. Of the species sampled in Hamilton, white ash and black walnut store the most carbon.

Trees that are planted in proper locations relative to buildings can reduce energy consumption from heating and cooling by shading, providing evaporative cooling, and blocking winter winds. An additional $3.6 million dollars[31] in energy savings is provided by the urban forest through reductions in cooling and heating costs. Trees also provide an additional $790,000 in value by reducing the amount of carbon released by fossil-fuel based power plants (a reduction of 6,880 tonnes of carbon emissions).

Street Trees[32]

Street trees are a distinct population of trees in the City that tend to be more intensively managed. Their location on City road right-of-ways means that street trees have additional stresses like compacted soil, the effects of road salt and limited growing space. In some densely built neighbourhoods, street trees can represent most of the urban canopy cover. This makes them an important part of neighbourhood character and livability.

The structural (replacement) value of Hamilton's 168,610 street trees is approximately $500 million. Structural value estimates the replacement or compensatory (if a tree is too large to be directly replaced) value of a tree and is based on a formula from the Council of Tree and Landscape Appraisers. This value can vary by location, tree size, species, and condition of the tree. [33]

Street trees only make up about 3.2% of Hamilton's total tree population but their structural value represents about 23.7% of the total value of Hamilton's trees. This is because of their larger average size. Larger trees are worth more and contribute more urban forest benefits than small trees. In Hamilton, street trees are the most intensively managed portion of the urban forest, taking up a significant portion of the Forestry budget. Meanwhile, natural areas with high levels of forest cover see little investments in active management.

HAMILTON'S STREET TREES

Number of Street Trees:
168,610 (3.2% of all trees in Hamilton)

Structural Value of Street Trees:
$500 million

Average dollar value selected benefits provided (carbon storage, air quality improvements, and aesthetic benefits):
$88.50 per tree

Current stocking level in Right-of-Ways: 82%

Potential Planting Sites in Right-of-Ways: 37,000

Top three species by number of trees:
Norway maple, eastern white cedar, honeylocust

Top three species by leaf area (m^2):
Norway maple, honeylocust, silver maple

Total number of street tree species:
155

Percentage of trees rated in 'Good' condition: 87%

[28] *Calculated based on the social cost of carbon, $114.87/tonne.*
[29] *Calculated based on the current market price of carbon, $20/tonne.*
[30] *The social cost of carbon is a measure of the economic harm from those impacts, expressed as a dollar value, of the total damages from emitting one tonne of carbon dioxide into the atmosphere. It is meant to be a comprehensive estimate of climate change damages and includes, among other things, changes in net agricultural productivity, human health, property damages from increased flood risk and changes in energy systems costs, such as reduced costs for heating and increased costs for air conditioning. EPA Fact Sheet: Social Cost of Carbon, December 2016 - https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf.*
[31] *Based on the prices of Can$75 per MWH and Can$10.4544285106757 per MBTU. Refer to Urban Forest Effects and Values Report for City of Hamilton, November 2018.*
[32] *A detailed study report is found in Appendix B. This report only includes trees found along City right-of-ways.*
[33] *Nowak, D. 2016. Assessing the Sustainability of Agricultural and Urban Forests in the United States. URL: https://www.fs.fed.us/nrs/pubs/jrnl/2016/nrs_2016_nowak_002.pdf*

Approximately 82% of potential street tree planting sites are currently planted with a tree. There are an estimated additional 37,000 possible street tree planting sites available across the City of Hamilton.[34] These sites represent an opportunity for Hamilton to increase its tree cover on public lands. However, public outreach and education about the value of trees will be an integral part of capitalizing on these planting opportunities. Forestry staff have had low uptake on street tree planting in right-of-ways located in front yards in recent efforts to increase planting in residential areas of the City.

The health of Hamilton's street trees is relatively good. About 87% of all street trees were considered to be in 'Good' condition, while 'Dead' trees comprised just less than 3% of the street tree population. This speaks to the importance and success of the City's street tree maintenance program.

Green and white ash are two species in the worst condition, with a significant percentage of their populations (57.3% and 34.0% respectively) either dead or dying. This is not surprising, given the severe impacts of emerald ash borer on ash trees in recent years.

In terms of size class distribution, Hamilton's street trees fall short of the ideal.[35] Smaller trees are somewhat overrepresented, whereas the population currently falls short in the larger size classes (Figure 8). These numbers may be a reflection of the consistent and increasing street tree planting program, which has resulted in a relatively higher number of smaller trees. However, it may also indicate a need to examine options for reducing the number of mature street trees removed in Hamilton.

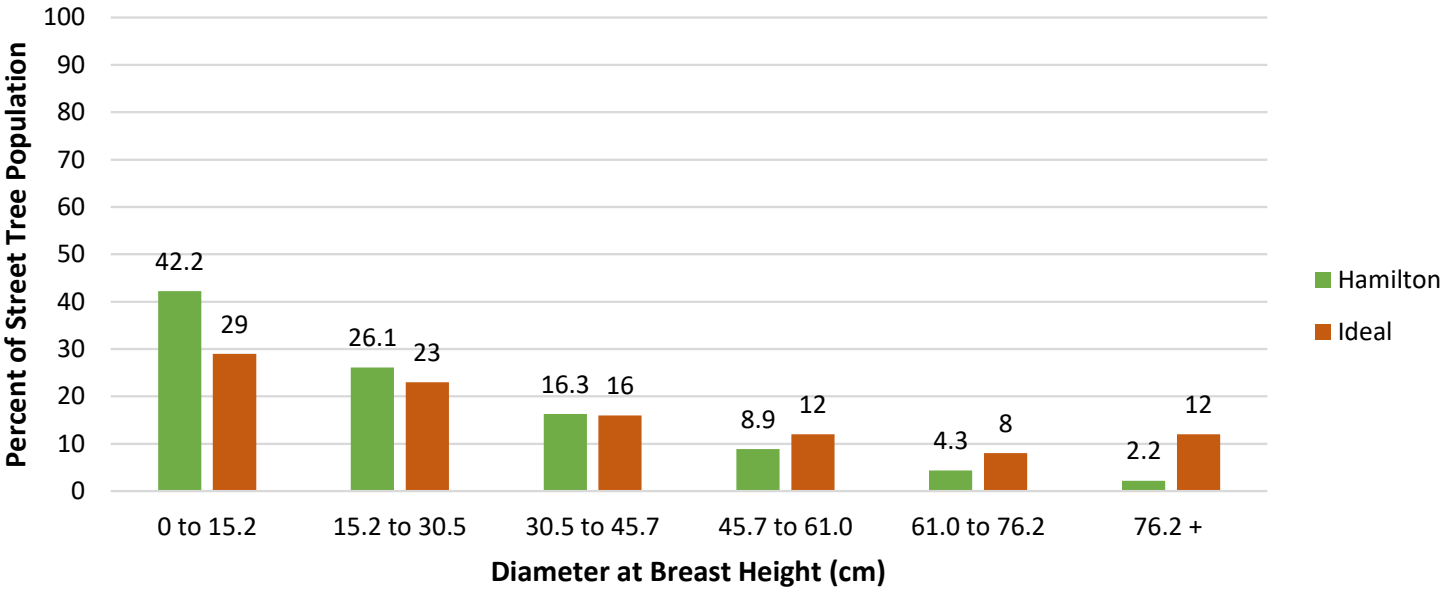


Figure 8. Size class distribution of street trees compared to the ideal (Source: i-Tree Streets study data, 2018).

In terms of population, Norway maple is the most abundant street tree, comprising 19.2% of the total street tree population and 22.9% of the total leaf area. This is followed by eastern white cedar (found extensively in hedge form along City streets) and honeylocust, a species that thrives in urban growing conditions (Figure 9). With the exception of maples, which make up a large portion of the street tree population, the overall composition of Hamilton's street trees is fairly diverse. This helps to protect the City's urban forest from threats due to pests and disease that target specific tree species. However, currently well over 30% of the City's leaf area is comprised of maple species. This means that Hamilton's

[34] *Extrapolated from i-Tree field data sample plots.*
[35] *This ideal distribution is being utilized by other Canadian municipalities, such as Toronto, Cambridge and Fredericton, and comes from Richards, N.A., 1983. Modeling survival and consequent replacement needs in a street tree population. Journal of Arboriculture 5 (11):251-255.*

street tree population is susceptible to an infestation of Asian longhorned beetle. To date, this pest has been controlled in Ontario, but future street tree planting should aim for a reduction in maple leaf area to ensure the resiliency of the City's street tree population.

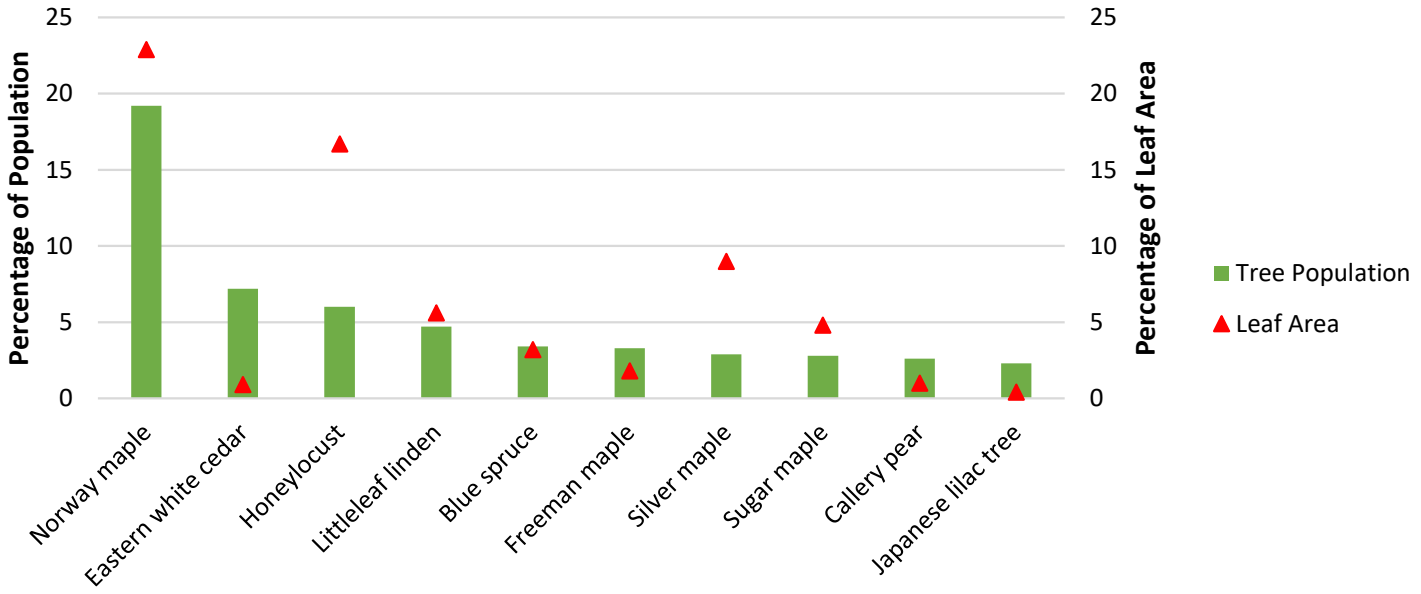


Figure 9. Top ten species of street trees by population, with total leaf area (Source: i-Tree Streets study data, 2018).

With the exception of eastern white cedar, callery pear, and Japanese lilac tree, Hamilton's top ten street tree species are capable of growing into medium- to large-stature trees. This means that they have the potential to deliver more significant benefits, provided the conditions exist to allow them to grow to their full biological potential. As large stature trees, their per-tree leaf area would be much greater than a smaller stature tree such as Japanese lilac tree, and hence each tree would deliver proportionately more benefits.

Further investments in Hamilton's street trees will be needed so they continue to provide important environmental services to residents. Investments in Hamilton's street trees have helped to improved overall tree condition and provided benefits that are disproportionately large compared to the overall tree population. In order to maintain the degree of environmental benefits currently provided by street trees, there must be a combination of regular maintenance and sufficient tree planting to sustain a healthy street tree population over the long term.

Tree Canopy and Land Cover Change[36]

Between 2006 and 2017, overall urban canopy cover decreased slightly (-0.9 percentage points) across Hamilton's urban area from 22.1% to 21.2%, though the measured change was not statistically significant. Of note in Hamilton, however, is the high variability in canopy cover levels between wards and neighbourhoods.

In the same time period the amount of hard (impervious) surfaces[37] increased by 4.1 percentage points, while the amount of soft (pervious) surfaces decreased by 3.7 percentage points.[38] The increase in hard surface is

[36] *A complete i-Tree Canopy study report is found in Appendix C.*
[37] *Buildings, parking lots, sidewalks, roads.*
[38] *The decline in grass cover was statistically significant.*

relevant to forestry because an increase in hard surface in the City reduces the amount of potential growing space for trees (Figure 10). Maintaining pervious areas supports quality growing space for trees, but also has other benefits for stormwater management and mitigating the urban heat island effect.

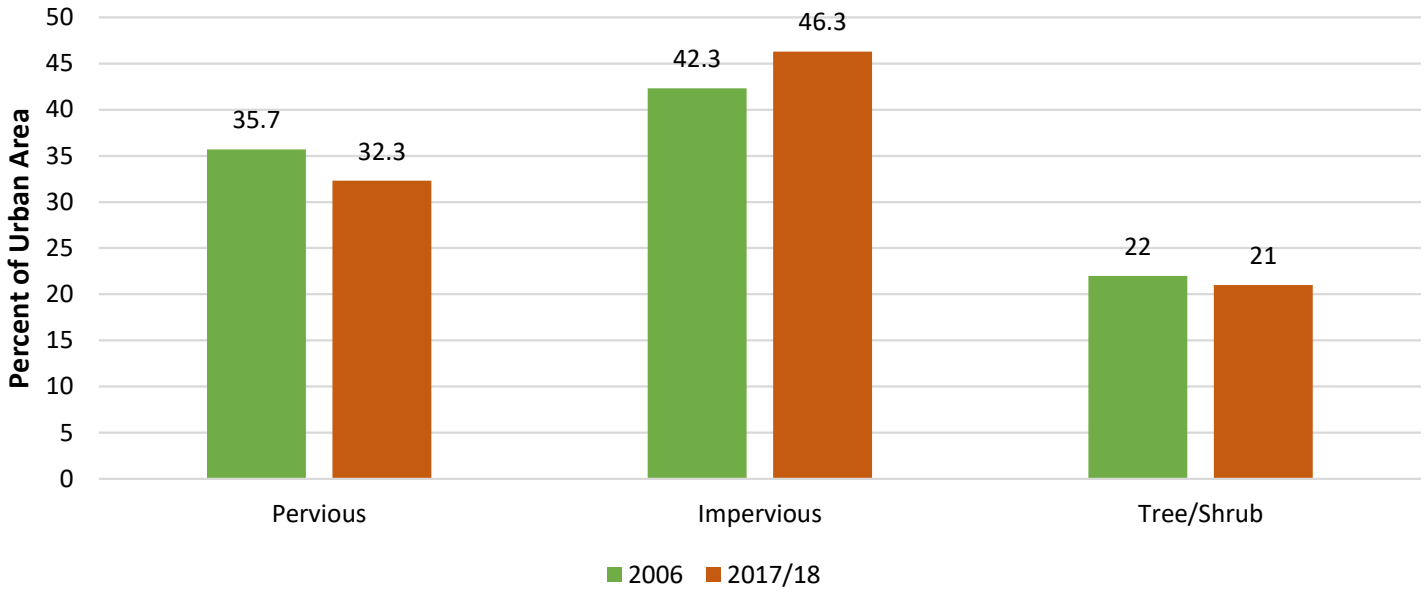


Figure 10. Change in impervious, pervious (not including Tree/Shrub), and Tree/Shrub land cover class from 2006 to 2017/2018. (Source: i-Tree Canopy point sample study data, 2006 and 2017/2018).

Canopy Cover Change by Ward (2018 Ward Boundaries) [39]

The highest areas of relative canopy loss were on the outskirts of Hamilton's urban boundary, in Wards 7, 8, and 12, with Ward 7 showing the greatest loss (-27.3%). Wards 3, 14 and 15 have seen gains in tree canopy, with the greatest increase of 15% between 2006 and 2017 in Ward 15. Wards 1, 2, 5, and 13 saw no significant change in tree canopy between 2006 and 2017 (Figure 11).

While the study data provides information about the location and extent of canopy change, it does not give managers any information about the root cause of change. Local experience would suggest it is a combination of several factors: emerald ash borer removals over the last 10 years, ongoing urbanization and increased density leading to removal of trees to accommodate growth, some natural mortality of older/mature trees and private tree removals by homeowners. Understanding root cause is important, because it enables the development of appropriate solutions to address the main issues driving canopy change.

ACTIONS:

- Complete land cover and canopy cover mapping for the City of Hamilton urban area.
- Determine the main drivers of canopy change in Hamilton.

[39] *A small sample size resulted in a high standard error for some wards sampled.*

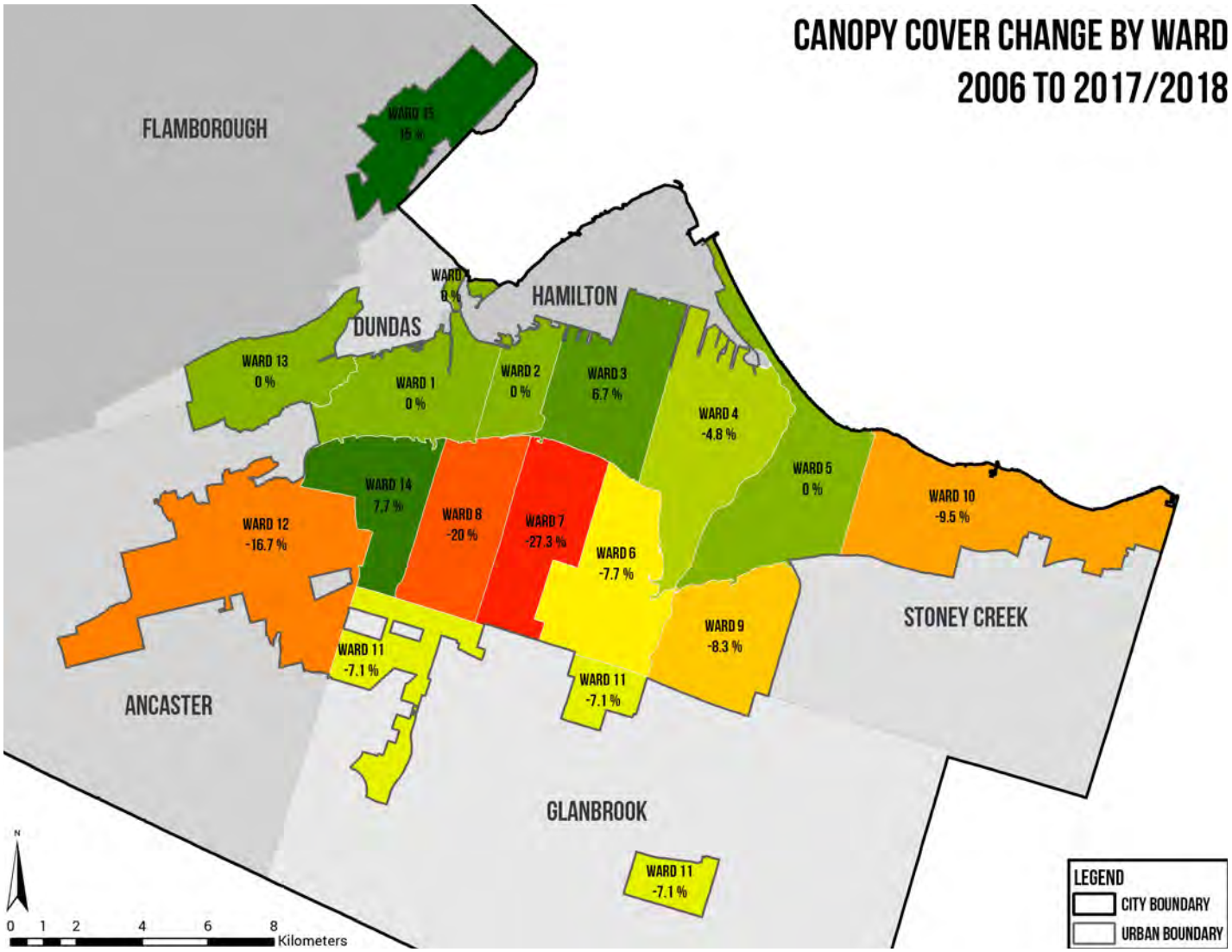


Figure 11. Percent tree cover change by 2018 municipal wards, Hamilton (Source: i-Tree Canopy study data, 2006 and 2017/2018).

State of the Urban Forest Asset (2016)

CHALLENGES FOR HAMILTON'S URBAN FOREST PROGRAM

In 2016, the City undertook a review of its forestry resources and trends in a State of the Asset Report. The report upgraded the City's score on consolidated Forestry and Horticulture (F&H) assets from a "C-" to a "C". However, this rating included all assets under the F&H umbrella.

Separating out trends in just the urban area within the scope of the UFS, the report identified that condition ratings for the City's forestry asset were downgraded from their status in 2009. In addition, the projected 25-year urban forest trends were stable for assets in the City's road allowances, but negative for these in parks and rural areas. This is an issue because of the declining condition and health of woodlands due to factors including climate change, increased recreation pressures and invasive species.

Several challenges were identified in the 2016 State of the Asset Report. Firstly, the City's tree canopy goal of 35%[40] is not expected to be met by 2035 – reasons provided include a lack of capital funding for additional tree planting.

[40] *As cited in the 2016 State of the Infrastructure Report & Asset Report Card – the Official Plan goal is 30%.*

Hamilton has had a dedicated budget for tree planting that has remained fairly constant over time (at approximately $1.345 million/year). Other funding sources include:

1. Cash in lieu of planting from developers, which funds subdivision planting;
2. The commemorative tree fund ($500/tree), planted in parks;
3. Separate 'motion' funding for Wards 3, 4, and 5; and,
4. Emerald ash borer funding, to replace trees removed due to emerald ash borer mortality.

This funding has not been sufficient to increase the number of trees planted in the City over the last several years (Table 4). Tree planting is one of the limiting factors to canopy cover expansion, along with the protection of existing trees.

Table 4. Number of trees planted by type, 2016-2019 (Source: City of Hamilton Forestry data).

YEAR	2016	2017	2018	2019 (PLANNED)
Number of Trees Planted	14,338	8,587	11,862	11,500

ASSET MANAGEMENT

The 'adaptive management' cycle relies on reliable data to forecast and assess trends in the urban forest environment. Data from tree inventories and work management systems can be used to accurately track change in the urban forest. Hamilton's street tree inventory was completed in 2006-2007 and has not been updated. As a result, there is currently no reliable way to link management activities to the street tree inventory.

The Parks and Cemeteries inventory was updated between 2016 and 2019. This was identified as a priority because of known maintenance requirements. Amalgamation of inventory information into one spatial layer (street trees, parks and cemeteries) is underway. The City currently uses 'Hansen' software to manage and track City assets. The City has begun to link work orders to the tree inventory, but there is still no way to update tree condition based on work performed. Now that a baseline i-Tree inventory has also been completed, the City should consider making this part of the regular 10-year inventory update cycles as a series of permanent sample plots that can be used to assess change.

ACTIONS:

- Update urban forest inventories and studies every 10 years or in response to significant environmental change.
- Implement a forestry asset management system.

Expanding the Urban Forest

The i-Tree assessments completed as part of the UFS show that there are opportunities for tree planting across all land use classes in Hamilton. In terms of plantable area in hectares, the greatest opportunity for increasing Hamilton's tree cover is in the Low Density Residential, Vacant and Open Space land uses.

While the Open Space land use has achieved the highest level of 'stocking' (ratio of current to potential canopy cover), there are significant opportunities to increase canopy cover in this land use as well (Table 5).

Table 5. Summary of existing and potential canopy area and current stocking level by land use (Source: i-Tree Eco survey plot visual estimates).

LAND USE	CURRENT CANOPY COVER (hectares)	POTENTIAL PLANTABLE SPACE (hectares of pervious, non-treed land cover)	MAXIMUM POTENTIAL TREE CANOPY (hectares)	CURRENT STOCKING (ratio of existing to potential maximum canopy cover)
Agricultural	92	455	547	17%
Vacant Land[41]	192	572	764	25%
Industrial	73	125	198	37%
Commercial/Office	63	87	150	42%
Institutional	180	156	336	54%
Transportation and Utility	166	136	302	55%
Low Density Residential	1590	953	2543	63%
Med/High Density Residential	201	96	297	68%
Open Space	1366	526	1892	72%

The area estimates are derived from the 2018 i-Tree Eco plots and represent a starting point for understanding planting opportunities in Hamilton at a very high level. In that respect, completing land cover mapping using imagery taken with leaf-on conditions can help identify two things to further inform priority planting areas: a) it identifies the location of existing urban tree canopy, and b) it identifies the location of potential planting areas based on pervious land cover types. This data can be used to work with stakeholders and planners to identify and prioritize future areas for tree planting in the City of Hamilton.

Part of this strategy will involve reaching out to private landowners to encourage afforestation of private lands in an effort to meet the overall canopy cover target. Currently, outreach to private landowners does not fall under the mandate of any City department involved in managing the urban forest. A new staff position dedicated to implementing an outreach and communications program can assist in identifying opportunities for increased tree planting on private lands within the urban area, among other functions. This position will be a key part of UFS implementation, particularly as it relates to community outreach and education.

[41] Vacant lands are properties that do not contain any buildings or structures. These lands may have always been vacant, or may have become vacant due to demolition or redevelopment activity.

Evaluating the effectiveness of planting programs is an important part of assessing the return on investment for trees planted on public lands in the City. For example, the city will need to source a wider range of planting stock because some of the species currently being planted (including native species) have not survived. Climate change will also change the viability of some species for planting in the urban area. Genetic diversity and the suitability of genotypes to future climates to avoid/reduce maladaptation are important to create a resilient tree population. In the longer term, developing a plan for urban forest gene conservation is a much broader issue that affects many cities across the province. This work should be a coordinated effort between planting agencies, different levels of government and the private sector tree nurseries who grow the majority of stock that is used in municipal tree planting.

ACTIONS:

- Complete land cover and canopy cover mapping for the City of Hamilton urban area.
- Complete a tree planting priority analysis to guide a City-wide tree planting strategy.
- Increase the level of tree planting and/or natural forest regeneration in the City over the next five years.
- Apply standardized tree planting details and specifications in all City tree planting projects.

Tree canopy is also impacted by extreme weather and emerald ash borer damage which is increasing the demand on Operations and Maintenance (O&M) resources. Since 2014, the number of trees actually removed due to emerald ash borer exceeded the number of trees planned for removal (Figure 12). The rate of replacement has not kept pace with removals as the City has been prioritizing risk mitigation related to dead or dying ash trees. A lag in replacement planting following tree removals exacerbates canopy loss in the short term, since existing canopy is lost to tree removal and replacement canopy to support future growth and expansion of the City's canopy cover is delayed.

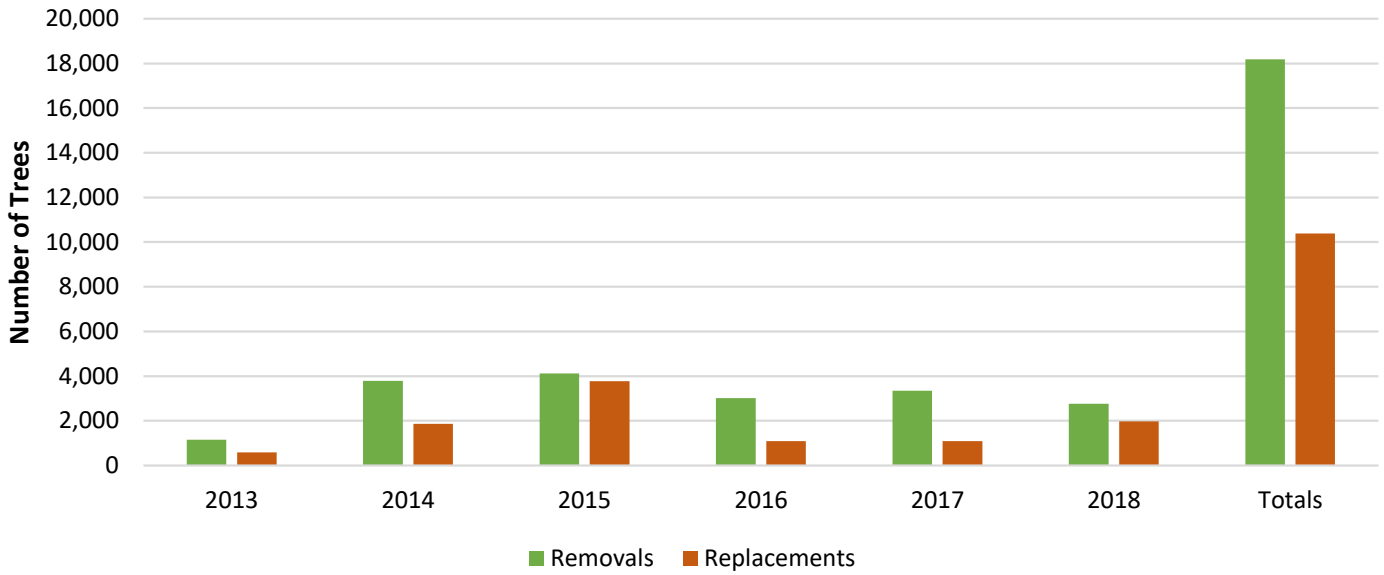


Figure 12. Number of tree removals and replacements done by City of Hamilton staff, 2013 to 2018 (Source: City of Hamilton, Forestry and Horticulture staff).

Growth of canopy, shrub and flower beds is resulting in increased service requests and demands, putting pressure on O&M budgetary resources that have not been increased in tandem with this growth. The increase in operations related service requests is shown in the forestry data for 2013 to 2018 (Figure 13).

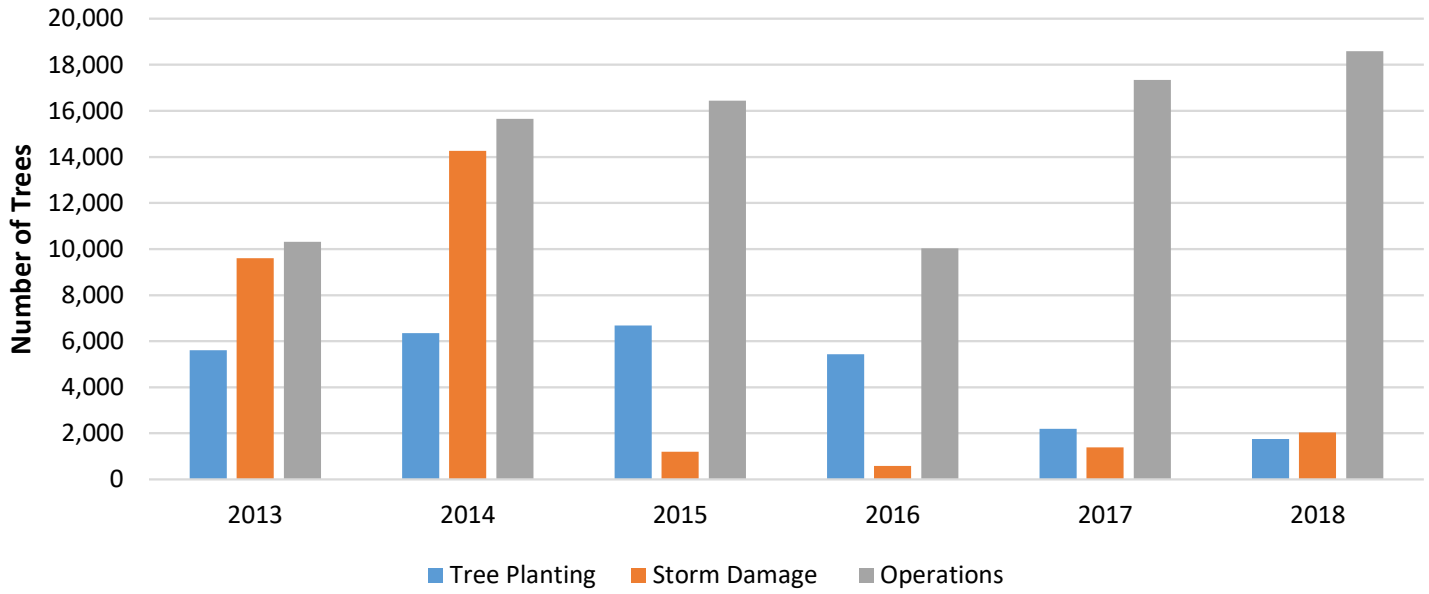


Figure 13. Service request by type, 2013 to 2018 (Source: City of Hamilton, Forestry and Horticulture staff).

To a certain extent and in tandem with current O&M practices, it may be possible to reallocate resources and find new approaches to achieve desired forestry outcomes without significant additional cost. For example, the number of trees established could be increased by reducing the number of large caliper trees planted in favour of smaller stock or allowing for natural regeneration by reducing mowing in designated park areas.

In Hamilton, however, many of the UFS goals and actions (including the management of natural areas) do not fall under the current mandate of the City departments tasked with managing the urban forest. For this reason, implementing the UFS will require additional investments in order to see positive gains in canopy cover and forest health, particularly in the City's natural areas. Identifying key resource management gaps will be part of implementing the UFS moving forward. Keeping Council informed and engaged on UFS implementation will help support progress toward the UFS goals.

ACTIONS:

- Review current management structures and identify resources required to achieve the City's urban forest vision.
- Present regular 'State of the Forest' reports to City Council.

How Does Hamilton Compare?

Many cities use canopy cover to measure the success of their urban forestry program. Many things can affect canopy cover, like the amount and distribution of green space, the relative distribution of land use types (e.g. more industrial and commercial lands could affect overall level of canopy cover as these areas tend to have less trees), and the age of residential neighbourhoods. A comparison of Hamilton to other cities suggests that Hamilton ranks toward the lower end of the scale for canopy cover.

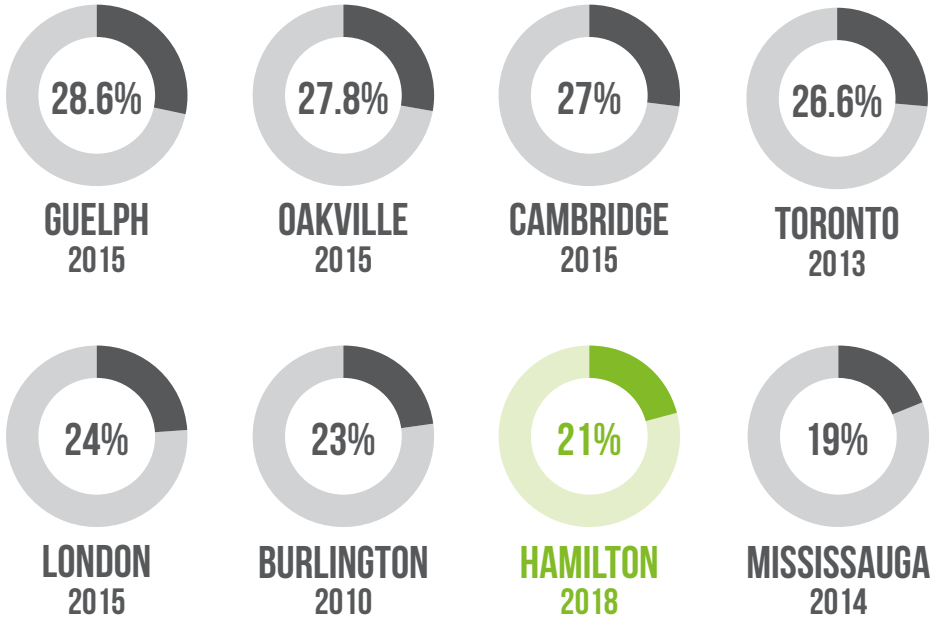


Figure 14. Canopy cover estimates in percent from various municipalities around southern Ontario.

A closer look at how canopy cover is distributed across land uses within cities (recognizing that the definition of land use may differ across municipalities) highlights some possible trends that may be worth further investigation. For example, Hamilton has considerably lower levels of canopy cover in Residential (particularly Low Density Residential), Industrial and Institutional land uses than most other cities (Table 6). On the other hand, canopy cover in the Commercial and Open Space land uses is comparable to levels reported by other jurisdictions.

Table 6. Urban canopy cover by land use in select southern Ontario cities (Sources: Available online study reports).

LAND USE CATEGORY	HAMILTON	OAKVILLE (2015 Study)	LONDON (2012 UFSMP)	MISSISSAUGA (2011 Technical Report)	NEWMARKET (2016 Study)	TORONTO (2018 Study)
Commercial	5.6	6.3	10	6	11	8
Industrial	2.3	N/A	12	5	11	8.7
Low Density Residential	18.6	44.2	27	20	27	33.2
Medium/High Density Residential	15.5	22.1	19	19	27	23.8
Parks/Open Space	54	64.6	55	44	53	58.3
Institutional	10.9	N/A	18	14	n/a	22

The background review compared Hamilton and the following five municipalities[42]:

- City of London Urban Forestry Strategy – Enhancing the Forest City (2014);
- City of Mississauga Urban Forest Management Plan (2014);
- City of New Westminster Urban Forest Management Strategy (2016);
- Halifax Regional Municipality (HRM) Urban Forest Master Plan (2013); and,
- North Oakville Urban Forest Strategic Management Plan (2011).

The comparative analysis used the framework of criteria developed in the USDA (United States Department of Agriculture) document, The Sustainable Urban Forest: A step-by-step approach[43]. The stepwise approach identifies 28 criteria (with associated 'targets') that can be used to assess the status of a municipality's urban forest condition and urban forestry programming. The USDA targets are arranged in three broad categories:

- Trees and Forest,
- Community Framework, and,
- Resource Management Approach.

Each of the 28 criteria represent a key part of a sustainable municipal urban forest. For each criterion, a municipality's performance can be evaluated against four levels of performance (Low, Fair, Good, and Optimal) using urban forestry performance indicators. The results are provided in Appendix E, including a summary of the applicable City of Hamilton urban forest policies, programs and by-laws assessed.

Key findings highlight the following priorities for the municipalities assessed:

- Establishing canopy cover targets;
- Completing and updating street tree inventories and urban forestry databases (in some but not all cases this can include woodlots);
- Developing policies for species diversity and native species selection;
- The importance of active management of publicly owned trees and natural areas; and,
- Creating a culture of cooperation and collaboration between municipal departments, higher levels of government, government agencies, the business community and industry.

For a minority (i.e., 7 of 28) of USDA targets, the City of Hamilton currently has urban forestry policies, programs, guidance documents and general practices that satisfy a low to moderate performance level based on indicators assessed (see Appendix E). An additional six USDA targets are partially satisfied. The USDA framework has been used to assess Hamilton's current urban forestry plans, programs and practices, and to establish baselines to track performance of key targets using specific indicators summarized in this UFS. This tracking will also allow for adaptive management of the urban forest in order to facilitate improvements to the performance level of key targets during the next phase of implementation.

[42] The detailed comparative review can be found in Appendix E.
[43] Leff, M. 2016. The Sustainable Urban Forest: A step-by-step approach. Davey Institute & United States Department of Agriculture, Forest Service.

What We Heard[44]

This section summarizes the engagement activities that took place in support of the development of the UFS. Through workshops, an online survey, public information centre and stakeholder meetings broad participation was encouraged to ensure that the UFS is a reflection of both current and future needs and priorities as articulated by the residents of Hamilton (Table 7).

Table 7. Overview of engagement activities in support of the development of the Urban Forest Strategy.

PHASE OF WORK	DATES	CONSULTATION EVENTS	PURPOSE
Phase 1 – Background Information Review	Spring – Fall 2018	Data Collection and Analysis; Consultation with UFS working group.	Visioning exercise, understanding priorities and values, establishing perceived impacts on urban tree canopy.
Phase 2 – Public Engagement	Spring 2018 to Fall 2019	March 29, 2018, September 17, 2018, June 18, 2018, and September 16, 2019 - Development Industry Liaison Group May 17, 2018 – Stage 1 Internal and External Stakeholder Workshops; May 29, 2018 – Public Open House; June 7, 2018 - Hamilton Aboriginal Committee June – September, 2018 – Online Survey; September 10, 2018 - Clean Air Hamilton October 3, 2018 – Air, Trees, and Technology Forum – public meeting November 21, 2018 - Hamilton Industrial Environmental Association November 20, 2018 and October 22, 2019 – Hamilton Clean and Green Committee April 17, 2019 – Stage 2 Internal and External Stakeholder Workshops; June 5, 19, and 24, 2019 – Public Workshops July 4 and August 14, 2019 - External stakeholder meetings (Conservation Authorities and NGOs) September 17, 2019 - Ward 13 (Dundas) Community Council meeting November 19, 2019 – "More Trees Please" Community Meeting hosted by Environment Hamilton and Hamilton Naturalists' Club November 28, 2019 - Seniors Tree Walk in Ancaster with Bruce Trail Conservancy March 10, 2020 - Bayfront Industrial Strategy Workshop	Collect feedback on the draft vision statement, canopy cover target, and goals and actions.

[44] *A summary of consultation activities and reports can be found in Appendix F.*

Phase 3 – Draft Report Preparation	Fall 2019 - Fall 2020	Draft Report Preparation	Preparing Technical and Summary Reports using data, research, and input from residents, staff, and stakeholders.
Phase 4 – Final Report	2021	Draft Report Review; Public Engagement; Final Report and Council Approval – 2021	Offer an opportunity for feedback from stakeholders on report findings and proposed actions, adoption of UFS by Council.

Hundreds of comments were received from members of the public and stakeholders – both in person and online – that helped identify key values and priorities. The following represents a summary of what was heard during the various engagement activities:

- **Beauty** –Trees contribute to the beauty of the urban landscape. That perception of beauty can promote a sense of local pride and add value to tourism. Trees can create a sense of connection to where people live, work and play. They can also screen unattractive views.
- **Air quality** – Trees provide oxygen, remove carbon dioxide from the atmosphere and make communities cleaner and more livable.
- **Stormwater management** – Trees absorb water from the ground, preserve soil, and reduce the risk of flooding. This is increasingly important in order to manage the impacts of intensified development and land use.

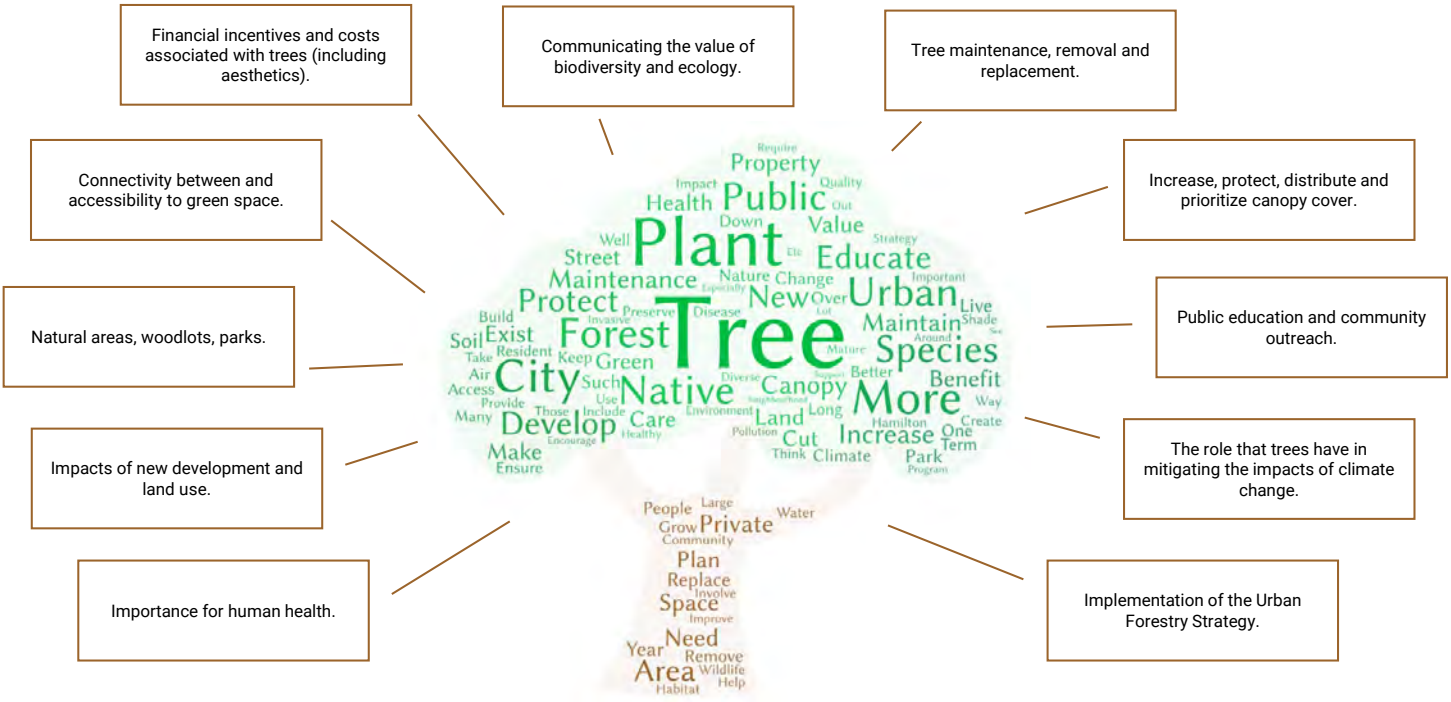


Figure 15. Schematic diagram of public opinion on the urban forest from an online survey (Source: City of Hamilton online survey, available June-July 2018).

- **Climate change mitigation** – Trees mitigate the impacts of climate change by absorbing CO2, reducing flooding during storms, providing shade, and reducing energy costs.
- **Environmental protection** – The urban forest provides habitat for wildlife, insects and plants. Ensuring proper tree maintenance, removal, and replacement benefits trees and other living organisms in local ecosystems.
- **Mental health and well-being** – The innate beauty and benefits that trees offer can provide people with calmness, serenity and improve quality of life. They can also encourage outdoor activity, provide opportunities for play and create linkages to other green spaces.

Extensive public input was utilized to develop five key UFS themes, as well as the actions that will help improve the state of Hamilton's urban forest moving forward.

Feedback on Hamilton's Urban Forest Program

The UFS builds on identified strengths in urban forestry program areas. In that respect, public tree maintenance is described as one of Hamilton's success stories. Hamilton has implemented an ongoing grid tree trimming program where crews move systematically through the City's urban areas to perform tree maintenance. This includes the maintenance of newly planted trees. The target cycle for mature trees is five years, which is consistent with recommended industry standards. The City is close to achieving the target for mature street trees at around a 7-year return cycle (compared to 13 years after the 2013 ice storm). According to Forestry staff, regular tree maintenance has reduced the frequency of individual service calls.[45]

As noted in the UFS actions, active management in natural areas and woodlots to improve the health and condition of forests remains limited. This has been identified as a resource and funding gap. However, other aspects of Natural Heritage System (NHS) management have been recognized as a best practice in Hamilton. This includes recognition of the importance of connectivity between core areas in the NHS. This is supported by a requirement for Linkage Assessments where new development or site alteration is proposed within an identified Linkage in the NHS.[46]

Similarly, Urban Hamilton Official Plan (UHOP) Volume 1, Section C.2.3 Natural Heritage System - Core Areas protects woodlands and other natural features through policy statements such as the following: *"The natural features and ecological functions of Core Areas shall be protected and where possible and deemed feasible to the satisfaction of the City enhanced. To accomplish this protection and enhancement, vegetation removal and encroachment into Core Areas shall generally not be permitted, and appropriate vegetation protection zones shall be applied to all Core Areas."* This sound policy base is a good foundation on which to build more active management approaches to protect the long-term health of Hamilton's valued natural areas.

Another area of opportunity for Hamilton's urban forest program is the broad public support and high levels of engagement by non-profit groups in the City. Hamilton can benefit from the expertise of four Conservation Authorities involved in watershed management in the region. There are also several active community organizations that are engaged in urban forest stewardship in Hamilton. The City can capitalize on these resources by developing partnerships with agencies that support Hamilton's urban forestry goals.

ACTIONS: Partner with organizations that support the City's urban forestry goals.

[45] *Anecdotal reports from Forestry staff.*
[46] *Best Practices Guide to Natural Heritage Systems Planning. 2014. Ontario Nature.*

The Future of Hamilton's Urban Forest

Themes and Actions

Part of the background work for the UFS was to identify the main challenges and opportunities for growing the City's urban forest. The themes and actions that resulted from this background study identified the foundational work that needs to be done to accurately describe and monitor the urban forest, as well as the policy changes that will be necessary to move the City forward on its urban forestry goals. Five themes have been identified for Hamilton's UFS:

1. Inspire
2. Act
3. Protect
4. Grow
5. Adapt

The themes are supported by guiding principles, which are implemented through 25 actions. These follow below and include a brief overview of context for each action as well as the link to relevant monitoring indicators under three categories: Trees and Forest (T - targets related to the status of the urban forest), Community Framework (C - the necessary engagement of stakeholders at all levels, and collaboration among them), and Resource Management (R - plans, practices, and policies to improve and sustain the forest resource).

Table 8. UFS Theme 1 (Inspire) with related actions.

THEME 1: INSPIRE	CONTEXT	LINK TO MONITORING INDICATORS
Guiding Principle: Engage and inspire the community with a bold vision for Hamilton's urban forest.		
Short-term (1-2 years)		
1. Develop and implement an inspiring urban forest communications strategy.	Creating a greater public appreciation for the value of Hamilton's urban forest through frequent, transparent and positive communications will help support the City's forestry goals. Applying marketing and branding principles with a consistent message to promote the value of the urban forest can be a powerful, effective tool to improve the awareness of and support for trees in Hamilton. These should include all aspects of the City's urban forestry presence, including a web page, educational materials and videos, public events, social media and open data.	C5 – Citizen Involvement and Neighbourhood Action C6 –General Appreciation of Trees as a Community Resource
2. Create a permanent new staff position in the Public Works Department dedicated solely to outreach, communications, education, and partnership development.	A major goal of the UFS is increasing general awareness of and appreciation for the urban forest. Inspiring the community to value trees is critical for building a strong forestry program in Hamilton. Outreach and education should target city departments, Council, private landowners, planners, developers, utilities and any other groups whose activities affect the urban forest. Activities will include outreach to landowners to identify opportunities for tree planting on private lands. This position is critical for supporting UFS implementation.	C1 – Municipal agency cooperation C2 – Utilities Cooperation C3 – Green Industry Cooperation C4 – Involvement of Large Private and Institutional Landholders C5 – Citizen Involvement and Neighbourhood Action C6 –General Appreciation of Trees as a Community Resource C7 – Regional Collaboration R5 – Municipality-wide Urban Forestry Funding

THEME 1: INSPIRE	CONTEXT	LINK TO MONITORING INDICATORS
3. Work directly with Hamilton's development community to improve awareness, identify urban forest allies, and recognize best practices and innovation.	Integrating the urban forest in new community design or revitalization projects has social and economic benefits that are often poorly understood and communicated. Regular dialogue between planners, forest managers and the development community may uncover opportunities for innovative design and cost-neutral options for making trees a valued part of Hamilton's urban future. Recognizing best practices and innovation is an important part of this work.	C4 – Involvement of Large Private and Industrial Landowners C3 – Green Industry Cooperation
4. Partner with organizations that support the City's urban forestry goals.	Many types of external organizations can add value to municipal urban forestry programs and help diversify funding sources for urban forest management. The City should broaden its scope to include non-traditional partners, which could include emergency response agencies, power companies, philanthropic organizations, medical facilities, corporate foundations and local universities and colleges. Identify areas where urban forestry intersects with organizational mandates and support partnership work with a dedicated staff position (see Action 1).	C5 – Citizen Involvement and Neighbourhood Action C3 – Green Industry Cooperation
5. Present regular 'State of the Forest' reports to City Council.	One of the most critical success factors for urban forestry programs is a supportive Council that understand the value of forests for creating livable, resilient cities. Council support for regulatory and policy changes that promote the integration of trees in policy, planning and urban development is key. A regular 'State of the Forest' Report to Council can help highlight progress and challenges and provide context for funding requests.	R4 – Municipality-wide Urban Forest Management Plan
6. Carry out an annual evaluation of the effectiveness of stakeholder engagement strategies.	Including social indicators in UFS monitoring is important for understanding trends in citizen and private sector engagement. The City should monitor engagement through social indicators, such as the number of visits to the City's Urban Forest webpage or the number of residents participating in community tree planting days. This information should be included in the "State of the Forest" report to Council.	C5 – Citizen Involvement and Neighborhood Action C4 – Involvement of Large Private and Industrial Landowners

Table 9. UFS Theme 2 (Act) with related actions.

THEME 2: ACT	CONTEXT	LINK TO MONITORING INDICATORS
Guiding Principle: "Goals are good. Action is better." (Vibrant Cities Lab)		
Short-term (1-2 years)		
1. Establish an inter-departmental working group to support UFS implementation.	The UFS includes actions that require collaboration to support successful implementation. Because the mandate for forest management is currently divided among several city departments, a working group will also support plan implementation and ensure that roles and responsibilities are assigned appropriately. The working group should meet regularly for the first five-year term of the UFS and report back to Council on progress through an annual 'State of the Forest' report.	C1 – Municipal Agency Cooperation
2. Improve implementation of Tree Protection / Management Plans and Landscape Plans required through development application review.	The city should ensure that required landscape and tree protection plans submitted as part of development applications are fully implemented. This should include costing, collection and release of securities, ensuring that qualified staff are conducting site inspections and providing a complete set of plans to inspection staff.	R2 – Canopy Cover Assessment Goals R5 – Municipality-wide Urban Forestry Funding
3. Complete land cover and canopy cover mapping for the City of Hamilton urban area.	Land cover maps describe the location and distribution of water, soil, trees, buildings, grass, roads and paved areas in the urban landscape. Detailed tree canopy maps can be derived from land cover data. Satellite imagery and specialized software are used to develop these maps, which are an important part of the urban forestry toolbox. They can be used to: • Map the distribution of canopy cover in Hamilton; • Set canopy cover targets for defined management areas; • Help staff identify and prioritize possible planting areas; and, • Track land and tree cover change.	R2 – Canopy Cover Assessment Goals R3 – Environmental Justice and Equity R7 – Tree Establishment Planning and Implementation
4. Apply standardized tree planting details and specifications in all city tree planting projects.	Tree planting details and specifications should be based on a review of best practices from other jurisdictions and address soil volume and quality, stormwater management and other key factors affecting tree growth. These should be implemented by all city departments that are involved in planting trees.	R8 – Growing Site Suitability

THEME 2: ACT	CONTEXT	LINK TO MONITORING INDICATORS
5. Develop and apply minimum canopy cover targets to new development proposals.	One of the key issues limiting expansion of the urban tree canopy in Hamilton is a lack of tools to translate high level policy goals (e.g., Official Plan goal of 30% canopy cover) into site level development activities. Targets for canopy cover can be set by land use area, neighbourhood, ward, secondary plan area, sub-watershed or other geographic unit of interest. These targets can be integrated in urban design guidelines to provide guidance for staff. Up-to-date data for land and tree cover can guide targets by land use or other area of interest for individual development projects. This will help Hamilton reach its 30% canopy cover goal and facilitate more equitable distribution of canopy cover.	T1 – Relative Tree Canopy Cover R2 – Canopy Cover Assessment Goals R3 – Environmental Justice and Equity C1 – Municipal Agency Cooperation
Medium-term (3-5 years)		
6. Identify and complete priority amendments to improve the integration of trees through applicable policies, plans, and guidelines.	Legislation, policies, plans, standards and guidelines that regulate and promote development in Hamilton have a strong influence on the current and future health of the urban forest. Having a strong voice for the urban forest at the table when these are being developed will help ensure trees are considered early on in urban planning, design and development. The city should identify and complete a list of priority amendments to improve urban forest canopy retention and establishment in planning processes such as Official Plan, secondary plans, urban design guidelines, master plans for stormwater and transportation planning, streetscape and urban design guidelines, Draft Plan Guidelines, Draft Plan of Condominium and Subdivision Guidelines, Site Plan Guidelines, City- Wide Corridor Planning Principles and Design Guidelines, Tree Protection/Management Plans for new developments, zoning by-laws, lot severance applications, minor variances, building permits, demolition permits and other relevant guiding documents.	T1– Relative Tree Canopy Cover R2 – Canopy Cover Assessment Goals C1 – Municipal Agency Cooperation
7. Determine the main drivers of canopy change in Hamilton.	A change detection completed for the UFS showed that canopy cover has remained the same or possibly declined between 2008 and 2018. However, it does not provide any information on the underlying cause of change. Understanding what is driving canopy change based on empirical data gives managers information to develop effective solutions. It also allows managers to allocate limited resources most efficiently.	T1 – Relative Tree Canopy Cover R5 – Municipality-wide Urban Forestry Funding

THEME 2: ACT	CONTEXT	LINK TO MONITORING INDICATORS
8. Review current urban forest management structures and identify resources required to achieve the City's urban forest vision.	The urban forest is defined as all trees and forests within the urban area and the connections between them. However, urban trees in Hamilton are currently managed separately from natural areas in the City, giving Forestry a very limited mandate for managing only a small portion of the city's urban forest. Consolidating responsibility for urban forest management under one city department may present opportunities to achieve cost efficiencies and improved forest management. The City should carry out a review of the division of roles and responsibilities for managing the urban forest.	R6 – Municipal Urban Forestry Program Capacity T10 - Maintenance of Publicly Owned, "Intensively" Managed Trees T11 – Management of Publicly Owned Natural Areas

Table 10. UFS Theme 3 (Protect) with related actions.

THEME 3: PROTECT	CONTEXT	LINK TO MONITORING INDICATORS
Guiding Principle: Trees are a valued city asset and an essential part of Hamilton's infrastructure.		
Short-term (1-2 years)		
1. Identify options for increasing the preservation of healthy trees in Hamilton.	Improving the retention of mature trees in Hamilton is a priority to prevent further canopy loss. Protection can be achieved through either regulation and incentives, or a combination of both. Approaches in Hamilton could include improved private tree by-laws and permitting systems, direct outreach to private landowners with significant trees, incentives for preserving existing trees on proposed development sites, outreach on best practices with other city departments and improved monitoring and enforcement of tree protection requirements.	R9 – Tree Protection Policy Development and Enforcement
2. Complete a climate change vulnerability assessment for Hamilton's natural systems, including the urban forest.	Climate change is already having impacts on the urban forest and these will increase in the future. Every city is different and is uniquely affected by climate change. 'Vulnerability assessments' look at the local context and work with community input to prioritize and find the best ways to mitigate the risks and reduce the residual effects of climate change on Hamilton's natural systems, including the urban forest.	R4 – Municipality-wide Urban Forest Management Plan
Medium-term (3-5 years)		
3. Develop and implement an Invasive Species Management Strategy.	The 2018 forest inventory shows that about 25 % of Hamilton's urban forest leaf area is comprised of Category 1 and 2 invasive species, which represent aggressive plants that interfere with native ecosystems. In the last ten years, the invasive Emerald Ash Borer has also resulted in the widespread loss of ash species across Ontario. Another invasive pest (the Asian Longhorned Beetle) represents a future threat to a third of Hamilton's urban tree canopy. Without intervention, invasive insect pests, diseases and plants will continue to degrade the quality of the urban forest. Hamilton should cooperate with neighbouring municipalities, Conservation Authorities and other levels of government to develop and implement an invasive species management strategy.	T4– Species Suitability C7 – Regional Collaboration R1 – Management of Publicly Owned Natural Areas R14– Native Vegetation

THEME 3: PROTECT	CONTEXT	LINK TO MONITORING INDICATORS
4. Develop service standards and emergency response plans for: Hazard trees and other forestry service requests. Severe weather events.	Risk management is currently undertaken through a combination of proactive and reactive methods. Risk management on City trees through removal of deadwood and structural pruning is a part of the City's regular grid maintenance program. City staff currently performs tree risk assessments, and if deemed necessary, conduct aerial inspections or hire consultants to perform advanced tree risk assessments. Formalizing the current risk management and emergency response approach is recommended.	R10 – Maintenance of Public Managed Trees R12– Tree Risk Management

Table 11. UFS Theme 4 (Grow) with related actions.

THEME 4: GROW	CONTEXT	LINK TO MONITORING INDICATORS
Guiding Principle: Regular investments in tree planting and maintenance programs will optimize long-term benefits and reduce risk to people, property and the health of the urban forest.		
Short-term (1-2 years)		
1. Increase the level of tree planting and/or natural forest regeneration in the City over the next five years.	The base tree planting budget has not increased in Hamilton over the last five years even though pressures on the forest have increased through Emerald Ash Borer, ice storm damage and ongoing storm events. Allocating more funds to tree planting is one approach to increasing canopy cover. City departments can also co-operate to identify other opportunities for increasing the number of trees established such as using smaller nursery stock for planting or identifying areas to promote natural forest regeneration.	C1 – Municipal Agency Cooperation R7 – Tree Establishment Planning and Implementation R8 – Growing Site Suitability
2. Develop a best practices manual for tree protection, planting and preservation to share with all City departments and utilities whose activities affect trees.	All City departments should prioritize the retention of mature trees, protection of trees from damage and the planting of new trees in capital and operations and maintenance projects. Early consideration of trees in planning should identify ways to reduce conflict for space with underground and overhead utilities. The manual should include clear criteria for planting site suitability and tree species selection as well as standardized tree planting specifications for all City departments, other agencies or private sector organizations involved with planting trees. Staff workshops to roll out a best practices manual will help improve awareness and reduce conflicts between trees and infrastructure/utilities in Hamilton. The manual should be reviewed periodically to ensure it reflects changing environmental conditions.	C1 – Municipal Agency Cooperation C2 – Utilities Cooperation
3. Complete a tree planting priority analysis to guide a city-wide tree planting strategy.	Detailed land cover data can be used to complete an analysis of priority tree planting locations. This is an operational tool that will help staff identify potential priority areas for increasing canopy cover on both public and private lands. These could include floodplains, areas with extreme summer temperatures, areas with low tree canopy or other criteria as determined by input from the community.	R7 – Tree Establishment Planning and Implementation R3 – Environmental Justice and Equity

THEME 4: GROW	CONTEXT	LINK TO MONITORING INDICATORS
Medium-term (3-5 years)		
4. Fund regular, active management of natural areas in Hamilton to support native biodiversity and forest health.	Urban trees and natural areas are interconnected systems, though they are managed separately in the City of Hamilton. Invasive species and growing recreation pressure are affecting the health of natural areas. These pressures will increase as Hamilton grows and the effects of climate change intensify. Increasing active forest management in high priority management areas will help protect native biodiversity and maintain the natural character of the City's trees and forests. There are many agencies and groups in Hamilton who can contribute expertise to identifying priority management areas. The city should investigate the costs of establishing a dedicated funding stream for natural areas management and include it as an annual budget request to Council.	R5 – Municipality-wide Urban Forestry Funding R11– Management of Publicly Owned Natural Areas R14– Native Vegetation

Table 12. UFS Theme 5 (Adapt) with related actions.

THEME 5: ADAPT	CONTEXT	LINK TO MONITORING INDICATORS
Guiding Principle: Urban forest management is evidence-based and responsive to change.		
Short-term (1-2 years)		
1. Implement a forest health monitoring program in Hamilton, including natural areas.	Forest health threats to Hamilton have already put intense pressure on the City's canopy cover. Emerald ash borer led to the removal of thousands of ash trees across the City. Insect and disease cycles are dynamic, and the City needs to have access to up-to-date information to be able to respond pro-actively to future forest health threats. Potential future threats include oak wilt and the Asian Longhorned Beetle which could affect over a third of Hamilton's total tree leaf area. The City should co-operate with other agencies to pro-actively monitor and report on forest health threats in Hamilton.	R4 – Municipality-wide Urban Forest Management Plan R10 – Maintenance of Public Managed Trees R11– Management of Publicly Owned Natural Areas
Medium-term (3-5 years)		
2. Implement a forestry asset management system.	Tree inventory data and location information should be managed using specialized software programs designed for urban forest management and other green assets. There are customized software programs for public works agencies that facilitate updating and link inventories to work order systems. These programs are also capable of producing required reports like: • Work histories and costs for each tree; • Citizen service and information requests; • Work orders; • Available planting sites • Tree valuation • Maps. As a management tool, customized software programs allow the municipality to efficiently allocate work crews and equipment, rapidly respond to service requests, identify safety risks, analyze costs, provide data for reporting and grant applications, and forecast budgets based on historical data.	R6 – Municipal Urban Forest Program Capacity R5 – Municipality-wide Urban Forestry Funding

THEME 5: ADAPT	CONTEXT	LINK TO MONITORING INDICATORS
Long-term (5-10 years)		
3. Update urban forest inventories and studies every 10 years or in response to significant environmental change.	Urban forest inventories are the cornerstone of good asset management. Having up-to-date information about urban forest structure, composition and condition is critical to effective strategic and operational planning as well as risk management in Hamilton. Inventories should be undertaken in tandem with the implementation of GIS-based asset management software that links the inventory to work order systems, to ensure that asset information remains reliable and up to date.	R1 – Tree Inventory T2 – Age Diversity (size class distribution) T3 – Species Diversity T4 – Species Suitability T5 – Publicly Owned Trees (managed "intensively") T6 – Publicly Owned Natural Areas (managed "extensively") T7 – Trees on Private Property

Tracking Progress

The UFS includes a framework for assessing progress using a set of criteria, indicators and targets (The Sustainable Urban Forest – A step-by-step approach).[47] This guide groups 28 indicators into three main categories, which were used previously to compare Hamilton's current state of the forest to other cities of interest. These include:

1. Trees and Forest – Indicators related to the state of the urban forest resource.
2. Community Framework – Indicators to describe the engagement of stakeholders at all levels and the collaboration among them.
3. Resource Management – Indicators to track plans, practices, and policies to improve and sustain the forest resource.

The criteria are a good way to communicate progress to the public and Council and identify areas that need more support or improvement. A detailed assessment of Hamilton's current level of achievement, based on information gathered in the background and policy review, i-Tree assessments, and feedback from City staff, is included in Appendix G.

A preliminary assessment of sustainable forest management criteria for Hamilton using data where available and a self-assessment by staff shows that the City is generally achieving a fair to good level of performance (Table 13). This is based on an assessment of the performance targets described in the monitoring approach.

Table 13. Baseline assessment of Hamilton's performance on urban forest criteria.

CATEGORY AND RATINGS (LOW TO OPTIMAL)	NUMBER OF INDICATORS
Category: Trees and Forest	7
Fair	5
Fair to Good	1
Good	1
Category: Community Framework	7
Low	1
Low or Low-Fair	1
Fair	2
Fair to Good	1
Good	2
Category: Resource Management	14
Fair	5
Fair to Good	4
Good	5
TOTAL NUMBER OF INDICATORS	**28**

The scoring suggests that the basics of a good urban forest program are in place, but that there are still many areas of opportunity to improve on current practices.

[47] *Leff, M. 2016. The Sustainable Urban Forest: A step-by-step approach. Davey Institute & United States Department of Agriculture, Forest Service.*

The Urban Forest: A Shared Resource

Approximately 42% of Hamilton's urban forest is located on public land and managed by either the City of Hamilton or other public agencies. Because of its location in the Carolinian forest region and along the Niagara Escarpment, the City shares the responsibility for managing one of the most diverse and unique remnant forest ecosystems in Canada. Over the past decade, the City has invested in street tree maintenance and planting programs that have improved the condition and number of street trees in Hamilton. There are community groups that are interested and actively engaged in urban forest stewardship and the City has a good foundation of communications and programming to support a thriving urban forest program.

At the same time, the UFS study found that canopy cover in Hamilton has not increased over the past decade, and has declined in some Wards. The condition of natural areas is also declining as the forest suffers the growing impacts of climate change, an influx of invasive species and disturbance due to urban development.

Another important finding from the forestry study is that more than half (58%) of Hamilton's forest is located on private property. This means that the future of the urban forest depends not only on City management efforts but is also in the hands of Hamilton's residents and private landowners. Along with City government, private landowners can do many things to help protect and grow the urban forest.

Examples of ways to support a healthy urban forest include:

- Preserving existing trees whenever possible on private and City property;
- Protecting quality growing space (soil) for trees during property development;
- Planting new trees (in proper locations to maximize growth, shade and energy savings);
- Taking care of tree health by watering young trees, having qualified professionals selectively pruning established trees and protecting underground tree root systems from construction, digging, soil compaction and other activities activities; and,
- Volunteer at community tree planting events or participate in a neighbourhood tree inventory.

The vision of this first UFS for Hamilton is to achieve a diverse, resilient, and beautiful urban forest that is valued as a shared asset. A bold strategy backed by strong Council support will help ensure a thriving urban forest that contributes to the well-being of all residents of Hamilton now and into the future.

Appendix A: UFS Themes and Actions

Table 1. UFS Theme 1 (Inspire) with related actions.

THEME 1: INSPIRE	CONTEXT
Guiding Principle: Engage and inspire the community with a bold vision for Hamilton's urban forest.	
Short-term (1-2 years)	
1. Develop and implement an inspiring urban forest communications strategy.	Creating a greater public appreciation for the value of Hamilton's urban forest through frequent, transparent and positive communications will help support the City's urban forest goals. Applying marketing and branding principles with a consistent message to promote the value of the urban forest can be a powerful, effective tool to improve the awareness of and support for trees in Hamilton. These should include all aspects of the City's urban forestry program, including a web page, educational materials and videos, public events, social media and open data.
2. Create a permanent new staff position in the Public Works Department dedicated solely to outreach, communications, education, and partnership development.	A major goal of the UFS is increasing general awareness of and appreciation for the urban forest. Inspiring the community to value trees is critical for building a strong forestry program in Hamilton. Outreach and education should target city departments, Council, private landowners, planners, developers, utilities and any other groups whose activities affect the urban forest. Activities will include outreach to landowners to identify opportunities for tree planting on private lands. This position is critical for supporting UFS implementation.
3. Work directly with Hamilton's development community to improve awareness, identify urban forest allies, and recognize best practices and innovation.	Integrating the urban forest in new community design or revitalization projects has social and economic benefits that are often poorly understood and communicated. Regular dialogue between planners, forest managers and the development community may uncover opportunities for innovative design and cost-neutral options for making trees a valued part of Hamilton's urban future. Recognizing best practices and innovation is an important part of this work.
4. Partner with organizations that support the City's urban forestry program.	Many types of external organizations can add value to municipal urban forestry programs and help diversify funding sources for urban forest management. The City should broaden its scope to include non-traditional partners, which could include emergency response agencies, power companies, philanthropic organizations, medical facilities, corporate foundations and local universities and colleges. Identify areas where urban forestry intersects with organizational mandates and support partnership work with a dedicated staff position (see Action 1).

5.	Present regular 'State of the Forest' reports to City Council.	One of the most critical success factors for urban forestry programs is a supportive Council that understand the value of forests for creating livable, resilient cities. Council support for regulatory and policy changes that promote the integration of trees in policy, planning and urban development is key. A regular 'State of the Forest' Report to Council can help highlight progress and challenges, and provide context for funding requests.
6.	Carry out an annual evaluation of the effectiveness of stakeholder engagement strategies.	Including social indicators in UFS monitoring is important for understanding trends in citizen and private sector engagement. The urban forest communications and engagement strategies should include indicators with supporting data to monitor and report on progress. This information should be included in the "State of the Forest" report to Council.

Table 2. UFS Theme 2 (Act) with related actions.

THEME 2: ACT	CONTEXT
Guiding Principle: "Goals are good. Action is better." (Vibrant Cities Lab)	
Short-term (1-2 years)	
1. Establish an inter-departmental working group to support UFS implementation.	The UFS includes actions that require collaboration to support successful implementation of the plan. Because the mandate for forest management is currently divided among several city departments, a working group will also support plan implementation and ensure that roles and responsibilities are assigned appropriately. The working group should meet regularly for the first five-year term of the UFS and report back to Council on progress through an annual 'State of the Forest' report.
2. Improve implementation of Tree Protection / Management Plans and Landscape Plans required through development application review.	The city should ensure that required landscape and tree protection plans submitted as part of development applications are fully implemented. This should include costing, collection and release of securities, ensuring that qualified staff are conducting site inspections and providing a complete set of plans to inspection staff.
3. Complete land cover and canopy cover mapping for the City of Hamilton urban area.	Land cover maps describe the location and distribution of water, soil, trees, buildings, grass, roads and paved areas in the urban landscape. Detailed tree canopy maps can be derived from land cover data. Satellite imagery and specialized software are used to develop these maps, which are an important part of the urban forestry toolbox. They can be used to: • Map the distribution of canopy cover in Hamilton; • Set canopy cover targets for defined management areas; • Help staff identify and prioritize possible planting areas; • Track land and tree cover change.
4. Apply standardized tree planting details and specifications in all city tree planting projects.	Tree planting details and specifications should be based on a review of best practices from other jurisdictions and address soil volume and quality, stormwater management and other key factors affecting tree growth. These should be implemented by all city departments that are involved in planting trees.
5. Develop and apply minimum canopy cover targets to new development proposals.	One of the key issues limiting expansion of the urban tree canopy in Hamilton is a lack of tools to translate high level policy goals (e.g., Official Plan goal of 30% canopy cover) into site level development activities. Targets for canopy cover can be set by land use area, neighbourhood, ward, secondary plan area, sub-watershed or other geographic unit of interest. These targets can be integrated in urban design guidelines to provide guidance for staff. Up-to-date data for land and tree cover can guide targets by land use or other area of interest for individual development projects. This will help Hamilton reach its 30% canopy cover goal and facilitate more equitable distribution of canopy cover.

Medium-term (3-5 years)	
6. Identify and complete priority amendments to improve the integration of trees through applicable policies, plans, and guidelines.	Legislation, policies, plans, standards and guidelines that regulate and promote development in Hamilton have a strong influence on the current and future health of the urban forest. Having a strong voice for the urban forest at the table when these are being developed will help ensure trees are considered early on in urban planning, design and development. The city should identify and complete a list of priority amendments to improve urban forest canopy retention and establishment in planning processes such as Official Plan, secondary plans, urban design guidelines, master plans for stormwater and transportation planning, streetscape and urban design guidelines, Draft Plan Guidelines, Draft Plan of Condominium and Subdivision Guidelines, Site Plan Guidelines, City- Wide Corridor Planning Principles and Design Guidelines, Tree Protection/Management Plans for new developments, zoning by-laws, lot severance applications, minor variances, building permits, demolition permits and other relevant guiding documents.
7. Determine the main drivers of canopy change in Hamilton.	A change detection completed for the UFS showed that canopy cover has remained the same or possibly declined between 2008 and 2018. However, it does not any provide information on the underlying cause of change. Understanding what is driving canopy change based on empirical data gives managers information to develop effective solutions. It also allows managers to allocate limited resources most efficiently.
8. Review current urban forest management structures and identify resources required to achieve the City's urban forest vision.	The urban forest is defined as all trees and forested landscape features within the urban area and the UFS reflects the high degree of connection between these elements. However, urban trees in Hamilton are currently managed separately of natural areas in the City, giving the Forestry Section a very limited mandate for managing only a small portion of the city's urban forest resource. Consolidating responsibility for urban forest management under one city department may present opportunities to achieve cost efficiencies and improved forest management. The city should carry out a review of urban forest management structure and determine if the current division of roles and responsibilities is optimal for achieving UFS and other strategic environmental goals.

Table 3. UFS Theme 3 (Protect) with related actions.

THEME 3: PROTECT	CONTEXT
Guiding Principle: Trees are a valued city asset and an essential part of Hamilton's infrastructure.	
Short-term (1-2 years)	
1. Identify options for increasing the preservation of healthy trees in Hamilton.	Improving the retention of mature trees in Hamilton is a priority to prevent further canopy loss. Protection can be achieved through either regulation and incentives, or a combination of both. Approaches in Hamilton could include improved private tree by-laws and permitting systems, direct outreach to private landowners with significant trees, incentives for preserving existing trees on proposed development sites, outreach on best practices with other city departments and improved monitoring and enforcement of tree protection requirements.
2. Complete a climate change vulnerability assessment for Hamilton's natural systems, including the urban forest.	Climate change is already having impacts on the urban forest and these will increase in the future. Every city is different and is uniquely affected by climate change. 'Vulnerability assessments' look at the local context and work with community input to prioritize and find the best ways to mitigate the risks and reduce the residual effects of climate change on Hamilton's natural systems, including the urban forest.
Medium-term (3-5 years)	
3. Develop and implement an Invasive Species Management Strategy.	The 2018 forest inventory shows that about 25 % of Hamilton's urban forest leaf area is comprised of Category 1 and 2 invasive species, which represent aggressive plants that interfere with native ecosystems. In the last ten years, the invasive Emerald Ash Borer has also resulted in the widespread loss of ash species across Ontario. Another invasive pest (the Asian Longhorned Beetle) represents a future threat to a third of Hamilton's urban tree canopy. Without intervention, invasive insect pests, diseases and plants will continue to degrade the quality of the urban forest. Hamilton should cooperate with neighbouring municipalities, Conservation Authorities and other levels of government to develop and implement an invasive species management strategy.
4. Develop service standards and emergency response plans for: Hazard trees and other forestry service requests. Severe weather events.	Risk management is currently undertaken through a combination of proactive and reactive methods. Risk management on City trees through removal of deadwood and structural pruning is a part of the City's regular grid maintenance program. City staff currently performs tree risk assessments, and if deemed necessary, conduct aerial inspections or hire consultants to perform advanced tree risk assessments as needed. Formalizing the current risk management and emergency response approach is recommended as part of the UFS outcomes.

Table 4. UFS Theme 4 (Grow) with related actions.

THEME 4: GROW	CONTEXT
Guiding Principle: Regular investments in tree planting and maintenance programs will optimize long-term benefits and reduce risk to people, property and the health of the urban forest.	
Short-term (1-2 years)	
1. Increase the level of tree planting and/or natural forest regeneration in the City over the next five years.	The base tree planting budget has not increased in Hamilton over the last five years even though pressures on the forest have increased through Emerald Ash Borer, ice storm damage and ongoing storm events. Allocating more funds to tree planting is one approach to increasing canopy cover. City departments can also co-operate to identify other opportunities for increasing the number of trees established such as using smaller stock material for planting or identifying areas to promote natural forest regeneration.
2. Develop a best practices manual for tree protection, planting and preservation to share with all City departments and utilities whose activities affect trees.	All City departments should prioritize the retention of mature trees, protection of trees from damage and the planting of new trees in capital and operations and maintenance projects. Early consideration of trees in planning should identify ways to reduce conflict for space with underground and overhead utilities. The manual should include clear criteria for planting site suitability and tree species selection as well as standardized tree planting specifications for all City departments, other agencies or private sector organizations involved with planting trees. Staff workshops to roll out a best practices manual will help improve awareness and reduce conflicts between trees and infrastructure/utilities in Hamilton. The manual should be reviewed periodically to ensure it reflects changing environmental conditions.
3. Complete a tree planting priority analysis to guide a city-wide tree planting strategy.	Detailed land cover data as recommended can help the city complete analysis on priority tree planting locations. This is an operational tool that will help staff identify potential priority areas for increasing canopy cover on both public and private lands. These could include floodplains, areas with extreme summer temperatures, areas with low tree canopy or other criteria as determined by input from the community.
Medium-term (3-5 years)	
4. Fund regular, active management of natural areas in Hamilton to support native biodiversity and forest health.	Urban trees and natural areas are interconnected systems, though they are managed separately in the City of Hamilton. Invasive species and growing recreation pressure are affecting the health of natural areas. These pressures will increase as Hamilton grows and the effects of climate change intensify. Increasing active forest management in high priority management areas will help protect native biodiversity and maintain the natural character of the City's trees and forests. There are many agencies and groups in Hamilton who can contribute expertise to identifying priority management areas. The city should investigate the costs of establishing a dedicated funding stream for natural areas management and include it as an annual budget request to Council.

Table 5. UFS Theme 5 (Adapt) with related actions.

THEME 5: ADAPT	CONTEXT
Guiding Principle: Urban forest management is evidence-based and responsive to change.	
Short-term (1-2 years)	
1. Implement a forest health monitoring program in Hamilton, including natural areas.	Forest health threats to Hamilton have already put intense pressure on the City's canopy cover. Emerald ash borer led to the removal of thousands of ash trees across the City. Insect and disease cycles are dynamic, and the City needs to have access to up-to-date information to be able to respond pro-actively to future forest health threats. Potential future threats include oak wilt and the Asian Longhorned Beetle which could affect over a third of Hamilton's total tree leaf area. The City should co-operate with other agencies to pro-actively monitor and report on forest health threats in Hamilton.
Medium-term (3-5 years)	
2. Implement a forestry asset management system.	Tree inventory data and location information should be managed using specialized software programs designed for urban forest management and other green assets. There are customized software programs for public works agencies that facilitate updating and link inventories to work order systems. These programs are also capable of producing required reports like: • Work histories and costs for each tree; • Citizen service and information requests; • Work orders; • Available planting sites; • Tree valuation; and, • Maps. As a management tool, customized software programs promote efficient allocation of work crews and equipment; speeds up responses to service requests; identify safety risks; helps with cost analysis; provide data for accurate reporting to Council and other departments; can provide information needed for grant applications and improve budget forecasting based on historical data.
Long-term (5-10 years)	
3. Update urban forest inventories and studies every 10 years or in response to significant environmental change.	Urban forest inventories are the cornerstone of good asset management. Having up-to-date information about urban forest structure, composition and condition is critical to effective strategic and operational planning as well as risk management in Hamilton. Inventories should be undertaken in tandem with the implementation of GIS-based asset management software that links the inventory to work order systems, to ensure that asset information remains reliable and up to date.

Appendix B: i-Tree Eco Study Report

i-Tree Eco Field Survey

Methodology

i-Tree Eco (formerly known as UFORE) combines field data with local hourly pollution and meteorological data to quantify the structural attributes, environmental effects, and economic value provided by the urban forest.

PLOT SELECTION

In 2018, Hamilton established a total of 220 plots (0.04 hectare plots), in accordance with i-Tree Eco recommendations. Plots were randomly located throughout the City of Hamilton's urban area.

LANDOWNER CONTACT

In order to secure permission from landowners whose properties were included in the i-Tree Eco plots, the City of Hamilton drafted a letter to property owners explaining the project purpose and requesting permission for field crews to access their property. Hamilton mailed the letters, along with pre-paid return postage, to landowners in the spring of 2018. Contractor staff conducted in-person follow-up visits to some properties whose owners did not return a reply to the initial letters. Additional permissions were obtained in this manner, and field crews continued to conduct landowner outreach during the data collection period, as necessary. Where permission was denied, field crews did not enter the property and ceased contact with the landowner.

A total of 212 plots received full landowner permission and were completed by field crews.

I-TREE ECO FIELD METHODOLOGY

Field crews assessed a total of 212 plots during the 2018 field season. Plots are circular and measure 0.04 hectares. Field duties were carried out by BioForest staff, under contract to the City of Hamilton. There was one regular field crew, comprised of one crew lead and one crew member, supervised by a project manager and project coordinator. Occasionally, an additional crew member joined to support data collection at particularly challenging plots. Field crews were trained by senior BioForest staff, and training took place from May 28 to 31 at various plot locations. Field crews collected data independently from June 1 to September 14, 2018. Field crews recorded data on paper data forms or electronically using digital tablets. Crews measured a total of 1,456 trees.

Field crews collected the following data at each plot:

<u>Plot Information</u>

- Plot ID number
- Date of data collection
- Crew
- GPS coordinates of plot centre
- Plot address/notes
- Reference object descriptions, and distance and compass directions to plot centre
- Tree measuring point, if used, where plot centre was inaccessible
- Percent tree cover (visual estimate)

- Percent shrub cover (visual estimate)
- Percent plantable space (visual estimate)
- Land use, as observed in the field
- Percent of plot within each land use (visual estimate, based on field map)
- Percent ground cover (visual estimate of each cover type)
- Shrub Data

Species ID

- Shrub mass height
- Shrub mass percent of total shrub area (visual estimate)
- Shrub mass percent missing (visual estimate of the percentage of shrub's volume not occupied by leaves)

Tree Data

- Tree ID number
  - Standing at plot centre facing north, trees are numbered working clockwise (starting at 1)
- Tree status
  - Planted, ingrowth, or unknown
- Compass direction and distance from plot centre (or tree measuring plot, if using)
- Land use in which tree is rooted
- Species ID
- Diameter at breast height (1.37 m) for up to six stems, if tree is multi-stemmed
- Tree height
- Live crown height
- Height to crown base
- Crown width (two measurements, in east-west and north-south directions)
- Percent canopy missing (visual estimate)
- Percent dieback (visual estimate)
- Percent impervious surface area under the canopy of the tree (visual estimate)
- Percent shrub area under the canopy of the tree (visual estimate)
- Crown light exposure (number of sides of the tree's crown that are exposed to direct sunlight)
- Distance and direction to residential buildings, for trees at least 6 m in height, and within 18 m of a residential building
- Tree site (street tree or not)
- Presence of Pests
  - Insect selections were limited to Asian longhorned beetle (*Anoplophora glabripennis*), beech bark scale (*Cryptococcus fagisuga*), emerald ash borer (Agrilus planipennis), European elm scale (*Gossyparia spuria*), fall/spring cankerworm (*Alsophila pometaria* and *Paleacrita vernata*), gypsy moth (*Lymantria dispar* ssp. *dispar*), and hemlock woolly adelgid (*Adelges tsuga*)
  - Disease selections were limited to beech bark disease (*Neonectria faginata*), Dutch elm disease (*Ophiostoma ulmi*), and oak wilt (*Bretziella fagacearum*)
  - When a pest was observed on a host tree, all related signs or symptoms were recorded

Materials

- Clipboard
- Pencils
- Paper data sheets
- Rangefinder
- Clinometer
- 30 m measuring tape
- DBH tape
- Compass
- GPS unit
- Samsung Galaxy Note or Galaxy Tab A tablet, programmed with Workforce and Esri Collector apps
- Flagging tape
- Chalk

Quality Control Audits

The i-Tree Eco protocol outlines methods for ensuring quality and accuracy of the data collected by field crews during the survey. Hot checks are procedures in which an auditor works along with the field crew as they collect data at an i-Tree plot to ensure that the crews have a good understanding of the protocol. Errors are corrected in person, and these checks are typically included in the initial field crew training sessions. Cold checks are procedures in which an auditor makes follow-up visits to plots where the field crew has already collected data. The auditor verifies the crew's data to ensure that it is accurate and complete. Plots selected for cold checks are chosen at random, and ideally include a variety of settings. The i-Tree protocol advises a distribution of about 30% hot checks and 70% cold checks, encompassing about 5% of plots.

Senior BioForest staff completed hot checks in the first week of training and cold checks in the two weeks following training when field crews were working independently. A total of 10 plots were audited, which represents 5% of all plots, in accordance with i-Tree Eco protocols.

Cold check procedures varied slightly based on the number of trees present in a plot. For plots with 5 trees or less, each tree was audited. The species ID, DBH, height, crown width, and building interaction (if applicable) were confirmed by the auditor. The land use, as reported by field crews, plot tree cover, and number of trees in the plot were verified. For plots with more than 5 trees, the auditor randomly selected 5 trees and confirmed species ID, DBH, height, crown width, and building interaction (if applicable). The auditor also confirmed the land use, plot tree cover, and total tree count, and verified species ID for all trees in the plot. During the audits, auditors encountered minor errors, such as incorrect species identification, small discrepancies in DBH or crown measurements, or occasionally a measurement that was not recorded properly. In one case, the crew was asked to revisit a plot in order to correct deficiencies in the data. These errors were observed only in plots that were surveyed during the first days of data collection. Plots that were surveyed later were free of errors, as the crews had by then attained greater proficiency with the i-Tree protocol.

When field staff entered data from paper data sheets into the digital tablet, supplemental quality control (not prescribed by i-Tree) was undertaken by BioForest staff to reduce the chances of errors due to manual data entry. 10% of all plots where data was recorded on paper and subsequently entered into the tablet, were audited. All measurements were checked by the auditor and no major errors were reported. There were a few minor instances of discrepancies in distances, directions, and percentages, however the errors were not significant.

Data Submission and Analysis

Throughout the data collection period, field crews used their tablets to submit their data to the i-Tree server, allowing the project coordinator to download and view the data using i-Tree Eco v. 6 on a desktop computer. Data was either inputted directly through the i-Tree web form in the field, or was entered at a later date, when field crews used paper data sheets to record field data. Following the completion of data collection, the project coordinator reviewed the collected data for errors.

Once the final edited version of the 2018 database was prepared, it was submitted for analysis using i-Tree Eco v. 6. The results of the analysis were returned by the i-Tree server on the same day. Results were downloaded from i-Tree Eco and organized into Microsoft Excel databases for further analysis and reporting purposes.

Results are presented as an extrapolation of the field data gathered from the 212 i-Tree Eco plots used for this study. These plots constitute a statistically representative sample of Hamilton's urban forest. A study using 200 urban plots in a stratified random sample is expected to yield a standard error of about 10%[1]. Therefore, the 212 plots used in Hamilton's i-Tree survey produce results that fall within the bounds of acceptable standard error. Only a complete inventory would eliminate the possibility of error, but the time requirements, ability to access private properties, and financial cost would make such an undertaking unfeasible.

2018 i-Tree Eco Study Results

Urban Forest Composition and Structure

Tree Species and Diversity

Hamilton's urban forest has an estimated 5,212,000 trees, at a density of about 205 trees per hectare. The three most common species are eastern white cedar (*Thuja occidentalis* [10.9%]),[2] white ash (*Fraxinus americana* [9.7%]), and European buckthorn (*Rhamnus cathartica* [9.4%]) (Figure 1). The highest tree densities occur in the Open Space land use category followed by Vacant Land and Low Density Residential (Figure 2).

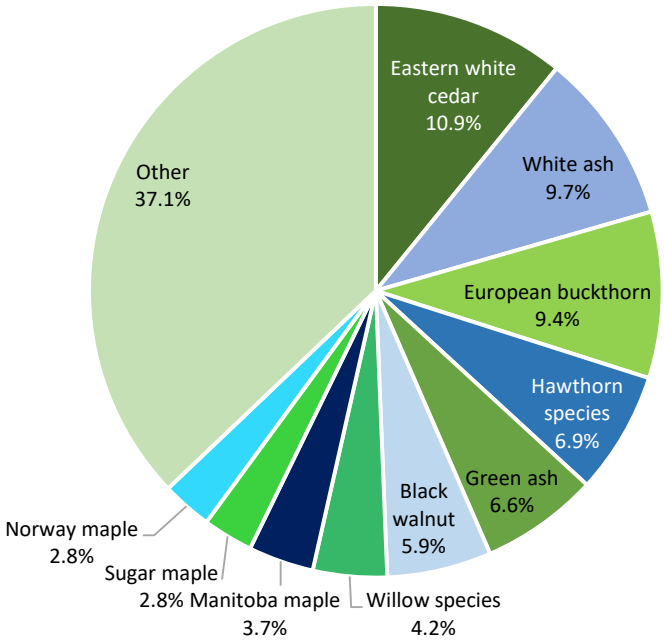


Figure 1. Tree species composition by population in Hamilton, 2018.

[1] *I-Tree Eco v6.0 User's Manual.*
[2] *It should be noted that the large population of eastern white cedar is not entirely due to natural cedar forests, but to the use of this species as hedges, primarily on residential properties.*

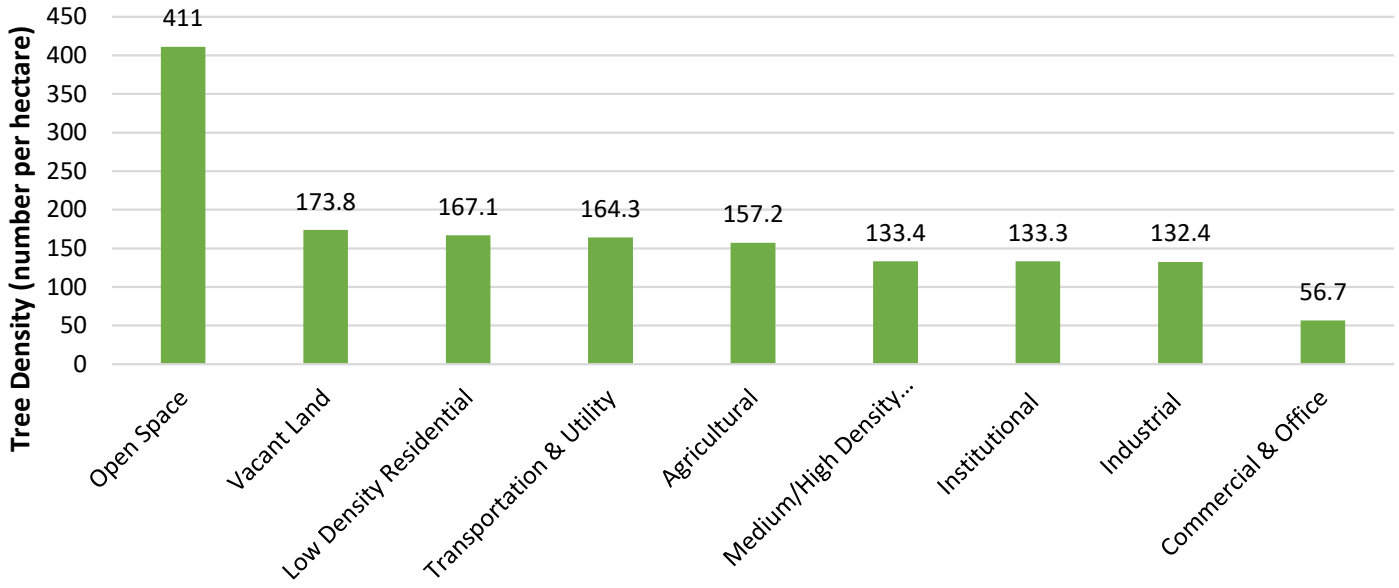


Figure 2. Number of trees per hectare in Hamilton by land use, 2018.

While tree populations provide insight into the relative abundance of tree species in the city's tree population, measuring the species' abundance by leaf area gives greater insight into which species are making greater contributions to the ecosystem services the urban forest provides. Leaf area is the primary part of a tree's physiology that filters pollution, casts shade, releases oxygen, and provides other valuable benefits. Tree species with a greater potential size at maturity are likely to provide the greatest benefits in the long term, provided conditions exist to support growth to their full biological potential.

Trees cover approximately 293.6 square kilometers of leaf area. Total leaf area is greatest in Open Space followed by Low Density Residential and Vacant Land (Figure 3).

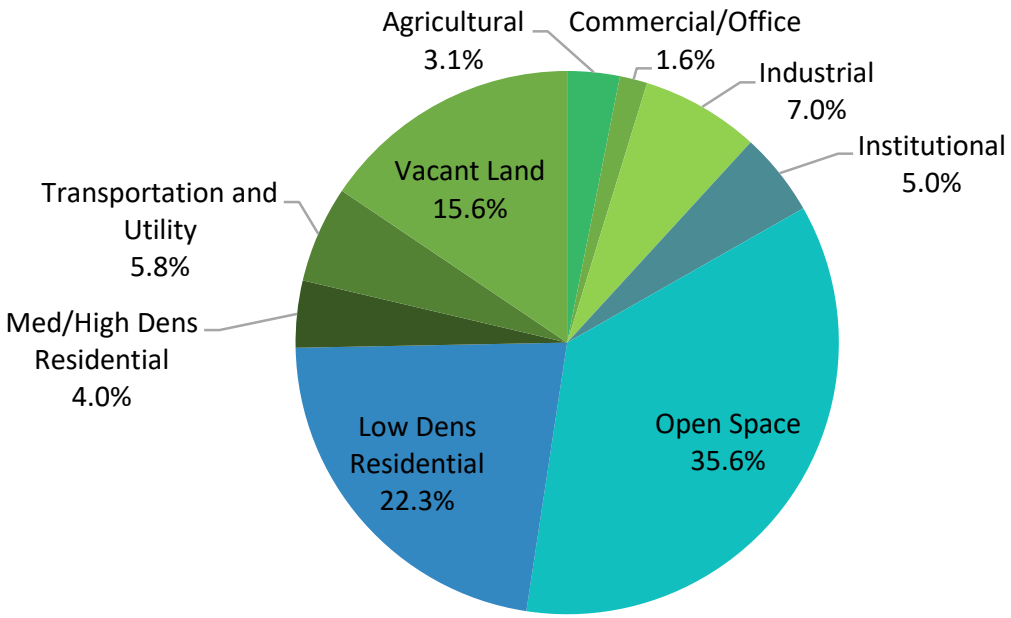


Figure 3. Leaf area by land use in Hamilton, 2018.

When ranked by leaf area, black walnut (*Juglans nigra*) is the most abundant tree in Hamilton's urban area, followed by Norway maple (*Acer platanoides*) and Manitoba maple (*Acer negundo*) (Figure 4).

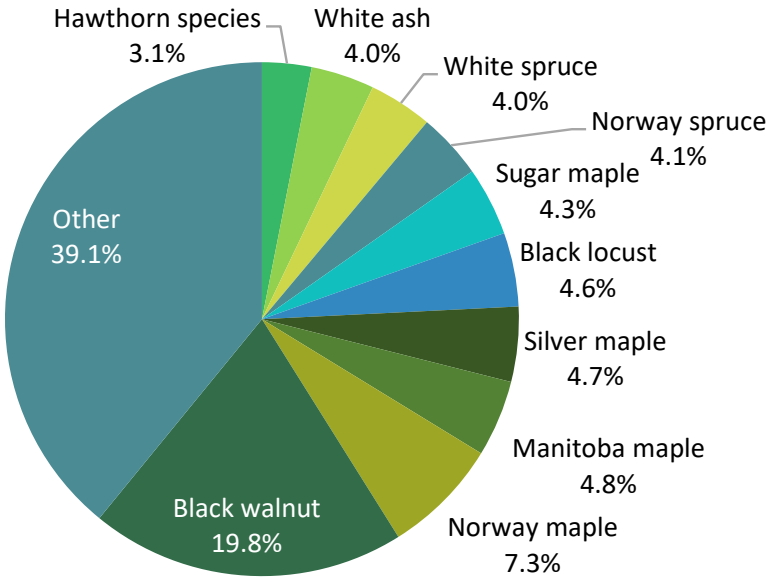


Figure 4. Leaf area by species in Hamilton, 2018.

Genetic diversity among trees in the urban forest ensures a resilient and sustainable urban forest. According to the USDA's Sustainable Urban Forest Guide,[3] a fair measure of diversity is represented by the total tree population being comprised of not more than 10% of one species, 20% of one genus, and 30% of one family. A good diversity rating lowers those thresholds to 5%/10%/15%, city-wide.

The Oleaceae family is the only family that exceeds the good threshold of 15% (Figure 5). Three genus, Fraxinus, Thuja, and Acer, exceed the good threshold of 10%, though Fraxinus represents the most of all at 16.8% (Figure 6). The top 5 species in Hamilton all exceed the good threshold of 5%, and eastern white cedar (*Thuja occidentalis*) slightly exceeds the fair threshold of 10%, and white ash (*Fraxinus americana*) is just below the threshold (Figure 7).

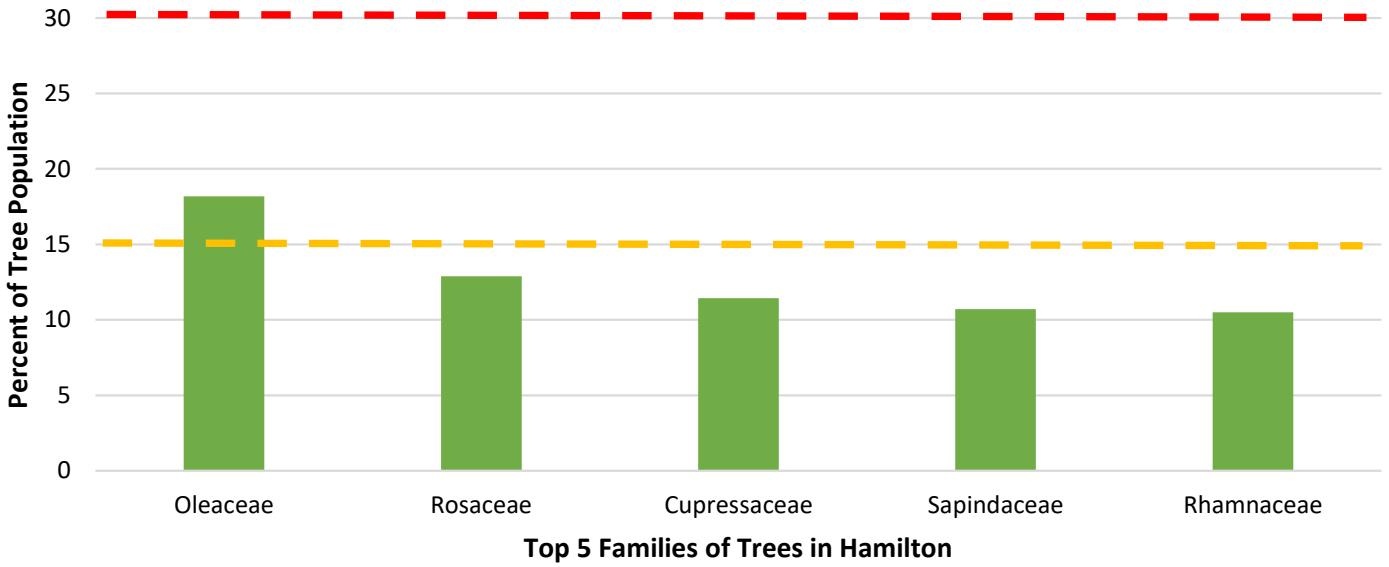


Figure 5. Top five families of trees in Hamilton, 2018, compared to USDA's "Fair" threshold of 30% (red line) and "Good" threshold of 15% (yellow line).

[3] *Leff, M. 2016. The Sustainable Urban Forest: A step-by-step approach. Davey Institute & United States Department of Agriculture, Forest Service.*

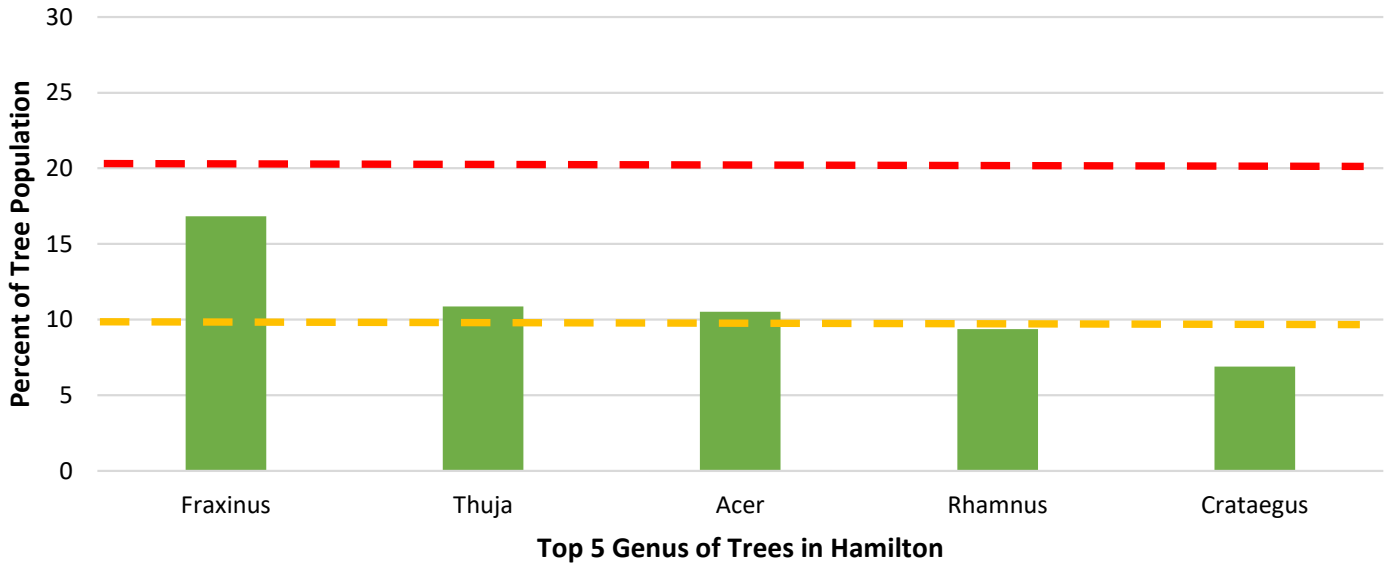


Figure 6. Top five genus of trees in Hamilton, 2018, compared to USDA's "Fair" threshold of 20% (red line) and "Good" threshold of 10% (yellow line).

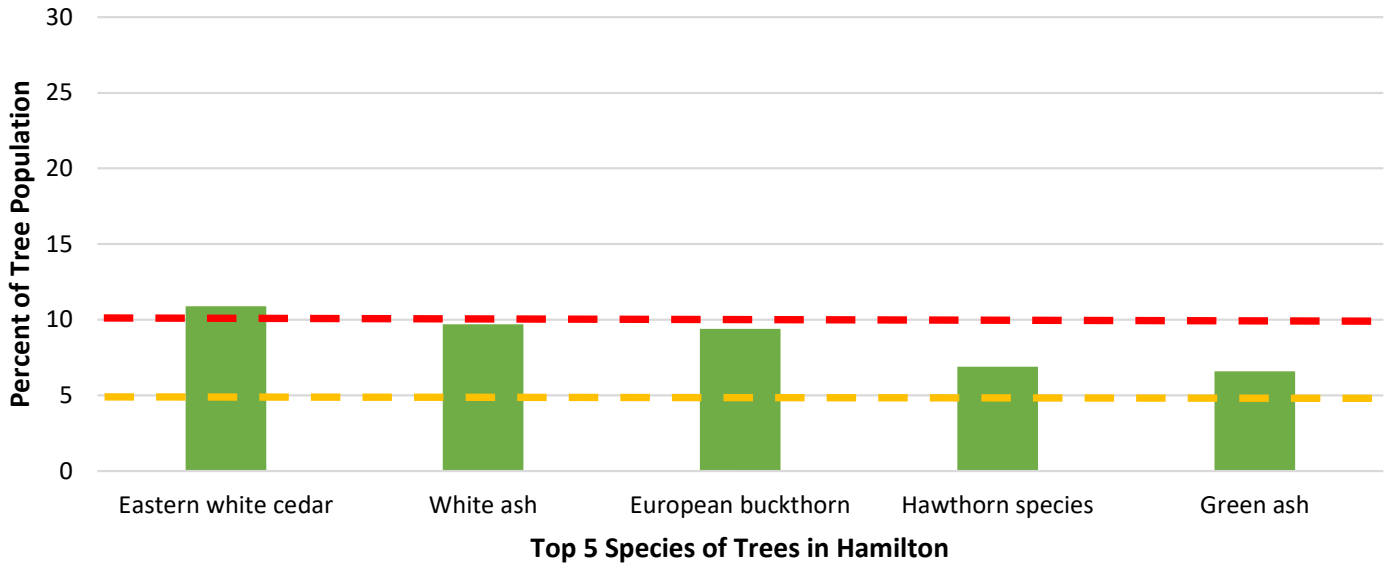


Figure 7. Top five species of trees in Hamilton, 2018, compared to USDA's "Fair" threshold of 10% (red line) and "Good" threshold of 5% (yellow line).

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 Hamilton, 2018.

SPECIES	COMMON NAME	PERCENT POPULATION	PERCENT LEAF AREA	IMPORTANCE VALUE
Juglans nigra	black walnut	5.9	19.8	25.7
Fraxinus americana	white ash	9.7	4.0	13.7
Thuja occidentalis	eastern white cedar	10.9	2.2	13.0
Rhamnus cathartica	European buckthorn	9.4	1.5	10.8
Acer platanoides	Norway maple	2.8	7.3	10.2
Crataegus spp.	hawthorn spp.	6.9	3.1	10.0
Acer negundo	Manitoba maple	3.7	4.8	8.5
Fraxinus pennsylvanica	green ash	6.6	0.9	7.5
Robinia pseudoacacia	black locust	2.7	4.6	7.4
Acer saccharum	sugar maple	2.8	4.3	7.2

Common ground cover classes (including cover types beneath trees and shrubs) in Hamilton include duff/mulch, buildings, unmaintained grass, bare soil, rock, water, and other impervious covers such as tar, and cement, and herbaceous covers such as grass and herbs. The most dominant ground cover types are Grass (26.2%) and Herbs (15.6%) (Figure 8).

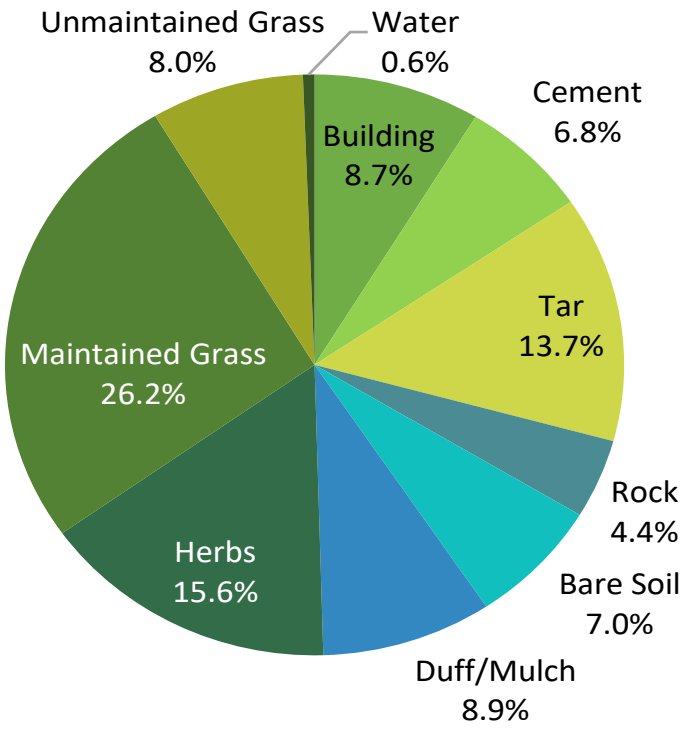


Figure 8. Percent of land by ground cover class in Hamilton, 2018.

Tree Ownership

Approximately 42% of Hamilton's trees are located on public land, while 58% are located on private land.

Tree Size Distribution

The majority of trees in Hamilton, approximately 76%, measure 15.2 cm DBH and under. Slightly more than half (51.1%) of Hamilton's trees currently belong to the smallest diameter class (7.6 cm and under),while 5.2% of trees measure more than 38 cm DBH, and only 0.7% of trees measure more than 61 cm DBH (Figure 9).

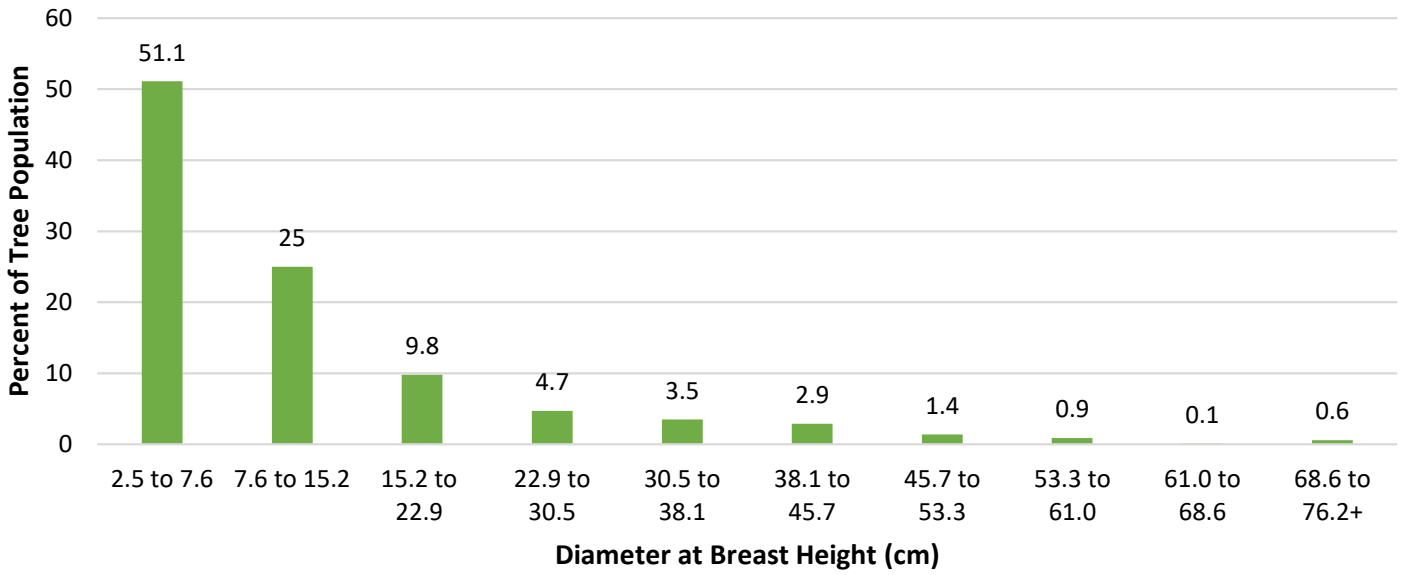


Figure 9. Distribution of Hamilton's tree population by diameter class (cm), 2018.

Due to the natural distribution of immature trees in natural forests, land uses characterized by natural areas are expected to have a distribution of DBH classes that skews more strongly towards the smaller classes. However, the land uses with the highest proportion of trees in the smallest diameter classes (i.e. under 15.3 cm DBH) were Transportation & Utilities (84.2% of trees were under 15.3 cm DBH) and Agricultural (83.7% of trees were under 15.3 cm DBH). The Commercial & Office land use had the smallest proportion of small diameter trees, with only 64.4% of trees measuring less than 15.3 cm DBH.

The Institutional land use had the largest proportion of trees in the largest diameter classes (30.6 cm DBH and up), with 17.4%. The Commercial & Office land use had the second largest proportion of trees in the largest diameter classes, with 15.4% (Figure 10).

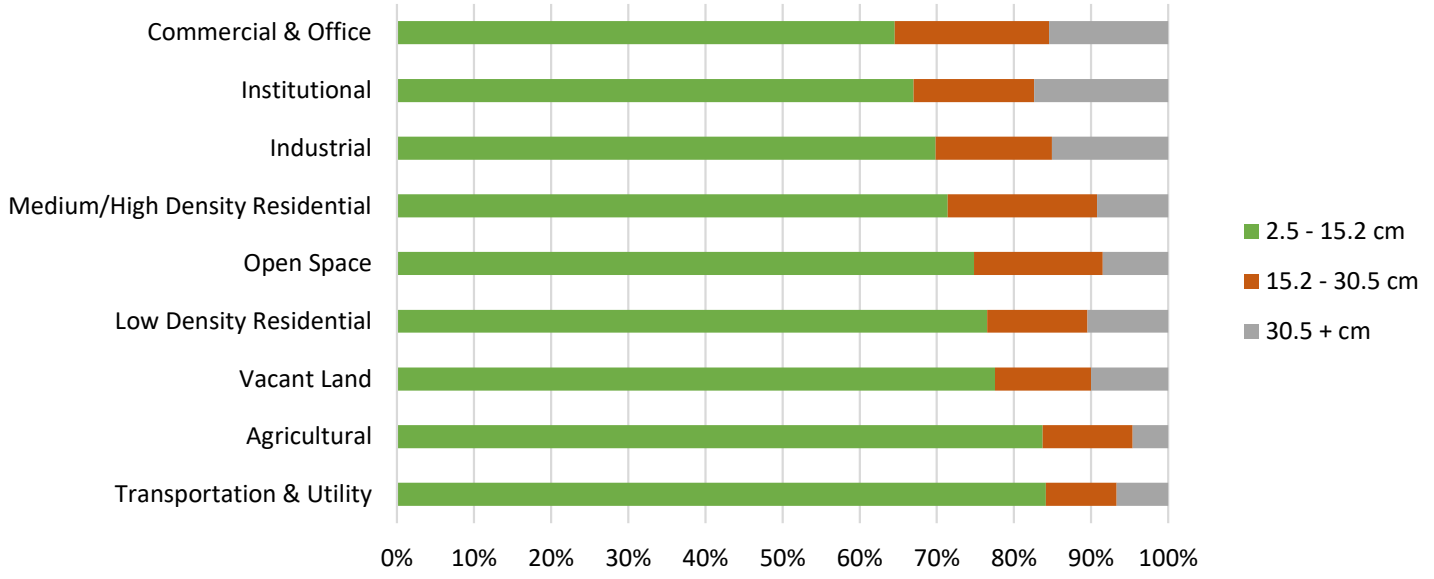


Figure 10. Tree size class distribution in Hamilton by land use, 2018.

The USDA Sustainable Urban Forest Guide outlines the ideal age distribution of trees to be: 40% juvenile (0-8 cm), 30% small (8-16 cm), 20% medium (16-24 cm), and 10% large (>24cm). Compared this "ideal" distribution, Hamilton's juvenile trees and large-size trees are overrepresented in the population (Figure 11).

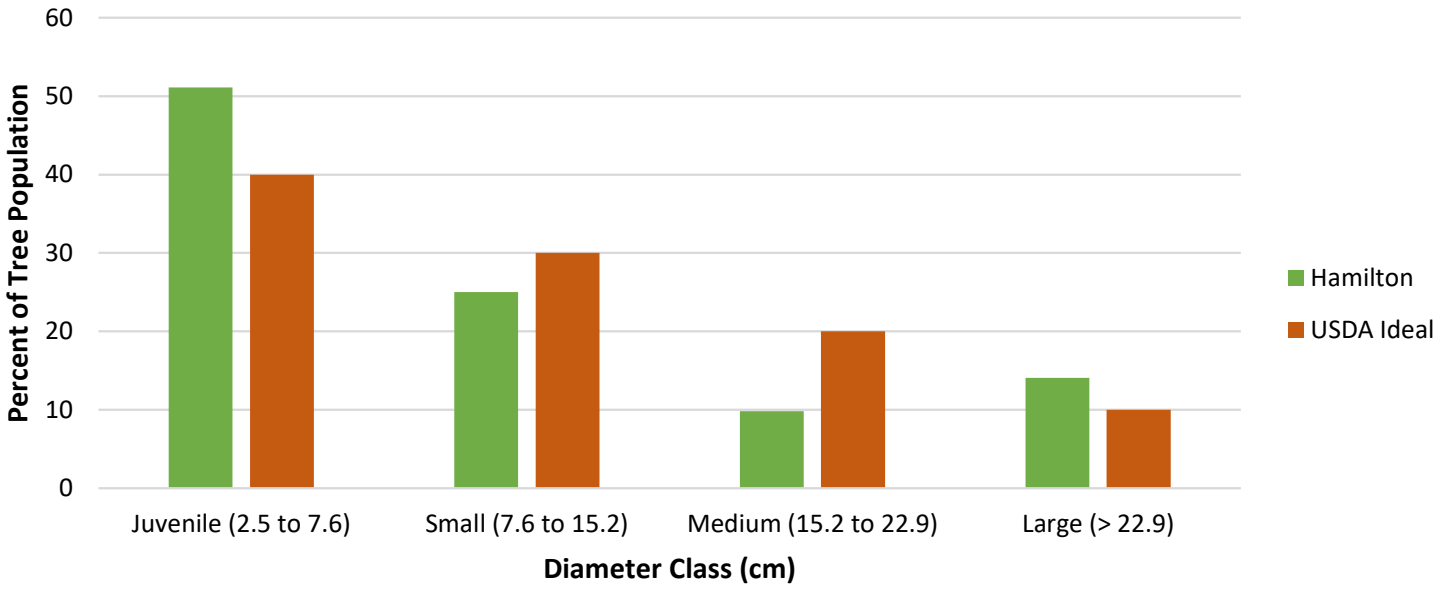


Figure 11. Tree size class distribution in Hamilton, 2018, compared to USDA ideal distribution from USDA's "The Sustainable Urban Forest: A step-by-step approach".

Tree Condition

All trees measured during the 2018 i-Tree Eco field survey were assessed for the level of dieback, expressed as a percentage of dead branches present in the live crown. In 2018, approximately 80.1% of trees were estimated to be in excellent or good condition (Figure 12).

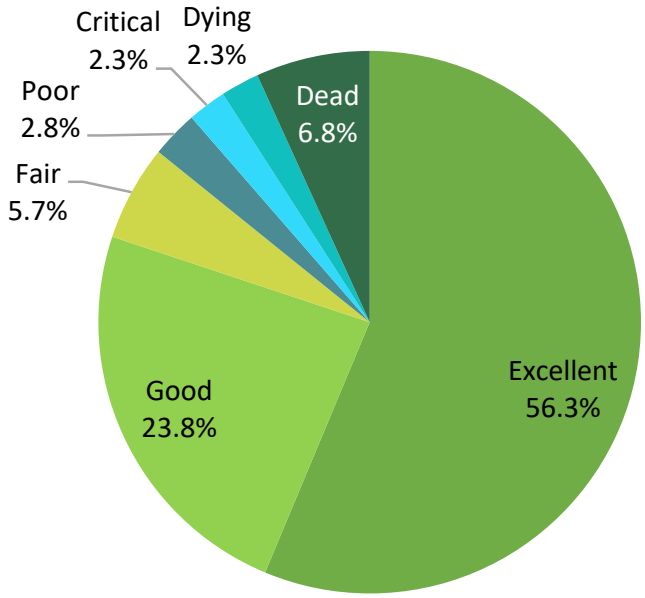


Figure 12. Distribution of Hamilton's tree population by condition rating, 2018.

The Medium/High Density Residential land use was characterized by the best tree condition ratings, with 92.4% of trees being in excellent or good condition (Figure 13). Trees in the Industrial and Low Density Residential land use categories were characterized by above average tree condition, with 89.3% and 86.6% of trees rated as being in excellent or good condition, respectively. The high proportion of trees in good condition or better in these categories is likely due to the active management and pruning of trees on residential properties in the municipal right-of-way. The Vacant Land category was characterized by the relatively worst overall tree condition, with 15.6% of trees being rated in critical condition or worse.

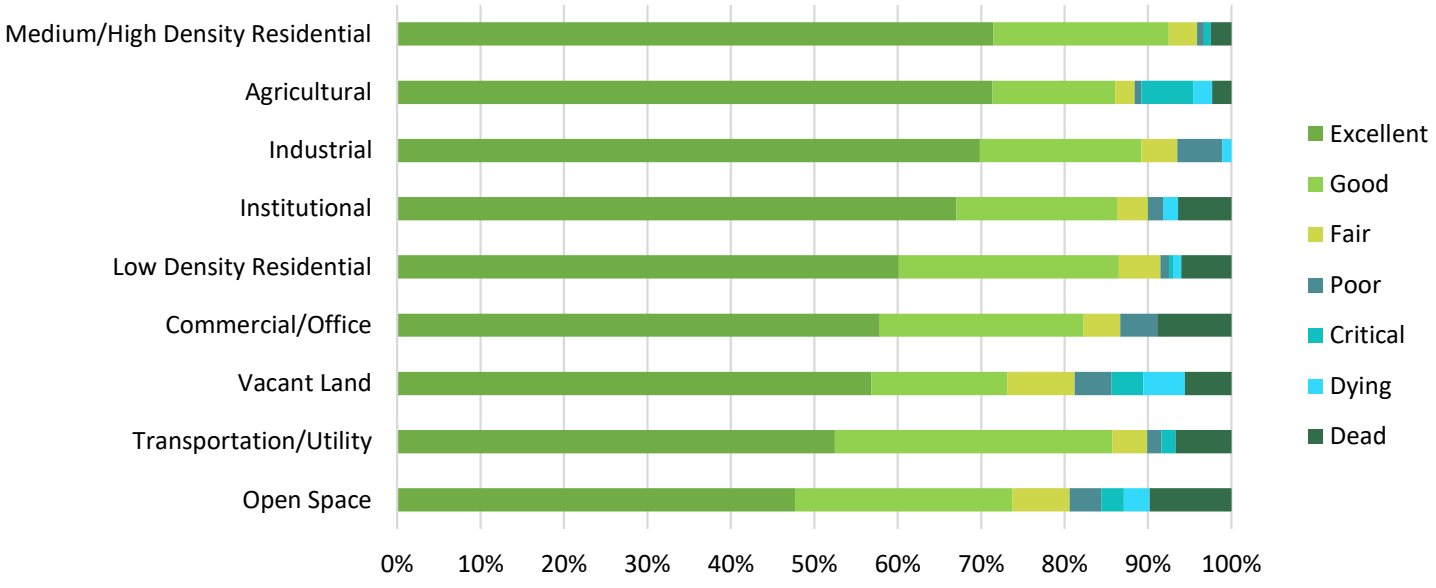


Figure 13. Condition rating of Hamilton's tree population by land use, 2018.

The i-Tree Eco software calculates average condition ratings for each tree species based on the average amount of dieback observed throughout the species' population. Average condition is expressed as a percentage, with 100% indicating excellent condition and 0% indicating completely dead trees. Of the top ten most abundant trees by population, white ash (*Fraxinus americana*) had the worst overall condition rating with an average condition rating of 56.3%; approximately 43.8% of white ash were rated in critical condition or worse. Of the top ten most abundant trees by population, eastern white cedar (*Thuja occidentalis*) and black walnut (*Juglans nigra*) had the best overall average condition ratings at 96.1% and 95.6%, respectively (Figure 14).

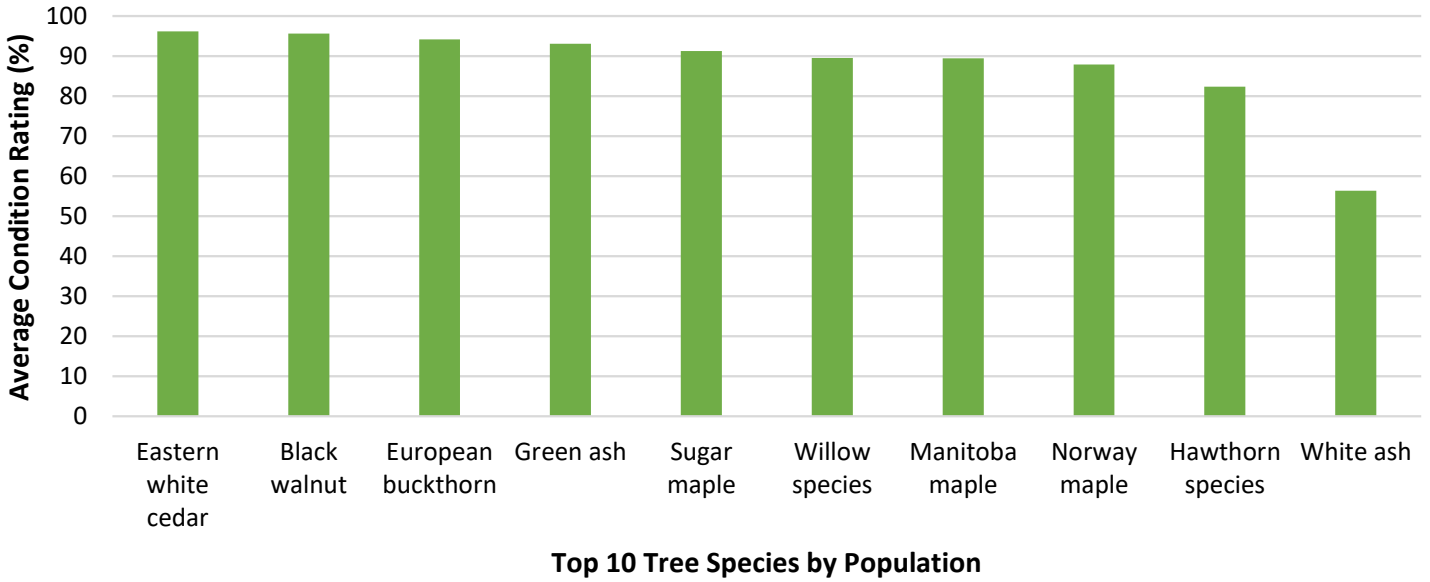


Figure 14. Average condition ratings of top 10 most abundant tree species by population, 2018.

When considering the top ten species by leaf area, silver maple (*Acer saccharinum*) and black walnut (*Juglans nigra*) were ranked highest with average condition ratings of 96% and 95.6%, respectively. White ash (*Fraxinus americana*) was again rated lowest in condition among the top ten species by leaf area (Figure 15).

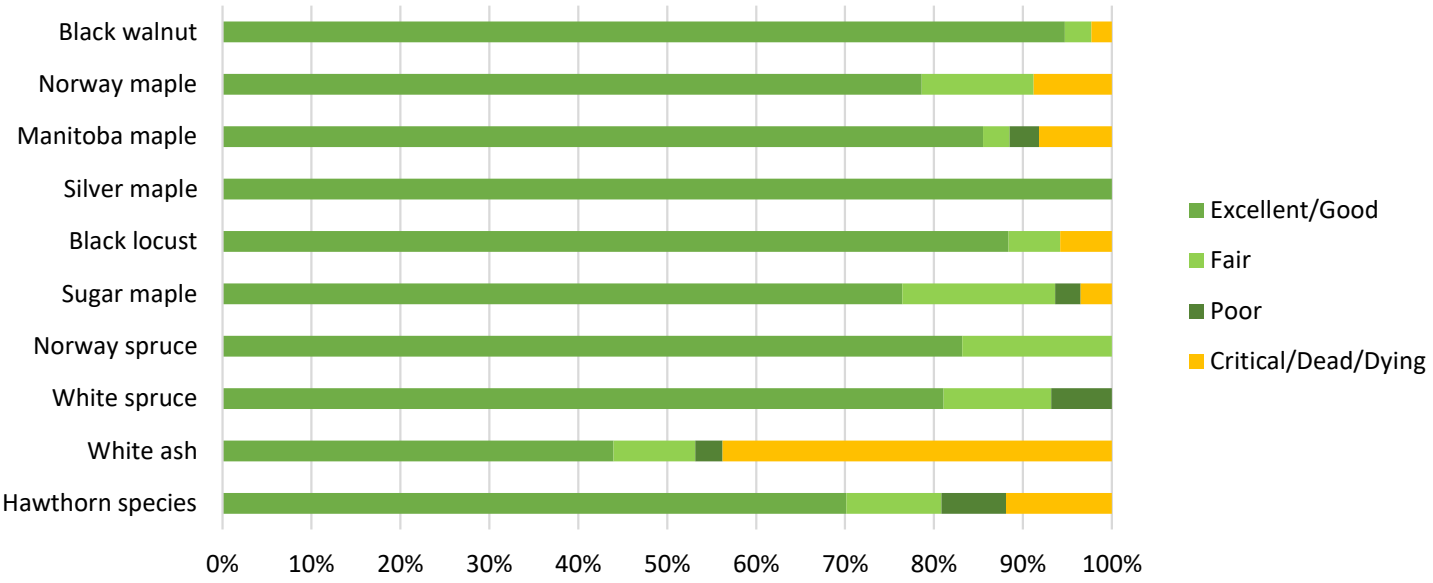


Figure 15. Condition ratings for top 10 tree species by leaf area, 2018.

Pest Susceptibility

As a major urban centre in southern Ontario, Hamilton is host to many native and non-native forest pests that can inflict damaging effects on the city's urban forest. Some of the most serious insect pests that threaten Hamilton's urban forest include the invasive Asian longhorned beetle (*Anoplophora glabripennis*), emerald ash borer (*Agrilus planipennis*) and European gypsy moth (*Lymantria dispar* ssp. *dispar*). Other insect species that pose a threat to Hamilton's urban forest health include fall and spring cankerworm (*Alsophila pometaria* and *Palecrita vernata*), hemlock woolly adelgid (*Adelges tsugae*), and beech bark scale (*Cryptococcus fagisuga*). Diseases of concern in Hamilton's urban forest include Dutch elm disease (*Opiostoma* spp.), beech bark disease (*Neonectria faginata* and *N. ditissima*), and oak wilt (*Bretziella fagacearum*).

ASIAN LONGHORNED BEETLE

While not present within Hamilton's city boundary, Asian longhorned beetle (ALHB) was detected along the Toronto-Vaughan border in 2003. The pest was subsequently eradicated through a quarantine program led by the Canadian Food Inspection Agency (CFIA) that resulted in the removal of approximately 13,000 host trees.[4] A new detection in Mississauga in 2013 resulted in the implementation of another quarantine program that is currently ongoing. ALHB poses a particularly serious threat to Hamilton's urban tree canopy because it has a wide range of preferred host species, which include maples (*Acer* spp.), birch (*Betula* spp.), willow (*Salix* spp.), poplar (*Populus* spp.), horsechestnut (*Aesculus* spp.), elm (*Ulmus* spp.), and katsura (*Cercidiphyllum* spp.). A total of approximately 1.2 million trees in Hamilton are currently threatened by this pest, with an associated structural value of about $673 million. These trees also represent approximately 32% (9,320 hectares) of the total leaf area of Hamilton's urban forest.

During the 2018 i-Tree surveys, no signs or symptoms of ALHB were detected by field crews.

GYPSY MOTH

European gypsy moth (gypsy moth) has been present on the landscape in southern Ontario for decades. The larval stage of this insect causes defoliating damage to many species of broadleaf trees, but oaks (*Quercus* spp.) are the preferred hosts of gypsy moth. Defoliation can reduce tree vigour and place stress on trees that can exacerbate other tree health issues. Multiple years of repeated severe defoliation can lead to tree mortality. Gypsy moth populations follow cyclical patterns of expansion and decline, so there are periodic threats to urban forest canopies during years when gypsy moth populations are at high levels. A variety of options are available to homeowners and municipalities to manage gypsy moth, including manual egg mass removal, tree injection of systemic insecticides, and aerial insecticide spraying. Approximately 1.1 million of Hamilton's trees are susceptible to damage by gypsy moth, with an associated compensatory value of $376 million. These susceptible trees account for about 15% (4,260 hectares) of Hamilton's total leaf area.

During the i-Tree field surveys, evidence of gypsy moth damage was detected in all land use categories except for Transportation & Utility. Approximately 5.6% of all trees were observed to exhibit damage from gypsy moth.

EMERALD ASH BORER

Since emerald ash borer was first detected in Hamilton in 2009, there has been large-scale mortality of all species of ash (*Fraxinus* spp.), the beetle's host genus. While many trees have been saved through canopy conservation programs using systemic insecticide treatments, the vast majority of untreated trees, including those in natural areas, have succumbed to the effects of the invasive beetle. Approximately 17%

[4] *Natural Resources Canada (NRCAN). 2018. Asian longhorned beetle. https://www.nrcan.gc.ca/forests/fire-insects-disturbances/top-insects/13369.*

(877,500 trees) of Hamilton's trees are currently susceptible to EAB, with a compensatory value of about $79 million. This equates to about 6% (1,664 hectares) of Hamilton's total leaf area. It should be noted that the compensatory value is somewhat low relative to the portion of the tree population that is at risk of infestation. This is likely due to the lingering effects of ash mortality on the landscape, which has seen the decline and mortality of large, mature ash, which have relatively high compensatory value. As a result of this widespread decline, ash populations are now characterized by relatively smaller, lower value trees.

DUTCH ELM DISEASE

Dutch elm disease (DED, caused by the fungus *Ophiostoma ulmi*) has been present on the landscape in Ontario for decades and has resulted in severe declines in the native population of elms (*Ulmus* spp.). As a result, elms occupy a much less significant place in Hamilton's urban forest than they once did. There are currently about 70,000 elm trees in Hamilton's urban forest that are susceptible to DED. These trees have a compensatory value of about $27.6 million and represent approximately 1.3% (418 hectares) of the tree canopy.

During the 2018 i-Tree surveys, evidence of DED was observed on 20% of all elms surveyed.

Oak Wilt

Oak wilt, a devastating disease of oaks caused by the fungus *Bretziella fagacearum*, has not yet been detected in Canada. However, the disease is present in 23 states in the US, including several that border Ontario. An infestation on Belle Isle in Detroit, MI, is less than a kilometer from Windsor, ON, making an introduction of this disease into Canada a likely possibility in the near future. All oaks are susceptible to infection by oak wilt, but oaks in the red oak group, including red oak (*Quercus rubra*), pin oak (*Quercus palustris*), and black oak (*Quercus velutina*), are particularly susceptible to rapid mortality.

There are approximately 52,000 trees in Hamilton's urban forest that are susceptible to infection by oak wilt, representing 2% (655 hectares) of the total leaf area. The compensatory value of these trees is estimated to be around $115 million which is quite high relative to the population at risk. This is likely due to the large stature of many mature oaks in the city's urban forest and the high value that those trees represent.

No suspected detections of oak wilt were reported during the 2018 i-Tree field surveys.

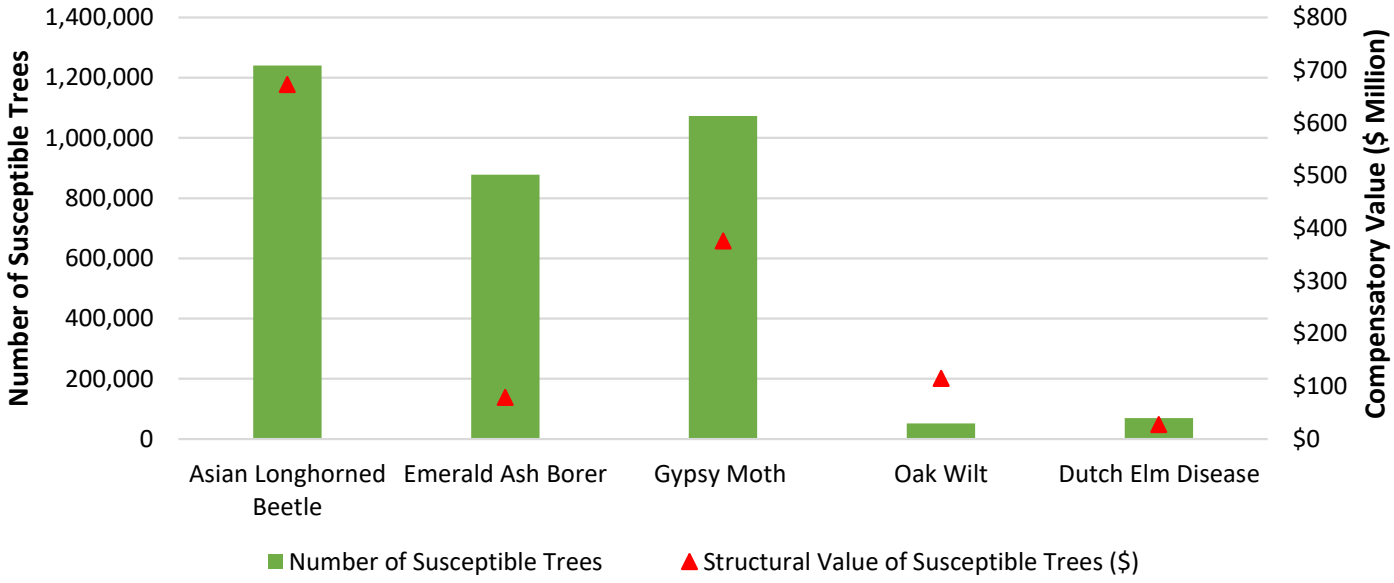


Figure 16. Susceptibility of Hamilton's trees to major invasive pests, 2018.

SHRUB SPECIES COMPOSITION

Shrubs are an important component of Hamilton's urban forest, and they make a valuable contribution to the total ecosystem services the urban forest provides. Overall, Hamilton's shrubs constitute about 9,267 hectares of leaf area, which is equivalent to about 31.5% of the leaf area represented by trees. Following i-Tree Eco protocols, shrubs include all woody vegetation less than 2.5 cm DBH, including immature individuals of tree species.

Table 2. Top 10 species of shrubs by leaf area in Hamilton, 2018.

SPECIES	PERCENT OF TOTAL SHRUB LEAF AREA
Gray dogwood	17.4
Honeysuckle species	13.4
European buckthorn	7.3
Yew species	5.8
Eastern white cedar	4.5
Rose of Sharon	3.7
Rose species	3.4
Hawthorn species	2.6
White ash	2.6
Juniper species	2.4

When measured by leaf area, the most dominant shrub species in Hamilton's urban forest is gray dogwood (*Cornus racemosa*) which comprises 17.4% of the total shrub leaf area (Table 2). This species is a popular native shrub used in landscaping and in residential gardens, and is also common in natural areas, which certainly contributes to its dominance. The second most abundant shrub is honeysuckle (*Lonicera* spp.) comprising approximately 13.4% of the total leaf area, and third is the invasive common buckthorn (*Rhamnus cathartica*), comprising 7.3%.

The dominance of the invasive European buckthorn is a concern, especially for management of natural areas because this species can inhibit regeneration of native species and affect forest succession. Indeed, common buckthorn was over-represented in the Open Space land use, comprising 12.7% of the shrub layer in this land use. The Agricultural land use category also contained a relatively significant amount of buckthorn, with about 8.1% of the shrub layer comprised of common buckthorn.

Figure 17 illustrates the proportion of invasive shrubs present in each land use. Values are expressed as the percentage of invasive leaf area out of the total shrub leaf area in each land use. Across all land uses, approximately 14.3% of the total shrub leaf area was comprised of invasive species. The list of invasive shrub species was drawn from the Canadian Botanical Conservation Network and Conservation Halton.[5,6] The Institutional land use category contained the highest proportion of invasive shrubs, with about 31.3% of the shrub leaf area consisting of invasive species, which was primarily due to an abundance of winged euonymus (*Euonymus alata*). About 19.8% of the shrub leaf area in Open Space was comprised of invasive species. Given that this land use consists of natural areas and woodland parks, this is a concerning statistic. Twelve out of the 15 invasive shrub species identified were present in Open Space.

[5] *http://www.rbg.ca/archive/cbcn/en/projects/invasives/i_list.html*
[6] *https://www.conservationhalton.ca/invasive-species-and-biodiversity*

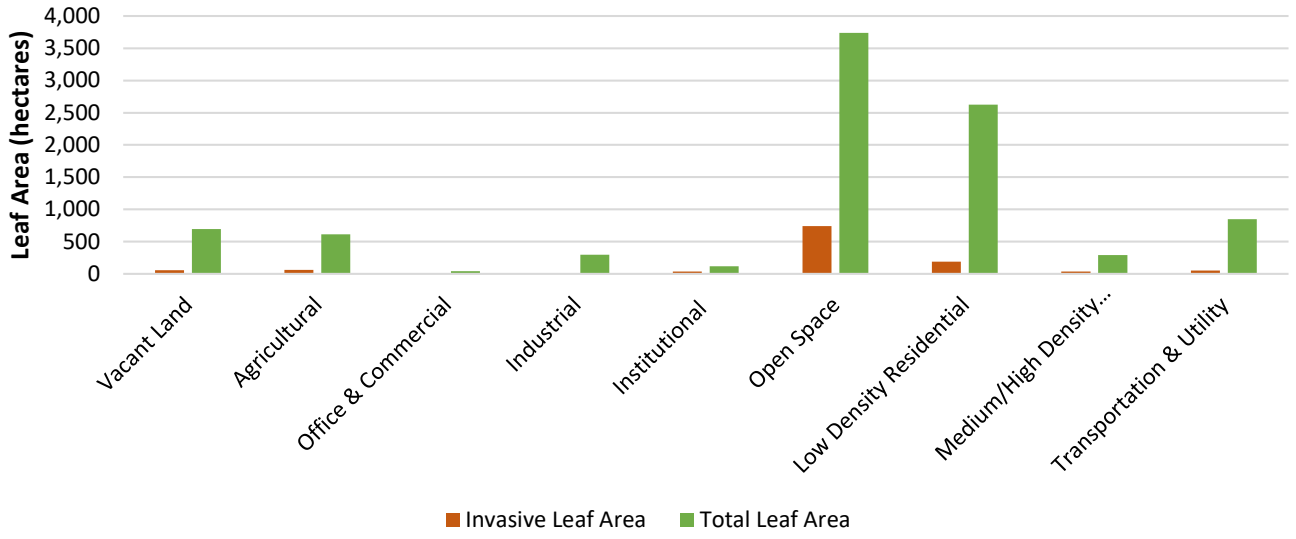


Figure 17. Leaf area of invasive shrubs by land use, compared to total leaf area in hectares, 2018.

Species Diversity

A total of 97 species were recorded during the 2018 i-Tree Eco field surveys. The Open Space land use had the highest number of species, with 46 species recorded. Low Density Residential was a close second with 45 species recorded. Open Space also had the highest amount of species per unit area, with 38.3 species per hectare. The lowest number of species was found in the Industrial land use, with only 14 species recorded (Table 3).

Table 3. Simpson Diversity Index ratings by land use, 2018.

LAND USE	SIMPSON INDEX
Agricultural	4.0
Commercial & Office	11.1
Industrial	4.3
Institutional	13.2
Open Space	10.4
Low Density Residential	5.7
Medium/High Density Residential	6.7
Transportation & Utility	7.9
Vacant Land	9.2

Species Origins

Figure 18 illustrates the level of invasive species in different land uses, based on the number of trees and leaf area. Overall, about 67.3% of Hamilton's urban forest canopy is made up of species native to southern Ontario. About 29.2% of the total leaf area in Hamilton's urban forest is comprised of invasive species, primarily common buckthorn (*Rhamnus cathartica*), Manitoba maple (*Acer negundo*), and Norway maple (*Acer platanoides*).

The land use with the highest proportion of invasive species is Commercial & Office, with approximately 44.4% of all trees being invasive. This amounts to almost half (48.3%) of the leaf area in this land use.

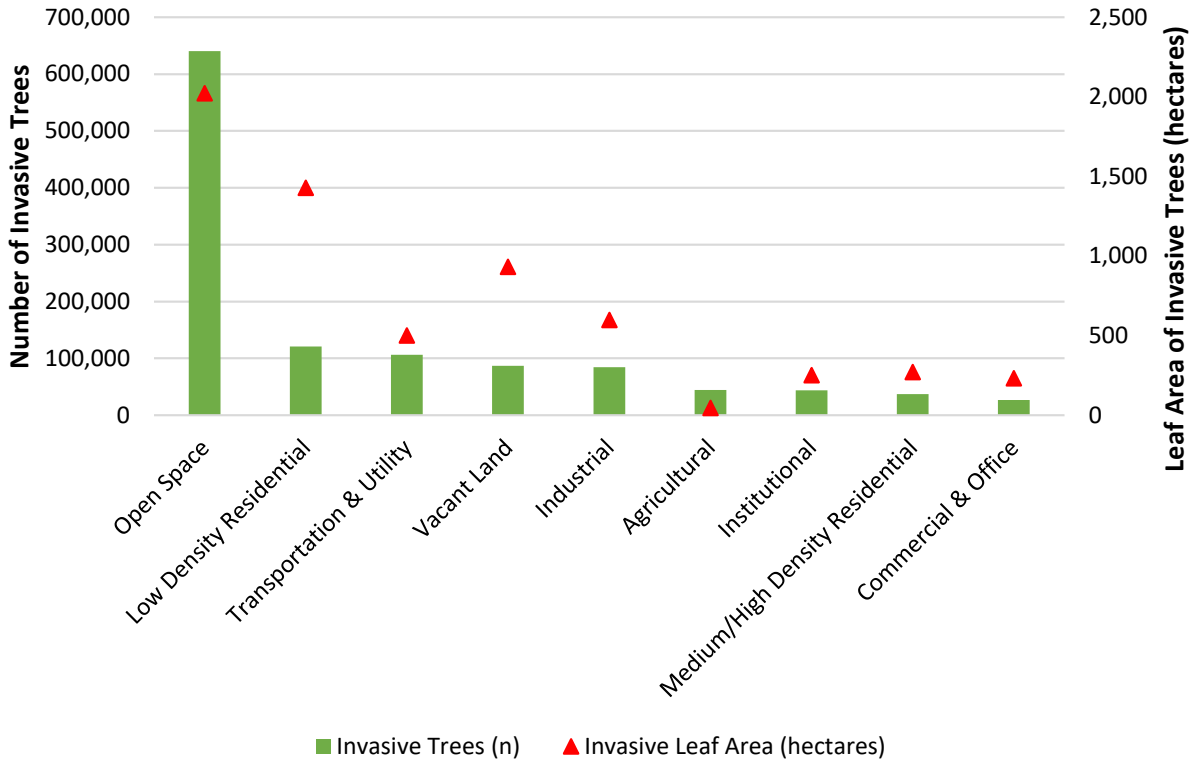


Figure 18. Amount of urban forest canopy cover comprised of invasive species by land use (tree population and leaf area), 2018.

Ecosystem Services

In 2018, Hamilton's urban forest was estimated to provide ecosystem services with an annual value of about $8.2 million. This figure includes home energy savings, carbon sequestration, pollution removal and avoided runoff (Table 4). Because these services are typically associated with leaf area and tree health, an analysis of ecosystem services provides additional insight into the functioning of the urban forest and its state of health over time. Furthermore, large stature trees with relatively large leaf area will make disproportionately large per-tree contributions to the ecosystem services provided by the urban forest when compared to smaller stature trees.

[7] *Only Invasive Levels 1 and 2, according to Conservation Halton, were included in this analysis. Invasive Level 1 refers to species that exclude all other species and dominate sites indefinitely. Invasive Level 2 refers to species that are highly invasive, dominate niches or does not spread rapidly. List available at: https://www.conservationhalton.ca/invasive-species-and-biodiversity.*

Table 4. Annual ecosystem services performed by Hamilton's urban forest, 2018.

BENEFIT	TOTAL UNITS	TOTAL (CAD$)	CAD$/TREE	CAD$/CAPITA
Energy savings	282,319 MBTUs			
2,378 MWHs	3,628,019	0.70	6.98	
Gross carbon sequestration	13,412 tonnes	1,540,641	0.30	2.96
Pollution removal	256 tonnes/year	1,128,664	0.22	2.17
Avoided runoff	815,639 m³/year	1,896,128	0.36	3.65
Total Annual Benefits		8,193,452	1.57	15.76

Carbon Storage

As trees grow, they accumulate wood in their stems and branches, which results in the long-term storage of carbon through the tree's life. As such, tree species that attain a large stature at maturity are capable of storing more carbon per tree than tree species that attain only small or medium stature at maturity. When trees lose biomass through injury or decay, or the tree dies, the stored carbon is released into the atmosphere over time, if the tree is able to decay naturally. Reusing or recycling the wood as wood products can maintain the storage of the carbon the tree accumulated during its lifetime.

In 2018, Hamilton's trees stored about 395,000 metric tons of carbon, which has a total value of $45.4 million or $7.9 million based on the social cost of carbon ($114.87/tonne) and the market price of carbon ($20/tonne), respectively. Of the species sampled, white ash (*Fraxinus americana*) stores the most carbon (approximately 11.8% of the total carbon stored). The amount of carbon stored by Hamilton's trees is equivalent to 58 days of carbon emissions in Hamilton, the annual carbon emissions from 308,000 automobiles, or 126,000 single family houses (See Appendix A3 for more relative tree benefits).

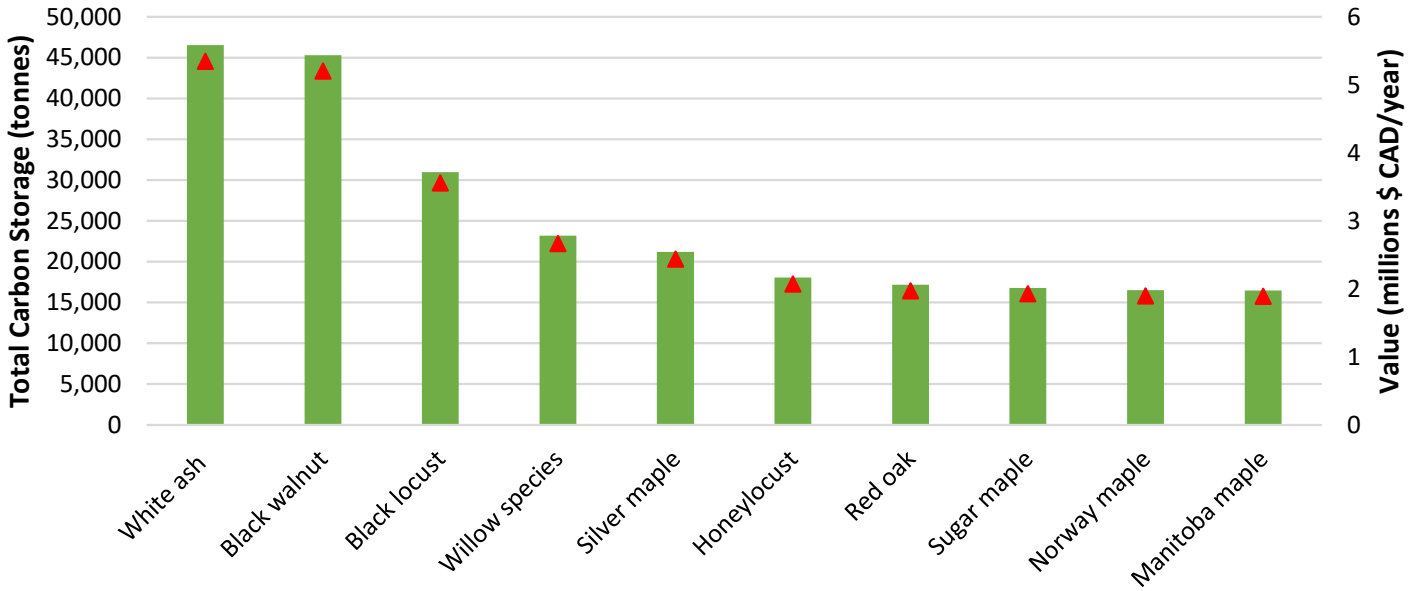


Figure 19. Total carbon stored by top 10 tree species by tonnes of carbon storage, 2018.

Carbon Sequestration

During the growing season, when trees are at their most active, they sequester atmospheric carbon through the process of photosynthesis. Carbon is captured through the leaves and deposited into the tree's leaves and wood, and in soils, where it is stored over the longer term. Carbon sequestration is measured in annual amounts, with net carbon sequestration calculated based on the gross amount of carbon sequestered and the amount of carbon loss through the decay of biomass.

In 2018, Hamilton's trees are estimated to sequester a total of 13,412 gross tonnes of carbon annually. After accounting for loss of carbon through mortality and decay, Hamilton's trees sequester about 5,048 net tonnes of carbon annually. This is equivalent to the annual carbon emissions from 10,500 automobiles or 4,300 single-family houses.

Black walnut (*Juglans nigra*) sequesters the most net annual carbon, approximately 890 tonnes per year. This is equivalent to the absorption of about 3,262 tonnes of carbon dioxide. Black locust (*Robinia pseudoacacia*) sequesters 860 tonnes per year, the second greatest amount, which is equivalent to 3,154 tonnes of carbon dioxide emissions.

The greatest annual loss of carbon is attributed to white ash (*Fraxinus americana*), which has a net annual carbon sequestration rate of -4,550 tonnes per year. This is equivalent to the annual emission of 16,687 tonnes of carbon dioxide.

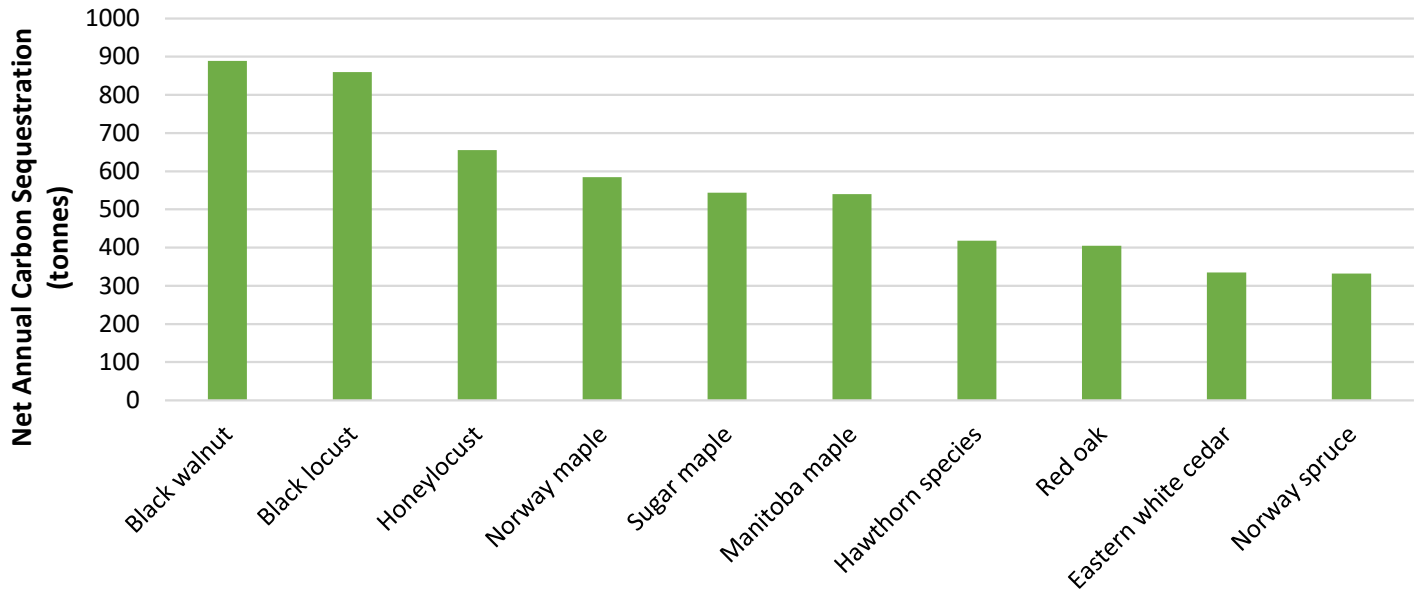


Figure 20. Net annual carbon sequestration of top 10 species by tonnes of carbon sequestered, 2018.

The trees in the Low Density Residential land use category are responsible for about 48.3% of the net annual carbon sequestration performed by Hamilton's urban forest. This is disproportionately higher than the population of trees in that land use, which only represent about 21.2% of the city's trees.

Pollution Removal

As with atmospheric carbon, trees remove pollution from the air by direct absorption through the leaf stomata as well as by capturing particulate matter on and in plant tissue. In doing so, trees can mitigate air pollution to some extent. The removal of air pollution and particulate matter can have beneficial effects on human health, including reducing instances of respiratory conditions.[8] Because this benefit is linked to leaf area and function and because sources of pollution may be scattered across a city, the distribution of the effect may be uneven across the landscape. Areas with less trees and trees of smaller stature may experience relatively less pollution mitigation benefits than areas with larger trees and more urban forest cover.

Pollution removal[9] by trees and shrubs in Hamilton was estimated using field data and the most recent and complete pollution and weather data available (from 2010). Pollution removal was greatest for ozone. It is estimated that trees and shrubs remove 392.8 metric tons of air pollution (ozone [O3], carbon monoxide [CO], nitrogen dioxide [NO2], particulate matter less than 2.5 microns [PM2.5][10], and sulfur dioxide [SO2]) per year with an associated value of $1.59 million.

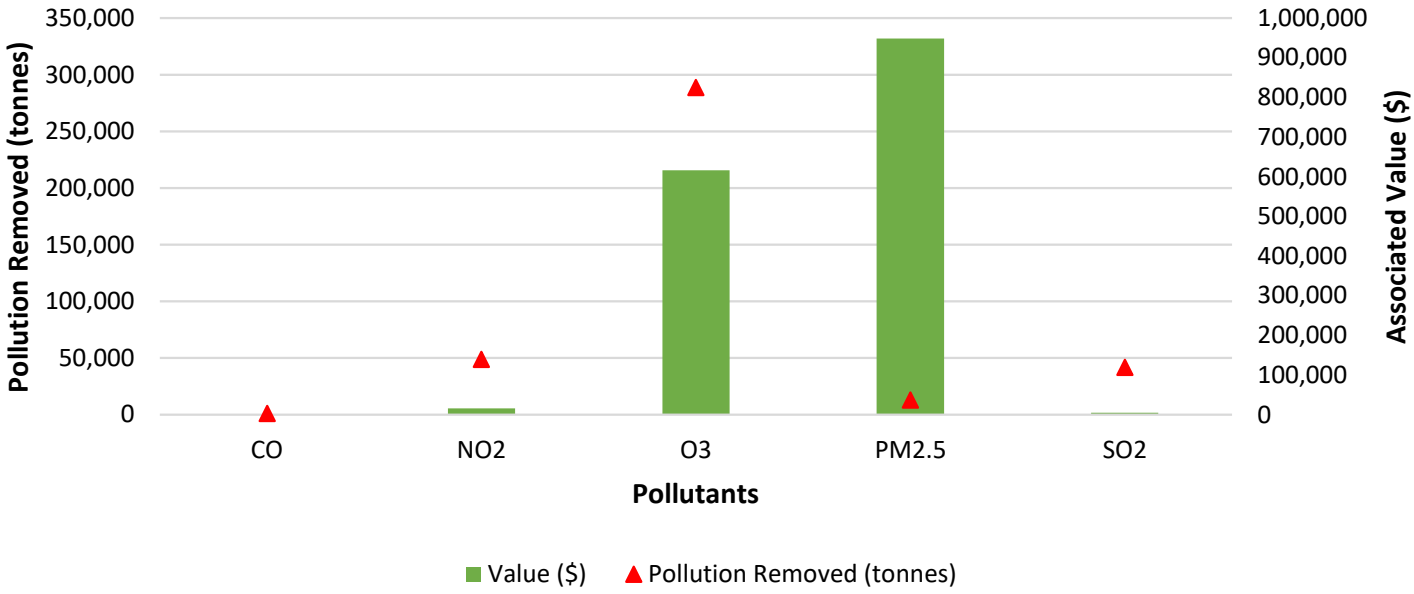


Figure 21. Annual pollution removal (points) and value (bars) by urban trees in Hamilton, 2018.

In 2018, trees in Hamilton emitted an estimated 123.9 metric tons of volatile organic compounds (VOCs) (50.39 metric tons of isoprene and 73.49 metric tons 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 Norway spruce (*Picea abies*) and black walnut (*Juglans nigra*). These VOCs are precursor chemicals to ozone formation. [11]

[8] 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.
[9] 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.
[10] 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 1 for more details).
[11] 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.

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.[12] 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. Hamilton's trees and shrubs help to reduce runoff by an estimated 815 thousand cubic metres a year with an associated value of $1.9 million.

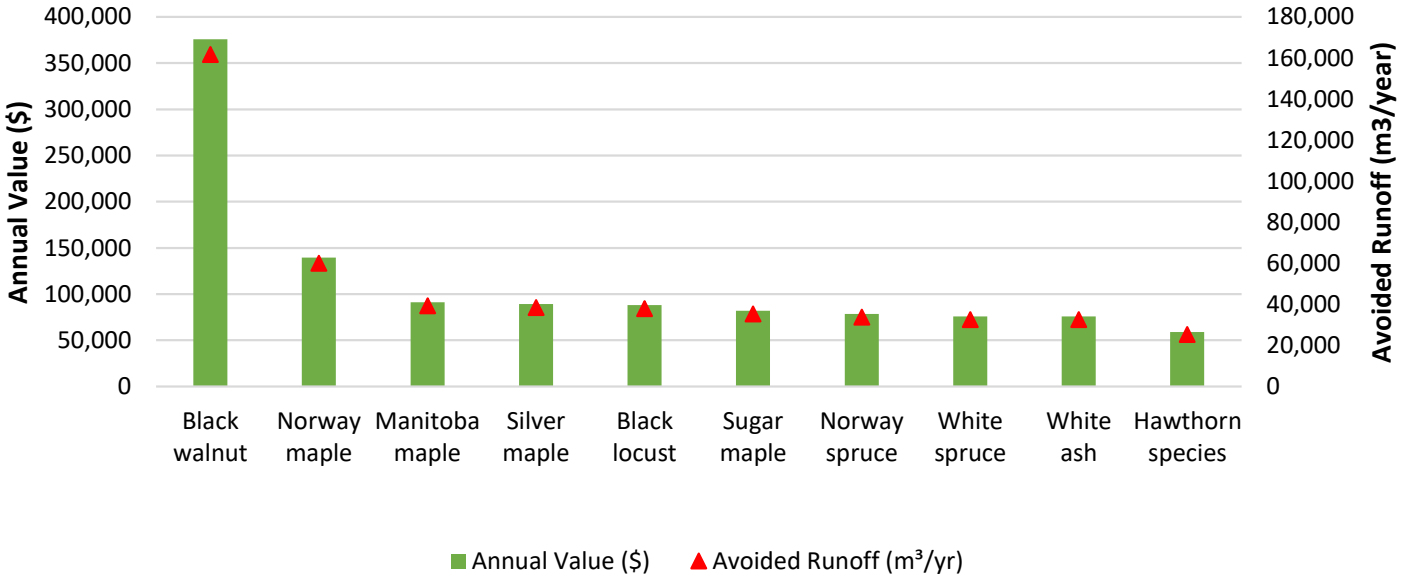


Figure 22. Avoided runoff (points) and value (bars) for species with greatest overall impact on runoff in Hamilton, 2018.

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.[13]

Trees in Hamilton are estimated to reduce energy-related costs from residential buildings by $3,630,000 annually. Trees also provide an additional $790,000 in value by reducing the amount of carbon released by fossil-fuel based power plants (a reduction of 6,880 tonnes of carbon emissions).

[12] *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.*
[13] *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.*

Table 5. Annual energy savings due to trees near residential buildings in Hamilton, 2018.

	HEATING	COOLING	TOTAL
MBTU*	282,319	N/A	282,319
MWH**	2,378	6,643	9,021
Carbon Avoided (tonnes)	6,426	451	6,877

*MBTU = one million British Thermal Unit **MWH = megawatt-hour

Table 6. Annual savings* ($) in residential energy expenditure during heating and cooling seasons due to trees near residential buildings in Hamilton, 2018.

	HEATING	COOLING	TOTAL
MBTU	2,951,481	N/A	2,951,481
MWH	178,345	498,193	676,538
Carbon Avoided (tonnes)	738,109	51,797	789,906

*Based on the prices of $75 per MWH and $10.45 per MBTU (See Appendix A1 for more details on pricing)

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 the number and size of healthy trees.[14] 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 can also decrease as the amount of healthy tree cover declines.

Structural value in Canada is calculated using the same procedure in the United States.[15] Base costs and species values are derived from the International Society of Arboriculture Ontario Chapter and applied to all Canadian provinces and territories.

Urban trees in Hamilton have the following structural values:

- Structural value: $2.13 billion
- Carbon storage: $45.4 million

Urban trees in Hamilton have the following annual functional values:

- Carbon sequestration: $1.54 million
- Avoided runoff: $1.9 million
- Pollution removal: $1.1 million
- Energy costs and carbon emission values: $3.6 million

[14] *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.*
[15] *Ibid.*

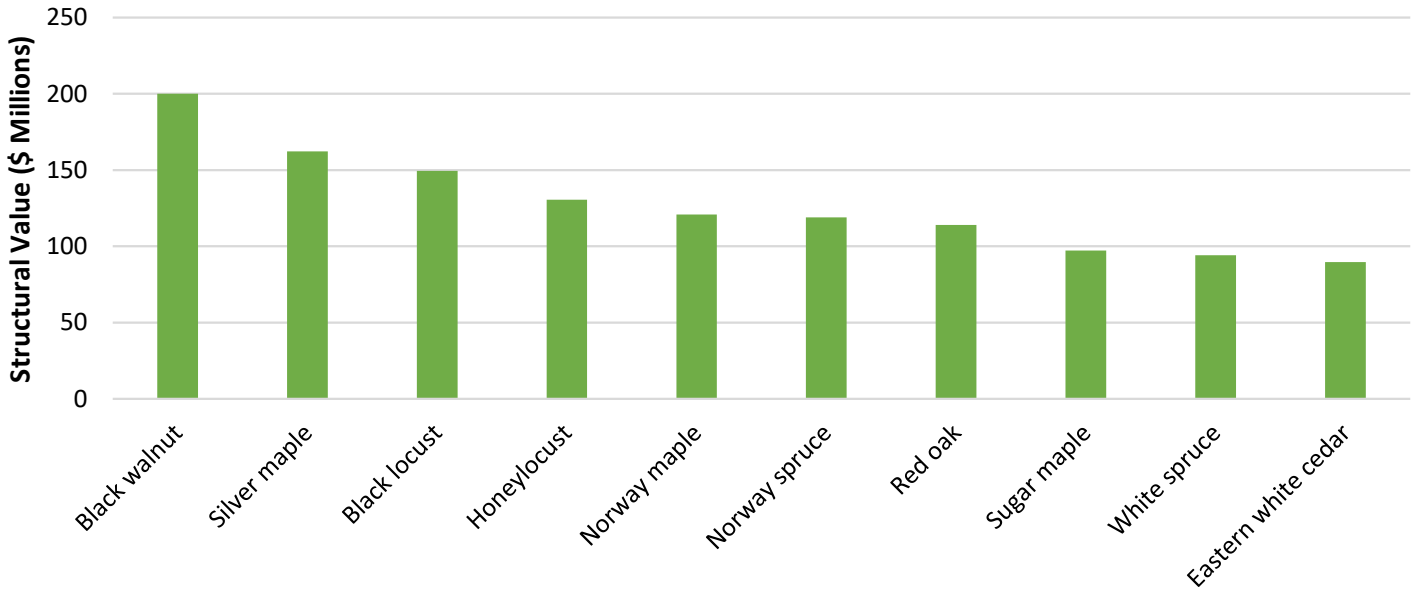


Figure 23. Tree species with the greatest structural value in Hamilton, 2018.

Appendix B1: i-Tree Eco Model and Field Measurements

i-Tree Eco is designed to use standardized field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects,[16] 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 annually
- 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 urban 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 oak wilt

All field data was collected by BioForest between June and September 2018, during the leaf-on season in order to properly assess tree canopies. Data collected 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.[17,18]

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. maple). In this report, tree species or genera are collectively referred to as tree species.

[16] *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.*

[17] *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, 34p. http://www.fs.fed.us/ne/syracuse/Tools/downloads/UFORE_Manual.pdf.*

[18] *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.*

TREE CHARACTERISTICS

Leaf area of trees was assessed using measurements of crown dimensions and percentage of crown canopy missing.

AIR POLLUTION REMOVAL

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.[19,20] 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 measure values from the literature[21,22] that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere.[23] 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.[24,25,26]

Trees remove PM2.5 when particulate matter is deposited on leaf surfaces.[27] 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. months 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.

This report used weather and pollution data from 2010, collected from the Hamilton International Airport weather station. Data quality was categorized as “Good”, based on the fact that all variables (excluding precipitation) had less than 8.2% missing data. This was the most recent dataset available in i-Tree with “Good” data quality.

Default air pollution removal value is calculated based on local incidence of adverse health effects and national median externality costs.[28] The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and PM2.5 using data from the U.S. Environmental Protection Agency’s Environmental Benefits Mapping and Analysis Program (BenMAP).[29] The model uses a damage-function approach that is based on the local change in pollution concentration and population.

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[19] Baldocchi, D. 1988. A multi-layer model for estimating sulfur dioxide deposition to a deciduous oak forest canopy. Atmospheric Environment. 22: 869-884.
[20] 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.
[21] Bidwell, R.G.S.; Fraser, D.E. 1972. Carbon monoxide uptake and metabolism by leaves. Canadian Journal of Botany. 50: 1435-1439.
[22] Lovett, G.M. 1994. Atmospheric deposition of nutrients and pollutants in North America: an ecological perspective. Ecological Applications. 4: 629-650.
[23] 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.
[24] 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.
[25] Hirabayashi, S.; Kroll, C.; Nowak, D. 2012. i-Tree Eco Dry Deposition Model Descriptions V 1.0
[26] Hirabayashi, S. 2011. Urban Forest Effects-Dry Deposition (UFORE-D) Model Enhancements, http://www.itreetools.org/eco/resources/UFORE-D enhancements.pdf.
[27] 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.
[28] In economics, an externality is the cost or benefit that affects a third party who did not choose to incur that cost or benefit.
[29] Nowak et al. 2014.

National median externality costs were used to calculate the value of carbon monoxide removal.[30] Values have been converted from U.S. currency to Canadian currency using the exchange rate of 1 USD = 1.29979 CAD.

For this analysis, pollution removal value is calculated based on the prices of $1,486 per metric ton (carbon monoxide), $2,135 per metric ton (ozone), $318 per metric ton (nitrogen dioxide), $116 per metric ton (sulfur dioxide) and $74,226 per metric ton (PM2.5).

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.[31] 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 this report, estimates are based on the carbon value for the United States[32,33] and have been converted from U.S. currency to Canadian currency using the exchange rate of 1 USD = 1.29979 CAD.

For this analysis, carbon storage and carbon sequestration values are calculated based on $114.87 per metric 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) x 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.[34]

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 the national average value for the U.S. and has been converted from U.S. currency to Canadian currency using the exchange rate of 1 USD = 1.29979 CAD. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series.

For this analysis, avoided runoff value is calculated based on the price of $2.32 per cubic metre.

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[30] 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.
[31] 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.
[32] U.S. Environmental Protection Agency. 2015. The social cost of carbon. http://www.epa.gov/climatechange/EPAactivities/economics/scc.html.
[33] 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
[34] Nowak, D.J.; Hoehn, R.; Crane, D. 2007. Oxygen production by urban trees in the United States. Arboriculture & Urban Forestry. 33(3):220-226.

BUILDING ENERGY USE

The seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature[35] using distance and direction of trees from residential structures, tree height and tree condition data.

For this analysis, energy saving value is calculated based on the prices of $75 per MWH and $10.45 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.[36,37]

POTENTIAL PEST IMPACTS

Potential pest impacts reflects the damage that a potential outbreak could have based on species diversity in Hamilton's 2018 tree population. The number of susceptible trees reflect only the known host species in Hamilton that could experience mortality due to the pest.

RELATIVE TREE EFFECTS

The relative value of tree benefits reported in **Appendix B2: Relative Tree Effects** 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.[38] 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, S02, for 2010,[39,40] PM2.5 for 2011-2015,[41] and CO2 for 2011[42] were multiplied by average miles driven per vehicle in 2011 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.[44,45]

- CO2, SO2, and NOx power plant emission per kWh are from Leonardo Academy.[46] CO emission per kWh assumes 1/3 of one percent of C emissions is CO based on Energy Information

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[35] McPherson et al. 1999.
[36] Nowak et al. 2002a.
[37] 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.
[38] Carbon Dioxide Information Analysis Center. 2010. CO2 Emissions (metric tons per capita). Washington, DC: The World Bank.
[39] 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.
[40] 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.
[41] 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.
[42] 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.
Federal Highway Administration. 2013. Highway Statistics 2011.Washington, DC: Federal Highway Administration, U.S. Department of Transportation. Table VM-1.
[43] Energy Information Administration. 2013. CE2.1 Fuel consumption totals and averages, U.S. homes. Washington, DC: Energy Information Administration, U.S. Department of Energy.
[44] Energy Information Administration. 2014. CE5.2 Household wood consumption. Washington, DC: Energy Information Administration, U.S. Department of Energy.
[45] Leonardo Academy. 2011. Leonardo Academy's Guide to Calculating Emissions Including Emission Factors and Energy Prices. Madison, WI: Leonardo Academy Inc.
[46] Energy Information Administration. 1994. Energy Use and Carbon Emissions: Non-OECD Countries. Washington, DC: Energy Information Administration, U.S. Department of Energy.

Administration.[47] PM10 emission per kWh from California Energy Commission.[48]

- 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.[48]
- CO2 emissions per Btu of wood from U.S Department of Energy.[49]
- CO, NOx and SOx emission per Btu based on total emissions and wood burning (tons) from British Columbia Ministry of Water, Land and Air Protection,[50] and Georgia Forestry Commission.[51]

Appendix B2: Relative Tree Effects

The urban forest in Hamilton 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 B1 for methodology.

Carbon storage is equivalent to:

- Amount of carbon emitted in Hamilton in 58 days
- Annual carbon (C) emissions from 308,000 automobiles
- Annual C emissions from 126,000 single-family houses

Carbon monoxide removal is equivalent to:

- Annual carbon monoxide emissions from 11 automobiles
- Annual carbon monoxide emissions from 29 single-family houses

Nitrogen dioxide removal is equivalent to:

- Annual nitrogen dioxide emissions from 7,680 automobiles
- Annual nitrogen dioxide emissions from 3,460 single-family houses

Sulfur dioxide removal is equivalent to:

- Annual sulfur dioxide emissions from 494,000 automobiles
- Annual sulfur dioxide emissions from 1,300 single-family houses

Annual carbon sequestration is equivalent to:

- Annual C emissions from 10,500 automobiles
- Annual C emissions from 4,300 single-family houses

Appendix B3: Comparison of Urban Forests in Canada

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.

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[47] Layton, M. 2004. 2005 Electricity Environmental Performance Report: Electricity Generation and Air Emissions. CA: California Energy Commission.
[48] Leonardo Academy. 2011.
[49] Energy Information Administration. 2014.
[50] British Columbia Ministry of Water, Land, and Air Protection. 2005. Residential wood burning emissions in British Columbia. British Columbia.
[51] Georgia Forestry Commission. 2009. Biomass Energy Conversion for Electricity and Pellets Worksheet. Dry Branch, GA: Georgia Forestry Commission.

CITY	% TREE COVER	NUMBER OF TREES	CARBON STORAGE (TONNES)	CARBON SEQUESTRATION (TONNES/YEAR)	POLLUTION REMOVAL (TONNES/YEAR)
Hamilton, ON (2018)	17.4 (i-Tree Eco) 21.2 (i-Tree Canopy)	5,212,000	395,092	13,412	256
Toronto, ON (2018)	28.4	11,500,000	1,100,000	35,170	972
London, ON (2012)	24.7	4,376,000	360,000	12,500	370
Oakville, ON (2015)	27.8	2,000,000	148,000	5,940	113

Appendix B4: Complete List of Tree Species

SPECIES	PERCENT POPULATION	PERCENT LEAF AREA	IMPORTANCE VALUE
Abies	0.00	0.20	0.20
Acer ginnala	0.00	0.00	0.00
Acer negundo	3.70	4.80	8.50
Acer palmatum	0.30	0.30	0.50
Acer platanoides	2.80	7.30	10.20
Acer rubrum	0.20	1.20	1.40
Acer saccharinum	0.30	4.70	5.00
Acer saccharum	2.80	4.30	7.20
Acer x freemanii	0.30	0.20	0.50
Aesculus hippocastanum	0.20	0.10	0.30
Ailanthus altissima	1.80	1.10	3.00
Amelanchier	0.10	0.10	0.20
Amelanchier laevis	0.00	0.10	0.10
Betula	0.20	1.50	1.70
Betula alleghaniensis	0.10	0.00	0.10
Betula pendula	0.20	0.30	0.40
Carya ovata	0.30	1.00	1.30
Catalpa	0.10	0.00	0.10
Cedrus	0.10	0.00	0.10
Celtis	0.10	0.00	0.10
Cercis	0.10	0.00	0.10
Cercis canadensis	0.30	0.40	0.70
Chamaecyparis nootkatensis	0.00	0.00	0.00

SPECIES	PERCENT POPULATION	PERCENT LEAF AREA	IMPORTANCE VALUE
Cornus	0.10	0.00	0.10
Cornus alternifolia	0.10	0.00	0.10
Cornus florida	0.20	0.00	0.20
Cornus kousa	0.10	0.00	0.10
Cornus racemosa	0.50	0.00	0.60
Corylus colurna	0.10	0.00	0.10
Crataegus	6.90	3.10	10.00
Elaeagnus angustifolia	0.20	1.20	1.30
Frangula	1.10	0.60	1.60
Frangula alnus	0.10	0.00	0.10
Fraxinus americana	9.70	4.00	13.70
Fraxinus excelsior	0.50	0.80	1.30
Fraxinus pennsylvanica	6.60	0.90	7.50
Ginkgo biloba	0.00	0.10	0.20
Gleditsia triacanthos	0.90	2.30	3.20
Hibiscus syriacus	0.10	0.00	0.10
Juglans nigra	5.90	19.80	25.70
Juniperus	0.40	0.10	0.50
Juniperus virginiana	0.10	0.10	0.20
Ligustrum	0.20	0.00	0.20
Ligustrum vulgare	0.50	0.10	0.50
Liriodendron tulipifera	0.10	0.30	0.40
Lonicera	2.00	0.20	2.20
Lonicera japonica	0.10	0.00	0.10
Magnolia	0.10	0.00	0.10
Malus	1.90	1.10	3.00
Malus tschonoskii	0.10	0.20	0.30
Morus	0.10	0.10	0.20
Morus alba	0.60	0.20	0.80
Ostrya virginiana	0.10	0.00	0.10
Picea abies	0.60	4.10	4.80
Picea glauca	1.60	4.00	5.60
Picea pungens	0.50	1.10	1.60
Picea rubens	0.30	0.10	0.40
Pinus banksiana	0.00	0.00	0.00
Pinus nigra	0.30	0.50	0.80
Pinus resinosa	0.10	0.40	0.60

SPECIES	PERCENT POPULATION	PERCENT LEAF AREA	IMPORTANCE VALUE
Pinus strobus	0.20	0.30	0.50
Pinus sylvestris	0.30	0.60	0.90
Platanus x acerifolia	0.10	0.30	0.50
Populus	0.40	0.40	0.80
Populus deltoides	0.10	3.00	3.20
Populus nigra 'Italica'	0.40	0.50	0.90
Prunus	0.10	0.00	0.10
Prunus avium	0.20	0.20	0.40
Prunus domestica	0.20	0.10	0.30
Prunus serotina	1.90	1.50	3.40
Prunus virginiana 'Shubert'	0.10	0.10	0.10
Prunus x orthosepala	0.20	0.60	0.80
Pyrus	0.60	0.80	1.30
Pyrus calleryana	0.30	0.30	0.60
Quercus alba	0.10	0.00	0.10
Quercus bicolor	0.30	0.00	0.30
Quercus macrocarpa	0.10	0.00	0.10
Quercus robur	0.00	0.00	0.00
Quercus rubra	0.60	2.20	2.80
Rhamnus cathartica	9.40	1.50	10.80
Rhus	2.50	0.20	2.60
Rhus hirta	2.60	0.30	2.90
Robinia pseudoacacia	2.70	4.60	7.40
Rosa	0.20	0.00	0.30
Salix	4.20	0.90	5.10
Salix matsudana	0.20	0.70	0.90
Sorbus	0.10	0.00	0.10
Syringa vulgaris	0.60	0.20	0.80
Taxus	0.60	0.20	0.80
Thuja occidentalis	10.90	2.20	13.00
Tilia americana	1.00	1.60	2.60
Tilia cordata	0.40	1.90	2.30
Ulmus Americana	0.60	0.20	0.80
Ulmus parvifolia	0.10	0.10	0.20
Ulmus pumila	0.70	1.20	1.90
Ulmus rubra	0.10	0.00	0.10
Viburnum lantana	0.10	0.00	0.10

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Appendix C: i-Tree Streets Study Report

2018 Hamilton i-Tree Streets Study Report

i-Tree Streets Field Survey

BACKGROUND AND RATIONALE

Street trees represent an important component of a city's urban forest. Street trees enhance the aesthetics of neighbourhoods, provide valuable ecosystem services, and make up a significant portion of cities' urban forest cover. In some densely built neighbourhoods, street trees can represent most of the urban forest cover, and thus make valuable contributions to neighbourhood character and livability. Street trees also play an important role in increasing urban environmental equity in low income and underserviced communities. Street trees have been linked to reduced asthma rates in young children.[1] Street trees also help to reduce runoff from asphalt during rain storms, thereby helping to reduce the burden of storm events on municipal infrastructure.[2]

However, their location adjacent to roadways also predisposes street trees to a variety of stress factors that trees in woodlands and yards are unlikely to face. Street trees are often subject to salt deposits during the winter that can alter soil chemistry. Street trees may be planted in confined growing spaces with inadequate soil volume and poor soil quality. When planted along heavily trafficked streets, this soil can become compacted by repeated pedestrian trampling, which contributes to anaerobic soil conditions. Street trees can also be injured by snow removal or construction equipment, vehicles, and vandals. Street trees growing in areas with abundant impervious ground cover and reflective building surfaces can suffer heat stress during the summer months. Injuries and increased stress can predispose trees to insect and disease infestation, further endangering their longevity and sacrificing the benefits that are provided by mature trees.

An analysis of the benefits provided by Hamilton's street trees complements the assessment of the City's entire urban forest by highlighting the value provided by the street tree population as a municipal resource. The value of a street tree resource is in many ways contingent on the health of the trees and the extent of leaf area they collectively represent. As the City is responsible for planting, maintaining, and removing street trees, an overview of the benefits provided by street trees can provide insights into the outcomes of the City's investments in the resource, and can help to inform management decisions.

While an analysis of the City's existing street tree inventory was originally proposed, the vintage (2006) limited the practicality of the results.[3] Therefore, an alternative was proposed, which would more accurately reflect the current street tree population.

The i-Tree Streets software application provides a protocol for a statistically-relevant street tree sample inventory, so it was decided that a sample street tree inventory would be conducted in the summer of 2018 in order to obtain more up-to-date street tree data for the purposes of informing the Urban Forest Strategy.

[1] *Lovasi, G.S., Quinn, J.W., Neckerman, K.M., Perzanowski, M.S., and A. Rundle. 2008. Children living in areas with more street trees have lower prevalence of asthma. Journal of Epidemiology & Community Health 62: 647-649.*
[2] *Armson, D., Stringer, P., and A.R. Ennos. 2013. The effect of street trees and amenity grass on urban surface water runoff in Manchester, UK. Urban Forestry & Urban Greening 12(3): 282-286.*
[3] *Memo – i-Tree Streets Data Review, dated March 7, 2018.*

METHODOLOGY

i-Tree Streets (an adaptation of the Street Tree Resource Analaysis Tool for Urban Forest Managers [STRATUM]) is an easy to use software tool with a focus on a municipality's street trees that enables any community to inventory and asses the benefits its urban forest is providing. The analysis provides baseline data to improve street tree management by reporting on the following aspects of a street tree population: structure, function, value, and management needs.

STREET SEGMENT SELECTION

In 2018, Hamilton decided to conduct a random sample street tree inventory on 3% of their street tree segments (3% is recommended by i-Tree for communities with populations greater than 250,000). Sample selection followed simple random sampling conventions and produces about a 10% standard error for the total number of trees citywide.

The random sample was determined using ArcGIS, and only City-owned public streets within the urban boundary were eligible. A total of 408 segments were selected to be surveyed.

I-TREE STREETS FIELD METHODOLOGY

The field crew inventoried a total of 408 street segments during the 2018 field season. Field duties were carried out by BioForest staff, under contract to the City of Hamilton. There was one regular field crew member who was dedicated to this project throughout its entire duration. The inventory data was collected from June 28 to September 25, 2018. The field crew recorded data on paper data forms and subsequently entered it into a Microsoft Excel database. All trees along each selected street segment, within the municipal right-of-way, were surveyed. A total of 5,686 trees were inventoried.

The following data was collected for each tree along all selected segments, within the municipal right-of-way:

Segment Information

- Segment ID number
- Ward ID number
- Date of data collection
- Crew
- Segment notes

Tree Data

- Street name
- Street address
- GPS coordinates
- Species ID
    - i-Tree specific species codes, or one of the following:
    - AVPLS – available planting site, suitable for a small tree
    - AVPLM – available planting site, suitable for a medium tree
    - AVPLL – available planting site, suitable for a large tree
    - STUMP – stump
    - The field crew used the following City of Hamilton Site Requirements for Tree Planting and City of Hamilton Design Standards in order to determine suitability of available planting sites:

- Diameter at breast height (1.37 m) for up to six stems, if tree is multi-stemmed
- Land use type in which tree is rooted
- Planting site type in which tree is rooted (front yard, boulevard, median, tree pit, etc.)
- Tree condition

Materials

- Clipboard
- Pencils
- Paper data sheets
- 30 m measuring tape (to validate right-of-way boundaries)
- DBH tape
- GPS unit

Data Submission and Analysis

Throughout the data collection period, the field crew recorded all information on paper data forms. At the conclusion of the field data collection, the same field crew member inputted all data into a Microsoft Excel database. Once all data was entered, it was uploaded and processed using i-Tree Streets v5.1.7.

Results are presented as an extrapolation of the field data gathered from the 408 i-Tree Streets street segments selected for this study. These segments constitute a statistically representative sample of Hamilton's urban street tree inventory. A study using a 3% random sample, in a municipality with a population greater than 250,000 people, is expected to yield a standard error of about 10%, according to the i-Tree Streets User's Guide. The 408 segments using in Hamilton's street tree sample inventory represent slightly more than 3% of the total municipal street segments within the urban boundary, therefore the results can be considered to fall within the bounds of acceptable standard error. As with the i-Tree Eco study, only a complete inventory would eliminate the possibility of any error, but the time requirements and financial costs made such an undertaking unfeasible for the purposes of this project.

2018 i-Tree Streets Study Results

The structural value of Hamilton's street trees (estimated population 168,610), is approximately $500 million. Street trees comprise an estimated 3.2% of Hamilton's total tree population, but their structural value represents about 23.7% of the structural value of Hamilton's trees.

Each street tree in Hamilton provides an average of $88.50 in annual benefits, a combination of estimated economic values for carbon stored, air quality improvement, and aesthetic benefits. On average, Hamilton's street tree population provides a value of approximately $29.95 per resident on an annual basis.

These initial results indicate that the benefits provided by Hamilton's street trees are outsized compared to the portion of the total tree population that they represent. This may be attributed in part to the relatively good condition and health of the street tree population, which the City is responsible for managing, as well as their relative size. The results also speak to the importance of investing in municipal green infrastructure, as the City of Hamilton's management of its street tree resource has clearly resulted in substantial environmental benefits. The City's role in improving neighbourhoods and delivering the benefits to the residents of Hamilton that flow from street trees is significant.

The overall stocking level of Hamilton's streets is 82%, meaning that approximately 82% of potential street tree sites are currently planted with a tree. There are approximately 9,391 available planting sites that would support small-stature trees, 17,198 available planting sites for medium-stature trees, and

7,690 available planting sites for large stature trees. There are also 3,260 stumps currently occupying potential planting sites. All available planting sites represent opportunity to increase Hamilton's street tree canopy on public lands.

The health of Hamilton's street trees is relatively good (Figure 1). About 87% of all street trees were considered to be Good condition, while Dead trees comprised just less than 3% of the street tree population.

Green ash (*Fraxinus pennsylvanica*) and white ash (*Fraxinus americana*) are two species in the worst condition, with a significant percentage of their populations, 57.3% and 34% respectively, either dead or dying.

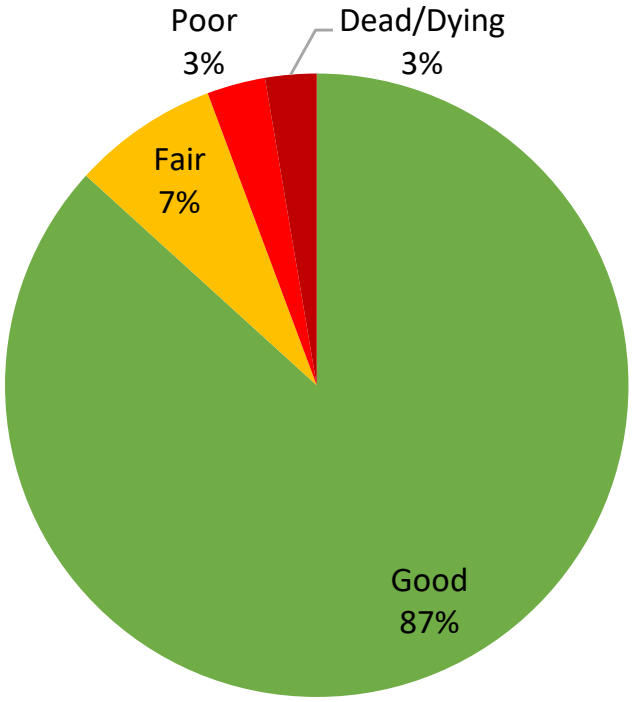


Figure 1. Average condition rating by percentage of Hamilton's street tree population, 2018.

The majority of Hamilton's street trees fall within the smallest diameter classes (less than 20 cm and 21 to 40 cm). The smallest class is overrepresented compared to the ideal percentage of 40%/30%/20%/10%,[4] while the next smallest size class is slightly underrepresented.

The two largest diameter classes (41 to 60 and +61 cm) are both underrepresented, comprising only 14.1% and 7.1% of the total street tree population, respectively (Figure 2).

[4] *This ideal street tree distribution is being utilized by other Canadian municipalities, such as Toronto, Cambridge and Fredericton, and comes from Richards, N.A., 1983. Modeling survival and consequent replacement needs in a street tree population. J. Arboric. 5.11:251-255.*

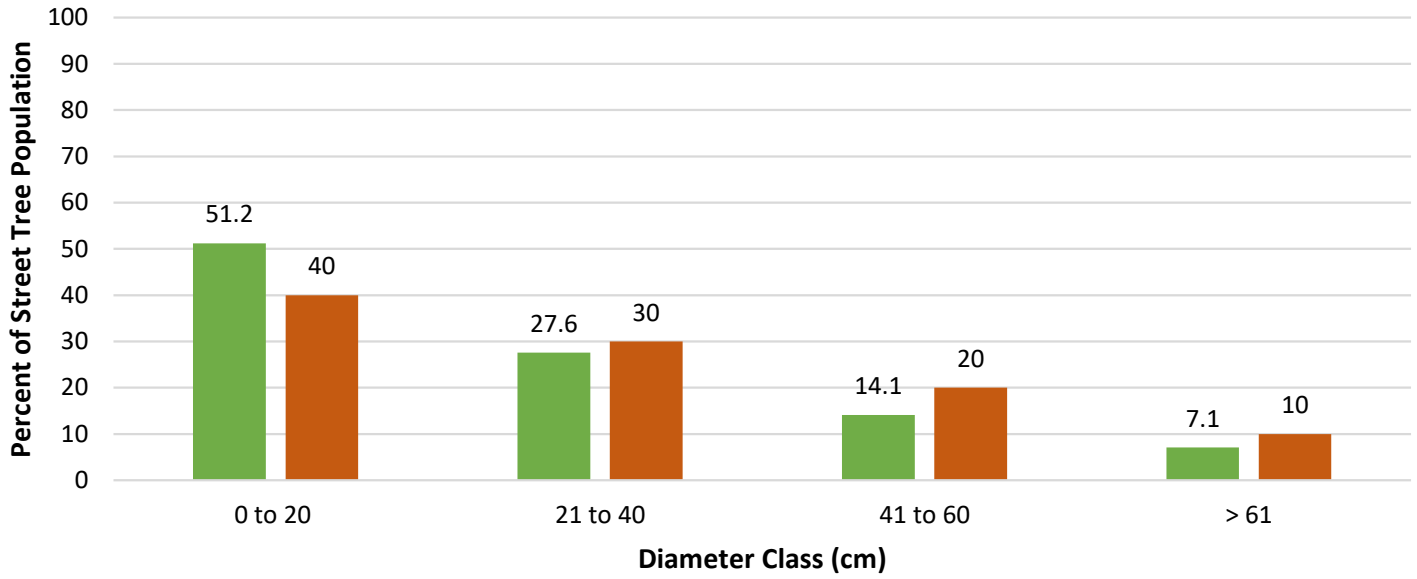


Figure 2. Distribution of Hamilton's street tree population by diameter class (cm), compared to suggested ideal distribution (from Richards 1983), 2018.

In terms of population, Norway maple (*Acer platanoides*) is the most abundant street tree, comprising 19.2% of the total street tree population. It is also the most abundant species in 12 out of 14 wards, comprising between 10.3% and 35.5%. In the two wards where it is not the most abundant species, it is the second most abundant species. Norway maple also has, by far, more leaf area than any other species of street tree, contributing 22.9% of the leaf area of all street trees (Figure 3).

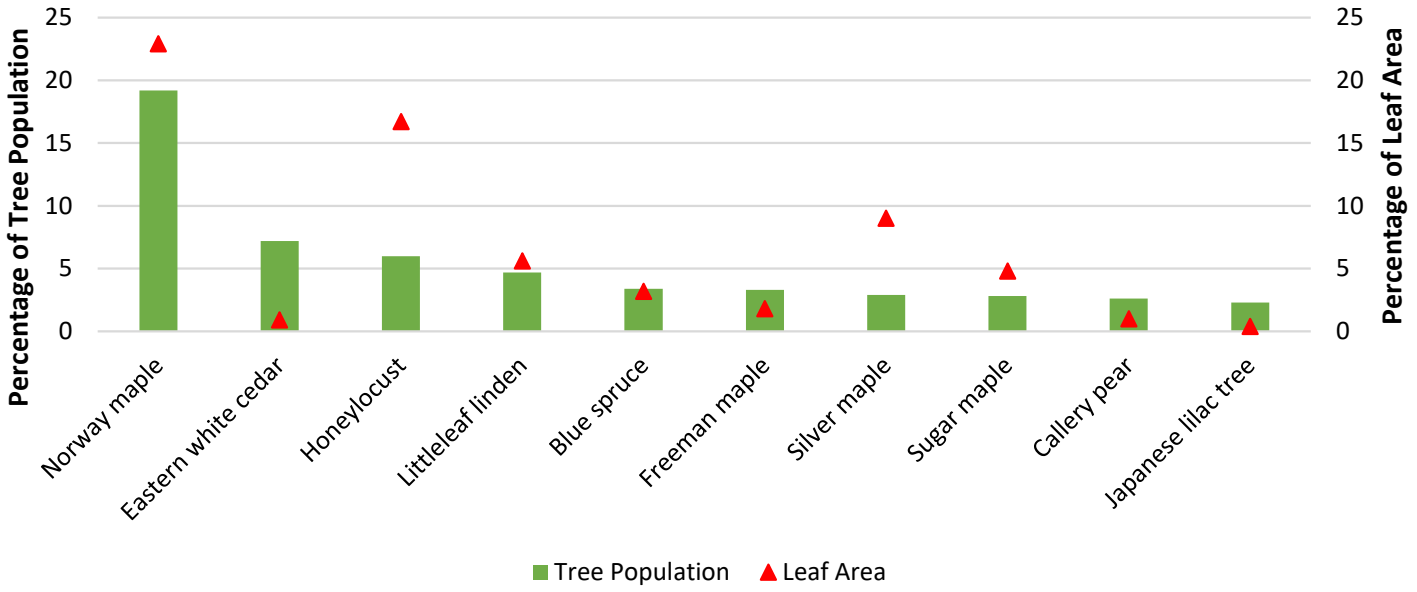


Figure 3. Top ten species of street trees by population (bars), with total leaf area (points), 2018.

Norway maple plays a significant role in delivering the benefits provided by street trees. The legacy of this invasive species with respect to ecological health in forest and ravine habitats is problematic, but its contributions to the provision of ecosystem services by the urban forest are undeniable.

However, it should also be noted that Norway maple is one of the preferred host species of Asian longhorned beetle (*Anoplophora glabripennis*), along with other species of maple, which are abundant in Hamilton's street tree population. The vulnerability of such a large contingent of the street tree population to a devastating pest is a concern for the long-term resilience of the street tree resource. Planting Norway maple along streets has fallen out of favour, due to its invasive tendencies, so there is an opportunity to gradually reduce the population of Norway maple over time. This will be a long-term outcome, as mature Norway maples gradually decline and are replaced by a more diverse set of species.

Indeed, the City of Hamilton has recently revised its street tree planting lists and significantly reduced the number of maple trees planted by the City, in order to reduce the dominance of the Acer genus. The effects of this decision should become evident over the next decade or so.

Eastern white cedar (*Thuja occidentalis*) is also highly abundant in Hamilton's street tree population. It is the most abundant species in one ward, and is in the top three most abundant species in six out of 14 wards ranging from 7.4% to 17.2%. Despite being an abundant street tree species, eastern white cedar is characterized by relatively low leaf area compared to its population, representing less than 1% of total leaf area. This is likely due to a combination of its small stature and narrow growing habit.

Honeylocust (*Gleditsia triacanthos*) represents 6% of the street tree population, but contributes a relatively large percentage of leaf area (16.7%). This may be due to the frequency of large, healthy honeylocust street trees. Unlike Norway maple, honeylocust does not currently have a major vulnerability to a serious pest and it is considered to be a species that thrives under urban conditions.

Freemanii maple (*Acer x freemanii*) is currently the sixth most populous street tree, comprising 3.3% of the total street tree population. This species is capable of maturing into a large stature tree, however its current relative contribution to overall leaf area is quite small (1.8%), suggesting that the majority of this population is currently made up primarily of immature specimens.

On the other end of the spectrum, silver maple (*Acer saccharinum*) and sugar maple (*Acer saccharum*) collectively comprise less than 6% of the total street tree population, but both species represent relatively large percentages of leaf area, 9% and 4.8%, respectively.

With the exception of eastern white cedar, callery pear (*Pyrus calleryana*), and Japanese lilac tree (*Syringa reticulata*), Hamilton's top ten street tree species are capable of growing into medium- to large-stature trees. This means that they have the potential to deliver more significant benefits, provided the conditions exist to allow them to grow to their full biological potential. As large stature trees, their per-tree leaf area would be much greater than a smaller stature tree such as Japanese lilac tree, and hence each tree would deliver proportionately more benefits.

Further investments in Hamilton's street tree resource will be needed to continue the provision of important environmental services it currently provides to residents. Investments in Hamilton's street trees have helped to improve overall tree condition and allow for the provision of benefits that are disproportionately large compared to the street tree population. In order to maintain the degree of environmental benefits currently provided by street trees, there must be a combination of regular maintenance and sufficient tree planting to sustain a healthy street tree population over the long term.

Appendix D: i-Tree Canopy Study Report

2018 Hamilton i-Tree Canopy Study Report

i-Tree Canopy Analysis

BACKGROUND AND RATIONALE

Hamilton's last canopy cover analysis took place in 2009. Since that time, emerald ash borer (EAB) has swept through the City, a major ice storm occurred in 2013, and significant land development has taken place. In order to understand how Hamilton measures up to its current canopy cover target of 30%, and understand trends in urban forest cover over time, a more up-to-date estimate was required as part of the Urban Forest Strategy.

The scope of this project did not allow for a full-scale canopy analysis, therefore an alternative tool (i-Tree Canopy) was utilized to conduct a quick and easy point-sampling exercise.

METHODOLOGY

The i-Tree Canopy tool – developed by the United States Department of Agriculture, Forest Service – is designed to allow users to easily and accurately estimate tree cover, as well as other land cover classes (e.g. grass, buildings, roads, etc.). The tool randomly lays points across a user-defined boundary, and overlays this onto imagery from Google Earth. The user then examines each point and classifies it according to which land cover class it falls on. The proportion of sample points represented by each land cover type statistically represents the relative amount of urban forest canopy cover and other land cover types, expressed in terms of percent cover for the area sampled. Because a standard error for each cover type estimate can be calculated, the statistical significance of differences within and among land cover types over time can readily be assessed.

However, because these estimates are based on point-sampling, the precise spatial distribution of the estimated canopy cover cannot be determined.

For the City of Hamilton, the urban boundary was uploaded to i-Tree Canopy and GIS staff investigated available Google Earth imagery to find years with the most visible aerial imagery. 2006 and 2017/2018 were selected for analysis because they had relatively clear, complete, and cloud-free imagery.

1,301 points were randomly allocated across this area, which produced a maximum standard error of 1.25% for 2006 and 1.2% for 2017/2018.

The following land cover classes were used for analysis:

- Tree/Shrub
- Grass or Meadow
- Building
- Parking Lot or Sidewalk
- Roads
- Water
- Soil/Agriculture

Limitations

The accuracy of the analysis depends on the ability of the user to correctly classify each point into its correct land cover class. Thus the classes that are chosen for analysis must be able to be interpreted from an aerial image. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. Another limitation of this process is that Google Earth imagery may be difficult to interpret in all areas due to relatively poor image resolution, environmental factors, or poor image quality.

In order to mitigate these limitations, one City of Hamilton staff member performed all point classifications to reduce the amount of observer bias. Additionally, the years to be analyzed were based on availability of acceptable Google Earth imagery.

2018 i-Tree Canopy Study Results

OVERALL TREE COVER

Since 2006, overall urban forest cover has decreased slightly across Hamilton's urban area from 22.1% in 2006 to 21.2% in 2017/2018, though this difference is not statistically significant.

Urban forest cover is one key indicator for measuring the success of Hamilton's urban forestry program, and the maintenance of canopy cover since 2006 is likely a positive outcome. However, because change detection doesn't consider which species are contributing to the increase, the role of invasive species in contributing to the increase in urban forest cover should be examined in future monitoring studies.

This particular change detection considered two datasets over a relatively long time span (11 years). It is therefore unclear if urban forest cover increased or decreased significantly at any time between these two time periods, which would provide greater insight into recent urban forestry trends in Hamilton.

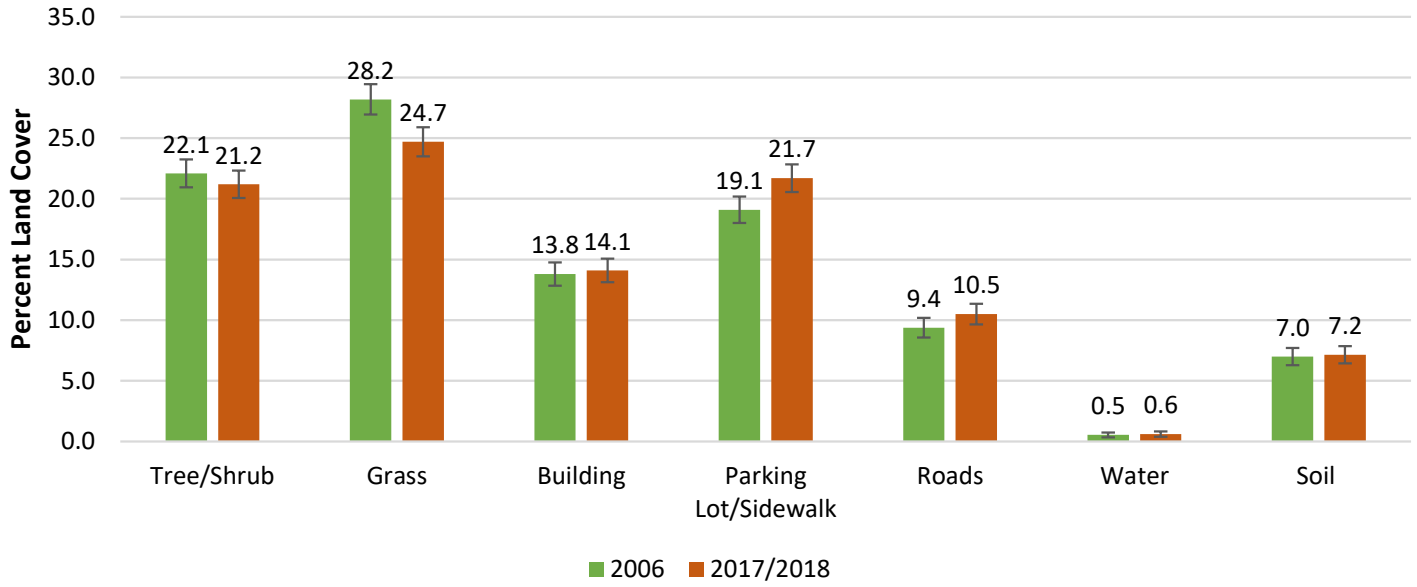


Figure 1. Change in land cover classes in Hamilton from 2006 to 2017/2018, calculated using i-Tree Canopy results.

While the Tree/Shrub cover has not significantly changed over the past 11 years, the amount of impervious surface (building, parking lot, sidewalk, and roads) appears to be increasing, while the amount of grass has decreased (statistically significant).

It is assumed that land cover does not change consistently across the City, and therefore further analyses were conducted to investigate changes in land cover over time using two different geographic units – land use and political ward boundaries.

TREE COVER BY LAND USE

One way to look at factors influencing tree cover change is to examine the change by land use. Different land use categories tend to have different levels of tree cover, based on the intensity and nature of development in those areas. For example, Low Density Residential areas tend to have lower intensity forms of development compared to Commercial or Industrial land uses. The land use categories used for this study were consistent with those identified for the i-Tree Eco study, and are as follows: Agriculture, Commercial & Office, Industrial, Institutional, Low Density Residential, Medium/High Density Residential, Open Space, Transportation & Utility, and Vacant Land.

The Open Space land use category (which includes parks, golf courses, cemeteries and woodlots) has the greatest amount of tree and shrub cover, relative to other land cover classes, with 54.5% in 2006 and 54% in 2017/2018. Industrial lands have the lowest amount of tree and shrub cover, with 3.9% in 2006 and 2.3% in 2017/2018.

The Transportation & Utility land use category experienced the greatest increase in tree and shrub cover between 2006 and 2017/2018, however, the standard error for these values exceeded 0.05. Commercial & Office experienced no change in tree and shrub cover, while all other land uses experienced varying degrees of canopy loss over the time period examined. The land use category with the greatest decrease in tree and shrub cover was Institutional, decreasing from 14.1% in 2006 to 10.9% in 2017/2018.

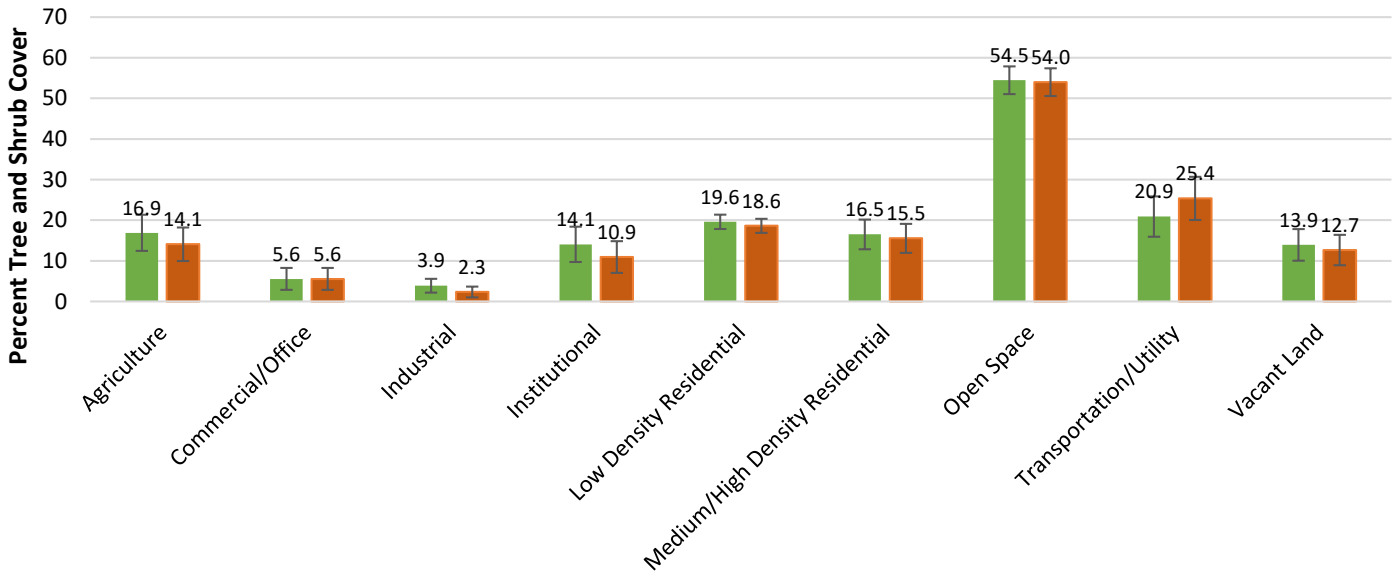


Figure 2. Tree and shrub cover change by land use in Hamilton.

TREE COVER BY WARD (2018 WARD BOUNDARIES)

Political ward boundaries can also influence the nature of tree canopy, whether by local leadership, resident initiatives or targeted municipal outreach efforts. The highest areas of canopy loss appear to be on the outskirts of Hamilton's urban boundary, in Wards 7, 8, and 12 with Ward 7 showing the greatest amount decreasing from 18.4% in 2006 to 14.5% in 2017/2018, a negative difference of 27.3%. Ward 8 was not far behind with a 20% decrease (9.1% in 2006 to 7.6% in 2017/2018).

There are some wards that have seen gains in tree canopy, the highest one being Ward 15 with an increase of 15% between 2006 and 2017/2018. Other wards demonstrating tree canopy increase are Ward 3 (+6.7%) and Ward 14 (+7.7%).

Wards 1, 2, 5 and 13 saw no change in tree canopy between 2006 and 2017/2018.

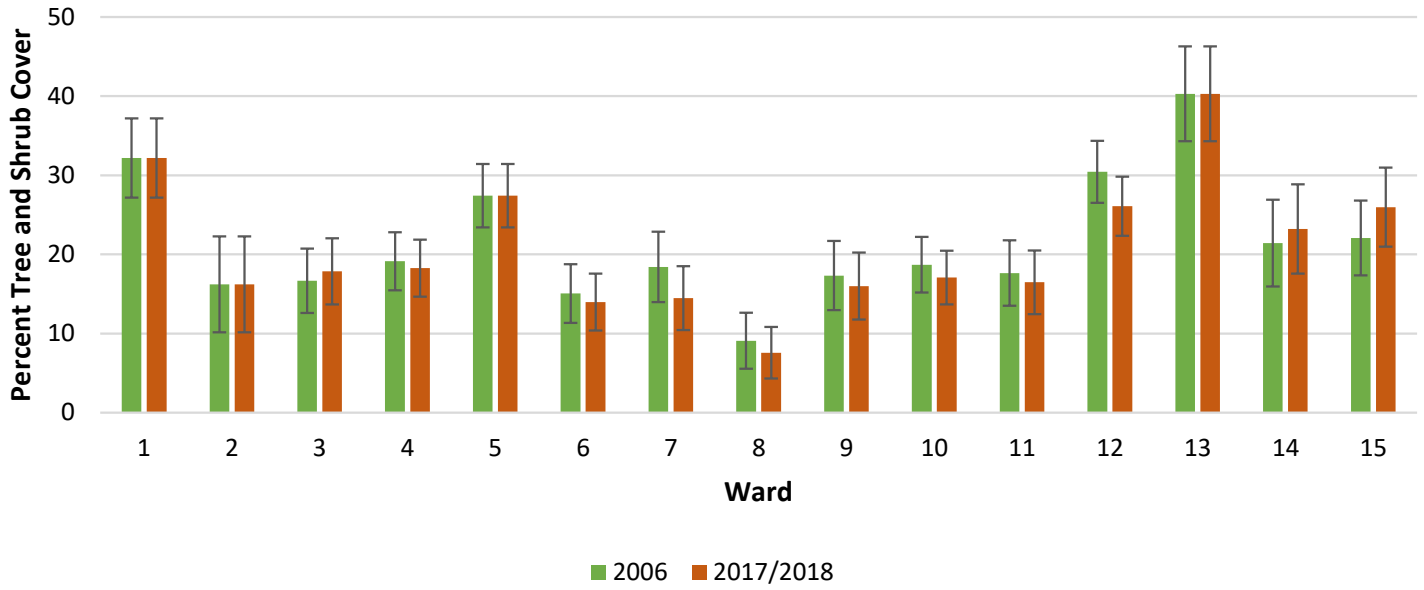


Figure 3. Tree and shrub cover change in Hamilton by ward (2018 ward boundaries).

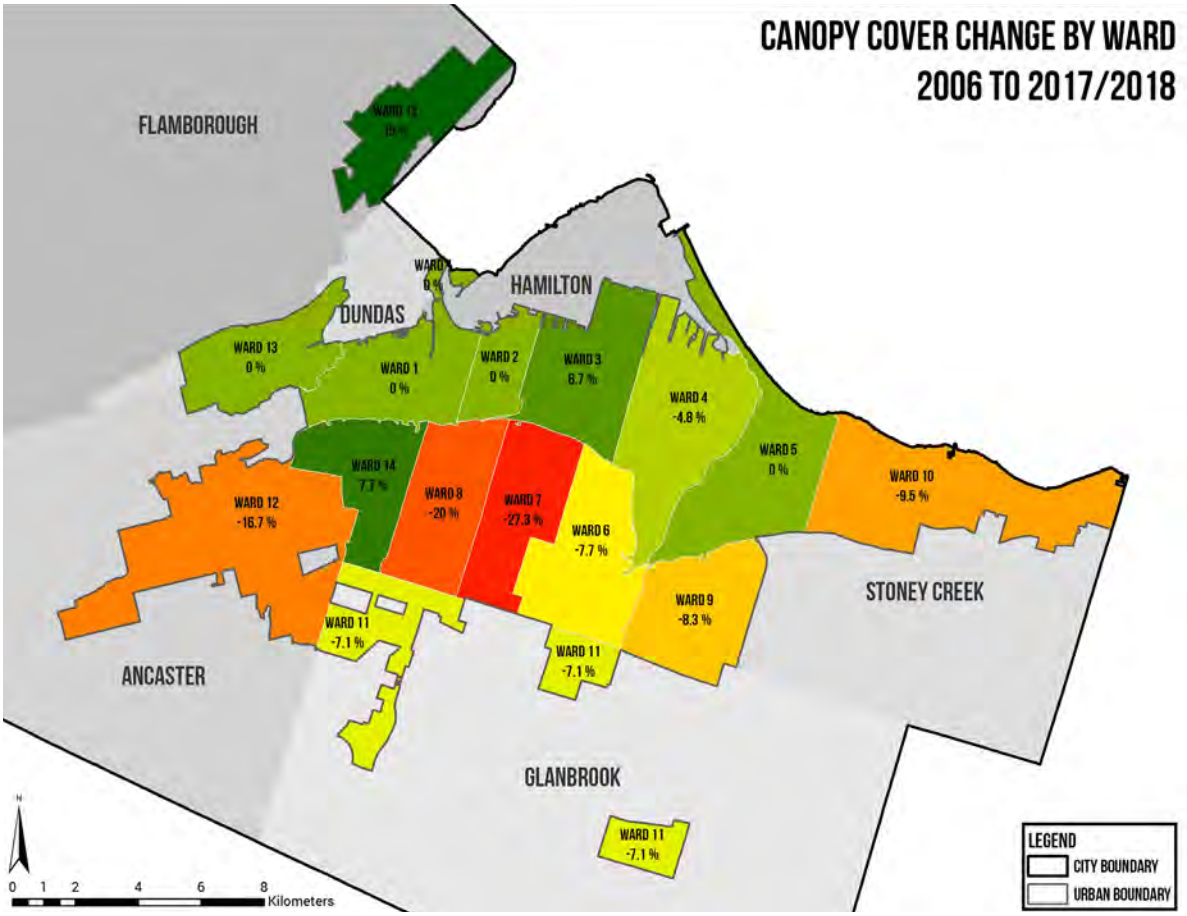


Figure 4. Percent tree cover change in Hamilton by ward (2018 ward boundaries).

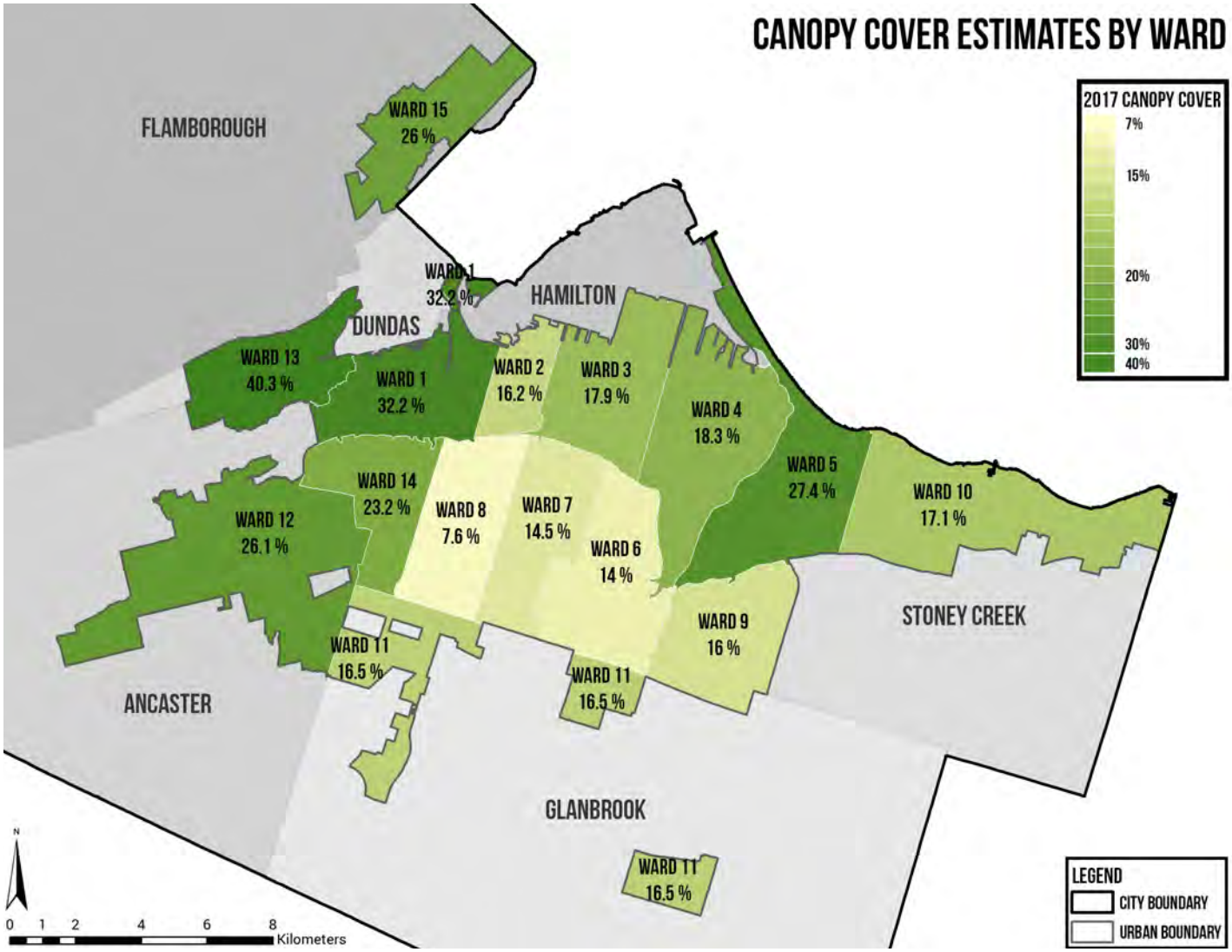


Figure 5. 2017/2018 percent tree cover estimates in Hamilton by ward (2018 ward boundaries).

Appendix E: Comparative Review of City of Hamilton Urban Forest Program

At an early stage in the development of the UFS, the City's informal and formal urban forestry plans, policies, programming and practices were compared to the information contained within five other municipal urban forestry plans. The purpose of this comparative analysis was to assess how the City measured up relative to five other municipalities that have advanced their urban forestry plans, establish a baseline understanding of current approaches used by the City to sustain and enhance the urban forest, and identify possible future challenges and opportunities to reach the City's urban forestry goals and objectives.

The framework for this comparative analysis was adapted from the Sustainable Urban Forest: A Step-by-Step Approach document authored by Davey Institute and the United States Department of Agriculture (USDA), Forest Service. This framework uses a standardized set of 28 criteria or 'targets', and associated key objectives and performance indicators to assess the status of a municipality's urban forest and urban forestry planning approach.

Comparison municipalities were selected in consultation with the City staff based on the following parameters:

- The municipality had to have a comprehensive urban forest plan or strategy that was publicly available;
- Only Canadian municipalities were selected and preference was given to municipalities in southern Ontario; and
- The municipality was of a similar size to Hamilton (to the extent possible);
- In one instance, a plan was recommended by City staff (i.e., New Westminster, British Columbia) for comparison due to the apparent quality of this plan's layout and content.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
Trees and Forest									
T1 Relative Tree Canopy Cover	Achieve desired degree of tree cover, based on potential or according to goals set for entire municipality and for each neighbourhood or land use	Yes - Good	Yes - Performance Level Not Reported	Yes - Moderate	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Good	Yes. The Urban Hamilton Official Plan has a 30% canopy cover target. By having an established target, Hamilton is consistent with the municipalities compared in this review. Hamilton's target of 30% is higher than some municipalities (Mississauga 15 – 20%; London 25%; and New Westminster 27%) yet is lower than North Oakville (40%) and Halifax (53%). Note that Halifax targets are land-use specific (40% in parks, 80% in riparian buffers) and also have specific targets by neighbourhood. London's targets are specific across a variety of land use types, ranging from 10% for commercial lands to 55% in natural areas and open space by 2035. It should be noted that these canopy targets have not generally been explicitly included in other planning documents such as Secondary Plans and Growth Management Plans.
T2 Age Diversity (Size Class Distribution)	Provide for ideal uneven age distribution of all "intensively" (or individually) managed trees – municipality-wide as well as at neighborhood level.	Yes - Moderate	Yes - Low	Yes - Good	Yes - Performance Level Not Reported	No	4	Moderate	No. Other than an ongoing tree planting program to ensure a consistent supply of young trees, Hamilton's current policies and programs do not explicitly address or provide targets for age diversity or size class distribution. Other municipal plans except North Oakville address this target, though specific age distribution criteria are not outlined in their plans. Rather, it is simply acknowledged in the plans that age diversity of trees should be a goal in growth of their urban forests.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
T3 Species Diversity	Establish a genetically diverse tree population across municipality as well as at the neighborhood level.	Yes - Good	Yes - Low	Yes - Moderate	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Moderate	Yes. Species diversity (or biodiversity) is specified in Hamilton policy documents, similar to the compared municipalities. Species diversity is specified in development-related planting through Hamilton's Street Tree Planting Policy, which states that no single species shall make up more than 20% of the total street tree population where the development includes 20 or more tree plantings, and no coniferous trees are permitted in street tree planting. Overall, there is no clear approach in Hamilton policy for species selection or achieving species diversity. Also, there is no long-term monitoring of species diversity or specific criteria targets for diversity. The plans of most municipalities compared in this review also do not provide specific criteria targets for species diversity, but instead simply acknowledge that some level of species diversity should be strived for, including generalized advocacy for native species. Mississauga has targeted that no tree species represents more than 5% of all trees city-wide or 20% for any given street.
T4 Species Suitability	Establish a tree population suited to the urban environment and adapted to the overall region.	Yes - Moderate	Yes - Low	Yes - Good	Yes - Performance Level Not Reported	No	4	Moderate	No. Hamilton's current policies do not provide targets or guidance for achieving a tree population suited to the urban environment or adapted to the region. Hamilton's Tree Protection Guidelines (October 2010) provide a list of native trees recommended for planting (Appendix 4) and non-native invasive trees not recommended for planting (Appendix 5). The other municipal plans, except North Oakville, address this target. London and Halifax plans focus generally on the principal of selecting the "right tree (species) for the right site", while New Westminster also specifies selection and planting of the largest tree species suitable to a site to also support canopy targets. Most others also consider management of invasive species as part of species suitability. For example, Mississauga has targeted a reduction to below 8% of invasive tree species in street and park trees.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
T5 Publicly Owned Trees (trees managed "intensively")	Current and detailed understanding of the condition and risk potential of all publicly owned trees that are managed intensively (or individually).	Yes - Good	Yes - Performance Level Not Reported	No	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	4	Good	No. Hamilton's current policies do not incorporate detailed information of the condition and risk potential of publicly owned trees and an up-to-date street tree inventory is not available. An inventory of public trees in parks and cemeteries is underway and will guide Forestry and Horticulture programming. Woodlots and naturalised areas have no budgets or active maintenance. Forestry goes into these areas without funding to mitigate risks. Most of the municipalities compared in this review incorporate detailed public tree inventory information in their plans as a baseline.
T6 Publicly Owned Natural Areas (trees managed "extensively")	Detailed understanding of the ecological structure and function of all publicly owned natural areas (such as woodlands, ravines, stream corridors, etc.), as well as usage patterns.	Yes - Good	Yes - Performance Level Not Reported	Yes - Optimal	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Optimal	Yes. Hamilton has a current and detailed understanding of its natural areas through the NAI (2014 update). Natural area protection is identified and facilitated through various policies, such as Official Plan and Secondary Plan policies. The compared municipalities all have some form of natural area inventory and policy protection measures in place.
T7 Trees on Private Property	Understanding of extent, location, and general condition of privately-owned trees across the urban forest.	No	No	No	No	Yes - Performance Level Not Reported	1	Target is not included or performance is not reported	No. Hamilton does not have detailed inventory data on private trees other than 2018 sample-based i-Tree data. Current practice does not include collecting detailed information regarding private trees other than what is submitted through the site development process. Specifically, the Tree Protection Guidelines for Development Sites document is used by the Planning and Economic Development Department to regulate development around trees on private land. None of the municipalities compared in this review address this target in their plans, though others have established private tree by-laws.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
Community Framework									
C1 Municipal Agency Cooperation	All municipal departments and agencies cooperate to advance goals related to urban forest issues and opportunities.	Yes - Good	Yes - Good	Yes - Good	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Good	No. Hamilton's current policies do not support broad formal interdepartmental and inter-agency cooperation; however, informal collaboration does occur. The City has a robust system for commenting on site plans, with about 250 plans reviewed each year. Other municipalities compared in this review identify such cooperation in their plans and three are rated as having good performance. For example, Mississauga's plan outlines a specific objective of cooperating with local CAs on riparian planting and restoration, while New Westminster identifies the use of informal teams among departments and agencies that are implementing common goals for specific projects. Halifax is currently developing policies and plans, e.g. a Stormwater Functional Management Plan, that will specify strategies for interagency collaboration toward urban forestry goals. North Oakville's strategy calls for an interdepartmental committee to promote cooperation between the Town and regulatory agencies. Hamilton works cooperatively with the four Conservation Authorities operating within the city.
C2 Utilities Cooperation	All utilities – above and below ground – employ best management practices and cooperate with municipality to advance goals and objectives related to urban forest issues and opportunities.	No	No	No	Yes - Performance Level Not Reported	No	1	Target is not included or performance is not reported	No. Hamilton's current policies and programs do not require or promote cooperation with utilities with respect to the development and implementation of urban forestry Best Management Practices such as utility line vegetation management plans or tree planting or urban forest canopy targets. This is also the case with most municipalities compared in this review. Only Halifax's plan addresses this in a passive way, acknowledging that utility cooperation should be incorporated into urban forestry plans.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
C3 Green Industry Cooperation	Green industry works together to advance municipality-wide urban forest goals and objectives and adheres to high professional standards.	Yes - Moderate	Yes - Moderate	Yes - Low	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Moderate	Partial. Hamilton's current policies do not require or promote formal cooperation with green industry; however, partnerships with non-government organizations and stewardship groups on green initiatives occur (e.g. Hamilton Naturalists Club, Environment Hamilton, Air and Trees Task Force, etc.). This positions Hamilton behind all the municipalities compared in this review, which all identify this target in their plans. However, the reported performance of this target is generally low for those municipalities, and their plans provide little detail on how to implement such cooperation.
C4 Involvement of Large Private and Institutional Landholders	Large private landholders embrace and advance municipality-wide urban forest goals and objectives by implementing specific resource management plans.	Yes - Moderate	Yes - Optimal	Yes - Low	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Good	No. Hamilton's current policies and programs do not require or promote involvement of large private and institutional landholders in furthering urban forest goals and objectives. Other municipalities compared in this review identify this target in their plans. The reported performance ranges from Low to Optimal (Mississauga). Mississauga identifies the responsibility of City forestry staff to conduct outreach and stewardship program activities to involve these stakeholders.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
C5 Citizen Involvement and Neighbourhood Action	At the neighborhood level, citizens participate and groups collaborate with the municipality and/or its partnering NGOs in urban forest management activities to advance municipality-wide plans.	Yes - Good	Yes - Moderate	Yes - Moderate	Yes - Performance Level Not Reported	No	4	Good	Yes. Hamilton's urban forest program incorporates informal citizen involvement and neighbourhood action. For example, the Hamilton Trees Please program involves citizen volunteers contributing to tree inventories for online mapping and tree planting programs. Hamilton has a particularly strong and engaged NGO community that has a long history of supporting forestry both in policy discussions and in practice (through community greening grants), where these groups undertake neighbourhood tree inventories and advocacy, as well as natural heritage system management and monitoring. Four of the municipalities compared in this review incorporate this target in their plans, for which performance is generally reported as good.
C6 General Appreciation of Trees as a Community Resource	Stakeholders from all sectors and constituencies within municipality – private and public, commercial and non-profit, entrepreneurs and elected officials, community groups and individual citizens – understand, appreciate, and advocate for the role and importance of the urban forest as a resource.	Yes - Moderate	Yes - Performance Level Not Reported	Yes - Moderate	Yes - Performance Level Not Reported	No	4	Moderate	Partial. Hamilton's current policies do not explicitly provide for this target; however, Forestry and Horticulture complete outreach activities such as those funded by the Environmental Mitigation Fund and the Eco-connection Fund for street tree planting. In addition, Forestry and Horticulture has Open House events at the Operations Yard and distributes environmental awareness (e.g. EAB) and promotional material to the public. Four municipalities compared in this review include this target in their plans, though reported performance is at the moderate level. Past efforts to improve protection for trees through by-laws were unsuccessful, with specific interest groups advocating against a new private tree protection by-law for Hamilton.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
C7 Regional Collaboration	Cooperation and interaction on urban forest plans among neighbouring municipalities within a region, and/or with regional agencies.	Yes - Low	Yes - Optimal	No	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	4	Good	No, but it should be recognized that Hamilton is a single tier municipality, and therefore, has no upper tier to collaborate with Hamilton's current policies do not provide for this target; however, Hamilton establishes agreements with local conservation authorities in the management of city-owned lands with natural features. Four municipalities compared in this review include this target in their plans. Performance ranges from Low (London) to Optimal (Mississauga) Mississauga identifies the responsibility of City staff (Planning and Building, and Forestry) to collaborate with upper tier (Peel Region) staff and the two local CAs to address issues and pursue larger scale natural heritage and urban forest objectives.
Resource Management Approach									
R1 Tree Inventory	Current and comprehensive inventory of tree resource to guide its management, including data such as age distribution, species mix, tree condition, and risk assessment.	Yes - Good	Yes - Good	Yes - Moderate	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Good	Partial. Hamilton's urban forest program incorporated a tree inventory in the past (i.e. 2006); however, it is not comprehensive or city-wide, and is largely outdated for many areas. There is an inventory of trees in parks and cemeteries that is ongoing. Most municipalities compared in this review have completed city-wide inventories with comprehensive and detailed information, which is updated regularly , used in long-term planning and can be accessed online by the public.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
R2 Canopy Cover Assessment and Goals	Urban forest policy and practice driven by accurate, high-resolution, and recent assessments of existing and potential canopy cover, with comprehensive goals municipality-wide and at neighborhood or smaller management level.	Yes - Good	Yes - Optimal	Yes - Good	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Optimal	Partial. Hamilton's urban forest program incorporates elements of this target (e.g. 30 – 35 % city-wide canopy cover target, increase canopy cover in certain underrepresented wards, etc.), which is consistent with the municipalities compared in this review. However, Hamilton's current policies do not explicitly call for comprehensive city-wide or neighbourhood-level up-to-date assessments of existing or potential canopy cover. Also, developing neighbourhood-level canopy cover goals have not been prioritized. Municipalities compared in this review report good to optimal performance.
R3 Environmental Justice and Equity	Ensure that the benefits of urban forests are made available to all, especially to those in greatest need of tree benefits.	No	No	No	Yes - Performance Level Not Reported	No	1	Target is not included or performance is not reported	No. Hamilton's current policies, plans and programs do not address this target consistent with most municipalities compared in this review. Only Halifax includes this target, through one of its operational principles, which states that all citizens deserve to enjoy the benefits of the urban forest where they live, work, learn and play, and that policies should consider neighbourhood wealth and needs in planning and allocating resources to sustain and grow the urban forest.
R4 Municipality-Wide Urban Forest Management Plan	Develop and implement a comprehensive urban forest management plan for public and private property.	Yes - Low	Yes - Low	No	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	4	Low	No. Hamilton does not have a comprehensive city-wide management plan for public and private property; however one is being developed. Amalgamation legacy issues could contribute to this challenge. Four municipalities compared in this review have a management plan, though reported success of plan implementation is generally low.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
R5 Municipality-wide Urban Forestry Funding	Develop and maintain adequate funding to implement municipality-wide urban forest management plan.	Yes - Low	No	No	Yes - Performance Level Not Reported	No	2	Low	No. Hamilton's current program does not include specific mechanisms for funding to implement a city-wide urban forest management plan. This is consistent with three of the municipalities compared in this review that do not outline funding requirements/recommendations in their plans. For those that do include funding targets, reported performance is low.
R6 Municipal Urban Forestry Program Capacity	Maintain sufficient well-trained personnel and equipment – whether in-house or through contracted or volunteer services – to implement municipality-wide urban forest management plan.	Yes - Good	No	No	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	3	Good	No. As Hamilton currently does not have a comprehensive city-wide urban forest management plan, there are no policies or mechanisms to ensure resources are devoted to it. Three municipalities compared in this review include this target in their plan, though performance reporting lacks detail.
R7 Tree Establishment Planning and Implementation	Comprehensive and effective tree planting and establishment program is driven by canopy cover goals and other considerations according to plan.	Yes - Moderate	Yes - Moderate	Yes - Moderate	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Moderate	Yes. Hamilton's current policies and supporting guidance documents address/ support this target on public lands, which is consistent with municipalities compared in this review. Average performance reported by other municipalities is moderate.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
R8 Growing Site Suitability	All publicly owned trees are selected for each site and planted in conditions that are modified as needed to ensure survival and maximize current and future tree benefits.	Yes - Good	Yes - Moderate	No	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	4	Good	No. Hamilton's current policies do not explicitly address this target as there is no clear tree planting strategy to outline the City's approach to direct the goals and objectives of a city-wide tree planting program on public lands. This positions Hamilton behind most municipalities compared in this review; four of which include this target in their plan and generally indicate the performance level is good.
R9 Tree Protection Policy Development and Enforcement	The benefits derived from trees on public and private land are ensured by the enforcement of municipality-wide policies, including tree care "best management practices."	Yes - Moderate	Yes - Good	Yes - Low	No	Yes - Performance Level Not Reported	4	Moderate	Partial. Hamilton's current policies do not fully address this target. As noted, the injury or destruction of private trees is partially regulated in Hamilton, but is dictated by a number of by-laws that were in effect before amalgamation, and protection differs across the city. The Tree Protection Guidelines for Development Sites document is used by Planning to regulate/protect development around trees on private land. It should be noted that a lack of tools for tree protection has also been identified as a challenge for the City. Most of the municipalities compared in this review have tree protection by-laws and policies that are being implemented/ enforced.
R10 Maintenance of Publicly Owned, "Intensively" Managed Trees	All publicly owned, intensively (or individually) managed trees are well maintained for optimal health and condition in order to extend longevity and maximize current and future benefits.	Yes - Good	Yes - Good	Yes - Moderate	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Good	No. Hamilton's current policies do not address this target. As noted, forest health care appears to be undertaken on a reactionary basis in response to events that cause tree failure (e.g., ice storm, wind storm, EAB, etc.). The municipalities compared in this review address this target through ongoing forest management plans and programs, and performance levels reported on this metric are generally good.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
R11 Management of Publicly Owned Natural Areas	The ecological integrity of all publicly owned natural areas is protected and enhanced – while accommodating public use where appropriate.	Yes - Good	Yes - Moderate	No	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	4	Good	Yes. Hamilton's current policies address this target by protecting the ecological integrity of Core Areas and Linkages in the Official Plan. In this respect, Hamilton is in line with most of the municipalities compared in this review.
R12 Tree Risk Management	Comprehensive tree risk management program fully implemented, according to ANSI A300 (Part 9) "Tree Risk Assessment" standards, and supporting industry best management practices.	Yes - Moderate	Yes - Moderate	Yes - Moderate	No	No	3	Moderate	No. Hamilton's current policies do not address this target. Four municipalities compared in this review include this target in their plans and the performance level is generally rated as moderate. For example, Mississauga and New Westminster specifically identify goals of developing and adopting a comprehensive tree risk assessment protocol for municipal trees to be implemented by staff as part of tree inventory updates.
R13 Urban Wood and Green Waste Utilization	Create a closed system diverting all urban wood and green waste through reuse and recycling.	Yes - Moderate	No	Yes - Optimal	No	No	2	Good	Partial. Hamilton's current policies do not address this target which is consistent with most municipalities compared in this review. However, the City has a municipal mulch program available to the public as a means of reusing wood waste generated through Forestry operations. Of the two compared municipalities that address this target in their plans, reported performance is Moderate (London) and Optimal (New Westminster). New Westminster's details of implementation on this target are not described, but they indicate that waste biomass and mulch is utilized by the City to meet existing demand.

USDA TARGETS	KEY OBJECTIVE	LONDON	MISSISSAUGA	NEW WESTMINSTER	HALIFAX	NORTH OAKVILLE	TOTAL "YES" PER TARGET	AVERAGE PERFORMANCE LEVEL[1]	HAMILTON
R14 Native Vegetation	Preservation and enhancement of local natural biodiversity.	Yes - Good	Yes - Good	Yes - Low	Yes - Performance Level Not Reported	Yes - Performance Level Not Reported	5	Good	Yes. Hamilton's current policies address this target consistent with most of the municipalities compared in this review. Compliance with this target is addressed through policies related to the selection of native species for planting, management of natural areas and municipal practices/ guidance related to invasive species management.

Number of USDA Targets Included/Addressed:	25	22	18	24	19		7
Number of USDA Targets Not Included/Addressed:	3	6	10	4	9		21 (includes 6 targets identified as partially addressed)
Total USDA Targets with Optimal Performance	0	3	2	0	0		N/A
Total USDA Targets with Good Performance	13	5	4	0	0		N/A
Total USDA Targets with Moderate Performance	9	6	8	0	0		N/A
Total USDA Targets with Low Performance	3	4	4	0	0		N/A
Total USDA Targets with Performance Level Not Reported	0	4	0	24	19		N/A

Appendix F: Summary of Consultation Activities

Introduction

A key aspect in the development of the Urban Forest Strategy (UFS) is community engagement and outreach, to ensure that the UFS reflects the values, issues, and priorities of everyone who lives and works in Hamilton. The City of Hamilton provided several opportunities for stakeholder and public engagement in development of the Hamilton UFS. Internal and external stakeholder groups were engaged on two occasions to participate in workshops, an online survey was made available to the public, and representatives from the City UFS Working Group attended a variety of meetings to introduce, discuss, and share the UFS. Project updates and materials were made available online during the course of the project at https://www.hamilton.ca/city-initiatives/strategies-actions/urban-forest-strategy. This process engaged a wide range of groups and generated valuable comments that helped to prioritize the action items of the UFS report.

PHASE ONE

January to December 2018

Background Information Review

Data Collection and Analysis

PHASE TWO

May to November 2019

Public Engagement

Activities:

May 17, 2018 – Stage 1 Internal and External Stakeholder Workshops

May 29, 2018 – Public Open House

June – September 2018 – Online Survey

April 17, 2019 – Stage 2 Internal and External Stakeholder Workshops

June 5, 19, and 24, 2019 – Public Workshops

PHASE THREE

Fall 2019 to Fall 2020

Draft Report Preparation

PHASE FOUR

Fall 2020

Draft Report Review

Winter 2020-2021

Public Engagement

2021

Final Report and Council Approval

Summary of Consultation and Engagement Activities

STAGE ONE CONSULTATION

- Internal (City staff) Workshop #1 on May 17, 2018 – an internal staff working seminar
  - Attended by representatives from: Forestry and Horticulture; Community Planning; Development Planning; Public Health Services; Landscape Architecture Services; Planning and Engineering; Urban Renewal; Public Works Design; Hamilton Water; Parks and Cemeteries; Engineering Services; Risk Management
- External Stakeholders Workshop #1 on May 17, 2018 – provided context/objectives of the Hamilton Urban Forest Strategy and offered engagement activities
  - Attended by representatives from: Hamilton Conservation Authority; Conservation Halton; Hamilton Naturalist Club; Green Venture; Trees for Hamilton; Royal Botanical Gardens; Environment Hamilton; DeVos Tree Care; Keep Hamilton Clean and Green; International Village Business Improvement Area; Downtown Hamilton Business Improvement Area; Waterdown Business Improvement Area
- Public Open House on May 29, 2018 – poster boards were created to share important information with attendees, including the benefits of trees, project process information, what is an urban forest. Attendees were encouraged to share their thoughts on the urban forest and its management. Specific public engagement exercises included:
  - What do you value about Hamilton's urban forest?
  - What is your vision for the urban forest?
  - What can we do to improve the urban forest?
- Online survey available from May 15 to September 30, 2018
- Hamilton Aboriginal Advisory Committee Meeting on June 7, 2018
- Development Industry Liaison Group (DILG) Meeting on March 29, 2018
- Development Industry Liaison Group (DILG) Meeting on June 18, 2018
- Air and Technology Forum (Environment Hamilton/Trees Please) Meeting on October 3, 2018
- Hamilton Clean and Green Committee Meeting on November 20, 2018
- Hamilton Industrial Environmental Association (HIEA) on November 21, 2018
- Forestry Staff Meeting on January 16, 2019

STAGE TWO CONSULTATION

- Planning Committee presentation to Councillors on June 4, 2019 (public meeting)
- Meetings with individual (small groups of) Councillors to discuss draft report between April and May, 2019
  - Met with Councillors M. Wilson, C. Collins, E. Pauls, L. Ferguson, A. VanderBeek, J. Partridge, N. Nann's assistant, and J.P. Danko
- Internal (City staff) Workshop #2 on April 17, 2019 – an internal staff workshop to review the draft goals and actions
- Attended by representatives from: Forestry and Horticulture, City Planning, Public Health Services, Planning and Engineering, Public Works, Parks and Cemeteries, Engineering Services, Risk Management, and Development Planning

- External Stakeholders Workshop #2 on April 17, 2019 – review draft goals and actions
- Attended by representatives from: Hamilton Naturalists Club, Environment Hamilton, Green Venture, DeVos Tree Care, Royal Botanical Gardens, Keep Hamilton Green and Clean, International Village BIA, Downtown Hamilton BIA, Trees for Hamilton, and Hamilton Conservation Authority
- Public Workshops on June 5, 19, and 24, 2019 – received feedback on the draft vision statement, goals and actions
- External Stakeholders Meetings (agencies and NGOs) on July 4 and August 14, 2019
- DILG Committee Meeting on September 16, 2019
- Ward 13 (Dundas) Community Council meeting on September 17, 2019
- Hamilton Clean and Green Committee on October 22, 2019

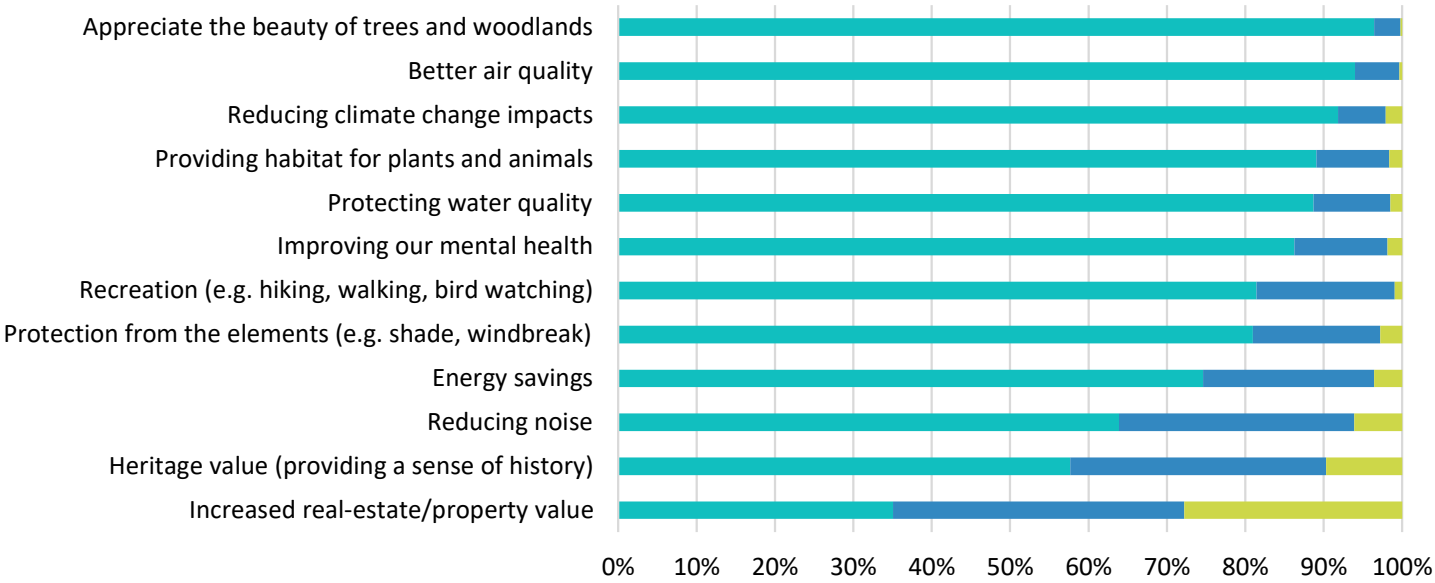
Online Survey

The purpose of this survey was to understand what residents know and value about Hamilton's urban forest. They were advised that their input would shape the overall vision for the urban forest, so that the completed strategy reflects the interests of Hamilton's citizens.

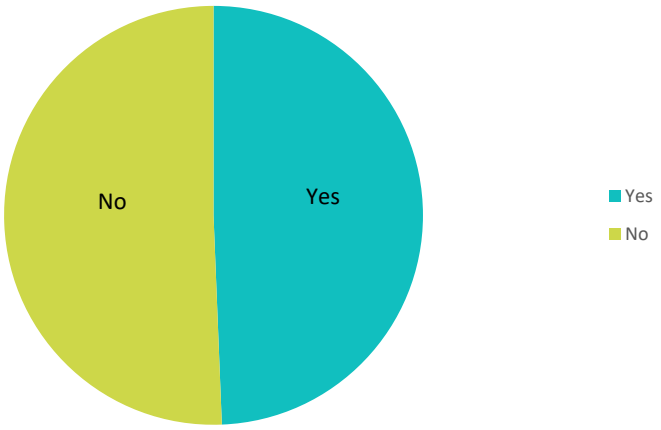
Compiled Results from Online Survey

The online survey received over 860 responses and identified some of the most important values of the urban forest. Below is a selection of questions and responses.

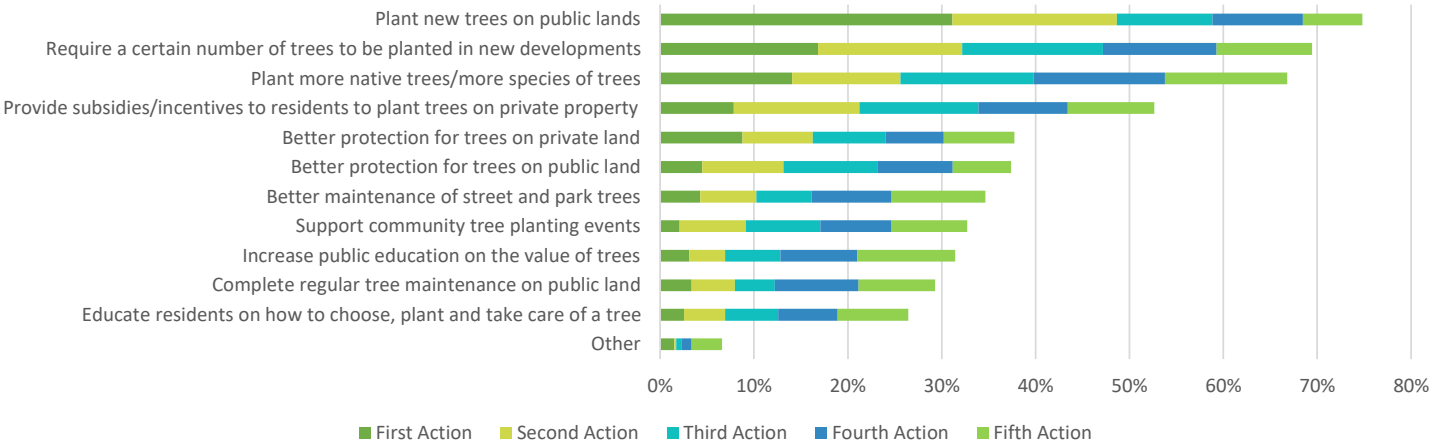
Question 1: What do you value most about trees and urban forests? Please rate the importance of each item listed below.



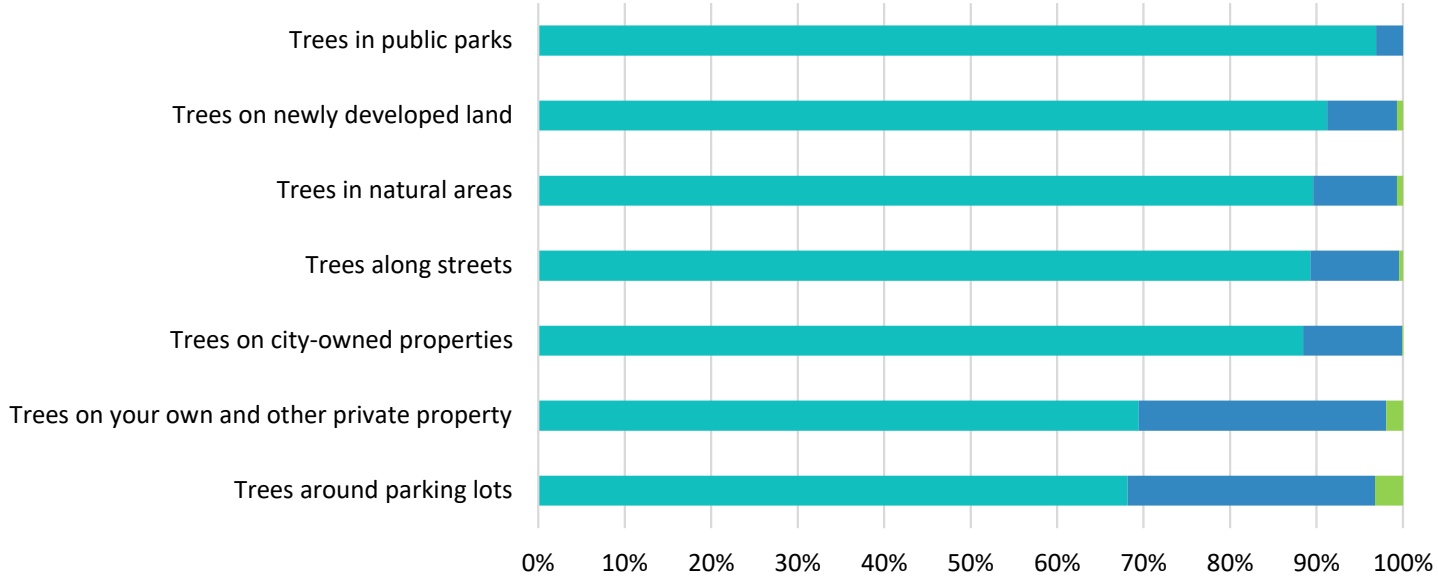
Question 2: In your opinion, does the City of Hamilton have a heathy urban forest?



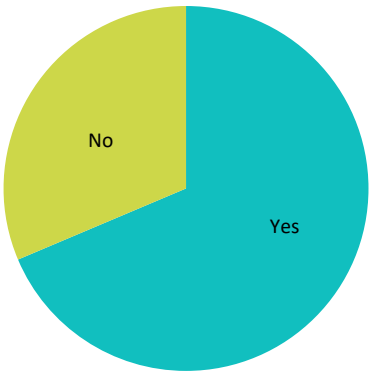
Question 3: The City wants to grow the urban forest by protecting existing trees and increasing the overall number of trees. From the list below, pick the actions that the City could take that you feel would have the greatest impact in growing the urban forest in Hamilton.



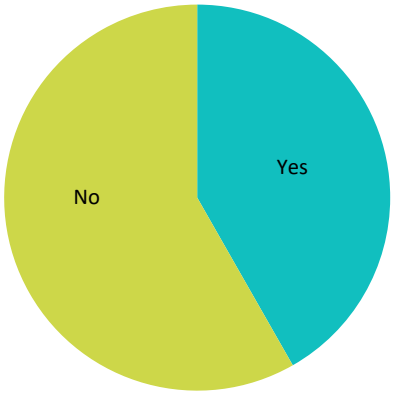
Question 5: How important is it to plant new trees and preserve and maintain existing trees in the following locations in Hamilton?



Question 6: Are you aware that the City of Hamilton has a free Street Tree Program?



Question 7: Are you aware of the community planting events that are hosted in partnership with the City of Hamilton?



2018 Public Open House Materials

City staff held a Public Information Centre on the evening of May 29, 2018 at the David Braley Centre in downtown Hamilton to introduce the Urban Forest Strategy project. Approximately 30 people attended the event. There were a number of panels which provided opportunities for resident input on values, vision, and recommended actions to improve the urban forest.

2018 Public Open House Summary

What is your vision for Hamilton's urban forest?

- Multi-layered, naturalized, native trees (5)
- Enhanced canopy in the downtown (3)
- Promote the Niagara Escarpment – it identifies Hamilton (2)
- Green neighbourhoods – lots of street and yard trees (2)
- Tree-lined streets to enhance active transportation (1)
- Right tree in right place (1)
- Pesticide free forest (1)
- Increase canopy goal to 50% (1)
- More trees at Bayfront Park (1)
- Trees of different ages (1)
- Reduce climate change impacts through tree planting (1)
- Include fruit trees in street tree program and integrate with not-for-profit food organizations (1)

What do you value about Hamilton's urban forest?

- Nature in the city (9)
- Shade and cooling (5)
- Better air quality (5)
- The escarpment and green, lush views, beauty (3)
- Calms traffic (2)
- Health benefits (2)
- Sense of place (1)

What can the City do to improve the urban forest?

- Education and awareness; promote stewardship (10)
- Develop and enforce private tree by-law (7)
- Improve methods for street tree planting (6)
    - Improve survival rates
- Site plan guidelines (5)
    - Mandate minimum tree coverage for parking lots, malls, etc.
    - Minimum soil volumes
    - New road cross sections must have full height for future tree canopy
- Urban design (4)
    - Less concrete, more trees
    - Plan space for trees
- Increase tree compensation requirements (4)
    - Every developer should be obliged to plant trees to get to the 30% target and replace trees they need to cut
    - Plant more based on the equivalent diameter at breast height (dbh) or more
    - Development of new subdivisions should include cost of CO2 reductions
    - Plant the LRT replacement trees now, not after construction.
- Strategic tree planting; prioritize tree planting (4)
- Parks management of invasive trees and naturalization (4)
- Tree management (3)
- School tree plantings (2)
- Miscellaneous
    - Subsidize backyard plantings in targeted areas (1)
    - Use inventory to inform urban forest strategy (1)
    - The urban forest strategy needs a Council champion (1)
    - Why is a strategy necessary? – just do it (1)

2019 Public Workshops Summary

Three public workshops were held on June 5 (Westmount Recreation Centre), June 19 (Huntington Park Recreation Centre), and June 24 (Bernie Morelli Recreation Centre). The purpose of the workshops was to gather input from residents on the draft Vision Statement, Goals and Actions for Hamilton's Urban Forest Strategy (UFS).

After a short staff presentation, participants were asked to break into small groups and review the goals and actions. Each group moved from table to table (World Café) until they had recorded their comments on all of the goals and actions.

The input received is shown below and the presentation from the workshops was posted online at: https://d3fpllf1m7bbt3.cloudfront.net/sites/default/files/media/browser/2019-08-12/urban-forest-strategy-public-workshop-june19-presentation.pdf.

Draft Vision Statement: *Hamilton's urban forest is resilient and sustainable. It contributes to the health and well-being of citizens and enhances the livability of the city. The City of Hamilton, and all residents value the urban forest as an essential shared asset that should be intentionally planned and maintained for all future generations.*

Comments:

- Support the health and livability of our city by maintaining a healthy, vibrant urban forest
- Hamilton is a Carolinian forest City
- Hamilton's urban forest is climate change ready
- This is not really a vision statement; more like value statements
- Include green infrastructure, climate change, public health aspects
- Include something about image, character of Hamilton – "green city", "trees are enduring assets", long-lived
- Check the tense of the vision statement
- Didn't like sustainable – old buzz word – over used
- Mention the increased financial value trees provide
- Like most visions, this is too complicated. I'd like a simpler vision that we can imagine
- The urban forest is vitally linked to the health of citizens
- Equity of canopy cover – all parts of the city have 30-35% canopy cover. For the second sentence, add something like, "with equal or greater tree canopy coverage throughout"
- Needs more umphhh! Vision should be a challenge that all Hamiltonians can get behind and be proud of
- Use climate change emergency to frame and prioritize funding for trees and rewilding
- Sustainable = dead; we need "regeneration"
- Hamilton's urban forest is essential to the health and well-being of citizens and the economy
- "…shared asset that should be intentionally and communally planned"
- Language needs more urgency
- Change "should " for "must"

General Comments on the Draft Goals and Actions:

- There needs to be more ecological/Natural Heritage System (NHS) recommendations – link urban forest to NHS. Currently the actions focus is on forestry– add more about natural areas and biodiversity
- Add an action to improve interdepartmental staff coordination
- Identify long and short-term priority goals
- Criteria & Indicators are not mentioned much but they are key to tracking our progress – make sure report clearly explains this
- Reduce the number of goals – concerned that 6 goals are too many. They need to be easy to remember. I suggest the 3 P's: Plan (communicate, analyze, monitor and adapt); Plant (climate change ready); and Protect (maintain)
- Green infrastructure should be emphasized more in the strategy with a link to the climate change emergency which was recently declared in Hamilton

- Compensation requirements are not good now – need to revise/rethink this
- Damage to public trees – educate staff who care for and plant trees – training
- Is 30% canopy cover target realistic?

GOAL 1: PLAN & ACT

- Title of goal may not be appropriate
- Need to be clear and specific – goal would be to achieve canopy cover
- Suggested to call the goal, "Prepare and Attack"

Draft Actions:

1. *Obtain spatial data for the entire municipality and use to determine canopy cover and identify planting areas.*
   - Use City's GIS to document data
   - Quantify the theoretical limit of tree canopy (e.g. 40%)
   - Consider differences between neighbourhoods in terms of proportion of rental housing
   - Rated as #1 priority under this goal
   - Ensure spatial data collection is neighbourhood specific (not ward)
2. *Use canopy cover data to develop land use targets for tree cover-integrate these targets in development processes.*
   - Also consider correct soil volume for planting (not just canopy cover)
   - Introducing canopy cover where there is none
   - Priority areas –industrial core – improve canopy here
   - No timeline given to achieve the canopy cover target
   - Incorporate land use targets for tree cover into the Official Plan and secondary plans
   - Rated as #2 to #3 priority under this goal
   - Shouldn't just be about land use, but land availability (greenfield vs. infill)
   - Just trees or does it include other vegetation?
   - Base canopy coverage requirements on intended land use
   - Higher requirement for tree cover for new development
   - Restore "brownfields" (contaminated areas)
3. *Forestry staff should actively participate in policy, plan and guidelines review to ensure Forestry goals are included.*
   - Involvement of Forestry department in plan review, technical expertise - do they have the capacity for this new role?
   - Set up advisory committee (Hamilton Naturalists' Club, McMaster, experts in the field)
   - Natural heritage staff should also be included
   - Use term "regularly" participate instead of "actively"
   - Increase interdepartmental communication

- This action will require an assessment of resources available – money, people, time
- Non-profit organizations should also participate
- More public consultation in policy, plans, and guidelines
- Rated #5 in priority for this goal

4. *Develop urban forestry 'best practices' to share with City departments whose activities affect the urban forest.*
   - Carolinian forest system as best practice, support initiatives to reintroduce species (e.g. American Chestnut)
   - Co-ordinated standards across City departments – standards should align (e.g. site plan guidelines align with Forestry specifications)
   - Update guidelines regularly (some are very out of date) – link site plan guidelines to Forestry standards and as Forestry updates them, the link will automatically take clients to these, so they are always current and you don't have to constantly update site plan guidelines
   - Rated #4 in priority for this goal.
   - Add "…share with city departments and private contractors" that the City hires
   - Review best practices every 5-10 years
   - Urban silviculture best practices
5. *Update and maintain an inventory of street trees. Include an assessment of tree condition/risk.*
   - Private tree inventory (include all trees in inventory, not just street trees)
   - Review NY City street tree map, tree care activities, benchmark for other cities for similar programs
   - This overlaps with other actions – could combine
   - Inventory of natural lands is more important than backyards
   - Tying all of this data together - temperature, air quality
   - Inventory more than just street trees
   - Idea of how many trees in an area and what the species – don't need precise data on every tree –focus on actions 1 and 2 instead

Are there any other actions you would include under the Goal, "Plan and Act"?

- Risk management hasn't been discussed (hazard prevention)
- Reduce pavement islands, replace infrastructure (hardscape) with plantings
- Landscaping incentive to replace tree canopy
- Increase width of landscape strip to allow tree/shrub planting
- More native trees in public spaces (less annuals and non-natives)
- Development needs to consider trees (need to protect trees; design and build around)
- Several actions are overlapping with other goals and actions
- Include climate change as part of goal
- Legislation that can aid in protection of greenspace
- Protection goal should be included in Plan & Act, as they are related
- Incorporate enforcement into Official Plan

- Strategy to introduce more species – assisted migration
- Incorporate policies into Zoning By-law
- Don't over-plan. Just do it. Don't need to have exact data – just trends.
- Add a goal to revise Tree Protection Guidelines (update and strengthen) and revise implementation processes (monitor to ensure Tree Protection Plans are being implemented properly).
- Create a local research industry
- Involvement of First Nations in planning
- Prioritize Forestry and Planning collaboration
- Encourage vertical green spaces in urban areas, green roofs, solar panels
- 1 to 1 compensation policy not good –have to plant what is taken away, compensate for true value of what is taken away
- Keep this work in the media; keep communication constant
- Include tree planting in the larger vision of the City
- Include ways to incentivize tree planting for developers
- Offer alternatives to planting street trees
- Other committees that report to Council on trees – share with other groups (Conservation Authorities, RBG, non-profits)
- Educating the public and elected officials – understand the importance
- Should have cost analysis of mature trees being removed
- Include healthy urban forest in strategy (proper maintenance)
- Have a plan to give out trees
- Provide tree list – size, shape, how large they grow, make it easier for people to understand
- City should offer assistance with trimming and tree care
- Revamp street tree process – too complicated now
- Climate emergency has not been mentioned; City has declared a climate emergency; we MUST take action.

GOAL 2: PROTECT

Draft Actions:

1. *Implement a private tree by-law for Hamilton's urban area that includes individual trees on private property.*
    - This will be a tough political sell
    - Would have to do intensive public engagement
    - We have to do this, regardless of attitudes
    - We need to prioritize trees
    - Good idea, but there will be a lot of resistance
    - Not a good idea – creates red tape for homeowners- cost for homeowners
    - Needs to be education for homeowners
    - Education is important
    - Tax rebate/similar incentive for planting trees

- Private developers should be held to a higher standard
- What are incentives to landowners to maintain woodlots – this is better than a by-law
- Need education to change views, so people don't think of trees as impediments
- Significant fines for careless removal of large trees – removing without good cause
- Need to make sure people can use their woodlots (firewood, etc.)
- People don't want to be told what to do
- Penalty would need to be sufficiently high
- Yes, great idea – Tree Protection Plans for developers are not adequate
- By-law should not apply to non-native trees
- Implement private by-law for priority areas only, instead of the whole City of Hamilton
- Can it be enforced?
- Take down diseased trees only
- Trees crossing property lines – protect overhang
- Need some flexibility – incentive is better to protect a tree
- How effective will it be?
- How much will it cost to pass and enforce?
- Protect all woodlands City wide
- City should better protect public trees and follow their goals and policies
- Provide incentives for canopy cover and place monetary value on canopy cover – put it into people's taxes
- Higher taxes if you have less greenspace – not everyone can take care of greenspace – so don't penalize
- Prevent people from cutting before new by-law is passed – see what other municipalities have done
- Tenants should have a say on trees in their amenity areas
- Rated as priority #1 for this goal

2. *Collect data to identify the root causes of change/loss in the urban tree canopy.*
   - Data is important, but action is also important.
   - Root cause is development – don't need intensive data to determine cause
   - Need good baseline data to compare
   - Use citizen science – this can provide a lot of the data
   - Look at deer populations – too many can cause damage to trees and reduce diversity
   - Use information available on regional/provincial/national scale – access these sources
   - Ask for data from private tree companies
   - Yes, this is of value
   - Need to capture aggregate level – change in specific areas
   - Canopy cover is only one measure – trees species are another measure – need to factor in quality - composition of native vs. non-native species.

- Could do test areas for change detection
- Awareness of insects, fungus, and plant non-uniformity
- Survey through tax slips, log in to website for easy access
- Use data from boulevard parking permits to monitor tree loss (trees removed for parking space)
- Rated as #3 for this goal.

3. *Require a calculation of canopy balance (leaf area of trees removed vs. proposed planting) as part of arborist reports for development applications.*
   - Juvenile trees do not compensate fully for mature trees
   - Yes, we should require this
   - Try to meet canopy goal in new developments (30-35%)
   - New developments have to do more to protect existing trees
   - Hard to calculate leaf area for new trees – will depend on the health of the tree – don't know if it will be accurate
   - Another way to measure is trunk size
   - 3D scanning technology is available
   - Reduces a 3D figure to 2D – what about height? Overlooks the growth habits of different species
   - Can create a standard tree value measurement based on various criteria
   - Goal is to increase canopy cover-more juvenile trees are needed to offset removal of single large tree
   - Yes, this is needed. Should be aiming to create equal replacement coverage – should aim for a canopy balance within a short term (3-5 years)
   - Should also be done for park areas/new parks. Tree planting should be done immediately, not after rest of development has been built.
   - Needs to be something more in place to ensure that City standards are being met – extra site checks.
   - Use software to determine canopy balance
   - Specify length of time
   - Calculate monetary value cash-in-lieu for trees
   - Add "to ensure appropriate compensation" at end of action
   - Expand required canopy compensation to include nearby properties
   - Agree with this action
   - Developer should replace with larger tree stock (caliper) rather than small whips
   - Rated as #2 for this goal.

4. *Report on canopy balance as a performance indicator for Hamilton.*
   - How often should we report on this – every 5 years?
   - Trees grow very slowly but destruction of tree is very fast
   - Track how many street trees are dying each year and then find out why
   - Is there healthy vertical structure? Need to look at all levels of trees from ground cover to

middle.

- Need to keep measurement parameters the same over time
- i-Tree Eco is a good indicator – should calculate financial value as indicator
- Suggested reporting on canopy coverage instead
- Key Performance Indicators (KPIs) is important – need to break it down by area – not just overall.
- Pines are important but small footprint – can skew the numbers
- Could put this action under "monitor"
- Define "canopy balance" so it is understandable.
- Total canopy cover needs to be revised – include understory – consider the balance of layers in forest.
- Rated as #4 priority for this goal.

Are there any other actions that you would add under the Goal, Protect?

- Plans must be in place to prevent developers from clear-cutting woodlots prior to applications
- Training for City staff/contractors cutting grass to prevent damage to trees (i.e. use of weed whackers), no mulch volcanos.
- Use tree guards or mulch for street trees
- Need to develop genetic protection for native tree species (genetic modification for disease resistance)
- Need to cultivate the soil under street trees to ensure their health (No - disagree) – need good quality soil.
- Designate significant trees as heritage trees under Ontario Heritage Act
- Stronger regulations for developers need to be put in place
- Tax incentives for landowners to protect heritage trees/old growth trees
- Need to preserve environment for wildlife – also consider shrubs and supporting plants.
- Actually enforce by-laws (e.g. illegal parking pads)
- Prioritize certain protection areas of the city (e.g. Stoney Creek, waterfront, escarpment lands)
- Prioritize areas with tree connectivity (e.g. near conservation areas)
- Consistent policies across all areas of the city and consistent implementation
- Explore zoning bonuses as incentive to protect trees
- Protect native species

GOAL 3: PLANT

<u>Draft Actions:</u>

1. *Identify the number of trees required to be planted in Hamilton over the next 20 years to meet canopy cover target and increase funding for tree planting to meet target.*

- Separate public and private plantings and track using GIS
  - Suggest 30 years – gives more time to plan/budget
  - Develop planting cycle, showing the number of trees to be planted per year
  - Encourage naturalized plantings in public areas

- Higher canopy cover target of 40% - look beyond canopy, gaps are good and natural part of forest

2. *Reduce the use of maple species in street tree planting.*
   - Maples will start dying, so reduce use by 2030
   - Still allow hard maples
   - Allow native maples
   - Change wording to focus on including biodiversity
   - Combine this action with #3 –they are similar
   - Rephrase this action in positive manner – increase diversity of tree species planted
3. *Review planting lists periodically to ensure species diversity.*
   - Consider planting different species based on warming climate (Carolinian trees, assisted migration)
   - Select species that best sustain wildlife, insects, and biodiversity
   - Include fruit trees
   - Plant trees with symbiotic relationships that grow and work together
   - Plant species resistant to disease
   - Native trees only?
   - Need trees that are climate change ready (Carolinian forest species)
   - Plant variety of trees to reduce/avoid conflicts with solar panels (e.g. Kentucky Coffee Tree)
   - Focus on Carolinian forest species, climate change impacts
   - Need statistics on mortality rates of trees – which ones are doing well – add these to planting lists
   - Consider the forecasted land use when selecting species to plant at a site
   - Mitigate flooding issues and soil erosion, support soil remediation
   - Use species appropriate for soil conditions and geographic location
   - Mention using climate-adapted species
   - Fruit trees
   - More native species, locally rare species where possible, as this is better for biodiversity
   - Avoid species like Gingko, which are biological deserts; no insects, no birds like them
   - Try to plant trees that will have large canopy, instead of Tree Lilacs, lollipop trees
   - Collect climate change data and use to determine what tree species will grow best
4. *Use standard specifications in all City of Hamilton plantings.*
   - Also include standards for after-planting care (e.g. watering)
   - Include soil health, minimum soil volumes
   - Silva cells
   - Consider complete ecosystem
   - Should focus on soil zone – different trees on the Mountain compared with downtown because soil differs (soil health)

- Bushes as buffers to allow tree growth
- Dig deeper holes for trees – public trees are currently planted too shallow
- Consider wind impacts
- Recognize the different areas of Hamilton (soils, microclimate)
- Require minimum canopy cover in zoning
- Co-ordinate with city engineering and landscape architects, urban designers
- Make standards flexible/adaptable
- Have standards for Low Impact Development

5. *Examine tree planting budgets and programs to identify how to plant more trees over the next 5 years.*
   - Add tree planting budget to permit planting with community organizations
   - Suggest 10 years
   - How do we align budgets with non-profits?
   - Government to give incentives for planting on private property; many residents may not be planting because of cost
   - Allow landowners the option to plant their own public tree on public land so they don't have to wait two years for City to plant – speeds up trees planted
   - Have public and private tree pick-up days. People can submit order for trees on line and pick up to plant themselves
   - Can make use of trees growing in hedgerows, alleyways – transplant volunteer seedlings
6. *Prioritize tree planting locations, outreach and partnership efforts in different land uses.*
   - Distribute tree planting across the city, instead of prioritizing industrial areas
   - Work with neighbourhood groups to identify priority areas for planting
   - Prioritize storm water management areas, areas prone to erosion
   - Remove concrete for tree planting
   - Focus on industrial areas, schools, woodlots and older subdivisions in need of renewal, parks, and arboretums
   - Partnerships are really important part of this action
   - Use Code Red to consider social equity when selecting planting locations
   - Focus on industrial areas to improve air quality
   - Consider soil drainage and quality
   - Consider areas with low canopy and redeveloping areas
   - Increase buffers around natural areas and plant in the buffers
   - Plant in unused park spaces, naturalize, re-wilding
   - City could consider silviculture on vacant lands (e.g. Scotland – Sterling, Glasgow - have examples of this)
7. *Identify available planting space for street trees. Prioritize planting on higher quality sites and in areas of low and mature canopy.*
   - Prioritize planting along main streets as tourist attractions
   - Urban design – planting strips

- Suggest separating the two sentences into separate actions
- Provide tree identification information to help residents select which street tree they want – showing size, leaf, growth form, and best planting conditions (soil, slope)
- Plant trees on road allowance when a house sells and doesn't have a street tree – way to get more public trees planted
- Unsure what "higher quality" means
- Identify planting space on private lands too
- Fill up parks with trees
- Planting along highways (e.g. the Linc)
- Mandate/require street tree plantings
- Establish demonstration forests, can use different themes (e.g. Carolinian trees) like the Millenium Forest in Vineland, Ontario
- Plant as soon as a tree is removed. Can even plant before trees are removed, in advance of work, as trees take time to grow

Are there any other actions that you would add under the goal, Plant?

- Higher ratio for compensation trees (for private trees, it is currently 1:1)
- Rewarding people for planting (tax rebate)
- Free tree program – make it easier to go online to order tree to plant, provide better information on trees
- Incentives for private tree plantings
- Educate on the economic value of trees and use as an incentive to plant – carbon value of trees
- Developments – need to plant larger trees, variety of sizes and calipers, don't strip topsoil
- Improve planting practices and techniques – train private contractors, use better specimens/tree stock, no volcano mulching, no shallow planting holes, no cages
- Transplanting trees to other sites instead of removal
- Plant in rain gardens
- Plant something other than trees, if there is no room (shrubs, perennials)
- Look at Carolinian forest as roadmap for species diversity
- Plant near railways
- Focus on businesses and business parks Rural area has greatest potential
- Plant to enhance wildlife corridors
- Stagger the age/size of trees when planting
- Communication between city and developer to ensure that appropriate tree cover is being planted
- Use other vegetation in areas where no room for trees
- How does this relate to brownfields? Don't just look at high quality areas
- Don't just assume we can plant to replace; use proper replacement rate
- Volunteer planters with high schools
- Industrial planting plan
- Student jobs to plant trees

- Larger planting strips on landscape plans
- Conifers as street trees
- Plant in older subdivisions
- Give regular update on number of trees planted annually
- Larger soil volumes in parking lots
- Shift funding from annual floral plantings and spend on trees
- Tree giveaways for private property – addresses equity
- Provide free private tree for landowners who lose trees in back yard to Emerald Ash Borer
- Plant for future removal of trees that you know will be removed
- More native trees
- Consider security and safety concerns with more forest/vegetation cover
- Need to adapt for future climate
- Innovative technologies for street plantings (silva cells)

GOAL 4: MAINTAIN

Draft Actions

1. *Update and actively maintain a street tree inventory*
   - It is too limiting to focus on street trees; include private backyard trees
   - Include age diversity in data gathered
   - This also relates to Goal 5 – Communicate – online mapping tool
   - Should include all trees (public and private)
   - Need access to street tree inventory online
   - Use database also for education and give residents the ability to report on maintenance issues, self-report private tree plantings to add to database
   - Use Google drone; use local drone enthusiasts
   - Use the public and neighbourhood associations to help with data collection
   - Back yard tree inventory – ask people to add to the database
2. *Focus on the removal of 'poor, dead, or dying' street trees*
   - Add "and replacement" to this action – make sure you are replacing the trees removed
   - Prioritize health care for mature trees
   - What about endangered species that use dead trees as habitat?
   - Yes, this is important
   - Consider keeping dead trees where safe (open space)
   - Succession plantings
3. *Develop an invasive species management policy for Hamilton.*
   - Call it an "Invasive species plan/strategy" – use stronger language
   - Educate on invasive plants
   - Ban the sale of invasive (e.g. honeysuckle) or provide incentives to plant native species through

education

- Distinguish between non-native and invasive species
- Combine this action with "Examine opportunities to control invasive species under property standards regulations"
- Focus on removing invasives in ravines and replanting with natives – don't just focus on parks
- Be aggressive/proactive in re-introducing impacted species (e.g. Butternut, American chestnut, ash)
- Don't completely rule out non-native species – they have a role to play
- Include limits on aggressive, invasive species though

4. *Work with Conservation Authorities to prioritize areas where forests will be managed to improve their health.*
   - Should focus on the City, and not Conservation Authority owned lands
   - Also include other organizations (e.g. Hamilton Naturalists' Club), farmers, RBG
   - Include Forestry staff in woodland management
   - Management of Norway Maple which is dominant in parts of Niagara Escarpment – remove selectively and replant with native species
   - Phasing plan for the removal of Norway Maple
   - Include connected woodland system – tree corridor, wildlife corridor
5. *Examine opportunities to control invasive species under property standards regulations (e.g. Yard Maintenance By-law)*
   - Eliminate by-laws that attack native species (i.e. property standards)
   - Public-private partnerships between city and residents – how to control invasive plants and where to take them
   - Education of school children on impacts of invasive plants
   - Renters vs. property owners – education
   - Property stewards
6. *Develop a policy on how the City will monitor and manage forest health threats in Hamilton.*
   - To do this, it must occur with a private tree by-law
   - Not just health threats, policy should be stronger to avoid clear-cutting – give value to Tree Protection Plan
   - Phasing plan to ensure canopy and diversity
   - Make policy for tree replacement/compensation
   - Annual monitoring and education
   - Yes, this is important
   - Climate change impacts on forest threats
   - Severe weather should be included
   - Does Forestry keep knowledge up to date with current standards?
   - Need entomology/pathology data to see which diseases are coming our way
7. *Develop service standards for hazard trees and other forestry service requests.*
   - Service standards for mature and existing trees related to soil volumes

- Targeted risk assessments rather than indiscriminate maintenance
- More focus on maintenance, rather than data collection

Are there any other actions that you would add under the goal, "Maintain"?

- Citizen science – use an app for data collection
- Reduce competing processes (e.g. composting by City)
- Resident to enter data on their trees using online mapping (i.e. tree needs pruning, disease problems)
- Rely on neighbourhood groups to help maintain
- Licence arborists locally
- Provide incentives to residents to maintain trees (e.g. free leaf bags in the fall)
- Develop a citizen tool kit – how to maintain their trees
- Leaf-raking angels – similar to snow angels to help others with maintaining trees
- Avoid penalizing seniors for poorly maintained trees
- Provide information on new tree care - watering, wood chip mulch annually
- Neighbourhood ambassador for trees
- Adopt an asset management approach to urban trees
- Forestry-specific climate change strategy
- Students who cut grass for City need to be better trained
- Park stewards to protect trees in park
- Doing a good job with private lands – need to do a better job with public lands, schools, and parks
- Forestry to audit/follow up with private contractors who maintain and plant trees to ensure it is being done correctly
- Hire certified arborists to care for city trees
- Remove tree grates so they do not damage tree
- Focus on succession planting – before trees die, plant more
- Licenced arborists
- Increase biodiversity
- People should share the maintenance
- Expand understory for wild pollinators

GOAL 5: COMMUNICATE

- Suggest re-wording goal to "Community Engagement"
- Who is receiving audience for communication? City staff or public? Who is communication targeting?

Draft Actions

1. *Complete a detailed study to identify the attitudes towards trees and other opportunities and barriers to growing the urban forest.*
   - Important to know attitudes, but we probably already know this, so not a high priority action

- Agree with this action – educating homeowners and residents, involve schools (interactive)
- Want results instead of more study; action is necessary
- Complete a communication plan instead
- Do not prioritize this action – rely on existing evidence – we already know about attitudes
- This action relates to action 2 below - combine them into one action
- Don't use this study as an excuse for inaction - do concurrent with other work
- What is time frame for study?
- Continue to communicate easy messages/attitudes (children)
- Move forward based on existing data (literature review)
- Engage people instead of study – need to ensure public is involved
- Focus on values
- Diverse attitudes haven't been captured; think study needs to be done

2. *Use the results of the study to prepare a targeted outreach strategy.*
   - Use media to get message out on how to care for trees; message should be something people can relate to
   - Use available resources, ad space ("At Your Service") for regular and ongoing public education
   - Highlight the very specific monetary, pollution, and temperature benefits of trees
   - In-reach strategy for city staff, Committee of Adjustment, and education of applicants
   - Delete the first action and just keep this one – create a communication plan
   - Problem solving – why are there negative attitudes?
3. *Build online mapping tools to communicate the location and condition of Hamilton's urban forest, based on available spatial data.*
   - Engage with Mohawk College and McMaster students to help (if so, be sure to compensate students or allow to use toward their thesis)
   - Many online tools are available
   - City should be custodian of data
   - City should provide non-profits with incentives to create/contribute to data
   - Environment Hamilton/Trees Please online tool is very useful
   - Should be accessible for everyone
   - Mapping should be multi-layered – include different departments, data from multiple sources
   - Allow people to enter data on where they plant trees
   - Like this action
   - Agree with this action
   - Ensure that data is separated into neighbourhoods and wards
   - Keep data up to date
   - Don't spend a lot of budget on mapping – put more effort into planting (on the ground)
   - City should maintain database, but include data from non-profits
   - Easy for everyone to view; include data on different years

- Include what is being planned (parks, development applications)

4. *Work with local non-profits to explore applications in citizen science that will support the Urban Forest Strategy goals.*
   - This is a very important part of this goal
   - Expand the existing citizen science inventories
   - Involve schools, Hamilton Naturalists' Club, Green Venture, Ancaster Horticultural Society, Environment Hamilton, McMaster, corporate sponsorship, Paul O'Hara
   - NGOs can help with citizen science and outreach
   - Ensure open communication between city and NGOs
   - Communication with non-profits
   - Continue to work with non-profits
   - Increasing grants to non-profits (efficient use of money)
   - Collaborate with neighbourhood associations and school boards

Are there any other actions that you would add under the goal, "Communicate"?

- Provide tree selection resources to the public to suit their needs – provide advice
- Put write up on available street trees on web site; include photos
- City incentives to plant/own/care for tree – make information easy to find
- Drop off street tree program flyers to houses which could accommodate a tree on the city right-of-way on their front lawn
- Citizen tree planting day
- Accountability
- Allocate budget for communication and engagement
- Educate people on how they can help with invasive species
- Partner with RBG and Hamilton Art Gallery to use pruned/removed trees to communicate benefits of trees to the broader community
- More use of social media; need to communicate through a variety of platforms
- Community volunteer works days to ensure tree planting or maintenance occurs
- Keep communication simple
- Information packages should be provided on how to implement the strategy (through planning applications, building permits)
- "Just do it" – less study and more action; plant more trees
- Green Venture – backyard tree program (city could provide funding source)
- Use climate change emergency to communicate benefits of trees to residents
- Build a culture of trees and forestry appreciation
- Tree festival (nature education like water festival)
- Video of famous Hamiltonians planting trees/caring for trees
- Connection with climate emergency needs to be made
- Make it easy to contact the City - have central phone number and online database for trees

- Recognition in neighbourhoods/wards for trees (similar to Monarch awards)
- Policy/programs to communicate with landlords – holding them accountable for canopy cover and encourage native species
- City needs public declaration to be committed to urban forest strategy (need advocates, champions to indicate we are serious)
- Neighbourhood associations and wards need to have more autonomy in planting
- Create partnerships with other agencies (e.g. Metrolinx)
- Ontario Woodlot Association does educational activities – can work with them on education
- Linking with community benefits organization
- Art installation at Supercrawl that reinforces attitudes toward trees
- Communicate through other City programs
- Provide notice in tax assessments about incentives to plant trees on property
- Offer assistance to people for cost of trees (low income)
- Communicate more online about invasive species, health of trees, service/maintenance requests
- Communicate using variety of methods (e.g. bus shelters, buses, online, popup events, flyers)
- Bring more stakeholders to the conversation (e.g. private tree companies, developers) – meet periodically to increase communication

GOAL 6: MONITOR & ADAPT

- Suggest calling this goal, "Monitor and maintain/improve"
- Spend more on planting rather than monitoring
- Call this "Monitor and Adjust", because constantly evolving
- Suggest calling it "Monitor and Achieve"
- Too many actions under this goal – reduce – some overlap
- Actions are heavy on monitoring and not on adapting

Draft Actions

1. *Monitor changes in canopy cover*
   - Monitor how the percentage of non-native trees are changing
   - Say we will monitor changes every 5 years
   - Aerial and trunk analysis
   - Differentiate between each of the spaces and determine the impact of changes – natural forest compared to man-made plantings (eg. Parks, school yards, roads)
   - Ranked as Priority #1 under this goal
   - Should be reviewed with every term of Council (4 years)
2. *Report to Council on the best options for a forestry data management system*
   - Communal database to keep updated information
3. *Update the Urban Forest Strategy every 10 years or in response to significant environmental change*
   - Review more frequently – every 5 years (3)

- Multiple strategies for private trees, street trees, public places, ravines – separate more within the UFS (make the distinction between different components of the urban forest in the strategy)
- Like 10-year time period – appropriate for trees which are long-lived
- Use a 40-50-year planning horizon
- Track positive growth only
- Link this action with action #6

4. *Use available tools (i-Tree) to assess change in canopy cover every 2 years*
   - Report on an annual basis
   - Report every 10 years
   - Doing studies to project outwards – how many trees are required to meet canopy target?
   - The public can help to determine existing canopy (neighbourhood associations)
5. *Monitor change using Urban Forest Strategy criteria and indicators*
   - Suggested indicators – trees planted, spending on public trees, track number of by-law complaints and violations on an ongoing basis as UFS is implemented
   - Determine which tree species can withstand different weather conditions
6. *Using criteria and indicators, report to Council on progress toward meeting urban forest goals (every 5 years)*
   - Suggest reporting annually or every 2 years to Council (2)
   - Provide updates every 5-10 years
   - City must seriously listen to information and feedback provided
7. *Select three corporate indicators to report on progress toward urban forest goals*
   - Don't like word "corporate" – re-word this action
   - Felt this was the same as criteria and indicators (action #6 above) – perhaps delete this action, combine with #6, or re-word so easier to understand
   - Did not understand "corporate indicators" – rephrase this action
   - Use easy graphics to see updates to performance indicators
   - Provide top 5 priority indicators and adapt to Hamilton (difficult to understand without knowing indicators)
   - Recommend using canopy cover, socio-economic distribution/equity.
8. *Monitor street tree mortality using data management system to determine if planting program is*

effective.


URBAN FOREST STRATEGY
If a tree falls in the forest, do you care?
WE THINK SO.
WELCOME
TO THE URBAN FOREST STRATEGY PUBLIC WORKSHOP
THE CITY OF HAMILTON IS PREPARING AN URBAN FOREST STRATEGY (UFS).
Help us to create the goals, actions and vision for the Strategy. Your insight will guide the management of the city's urban forest. Your comments will be considered in the draft report which will be available for comment this September.
At tonight's public workshop you will:
• learn more about the current condition of Hamilton's urban forest.
• provide your input on the draft vision, goals and actions.
WE NEED TO HEAR FROM YOU!
• Visit the website at www.hamilton.ca/urbanforeststrategy
• Fill out a comment sheet
NEED MORE INFORMATION?
All materials will be available on the website.
Your input is valuable to us. We appreciate your contribution to maintaining and enhancing a healthy urban forest.
JAN to DEC 2018
PHASE 1
Data Collection and Analysis
Background Information Review
PHASE 2
Public Engagement
MAY to DEC 2018
PHASE 3
Prepare Draft Vision, Goals & Actions
SPRING 2019
Public Engagement
PHASE 4
Draft UFS Report for Review
SEPT 2019
DEC 2019
Final UFS Report
Council Approval
URBAN FOREST STRATEGY
PLANNING & ECONOMIC DEVELOPMENT
DEVELOPMENT PLANNING, HERITAGE AND DESIGN
If you have any questions or would like more information,
PLEASE CONTACT
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Natural Heritage Planner
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Hamilton

URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

CURRENT CONDITION OF HAMILTON'S URBAN FOREST

HERE'S WHAT WE ARE SEEING

Based on existing and new data collected in 2018

1. BENEFITS OF THE URBAN FOREST

Random sample data was collected using iTree Eco in Hamilton's urban forest during 2018.

WHAT IS iTREE ECO?

iTree Eco is a software suite from the USDA Forest Service that stores and analyses baseline data and calculates the economic value of trees.

The value of the services that Hamilton's urban trees provide has been calculated:

- Structural value (or estimated cost to replace trees) within Hamilton's urban forest:
  $2.13 BILLION
- Pollution Removal:
  393 METRIC TONS/YEAR ($1.59 MILLION/YEAR) - calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter less than 2.5 microns
- Stormwater Management - avoided runoff:
  815 THOUSAND CUBIC METRES/YEAR (VALUE OF $1.896 MILLION/YEAR)
- Building Energy Savings:
  $3.63 MILLION/YEAR
- Carbon Storage:
  395.1 THOUSAND METRIC TONS ($45.4 MILLION)
- Carbon Sequestration:
  13.41 THOUSAND METRIC TONS ($1.54 MILLION/YEAR)

URBAN FOREST STRATEGY
PLANNING & ECONOMIC DEVELOPMENT

URBAN FOREST STRATEGY

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CURRENT CONDITION OF HAMILTON'S URBAN FOREST

2. CANOPY COVER

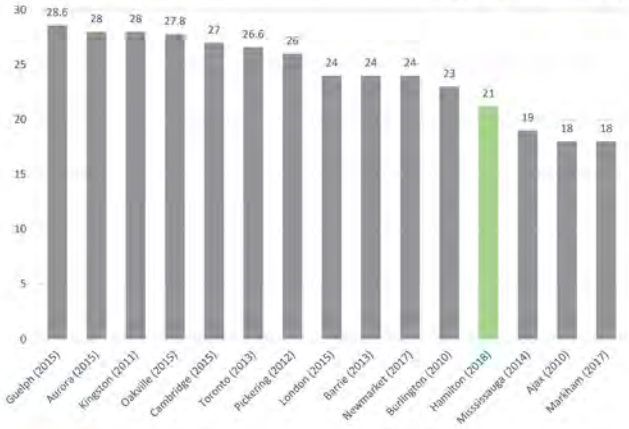
Canopy cover is the area of leaves and branches (tree crowns) measured, when viewed from above, as a proportion of total land area. It is usually shown as the percent of total ground area covered by tree crowns.

- The Urban Hamilton Official Plan sets a canopy cover target of 30% for the City's urban area. Forestry has a 35% canopy cover target.
- The current canopy cover in Hamilton is 21.2% (based on 2018 data).

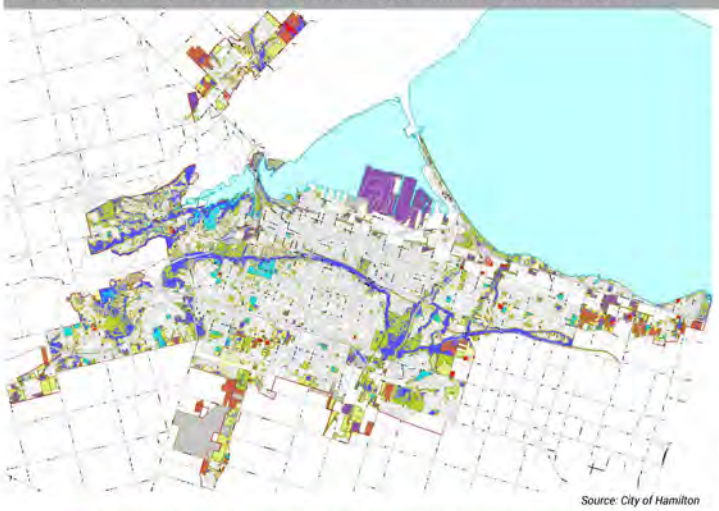
Hamilton's canopy cover compared to other municipalities in Ontario is shown in this graph.

PERCENT (%) OF TREE COVER - ONTARIO MUNICIPALITIES

Source: Bioforest/KBM/Dillon Consulting



DISTRIBUTION OF CANOPY COVER ACROSS HAMILTON'S URBAN AREA



Source: City of Hamilton

This map shows forest patches 0.5 acres or more in size in blue.

TRENDS:

- Hamilton's urban forest canopy cover is unevenly distributed across different land uses within the urban area.
- About 40% of the urban forest cover is found in City of Hamilton parks, golf courses, and the Hamilton Conservation Authority lands and the Niagara Escarpment.
- 27% of urban forest canopy cover is located within residential areas.
- A more even and continuous forest cover across the city would maximize the benefits that urban forests provide.

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DEVELOPMENT PLANNING, HERITAGE AND DESIGN

Hamilton

URBAN FOREST STRATEGY

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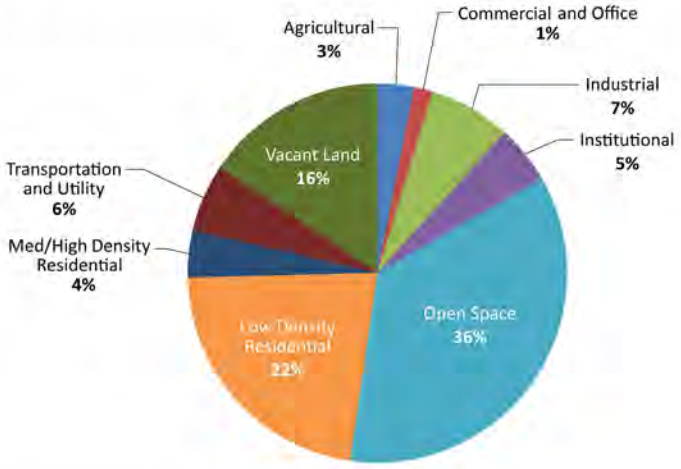
CURRENT CONDITION OF HAMILTON'S URBAN FOREST

2. CANOPY COVER (CONTINUED)

EXISTING PERCENTAGE OF TREE COVER BY LAND USE (2018)

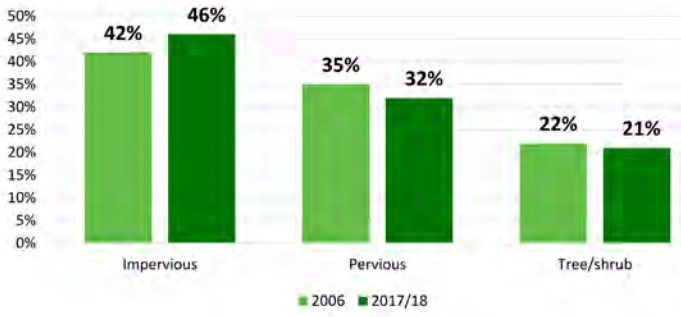


Source: iTree Eco Plots

TRENDS:

- Approximately 60% of the City's urban tree canopy is located on private land.
- Open Space and Transportation/ Utility land uses provide the greatest opportunities for planting on publicly-owned land.
- This information can be used to prioritize tree planting efforts by land use.

CHANGE IN LAND COVER TYPE (2006-2017/18)



Source: iTree Eco Plots

TRENDS:

- Between 2006 and 2017-2018, there was a slight decrease in the percent canopy cover (not statistically significant).
- The percent of paved surfaces (impervious) is increasing.
- Effects on tree canopy include a loss of growing space (particularly for large shade trees), challenging site conditions, & increased heat island effect.

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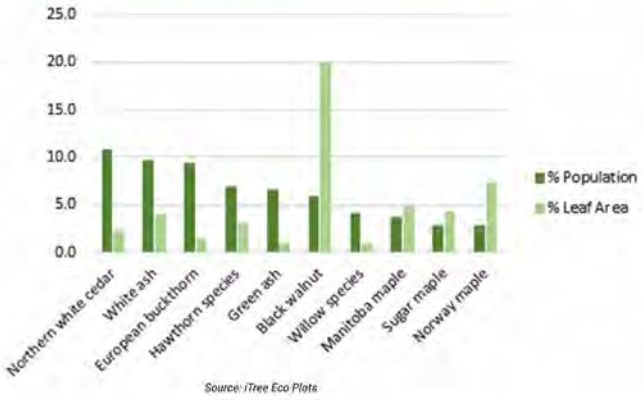
WE THINK SO.

CURRENT CONDITION OF HAMILTON'S URBAN FOREST

3. SPECIES COMPOSITION

This graph shows the top ten tree species found in the urban area.

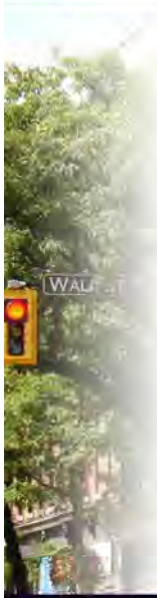


Source: iTree Eco Plots

TRENDS:

- Native black walnut represents about 20% of total urban forest leaf area.
- Ash species still include approximately 5% of total leaf area, but are threatened by Emerald Ash Borer.
- 20-25% of the total leaf area is invasive species (Norway Maple, Manitoba Maple, European Buckthorn and Black Locust).
- Larger trees provide the greatest benefits, but tree size distribution was skewed to smaller trees.

4. PUBLIC TREES



TRENDS:

- Hamilton has about 168,000 street trees.
- Norway maple is no longer planted, but it still forms 19% of the street tree population.
- Maple species represent 28.2% of the street tree population.
- Lack of diversity in tree species makes the urban forest more susceptible to pest and disease impacts (e.g. Asian Long-horned Beetle).
- Forestry's base tree planting budget has remained steady at $1.345 million per year for several years.

5. TREE CONDITION/MAINTENANCE

TRENDS:

- Hamilton has had a regular grid pruning program in effect for several years; has achieved a 7-year pruning cycle.
- The majority of 'dying' and 'dead' trees were natural areas, parks, cemeteries, recreational fields and golf courses.
- There is an opportunity to increase and improve the health of the tree canopy by removing and replacing dead and dying trees in these areas.

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URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

DRAFT VISION STATEMENT

HAVE YOUR SAY! HELP US WITH THE VISION STATEMENT FOR THIS PROJECT

Here's what the public & staff created based on input in 2018:

Hamilton's urban forest is resilient and sustainable.

It contributes to the health and well-being of citizens and enhances the livability of the city.

The City of Hamilton, and all residents, value the urban forest as an essential shared asset that should be intentionally planned and maintained for all future generations.

PLEASE PROVIDE YOUR INPUT!

Here's what to do - Using a sticky note, please provide your comments on this draft vision statement. Would you change anything? What would you add?

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URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

DRAFT GOALS

Six draft goals have been identified for the Urban Forest Strategy. Under each goal, there are a number of draft actions to achieve the goals.

1. PLAN & ACT

Hamilton has policies and guidelines that support the urban forest. One of the goals of the UFS is to develop better tools to implement these policies and guidelines as the City grows.

2. PROTECT

Protecting existing trees is important for maintaining and improving the City's tree canopy. The UFS will explore options for improved protection of the City's existing tree canopy, including the importance of private tree by-laws.

3. PLANT

Planting programs are an important part of growing the urban forest. The UFS will focus on how to prioritize and increase tree planting to help the City meet its canopy cover targets, with considerations for climate change, urban growth, and more uniform distribution of tree cover.

4. MAINTAIN

Trees are long-lived and need regular care to ensure that they grow to their full potential.

5. COMMUNICATE

Regular communications with the public and private sector help to improve the general appreciation for the value of urban trees. It also allows us to work together to use limited resources more efficiently.

6. MONITOR & ADAPT

The urban environment is constantly changing, which affects the status of the City's urban forest. Regular monitoring provides the data to guide the City's management programs.

URBAN FOREST STRATEGY
PLANNING & ECONOMIC DEVELOPMENT
DEVELOPMENT PLANNING, HERITAGE AND DESIGN

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URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

GOAL 1: PLAN & ACT

DRAFT ACTIONS:

- Obtain spatial data for the entire municipality and use to determine canopy cover and identify planting areas.
- Use canopy cover data to develop land use targets for tree cover - integrate these targets in development processes.
- Forestry staff should actively participate in policy, plan, and guidelines review to ensure Forestry goals are included.
- Develop urban forestry 'best practices' to share with City departments whose activities affect the urban forest.
- Update and maintain an inventory of street trees. Include an assessment of tree condition/risk.

ARE THERE ANY OTHER ACTIONS THAT YOU WOULD ADD UNDER THE GOAL "PLAN & ACT"?

URBAN FOREST STRATEGY
PLANNING & ECONOMIC DEVELOPMENT
DEVELOPMENT PLANNING, HERITAGE AND DESIGN

Hamilton

URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

GOAL 2: PROTECT

DRAFT ACTIONS:

- Implement a private tree by-law for Hamilton's urban area that includes individual trees on private property.
- Collect data to identify the root causes of change/loss in the urban tree canopy.
- Require a calculation of canopy balance (leaf area of trees removed vs. proposed planting) as part of arborist reports for development applications.
- Report on canopy balance as a performance indicator for Hamilton.

ARE THERE ANY OTHER ACTIONS THAT YOU WOULD ADD UNDER THE GOAL "PROTECT"?

URBAN FOREST STRATEGY
PLANNING & ECONOMIC DEVELOPMENT
DEVELOPMENT PLANNING, HERITAGE AND DESIGN

Hamilton

URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

GOAL 3: PLANT

DRAFT ACTIONS:

- Identify the number of trees required to be planted in Hamilton over the next 20 years to meet canopy cover target and increase funding for tree planting to meet target.
- Reduce the use of maple species in street tree planting.
- Review planting lists periodically to ensure species diversity.
- Use standard specifications in all City of Hamilton plantings.
- Examine tree planting budgets and programs to identify how to plant more trees over the next 5 years.
- Prioritize tree planting locations, outreach and partnership efforts in different land uses.
- Identify available planting space for street trees. Prioritize planting on higher quality sites and in areas of low & mature canopy.

ARE THERE ANY OTHER ACTIONS THAT YOU WOULD ADD UNDER THE GOAL "PLANT"?

URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

GOAL 4: MAINTAIN

DRAFT ACTIONS:

- Update and actively maintain a street tree inventory.
- Focus on the removal of 'poor, dead or dying' street trees.
- Develop an invasive species management policy for Hamilton.
- Work with Conservation Authorities to prioritize areas where forests will be managed to improve their health.
- Examine opportunities to control invasive species under property standards regulations (e.g. Yard Maintenance By-law).
- Develop a policy on how the City will monitor & manage forest health threats in Hamilton.
- Develop service standards for hazard trees and other forestry service requests.

ARE THERE ANY OTHER ACTIONS THAT YOU WOULD ADD UNDER THE GOAL "MAINTAIN"?

URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

GOAL 5: COMMUNICATE

DRAFT ACTIONS:

- Complete a detailed study to identify the attitudes towards trees, and other opportunities and barriers to growing the urban forest.
- Use the results of the study to prepare a targeted outreach strategy.
- Build online mapping tools to communicate the location and condition of Hamilton's urban forest, based on available spatial data.
- Work with local non-profits to explore applications in citizen science that will support the Urban Forest Strategy goals.

ARE THERE ANY OTHER ACTIONS THAT YOU WOULD ADD UNDER THE GOAL "COMMUNICATE"?

URBAN FOREST STRATEGY

If a tree falls in the forest, do you care?

WE THINK SO.

GOAL 6: MONITOR & ADAPT

DRAFT ACTIONS:

- Monitor changes in canopy cover.
- Report to Council on the best options for a forestry data management system.
- Update the Urban Forest Strategy (every 10 years or in response to significant environmental change).
- Use available tools (iTree) to assess change in canopy cover every 2 years.
- Monitor change using Urban Forest Strategy Criteria and Indicators.
- Using Criteria and Indicators, report to Council on progress toward meeting urban forest goals (every 5 years).
- Select three corporate indicators to report on progress toward urban forest goals.
- Monitor street tree mortality using data management system to determine if planting program is effective.

ARE THERE ANY OTHER ACTIONS THAT YOU WOULD ADD UNDER THE GOAL "MONITOR & ADAPT"?

URBAN FOREST STRATEGY
PLANNING & ECONOMIC DEVELOPMENT
DEVELOPMENT PLANNING, HERITAGE AND DESIGN

Hamilton

Appendix G: Baseline Assessment of Sustainable Urban Forest Criteria for the City of Hamilton, 2018

"The Sustainable Urban Forest Guide: A Step-by-Step Approach"

Monitoring progress is a critical part of the adaptive management feedback loop. Using a consistent monitoring framework will allow for regular and comparable assessments of progress toward urban forest targets and will allow for some comparison across municipalities.

The 2016 "*The Sustainable Urban Forest Guide: A Step-by-Step Approach*"[1] was developed by the Davey Tree Institute and the USDA Forest Service and is used by many municipalities in North America and groups sustainable urban forest management criteria into three main categories:

1. Trees and Forest – Criteria and targets related to the characteristics of the urban forest (e.g. canopy cover, species diversity, age).
2. Community Framework – Criteria that describe engagement of stakeholders at all levels and collaboration among them.
3. Resource Management Approach – Criteria that track plans, practices, and policies to improve and sustain the urban forest.

The following summary provides an assessment of the state of Hamilton's urban forest against 28 indicators of sustainable urban forest management. The ratings are based in part on a review of enabling policies and legislation, data provided by the 2018 urban forest study as well as a self-assessment by the City of Hamilton Urban Forest Strategy working group on how the city is performing where no empirical data are available. This information provides a baseline for tracking progress in future evaluations.

[1] *Leff, M. 2016. The Sustainable Urban Forest: A step-by-step approach. Davey Institute & United States Department of Agriculture, Forest Service.*

Trees and Forests - Targets related to the status of the vegetation resource itself and/or knowledge of that resource.

TREES AND FOREST	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/RATIONALE FOR RATING
T1 – Relative Tree Canopy Cover	Achieve desired degree of tree cover, based on potential or according to goals set for entire municipality and for each neighborhood or land use.	The existing canopy cover for entire municipality is <50% of the desired canopy.	The existing canopy is 50%-75% of desired.	The existing canopy is >75%-100% of desired.	The existing canopy is >75%-100% of desired – at individual neighborhood level as well as overall municipality.	Tree canopy is at approximately 71% of the 30% target (at 21.2%) based on a 2018 estimate.
T2 – Age Diversity (size class distribution)	Provide for ideal uneven age distribution of all "intensively" (or individually) managed trees – municipality-wide as well as at neighborhood level.	Even-age distribution, or highly skewed toward a single age class (maturity stage) across entire population.	Some uneven distribution, but most of the tree population falls into a single age class.	Total tree population across municipality approaches an ideal age distribution of 40% juvenile (0-8cm), 30% small (8-16cm), 20% medium (16-24cm), and 10% large (>24cm).	Total population approaches that ideal distribution municipality-wide as well as at the neighborhood level.	Tree canopy is not consistent with size-class distribution targets city-wide (51% juvenile [0-7.6cm], 25% small [7.7-15.2cm], 9.8% medium [15.3-22.9cm], and 14% large [>23cm]). The proportion of juvenile and large trees approaches the ideal while the proportion of medium trees is significantly lower than ideal.
T3 – Species Diversity	Establish a genetically diverse tree population across municipality as well as at the neighborhood level.	Five or fewer species dominate the entire tree population across municipality.	No single species represents more than 10% of total tree population; no genus more than 20%; and no family more than 30%.	No single species represents more than 5% of total tree population; no genus more than 10%; and no family more than 15%.	At least as diverse as "Good" rating (5/10/15) municipality-wide – and at least as diverse as "Fair" (10/20/30) at the neighborhood level.	No family represents more than 30% (the highest is 18.2%, Oleaceae or olive). No genus represents more than 20% (the highest is 16.8%, Fraxinus, or ash). Only one species exceeds 10% (*Thuja occidentalis*, or Eastern white cedar – often in hedge form). *Fraxinus americana* (white ash) and *Rhamnus cathartica* (buckthorn) are approaching the threshold at 9.7% and 9.4%, respectively.
T4 – Species Suitability	Establish a tree population suited to the urban environment and adapted to the overall region.	Fewer than 50% of all trees are from species considered suitable for the area.	>50%-75% of trees are from species suitable for the area.	More than 75% of trees are suitable for the area.	Virtually all trees are suitable for the area.	This analysis requires more detailed investigation and research on what are considered suitable species for the Hamilton area, based on local knowledge and expertise. The City has planting lists as well as guidelines for species selection in planting. Currently, based on the sample-based i-Tree Eco inventory, just over 20% of the city's tree population overall is comprised of Category 1 and 2 invasive species, which are not suitable for the maintenance of native biodiversity. The increased use of non-native, non-invasive species under future climate change scenarios is something that should be examined more closely in a climate change vulnerability assessment.

Trees and Forests - Targets related to the status of the vegetation resource itself and/or knowledge of that resource.

TREES AND FOREST	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/RATIONALE FOR RATING
T5 – Publicly Owned Trees (managed "intensively")	Current and detailed understanding of the condition and risk potential of all publicly owned trees that are managed intensively (or individually).	Condition of urban forest is unknown.	Sample-based tree inventory indicating tree condition and risk level.	Complete tree inventory that includes detailed tree condition ratings.	Complete tree inventory that is GIS-based and includes detailed tree condition as well as risk ratings.	The City of Hamilton has completed a 3% sample-based tree inventory (i-Tree Streets) that includes basic information about tree condition but not detailed risk potential. There is a 2006 inventory of all urban street trees that is now largely out of date. Parks and Cemeteries inventory completed with 150,000 trees measured and assessed for risk.
T6 – Publicly Owned Natural Areas (managed "extensively")	Detailed understanding of the ecological structure and function of all publicly owned natural areas (such as woodlands, ravines, stream corridors, etc.), as well as usage patterns.	No information about publicly owned natural areas.	Publicly owned natural areas identified in a "natural areas survey" or similar document.	Survey document also tracks level and type of public use in publicly owned natural areas.	In addition to usage patterns, ecological structure and function of all publicly owned natural areas are also assessed and documented	Natural areas inventories have been completed on public and private lands in 1991, 2001-2003, and 2011-2014. A Parks and Cemeteries inventory was completed between 2016-2019 and assessed 150,000 trees, including a risk assessment. However, the City does not have information on all city-owned natural areas nor detailed information about public use levels and pressures.
T7 – Trees on Private Property	Understanding of extent, location, and general condition of privately-owned trees across the urban forest.	No information about privately owned trees.	Aerial, point-based assessment of trees on private property, capturing overall extent and location.	Bottom-up, sample-based assessment of trees on private property, as well as basic aerial view (as described in "Fair" rating).	Bottom-up, sample-based assessment on private property, as well as detailed Urban Tree Canopy (UTC) analysis of entire urban forest, integrated into municipality-wide GIS system.	Hamilton has completed a sample-based 2018 i-Tree Eco inventory that includes trees on private property, as well as a point-based assessment of tree canopy extent for the City. To date, Hamilton has not completed a detailed UTC analysis to integrate as a data layer into the municipal GIS system.

Community Framework – The necessary engagement of stakeholders at all levels, and collaboration among them.

COMMUNITY FRAMEWORK	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA / RATIONALE FOR RATING
C1 – Municipal Agency Cooperation	All municipal departments and agencies cooperate to advance goals related to urban forest issues and opportunities.	Municipal departments/agencies take actions impacting urban forest with no cross-departmental coordination or consideration of the urban forest resource.	Municipal departments/agencies recognize potential conflicts and reach out to urban forest managers on an ad hoc basis – and vice versa.	Informal teams among departments and agencies communicate regularly and collaborate on a project-specific basis.	Municipal policy implemented by formal interdepartmental or interagency working teams on all municipal projects.	Permitting systems and bylaws are in place. Forestry and Planning communicate regularly on development application comments. It is informal but is happening regularly. Forestry reviews plans for diameter removals and try to encourage retention or diameter replacements for public works and comment on all project applications. Engineering Services is aware of the process. Forestry makes efforts to be involved early with city capital projects so budgets can be allocated for tree replacement or compensation. Other than the prescribed processes there is little regular interagency or departmental collaboration (e.g., through an established interdepartmental working group).
C2 – Utilities Cooperation	All utilities – above and below ground – employ best management practices and cooperate with municipality to advance goals and objectives related to urban forest issues and opportunities.	Utilities take actions impacting urban forest with no municipal coordination or consideration of the urban forest resource.	Utilities employ best management practices, recognize potential municipal conflicts, and reach out to urban forest managers on an ad hoc basis – and vice versa.	Utilities are included in informal municipal teams that communicate regularly and collaborate on a project-specific basis.	Utilities help advance urban forestry goals and objectives by participating in formal interdepartmental/ interagency working teams on all municipal projects.	Utilities reach out to Forestry, Natural Heritage Planning, and Municipal Law Enforcement staff to determine if by-laws apply, or if the municipality has any concerns with proposed tree removals in natural areas. Utilities are now routinely reaching out to CoH staff. The Growth Management Division (part of Planning) also coordinates CoH staff comments on major projects, such as new pipelines.
C3 – Green Industry Cooperation *"Green industry" is understood to encompass all professions and businesses that routinely support or engage in tree and vegetation management activities. Among others, these can include landscapers, nurseries, garden centers, contractors, maintenance professionals, tree care companies, landscape architects, foresters, planners, even developers.*	Green industry works together to advance municipality-wide urban forest goals and objectives and adheres to high professional standards.	Little or no cooperation among segments of green industry or awareness of municipality-wide urban forest goals and objectives.	Some cooperation among green industry as well as general awareness and acceptance of municipality-wide goals and objectives.	Specific collaborative arrangements across segments of green industry in support of municipality-wide goals and objectives.	Shared vision and goals and extensive committed partnerships in place. Solid adherence to high professional standards.	Some segments of the green industry (e.g. landscape architects, arborists, foresters) work in Hamilton routinely and are aware of our by-law and tree management plan requirements. *Note: Close cooperation with the green industry presents an excellent opportunity for municipal urban forest managers to influence management of the forest resource on private property.*[2]

[2] *Leff, M. 2016. The Sustainable Urban Forest: A step-by-step approach. Davey Institute & United States Department of Agriculture, Forest Service.*

Community Framework – The necessary engagement of stakeholders at all levels, and collaboration among them.

COMMUNITY FRAMEWORK	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA / RATIONALE FOR RATING
C4 – Involvement of Large Private and Industrial Landowners	Large private landholders embrace and advance municipality-wide urban forest goals and objectives by implementing specific resource management plans.	Large private landholders are generally uninformed about urban forest issues and opportunities.	Municipality conducts outreach directly to landholders with educational materials and technical assistance, providing clear goals and incentives for managing their tree resource.	Landholders develop comprehensive tree management plans (including funding strategies) that advance municipality-wide urban forest goals.	As described in "Good" rating, plus active community engagement and access to the property's forest resource.	There are limited resources put toward formal outreach or involvement to date by large, industrial private landowners. Outcomes of some pilot projects may show this as an area of opportunity for Hamilton.
C5 – Citizen Involvement and Neighborhood Action	At the neighborhood level, citizens participate and groups collaborate with the municipality and/ or its partnering NGOs in urban forest management activities to advance municipality-wide plans.	Little or no citizen involvement or neighborhood action.	Some neighborhood groups engaged in advancing urban forest goals, but with little or no overall coordination with or direction by municipality or its partnering NGOs.	Many active neighborhood groups engaged across the community, with actions coordinated or led by municipality and/or its partnering NGOs.	Proactive outreach and coordination efforts by municipality and NGO partners resulting in widespread citizen involvement and collaboration among active neighborhood groups engaged in urban forest management.	Strong and knowledgeable non-profit engagement and support is a strength and area of opportunity for Hamilton. There is high demand for street tree planting by homeowners as a result of canvassing efforts by volunteers and CoH staff in areas of low tree canopy. The CoH has a "schools program", where front-line staff work with two schools each month to do education about trees and their value. Examples of community involvement include: Air and Trees Task Force group, created in partnership with Environment Hamilton, TreesPlease, Neighbourwoods data collection. COH has had a partnership with the Hamilton Naturalists' Club to inventory natural areas in Hamilton since 1991. Information is used to map natural areas and develop Official Plan policies. COH is also working with the HNC on a Pollinators corridor/Bee City and Biodiversity Strategy.

[2] *Leff, M. 2016. The Sustainable Urban Forest: A step-by-step approach. Davey Institute & United States Department of Agriculture, Forest Service.*

Community Framework – The necessary engagement of stakeholders at all levels, and collaboration among them.

COMMUNITY FRAMEWORK	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/ RATIONALE FOR RATING
C6 – Appreciation of Trees as a Community Resource	Stakeholders from all sectors and constituencies within municipality – private and public, commercial and non-profit, entrepreneurs and elected officials, community groups and individual citizens – understand, appreciate, and advocate for the role and importance of the urban forest as a resource.	General ambivalence or negative attitudes about trees, which are perceived as neutral at best or as the source of problems. Actions harmful to trees may be taken deliberately.	Trees generally recognized as important and beneficial.	Trees widely acknowledged as providing environmental, social, and economic services – resulting in some action or advocacy in support of the urban forest.	Urban forest recognized as vital to the community's environmental, social, and economic well-being. Widespread public and political support and advocacy for trees, resulting in strong policies and plans that advance the viability and sustainability of the entire urban forest.	The City has not been successful in past efforts to pass a more comprehensive private tree by-law in Hamilton. Opposition to the by-law was voiced by specific interest groups. However, a 2018 online survey suggests that many of Hamilton's residents do place high value on trees. Currently, there seems to be a split in attitudes about the value of trees between interest groups and the public at large.
C7 – Regional Collaboration	Cooperation and interaction on urban forest plans among neighboring municipalities within a region, and/or with regional agencies.	Municipalities have no interaction with each other or the broader region. No regional planning or coordination on urban forestry.	Some neighboring municipalities and regional agencies share similar policies and plans related to trees and urban forest.	Some urban forest planning and cooperation across municipalities and regional agencies.	Widespread regional cooperation resulting in development and implementation of regional urban forest strategy.	There is little formal or co-ordinated interagency cooperation but there may be opportunities to formalize agreements with Conservation Authorities. There are some examples: The "Cootes To Escarpment Ecopark" involves a number of public agencies that meet monthly to co-ordinate management and promote stewardship e.g., RBG, McMaster University, Region of Halton, City of Burlington, and Conservation Authorities, who all own natural areas within this park system. There was good regional municipal co-ordination on the recent gypsy moth spray - Hamilton is a member of Regional Public Works Forest Health sub committee (RPWCO).

Resource Management Approach – Plans, practices, and policies to improve and sustain the forest resource.

RESOURCE MANAGEMENT APPROACH	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/ RATIONALE FOR RATING
R1 – Tree Inventory	Current and comprehensive inventory of tree resource to guide its management, including data such as age distribution, species mix, tree condition, and risk assessment.	No inventory.	Complete or sample-based inventory of publicly owned trees.	Complete inventory of publicly owned trees and sample-based privately-owned trees that is guiding management decisions.	Systematic comprehensive inventory system of entire urban forest – with information tailored to users and supported by mapping in municipality-wide GIS system.	The City does have a street tree inventory but it is dated 2006 and likely does not reflect the current state of street trees in Hamilton. There is currently no information management system in place to link management activities and work orders to updates in the inventory. A Parks and Cemeteries inventory for public trees was completed between 2016-2019. Given the effects of EAB as well as the rates of tree planting in past years, the street tree inventory should be updated to provide current and relevant data on the City's street trees. Hamilton has completed a sample-based inventory of both publicly- and privately-owned trees, using the i-Tree Eco approach developed by the USDA Forest Service (2018). This provides information on the average age distribution, species mix and general condition of trees across the City.
R2 – Canopy Cover Assessment Goals	Urban forest policy and practice driven by accurate, high-resolution, and recent assessments of existing and potential canopy cover, with comprehensive goals municipality-wide and at neighborhood or smaller management level.	No assessment or goals.	Low-resolution and/or point-based sampling of canopy cover using aerial photographs or satellite imagery – and limited or no goal-setting.	Complete, detailed, and spatially explicit, high-resolution Urban Tree Canopy (UTC) assessment based on enhanced data (such as LiDAR) – accompanied by comprehensive set of goals by land use and other parameters.	As described for "Good" rating – and all utilized effectively to drive urban forest policy and practice municipality-wide and at neighborhood or smaller management level.	Hamilton has completed a sample-based inventory as well as estimate of tree cover change over time. There is city-wide goal for canopy cover identified in the Urban Hamilton Official Plan (30%) though no time frame associated with achieving that goal.
R3 – Environmental Justice and Equity	Ensure that the benefits of urban forests are made available to all, especially to those in greatest need of tree benefits.	Tree planting and outreach is not determined equitably by canopy cover or need for benefits.	Planting and outreach includes attention to low canopy neighborhoods or areas.	Planting and outreach targets neighborhoods with low canopy and a high need for tree benefits.	Equitable planting and outreach at the neighborhood level is guided by strong citizen engagement in those low-canopy/ high-need areas.	There is no formalized approach but there is work being done by the Air and Tree Task Force to address distribution of tree canopy in response to need. Certain wards (2, 3 and 4) are being targeted for canvassing to promote tree planting to even out street tree canopy distribution (this decision was driven by air quality improvement objectives). 50% of street tree planting funds are dedicated to planting in these wards, and community planting events are targeted here. However, LAS is not currently receiving additional funding dedicated to tree planting in new parks in these wards.

Resource Management Approach – Plans, practices, and policies to improve and sustain the forest resource.

RESOURCE MANAGEMENT APPROACH	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/ RATIONALE FOR RATING
R4 – Municipality-wide Urban Forest Management Plan	Develop and implement a comprehensive urban forest management plan for public and private property.	No plan.	Existing plan limited in scope and implementation.	Recent comprehensive plan developed and implemented for publicly owned forest resources, including trees managed intensively (or individually) and those managed extensively, as a population (e.g., trees in natural areas).	Strategic, multi-tiered plan with built-in adaptive management mechanisms developed and implemented for public and private forest resources.	Hamilton is developing an Urban Forest Strategy (UFS) for the urban areas of the City. The scope of the UFS includes all trees on public and private land in the Hamilton urban area. Management responsibility in the UFS is shared between City departments, other agencies and other stakeholders in Hamilton.
R5 – Municipality-wide Urban Forestry Funding	Develop and maintain adequate funding to implement municipality-wide urban forest management plan.	Little or no dedicated funding.	Funding only for emergency, reactive management.	Funding sufficient for some proactive management based on urban forest management plan.	Sustained funding from public and private sources to fully implement comprehensive urban forest management plan.	The City's EAB management plan was proactive in removal and 1 for 1 replacement. Capital funding for $1.345 annually is provided for the free street tree planting program and replacement of trees removed through maintenance activities. The City also provides regular funding to tree maintenance activities. However, as one example of areas where tree funding has decreased over time, Park construction budgets have remained the same for many years while the cost of most materials have increased, leaving less money available for tree planting. Furthermore, the City's tree canopy has not grown since 2013, and in fact may have seen a slight decline. Working toward a goal of increasing tree canopy will require revisiting current funding levels to assess how the City will increase canopy cover.

Resource Management Approach – Plans, practices, and policies to improve and sustain the forest resource.

RESOURCE MANAGEMENT APPROACH	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/ RATIONALE FOR RATING
R6 – Municipal Urban Forest Program Capacity	Maintain sufficient well-trained personnel and equipment – whether in-house or through contracted or volunteer services – to implement municipality-wide urban forest management plan.	Team severely limited by lack of personnel and/or access to adequate equipment. Unable to perform adequate maintenance, let alone implement new goals.	Team limited by lack of trained staff and/ or access to adequate equipment.	Team able to implement many of the goals and objectives of the urban forest management plan.	Team able to implement all of the goals and objectives of the urban forest management plan.	COH has well-trained and industry-certified internal staff. Internal staff deal with a wide range of complex urban forest issues Staff have specialist equipment and training to deal with all aspects of urban forest management. There are standards in place for contractor services. The city is meeting grid rotation and tree planting targets. Response to tree health and pest/disease issues has been good as well (e.g. monitoring for gypsy moth, aerial spray and cooperation with other municipalities). Identified gaps include lack of capacity to respond effectively to extreme weather events and a lack of documented service standards. It also remains to be seen moving forward what resources are available to implement the findings of the new UFS.
R7 – Tree Establishment Planning and Implementation	Comprehensive and effective tree planting and establishment program is driven by canopy cover goals and other considerations according to plan.	Little or no tree planting; tree establishment is ad hoc.	Some tree planting and establishment occurs, but with limited overall municipality-wide planning and post-planting care.	Tree planting plan is guided by municipality-wide goals, with some post-planting establishment care.	Comprehensive tree establishment plan is guided by needs derived from canopy and other assessments, maintains species and age diversity, includes both planting and young tree care, and is sufficient to make progress toward canopy cover objectives.	The City has a street tree planting program that is over-prescribed, demonstrating high public interest in street trees. This receives annual funding and is ongoing. Other tree planting occurs as funding is made available.

Resource Management Approach – Plans, practices, and policies to improve and sustain the forest resource.

RESOURCE MANAGEMENT APPROACH	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/ RATIONALE FOR RATING
R8 – Growing Site Suitability	All publicly owned trees are selected for each site and planted in conditions that are modified as needed to ensure survival and maximize current and future tree benefits.	Trees selected and planted without consideration of site conditions.	Appropriate tree species are considered in site selection.	Municipality-wide guidelines in place for the improvement of planting site conditions and selection of suitable species.	All trees planted in sites with adequate soil quality and quantity, and with sufficient growing space and overall site conditions to achieve their genetic potential and thus provide maximum ecosystem services.	COH has urban forest design guidelines which address all aspects of tree health and survivability. Forestry has been working on planting specifications for tree soil volume. The City has policies that promote the use of native species and discourage planting invasive species. Bylaw bans certain species that are considered invasive. LAS follows Forestry-approved species list and consult with Forestry Staff where required for planting plans. The city uses a wide range of native species in its planting lists. Urban Hamilton Official Plan policies C.2.11.2 and C.2.5.13 related to native plantings. Tree Protection Guidelines state native plants to be used wherever possible when compensating for trees removed for development. A list of native trees is provided. It also states that non-native and invasive plants are not to be planted adjacent to Core Areas in the Natural Heritage System.
R9 – Tree Protection Policy Development and Enforcement	The benefits derived from trees on public and private land are ensured by the enforcement of municipality-wide policies, including tree care "best management practices".	No tree protection policy.	Policies in place to protect public trees and employ industry best management practices, but inconsistently enforced.	Policies and practices in place to protect public and private trees, generally enforced.	Integrated municipality-wide policies and practices to protect public and private trees, consistently enforced and supported by significant deterrents.	The City of Hamilton has protection in place for publicly owned trees, some protection for trees on private property as well as a Tree Preservation and Sustainability Policy. However, by-law coverage is inconsistent as is implementation. Some of the key issues noted include: • Compensation for private tree removal takes precedence over preserving existing trees; • Replacement ratio is 1:1 and applied inconsistently, most often resulting in a net loss of tree canopy in the short term where mature trees are removed; • Inspections of tree protection on development sites are generally reactionary and may be done by staff lacking appropriate training or expertise, leading to questions of effectiveness of tree protection policies.

Resource Management Approach – Plans, practices, and policies to improve and sustain the forest resource.

RESOURCE MANAGEMENT APPROACH	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/ RATIONALE FOR RATING
R10 – Maintenance of Public Managed Trees	All publicly owned, intensively (or individually) managed trees are well maintained for optimal health and condition in order to extend longevity and maximize current and future benefits.	No maintenance of publicly owned trees, or on a reactive basis only.	Publicly owned trees receive only periodic inspection and maintenance.	Publicly owned trees are inspected and proactively maintained on a cyclical basis.	All publicly owned, intensively managed trees are routinely and thoroughly maintained on ongoing basis according to comprehensive management plan.	The City of Hamilton has instituted a grid based tree trimming program for about 10 years and has achieved a 5 to 7-year pruning return cycle. This is in line with recommended industry standards.
R11 – Management of Publicly Owned Natural Areas	The ecological integrity of all publicly owned natural areas is protected and enhanced – while accommodating public use where appropriate.	No natural areas management plans or implementation in effect.	Only reactive management efforts to facilitate public use (e.g., hazard abatement, trail maintenance).	Management plan in place for each publicly owned natural area to facilitate appropriate public use.	Management plan for each publicly owned natural area focused on sustaining and, where possible, improving overall ecological integrity (i.e., structure and function) – while facilitating appropriate public use.	Conservation Authorities and the Royal Botanical Gardens have management plans for their lands within the urban area, including hazard tree management and habitat restoration, and control of invasive plants. On City lands, Parks maintains trails through natural open spaces and has a limited budget to maintain invasive plant species (Phragmites). Parks staff manage some natural areas, such as Albion Falls, for personal safety and risk. There are some limited enhancement projects (Hoary Mtn. Mint). There has also been some historical public education on noxious weeds, limited efforts/budget/resources for invasive plants. Impacts of informal trails and trampling of understory is often observed by Parks staff.

Resource Management Approach – Plans, practices, and policies to improve and sustain the forest resource.

RESOURCE MANAGEMENT APPROACH	KEY OBJECTIVE	LOW	FAIR	GOOD	OPTIMAL	SUPPORTING DATA/ RATIONALE FOR RATING
R12– Tree Risk Management	Comprehensive tree risk management program fully implemented, according to ANSI A300 (Part 9) "Tree Risk Assessment" standards and supporting industry best management practices.	No tree risk assessment or risk management program. Response is on a reactive basis only.	Level I (limited visual assessment) inspection and follow-up conducted periodically.	Level II (basic assessment) conducted periodically, resulting in scheduled follow-ups.	Level II (basic assessment) conducted routinely, according to defined cycle and intensive follow-up (i.e., priorities and timelines for mitigation established based on the characterization of risk).	There is little information on public tree condition (particularly street trees) although there was a 2016-2019 parks and inventory update. This included a health assessment that identified high risk trees, which were dealt with immediately. Some staff have TRAQ training, which qualifies them to undertake risk assessments. Consultants perform Level 3 assessments on trees (tomography and resistograph) as needed. These trees are assessed using industry standards, given mitigation options and options are implemented. Forestry & Parks are mainly managing hazard trees on trails in natural areas. Rotational pruning program helps improve tree condition and reduce risk in City Right of Ways. Hamilton has up to 25,000 service requests a year and is doing pro-active risk assessment on ash annually to identify risk. There are fewer ash remaining so these can be inspected more frequently. The City is currently undertaking a more comprehensive assessment of risk. Also working through defining service standards – current approach is 24/7 availability and prioritize calls that way. Are looking at other industry and municipal standards in order to eventually develop more formal service standards. 48 hours is current timeline to inspect, then inspection determines next priority level.
R13– Urban Wood and Green Waste Utilization	Create a closed system diverting all urban wood and green waste through reuse and recycling.	No utilization plan; wood and other green waste goes to landfill with little or no recycling and reuse.	While most green waste does not go to landfill, uses are limited to chips or mulch.	The majority of green waste is reused or recycled – for energy, products, and other purposes beyond chips or mulch.	Comprehensive plan and processes in place to utilize all green waste one way or another, to the fullest extent possible.	The City of Hamilton has a mulch program to address wood waste generated. Woodchips are used as mulch in parks and new street tree plantings and LAS uses City mulch for their projects wherever possible. Stump grindings are screened to utilize soil, and wood chips are used as bio filters at waste management facilities. Green waste diversion from landfill is included in contracts and tenders.

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R14– Native Vegetation	Preservation and enhancement of local natural biodiversity.	No coordinated focus on native vegetation.	Voluntary use of native species on publicly and privately-owned lands; invasive species are recognized.	Use of native species is encouraged on a project-appropriate basis in all areas; invasive species are recognized and discouraged on public and private lands.	Native species are widely used on a project-appropriate basis in all areas; invasive species are proactively managed for eradication to the full extent possible.	The City has policies that promote the use of native and discourage planting invasive species. Bylaws ban certain species that are considered invasive. LAS follows Forestry-approved species list and consult with Forestry Staff were required for planting plans. The city uses a wide range of native species in its planting lists. Urban Hamilton Official Plan policies C.2.11.2 and C.2.5.13 relate to native plantings. Tree Protection Guidelines state native plants to be used wherever possible when compensating for trees removed for development. A list of native trees is provided. It also states that non-native and invasive plants are not to be planted adjacent to Core Areas in the Natural Heritage System.