



Royal
Botanical
Gardens
CANADA

Forest Canopy Stewardship Strategy 2025-2035



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Document Description:

This document summarizes the overarching strategies, for forest canopy protection and management in the coming decade. Dramatic forest transition has been occurring as a result of pest, disease, and air pollution and is now expect even more rapidly change due to Climate Change. Recommendations and an action plan are included, which will be pursued by RBG pending relevant approvals, compatibility with broader RBG strategies, funding, and support from outside organizations and the public.



Heritage White Oak (Quercus alba), Bulls Point Trail Cootes Paradise. Tys Theijsmeyer 2025

Executive Summary

This Royal Botanical Gardens' Forest Canopy Stewardship Strategy aims to build ecosystem resiliency into the existing forest areas aiding in the transition to the future growing conditions of Climate Change expected to dominate by 2050 including more moderate winters, higher summertime temperatures, more powerful wind and rain events. Climate change is also anticipated to allow new invasive pest species currently limited by current growing conditions. The plant growing hardiness zone is expected to at minimum adjust 2-3 growing zones to the north, transitioning this region to a temperature deciduous forest environment similar to the Appalachian ecoregion. During the previous century this area was classed as hardiness zone 6A & 6B but with microclimates found on both southern facing slopes (warmer) as well as deeply incised cool spring feed ravines (cooler). As a result, several northern tree species are expected to disappear from the site including most conifer species, while several new southern species will find conditions that are suitable. As a result of the current and future conditions, trees species are expected to be lost such as the Eastern Hemlock and Balsam Poplar, while species such as the Tulip Tree and Cucumber tree are expected to become prominent.

Canopy Strategy Goal: To ensure long-term health, resilience, and sustainability of the forest canopy at RBG through targeted actions that mitigate the impacts of climate change, invasive species, high herbivore populations and human activity. The strategy includes a priority focus on protecting remnant intact old forest, particularly those found in the Special Protection Areas.

Currently, the forest is dominated by mature Red and White Oak trees. This dominance is partly a result of the historical loss of once-abundant species such as ash, elm, and chestnut. In adjacent regenerating old fields, Black Walnut is the prevailing species and is an example of a southern species adjusting to the changing climate. The oak-dominated ecosystem also supports a unique assemblage of rare understory plants, some of which are at the northern edge of their range. These include species like Few-flowered Clubrush (*Trichophorum planifolium*), and Fern-leaved False Foxglove (*Aureolaria pedicularia*). If existing oak populations remain resilient – and if climate-adapted oak species successfully migrate northward – these understory species may continue to thrive. At the same time, the increasing threats of Oak Wilt underscores the need for future reforestation strategies that are less reliant on oaks, ensuring greater ecological resilience in the face of climate change and new diseases.

Looking ahead, the forest faces growing threats from emerging pests and diseases. Oak Wilt and Spongy Moth are expected to have the most profound impacts over the next decade due to the heavy reliance on oak species across RBG's nature sanctuaries. Over the next decade, RBG staff and volunteers will continue to remove invasive shrubs from previously unmanaged forests and will also revisit previously managed areas to control regenerating invasive plants. Invasive shrub removal activities are guided by RBG's Invasive Species Strategy and species-specific management plans. Outreach and education on invasive species will continue through RBG's educational programs and volunteer invasive species removal events. Engagement in these activities will highlight the importance of SAR stewardship activities and education, while highlighting the importance of healthy habitats and the threats of invasive species. RBG staff will continue to conduct bird monitoring surveys which determine a species' presence on RBG property during the breeding season and will also continue to conduct long term forest monitoring which provides important species composition information to help guide management activities and future forecasting.

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Introduction

The Forest Canopy Stewardship Strategy for Royal Botanical Gardens (RBG) intends to protect existing forest canopy, while assisting in transition to new growing conditions and species dictated by climate change. Nature operates in chaos and now must overcome the challenge of a rapidly changing growing conditions and can be aided through assisted migration of more southern trees. This stewardship also involves addressing the key threats of invasive species, human impacts, and unbalanced wildlife populations, including inflated herbivore numbers. These threats have already significantly degraded forest health and biodiversity, impacting the ability of the forests' ability to survive and provide vital ecosystem services. This strategy combines ecosystem restoration, climate change adaptation, assisted migration of tree species, invasive species management, and wildlife population control to ensure the long-term sustainability and resilience of RBG's forest ecosystems.

Royal Botanical Gardens' Mission: *We dedicate our expertise in horticulture, conservation, science and education to connect people, plants and place for the purpose of nurturing and preserving healthy growing life on our planet.*

Table 1. A changing RBG forest, a summary of dominant tree species over time. Invasive plant species in bold while species largely lost due to introduced Eurasian diseases in italics.

Rank	1793 Surveyors Notes Conc. 1&2	1932-33 Senn Survey S. Cootes, by count	Current Large Heritage Trees	Current Survey by Count	Current by Canopy Cover	Current Understory Cover
1	White Pine	White Oak	Red Oak	Red Maple	Red Maple	Sugar Maple
2	Oak Species	Red Oak	Black Walnut	Black Cherry	Red Oak	Black Cherry
3	<i>American Chestnut</i>	Red Maple	White Oak	Red Oak	Black Cherry	White Ash
4	Maple Species	White Birch	Silver Maple	Shagbark Hickory	Shagbark Hickory	Norway Maple
5	American Beech	White Pine	Black Oak	Sugar Maple	White Oak	American Beech
6	Basswood	<i>Butternut</i>	Swamp White Oak	White Pine	White Pine	Red Maple
7	White Cedar	<i>Eastern Hemlock</i>	Shagbark Hickory	White Oak	Sugar Maple	Green Ash
8		Black Cherry	Sugar Maple	Black Maple	Black Maple	Smooth Serviceberry
9		Large-tooth Aspen	White Pine	Smooth Serviceberry	Black Oak	Sassafras
10		<i>White Elm</i>	Tulip Tree	Domestic Cherry	Domestic Cherry	Shagbark Hickory

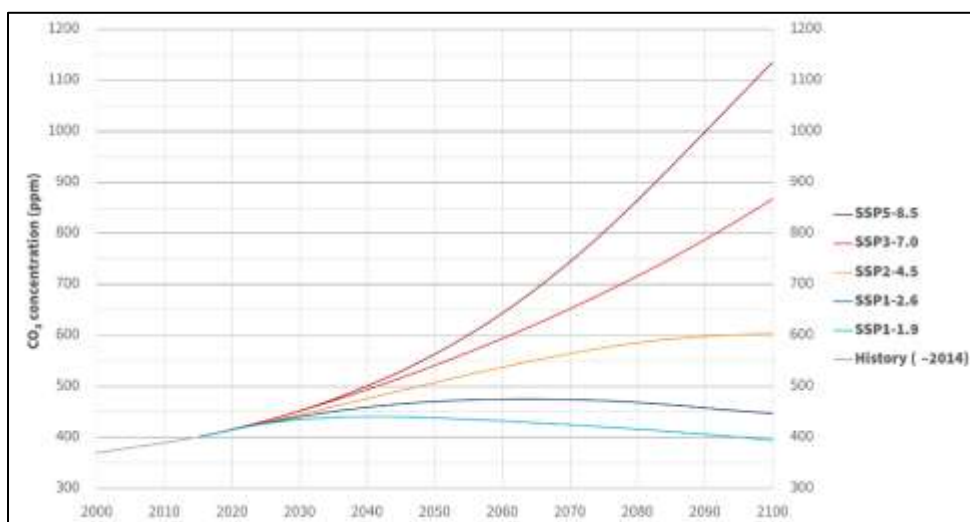
The current forest canopy of RBG includes both intact forest and regenerating forest and covers about 350 hectares across all three RBG nature sanctuaries and include 83 species. The nature sanctuaries fall into three geographic areas: Cootes Paradise, Hendrie Valley and the Escarpment Properties. Intact forests and regenerating old fields exist within these nature sanctuaries, with Oak species dominating the forest and Black Walnut in the regenerating fields. RBG is home to a variety of forest ecosystems,

many of which face increasing pressures from climate change, extensive invasive species populations, air pollution, diseases, and human activities. However, an often overlooked yet significant challenge to forest health is the presence of unbalanced wildlife populations, particularly high numbers of herbivores, such as White-tailed Deer. Overabundant herbivore populations severely damage the forest understory and hinder the regeneration of tree species. This strategy integrates wildlife management into forest protection and restoration efforts, to help the forest canopy become healthy and resilient for current and future challenges.

These stressors have already eliminated several tree species or significantly reduced them to a very minor presence in the tree canopy. Elimination of these species in the forest canopy has left gaps, which promotes the introduction and proliferation of invasive species due to increased available sunlight. Species included in the loss are American Chestnut, Elm species, Ash Species, Butternut, and Beech species all due to introduced pests and diseases. The remaining Oak dominated forest is continually under threat from Spongy Moth. Aerial sprays of Btk (*Bacillus thuringiensis var kurstaki*) were completed in 2008 and 2021/22 to interrupt the peak of the moth cycle stopping repeated total defoliation and eventual tree loss. Despite these recent efforts, a large number of heritage oaks have also been lost during the past 50 years.

Climate Change has also played a role in species' loss. The most notable example is with RBG's most common oak, Northern Red Oak (Figure 2), and extreme high summer temperatures. The most dramatic example occurred during August 2001 when temperatures reach 35°C - 38°C during the day for one week. The following year, several hundred moderates to large size Red Oak perished, which added large financial expense to manage the trees for trail safety and aesthetic purposes, notwithstanding the ecological impacts. The cause of death was due to the tree cambium consumed by naturally occurring insects, thereby girdling the tree, a result of a lack of cambium growth during the extreme heat (Rothfels, 2005). Further decline is noted through RBG's Long-term Forest Monitoring program, with the most recent report associated with Rock Chapel noting a 10% canopy cover decline in Red Oak between 2012-2024 (Peirce et al., 2024).

Figure 1. Climate Change scenarios based on CO2 concentrations. The SSP scenarios are a refinement of the RCP scenarios. The SSP scenarios were developed with respect to the sixth IPCC report (IPCC 2023).



<https://www.dkrz.de/en/communication/climate-simulations/cmip6-en/the-ssp-scenarios>

Natural Resources Canada provides resources to assist in planning for Climate Change forest transition and includes a summary of likely effects on 130 North American Trees Species (McKenney et al 2007). This includes information on likely distributions of many plants based on the CO² scenarios through the plant hardiness zone website. The scenario options include two models, various future time periods, and the above four climate scenarios. Model 1 is ANUCLIM and Model 2 is the more recent version called Maxent ([Canada's Plant Hardiness Web Site NRC](#)). As of 2024 global temperature has now risen 1.5C in the past 40 years (Scenario SSP126). The currently most abundant RBG canopy tree the Norther Red Oak has a potentially challenging future if extreme conditions occur.

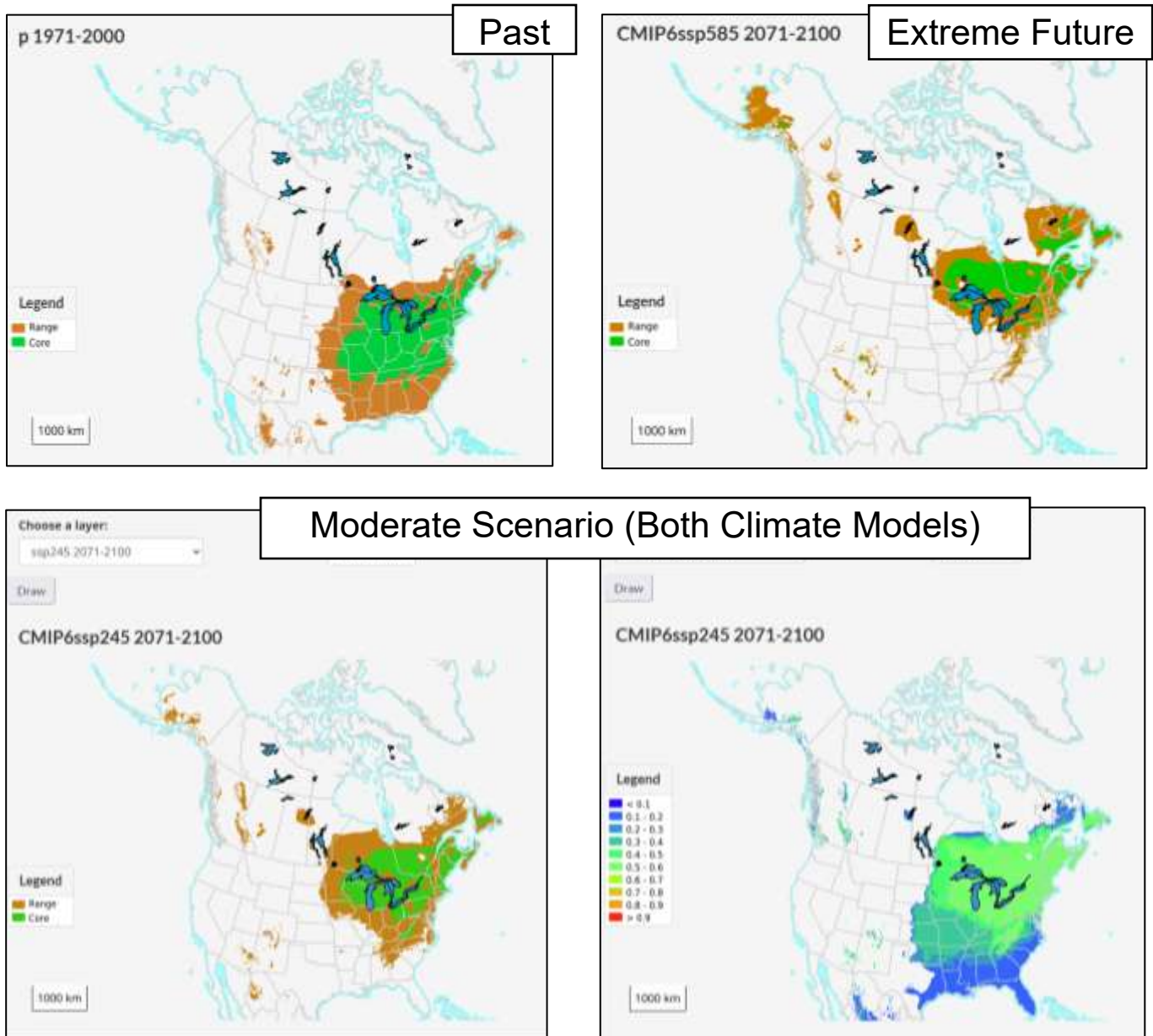


Figure 2. Northern Red Oak (*Quercus rubra*) Climate Change scenarios based by NRC on various CO² concentrations. The SSP scenarios were developed with respect to the sixth IPCC Summary report (IPCC 2023). Red Oak Distribution Maps Canada's Plant Hardiness Site | Natural Resources Canada.

Site Location and History

Royal Botanical Gardens is located at the western tip of Lake Ontario in the Hamilton-Burlington area with the 800-hectare landscape consisting mostly of nature sanctuaries, which includes approximately 450 hectares of terrestrial ecosystems. RBG's nature sanctuaries contain over 30 km of shoreline and 25 sub-watersheds carved into deep ravines. The dominant watersheds are Spencer Creek (270 km²) and Grindstone Creek (89 km²). Despite ongoing environmental challenges and human pressures, these two remain among the healthier watersheds around Lake Ontario, largely because they fall within Ontario's Greenbelt.

From the Niagara Escarpment plateau to the shores of Cootes Paradise Marsh, the land drops nearly 350 metres. Land use changes across the 25 contributing creeks have led to increased erosion, ravine slope collapses, sediment deposition, turbidity in the coastal marshes and loss of mature trees. These impacts are worsened by extreme rainfall and the collapse of mature trees, which block waterways and further destabilize the landscape.

Ecologically, RBG's lies within the Mixedwood Plains Ecozone - also known as the Lower Great Lakes and St. Lawrence Lowlands. This region includes four main physiographic regions: Iroquois Shore, Norfolk Sand Plain, Niagara Escarpment, and South Slope. It's often referred to as the Carolinian Zone due to the presence of more southern deciduous tree species such as hickories and sassafras. Within RBG, the Iroquois Shore dominates, encompassing much of Cootes Paradise and Hendrie Valley. The Escarpment Properties span from the South Slope at Berry Tract, across the Escarpment, and up to the edge of the Norfolk Sand Plain, where karst topography is present. Notably, the ravines in these areas have remained forested over time, preserving ecological continuity. Soil types are diverse ranging from sand to clay, poorly drained to well drained and from acidic to calcareous creating extensive microhabitats and species diversity with about 70 species of trees naturally occurring.



Figure 3. Distribution of intact forest areas (dark green), tree plantations (light green) and overall current wooded areas (medium green) across RBG properties.

Indigenous people shaped the landscape of what is now RBG through farming, controlled burning, and planting useful species along travel and trade routes. These routes remained in use until the arrival of European settlers, particularly, Empire loyalists in the 1780s. After their arrival, much of the flat land was fully cleared for farming, orchards, and pastures. Over time, intensive agriculture – including row crops – became widespread and was maintained throughout the 20th century.

In the early 1900s, parts of the lake side plateau land (Iroquois shore) were also heavily mined for clay, especially around Cootes Paradise. As a result, no part of the plateau remains untouched, although many of the ravines are still largely intact. However, these ravines now suffer from rapid erosion due to changes in how water flows through the creeks, which has led to scoured slopes and landslides

Cootes Paradise contains the largest area of intact forested ravines at RBG. These include deeply carved stream valley such as Hickory Brook, Long Valley Brook, Mink Brook, Borer’s Creek, Highland Creek, Westdale Creek, and Mac Landing Brook. In the northwestern corner, Hopkin’s Woods Special Protection Area helps preserve interior forest habitat, although some parts are plantations with low species diversity. Hendrie Valley is a narrow stretch of remaining forest, while both Cootes Paradise and Hendrie Valley were used for livestock grazing. Most of the Escarpment Properties have also been farmed in the past save for the steep talus slopes, which were too rugged for agriculture.

Forest Decline

Forest health and canopy cover across the region are being affected by a range of accumulated stressors. In Southern Ontario, the scale and complexity of these interacting factors have led to the phenomenon referred to as *forest decline*. The primary drivers of forest decline include invasive insects and diseases, imbalanced wildlife populations, and the spread of invasive plant species. A warming climate is further compounding the issue by enabling invasive species further north.

The forests of RBG have been in decline for nearly a century. The state of each of the forest areas is summarized in a series of reports and is supported by an ongoing monitoring program (Peirce et al, 2023-25, Barr et al. 2022). Today, they are primarily composed of mature Red Oak, Maple and Hickory species (Table 1). However, regeneration across these areas is dominated by a mix of invasive plants, along with Red Maple and Ash species. Notably, the largest and oldest trees tend to belong to the White Oak group, including a particularly significant specimen that is a challenge to identify– a Burr or Swamp White Oak – measuring 159cm in diameter.

In total, 89 species of trees have been recorded within the forested areas, 23 of which are introduced Eurasian species (Appendix 2). In regenerating habitats where forest cover was previously cleared, invasive species – especially Common Buckthorn- are prevalent. However, Black Walnut (a southern species), is beginning to establish itself across the sites. The sources are both historical reforestation efforts and from scattered large old individuals within the forest. Its allelopathic properties appear to be suppressing buckthorn growth, promoting the emergence of a Walnut-dominated forest. Black Walnut is among the future climate adapted species, and likely reflecting the influence of a warming climate.

The process of forest decline generally follows a recognizable pattern: a native tree species is weakened or killed by one of more stressors, creating canopy gaps. These gaps are then colonized by a mix of native and non-native species. However, herbivores such as deer and rabbits selectively browse on regenerating native plants, indirectly promoting the spread of invasive species. Without active management, these areas often transition to forests dominated by invasive trees and shrubs.

At RBG, invasive species are widespread and have significantly degraded even relatively intact forested areas. Several native tree species – such as Elm, Ash, Butternut American Chestnut, and Beech – have experienced serious decline or localized extinction due to introduced pests and pathogens. Key invasive plant species present in the area include Norway Maple (*Acer platanoides*), Magnolia species (*Magnolia sp.*), Eurasian Honeysuckle species (*Lonicera sp.*), Multiflora Rose (*Rosa multiflora*), and Common Privet (*Ligustrum vulgare*). Additionally, there are 40 distinct tree plantations established across RBG's old fields between 1950 and 1985. These plantations are typically low in species diversity, which makes them particularly vulnerable to invasions by non-native plants.

Given the complexity and severity of forest decline, a comprehensive Forest Canopy Strategy is needed. The primary goal of this strategy is to guide the transition from the current degraded state to a more resilient and diverse ecosystem. The priority themes of the strategy include:

1. Loss of tree species and canopy cover due to invasive pests and diseases.
2. Disturbed habitat resulting from introduced disease, invasive plants, anthropogenic disturbance, reduced water-retaining abilities on the landscape (wetlands), and loss of the marsh ecosystem.
3. Forest fragmentation resulting from historical land-clearing.
4. Low-diversity tree plantations that lack site-appropriate species.
5. Preparing to mitigate the effects of climate change.

Pest & Disease Species

Existing Invasive Eurasian Species: Diseases and Insects

- Beech Bark Disease: A complex disease involving both an insect and a fungus affecting beech trees
- Beech Leaf Disease: disease of beech trees that involves a worm-like, parasitic nematode.
- Butternut Canker: A fungus specific to Butternut Tree bark
- Chestnut Blight: A fungus specific to American Chestnut Tree bark
- Dutch Elm Disease (DED): A fungal disease affecting elm trees, transmitted by bark beetles
- Elm Zigzag sawfly: an insect affecting native elm tree species
- White Pine Blister Rust: Fungal disease affecting white pines, causing cankers and tree decline
- Emerald Ash Borer (EAB): An invasive beetle species that attacks and kills ash trees
- Spongy Moth: An invasive moth species that can defoliate trees, including oaks and aspen
- Needle Cast: Fungal diseases infect needles, leading to needle drop and potential death of the tree
- Hemlock Woolly Adelgid: a small aphid affecting hemlock trees
- Pine Shoot Beetle: an insect that affects all native species of pine.
- Box Tree Moth: an insect affecting *Buxus spp.* plants

Potential Nearby Threats – Anticipated to Emerge at RBG within the Next 10 Years

- Spotted Lantern Fly (*Lycorma delicatula*): An invasive planthopper primarily associated with Tree of Heaven, but also significantly impacts Black Walnut.
- Asian Long-horned Beetle (*Anoplophora glabripennis*): A highly destructive wood-boring pest of maples and other hardwoods including birch, poplar, and willow.
- Oak Wilt (*Bretziella fagacearum*): A vascular disease of oak trees, caused by a fungus transmitted through beetle activity.
- Thousand Canker Disease (*Geosmithia morbida*). An insect-fungus complex impacting Black Walnut trees, driven by the native Walnut Twig Beetle and an introduced fungal pathogen.

Climate Change and Eastern Hemlock (*Tsuga canadensis*) in Southern Ontario

For ecologists and gardeners alike, plant hardiness zones are well known key tools in determining a species' ability to exist and thrive in various climactic parameters across North America. First developed in the 1960s, these original models are soon to be considered obsolete as the climate continues to change at a rapid pace. The Eastern Hemlock is a climax forest dominant evergreen in the current forest system, and an example of species slowly shifting north. It is currently reduced to cool ravines within RBG lands. Using NRC growing zone forecasting models and associated maps to predict the range shift these models predict that the range of suitable climactic conditions for Eastern Hemlock will shift northward, with the RBG location excluded from both "Core" and "Range" habitat potentials (Figure 4). This is true for a number of tree species including most evergreens, many birch species and some serviceberry species. The Eastern Hemlock was only recently affected by a newly colonizing Eurasian insect, the Hemlock Woolly Adelgid, first identified on site in 2023 and now subject of a management plan (Barr et al 2025).



Figure 4. Climate Change Models and Future Eastern Hemlock (*Tsuga canadensis*) 2071-2100. Distribution Maps AR5RCP 2.6, AR5RCP 4.5, AR5RCP 8.5. <https://www.planthardiness.gc.ca/?m=13&lang=en>.

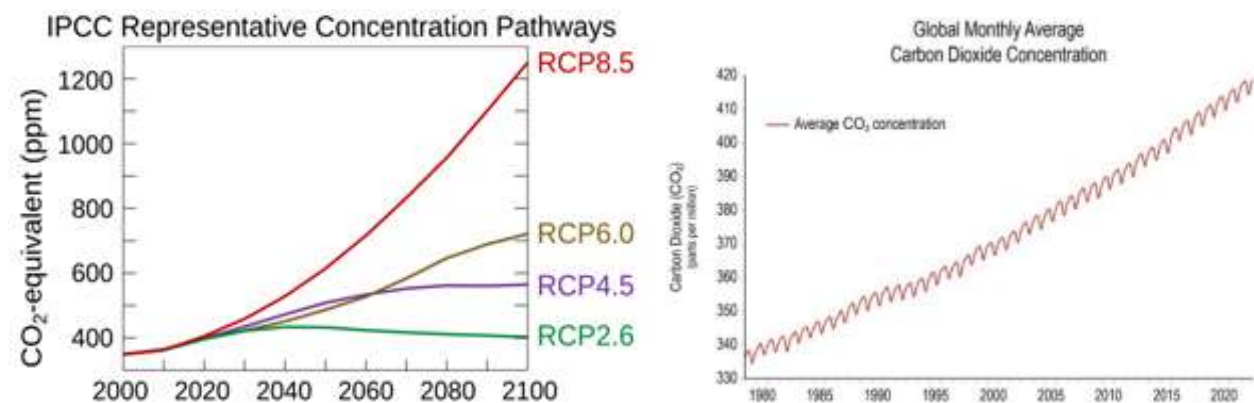


Figure 5. Intergovernmental Panel on Climate Change (IPCC) Climate Models and associated CO₂ concentrations. <https://www.ipcc.ch/>, and monthly mean carbon dioxide measured at Mauna Loa Observatory 1958-2024, <http://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxides://www.globalchange.gov/indicators/atmospheric-carbon-dioxide>

Forest Canopy, Rare Understory Species & Climate Change.

Few-flowered Club-rush (also known as Bashful Bulrush) is a highly endangered sedge species found in only two locations in Canada. A *Recovery Strategy* for the species was developed by Smith and Rothfels (2007), highlighting its critical dependence on intact Oak Forest and Woodland habitats, which are maintained by the presence of mature oaks. The Recovery Strategy identifies “Critical Habitat” for the species to the extent possible, which includes eight known sites within Cootes Paradise. These sites fall within two key habitat types as defined by the *Ecological Land Classification (ELC) for Southern Ontario* (Lee et al. 1998): Dry-Fresh Oak-Red Maple Deciduous Forest and Dry Black Oak – White Oak Tallgrass Woodland. These habitats are typically found on warm, well-drained slopes with slightly higher light availability due to factors such as canopy gaps from fallen trees or steep terrain.



As climate shifts northward, oak species are becoming increasingly favoured. However, their future – and that of Few-flowered Club-rush – is at risk from emerging threats such as invasive pathogens including Oak Wilt, which could severely impact the oak-dominated ecosystems.

Figure 6. INaturist Observation/Distribution Map for Few-flowered Club-rush (*Tricophorum planifolium*), 2025.

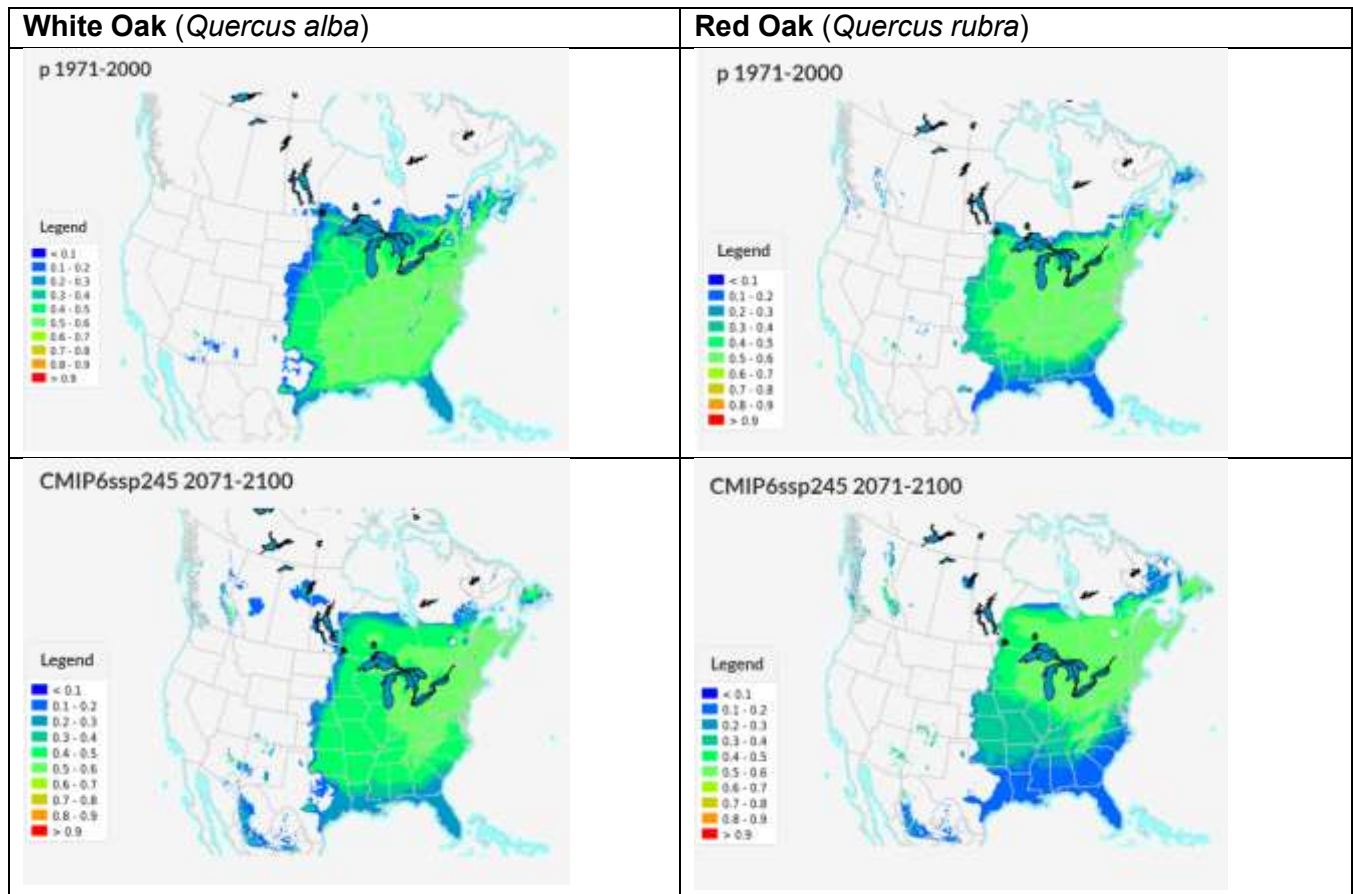


Figure 7. Maps showing changes for Red and White Oak under a moderate warming scenario -ssp245.

Forest Canopy Stewardship Strategy

Goal: Ensure long-term health, resilience, and sustainability of RBG’s forest canopy through targeted actions that mitigate the impacts of climate change, invasive species, high herbivore populations, and human activity.

Forest Strategy Objectives:

1. **Protect Existing Canopy:** Safeguard the mature tree canopy and promote regeneration through monitoring, invasive species management, creek erosion mitigation, and improving forest structure.
2. **Restore Damaged Ecosystems:** Rehabilitate degraded areas through reforestation, natural regeneration, invasive plant species control, water storage, and controlled wildlife management.
3. **Enhance Resilience:** Improve forest resilience to climate change and herbivore pressures through diversification, assisted migration of plant species, and wildlife population control.
4. **Promote Public Awareness of Issues:** Educate local communities and visitors about the importance of forest conservation, invasive species, wildlife management, and climate change adaptation with the key objective of fostering financial support of actions.

The Forest Strategy prioritizes protecting intact forest areas (Objective #1) and is structured around four key themes under “Threats and Challenges” and five under “Strategic Actions”. These actions will guide project selection and budgeting, with detailed budgets developed in collaboration with funding partners and, where applicable, other stakeholders or experts. A tree species list is found in Appendix 1

Timelines

Short-term (1–3 years): Focus on invasive species control, climate change adaptation research and migration trials, and community engagement. Continue forest health monitoring programs.

Medium-term (3–7 years): Implement large-scale reforestation projects and restoration of degraded forest areas. Expand public awareness initiatives. Acquire strategic lands for habitat defragmentation and habitat corridors.

Long-term (7+ years): Continue adaptive management, monitor progress, and refine strategies based on new scientific knowledge and climate models.

Key Threats and Challenges

1. Climate Change
 - Impact on species distribution: Shifts in temperature and precipitation patterns are altering the suitability of the current species composition in RBG’s forests.
 - Increased frequency of extreme weather events: Heavy rains, winds, droughts, and heatwaves are damaging mature trees, disrupting forest dynamics and eroding ravine creek banks.
 - Forest health decline: Changes in the growing season, carbon availability, temperature extremes, and shifting pest pressures are leading to increased forest mortality and impacted tree growth.
 - Forest fire risk: Changes in moisture levels may increase the risk of wildfires, which can devastate forest canopies and disrupt ecosystem services.

2. Invasive Species

- Invasive plants: Species such as buckthorn honeysuckle and garlic mustard can outcompete native vegetation, disrupt forest understories and prevent natural regeneration.
- Invasive insects: Insects such as the Emerald Ash Borer and Spongy Moth pose direct threats to key tree species, causing defoliation and mortality.
- Invasive fungi and diseases: Pathogens like the Dutch elm disease, Butternut Canker and Chestnut Blight have devastated certain tree species in the region.
- Falling dead trees are plugging up the ravine creeks causing ravine erosion.

3. Unbalanced Wildlife Populations

- Overabundant herbivores: High populations of white-tailed deer and other herbivores are significantly impacting forest regeneration by over-browsing young saplings, native shrubs, and understory plants. This prevents new trees from growing, thus threatening the future canopy structure and biodiversity.
- Impacts on biodiversity: Herbivores, by consuming large quantities of native plants, reduce plant diversity, which in turn affects invasive plant recolonization, forest structure and wildlife habitat. Additionally, certain plant species crucial for forest regeneration are over-browsed to the point of local extinction in some areas.
- Missing species including predator species as well as amphibians that would exert more balanced population dynamics on both herbivores and invertebrates.

4. Human Impact

- Urbanization and land use change: The encroachment of human settlements is causing further habitat fragmentation, pollution, and increased pressure on forest ecosystems.
- Recreation and tourism: Overuse of trails and outdoor spaces is contributing to soil compaction, erosion, and off trail use damage to sensitive forest areas and displacing wildlife.
- Harvesting: Collection of forest material (e.g., plants, firewood, non-timber products) can disturb canopy dynamics and reduce forest regeneration.
- Homeless Encampments: Ongoing and growing encampments within the property and damaging habitat through trampling, harvesting, and displacing of wildlife.
- Land use changes have changed creek hydraulics and geomorphology eroding creeks, which are undermining and collapsing ravine slopes that host the remaining intact forest.

Strategic Actions

Climate Change Adaptation and Mitigation

1. Forest Composition Diversification

- Introduce a greater diversity of tree species, particularly native species that are more resilient to predicted climate changes (e.g., drought-resistant and heat-tolerant species).
- Prioritize species that support wildlife and are beneficial for maintaining ecosystem services (e.g., carbon sequestration, water regulation).
- Reintroduced surviving disease resistant varieties of lost tree species such as American Chestnut, Butternut, and American Elm.

2. Assisted Migration of Plant Species
 - Relocate species that are expected to struggle under future climate conditions to areas within RBG where they are likely to thrive. This could involve relocating species like Chestnut Oak or Shellbark Hickory into areas that align with future climate models.
3. Carbon Storage Capacity
 - Implement measures to enhance carbon sequestration in RBG's forests, including promoting the growth of fast-growing species such as Tulip Tree, as well as protecting mature trees with forest edge buffers to reduce wind impacts.
 - Establish a carbon monitoring system to assess the carbon storage potential of the forest
4. Water Management and Ecosystem Resilience
 - Implement strategies to manage water resources, such as enhancing riparian zones and establishing wetlands to regulate creek flows and water levels and mitigate droughts.
5. Forest Health Monitoring
 - Implement a monitoring system to track changes in forest health, tree mortality, and growth.
 - Use data from monitoring to guide adaptive management strategies for forest restoration and climate change resilience.
 - Regular safety inspection/mitigation for hazardous trees adjacent to infrastructure/trail system.

Invasive Species Management

1. Early Detection and Rapid Response (EDRR)
 - Establish a dedicated invasive species team to regularly monitor RBG forests for invasive plants, insects, and diseases.
 - Develop and implement early detection protocols to quickly respond to new invasions, reducing their spread and impact.
2. Invasive Plant Removal and Native Plant Restoration
 - Conduct large-scale invasive plant removal projects, particularly in the understory, to encourage the regeneration of native species.
 - Replant native vegetation, focusing on species that are adapted to local conditions and enhance forest biodiversity.
3. Pest Control and Tree Health Initiatives
 - Work with forestry experts and local municipalities to develop and implement control measures for invasive pests like the Hemlock Woolly Adelgid.
 - Investigate and deploy biological control options and tree disease management programs, particularly for species like ash and elm.

Forest Canopy Restoration and Resilience Enhancement

1. Natural Regeneration and Assisted Natural Regeneration
 - Promote natural regeneration through seedling establishment and careful thinning of over-dense invasive plant species areas and reducing browsing pressure from herbivores.
2. Reforestation Projects
 - Replanting with Climate-Resilient Species: Re-forest interior forest where tree cover has been lost, focusing on a mix of native and future climate-adapted species.

- **Habitat Continuity:** Re-forest fragmented edges to establish buffer areas and create core forest habitats while maintaining areas for grasslands and savannahs.
- **Ecosystem-Based Restoration:** Focus on restoring not only the tree canopy but also the understory and forest floor, which are crucial for ecosystem health & biodiversity.
- **Diversify plantings** away from oak tree planting to reduce predominance of oak species due to the anticipated impacts of Oak Wilt.

Unbalanced Wildlife Population Management

1. Control of Herbivore Populations

- **Monitoring and Population Management:** Implement regular monitoring of herbivore populations, particularly White-tailed Deer, through non-lethal methods (e.g., camera traps, visual surveys) to assess browsing pressure on forest regeneration.
- **Deer Population Management:** Collaborate with wildlife management agencies and local municipalities to develop a comprehensive deer management plan. This may include controlled hunting, the use of birth control methods, and habitat modification (e.g., fencing or reforestation in key areas) to reduce herbivore impacts.
- **Deer Exclosure Fencing:** Use temporary or permanent exclosure fences in key regeneration areas to protect young saplings and native plants from browsing pressure.
- **Old Field Wetland Re-establishment:** Excavate infilled and drained wetlands in the old fields where water ponding can facilitate reproductive ponds for amphibians.
- **Established appropriately sized core undisturbed areas and corridors** for top predator species. Top predators include mammals like Red Fox, Coyote, Bobcat, various mustelids, and raptors.

2. Habitat Restoration for Wildlife

- **Biodiversity Support:** Promote the restoration of biodiversity by enhancing habitat for predators and other species that naturally regulate herbivore populations.
- **Understory Regeneration:** Actively regenerate the forest understory with plants that are not favored by herbivores and use fencing to protect these critical areas as they regenerate.

3. Adaptive Management

- Implement an adaptive management approach for wildlife and herbivore populations, adjusting strategies as needed based on monitoring results and ecological outcomes.

Human Impact Management and Engagement

1. Community Awareness and Engagement

- Develop and promote educational programs for RBG visitors on the importance of forest canopy protection and climate change adaptation.
- Encourage responsible outdoor activities that minimize damage to fragile ecosystems, such as staying on designated trails and following Leave No Trace principles.

2. Community Involvement in Wildlife Monitoring

- Encourage local communities and RBG visitors to participate in wildlife monitoring through citizen science programs, particularly for tracking herbivore populations and forest regeneration.

3. Sustainable Land Management

- Collaborate with neighboring landowners and municipalities to implement land-use policies that reduce pressures on RBG's forest ecosystems, including strategies to protect wildlife corridors and prevent urban sprawl near sensitive areas.
- Undertake periodic reviews of the property for homeless encampments and coordinate with community support and police for removal from site
- With strategically located and branded signs identify property edges and protection mission.

Restoration Planting & Assisted Migration Species

Restoration planting will reflect the dominant species of the existing plant community. However, a key challenge is climate change, which renders some current species completely unsuitable for RBG's nature sanctuaries while creating opportunities for other species better adapted to forecasted future conditions. A further challenge is the dominance of oak relative to the future impacts of Oak Wilt. In total about 80 tree species will be suited to the changing climate, with only 10 currently not present (Appendix 1), and another 12 forecasted as no longer suitable for the site by as early as 2050.

Community Composition

- Existing forest community common species: Red Oak, White Oak, Sugar Maple, Red Maple, White Pine, Shagbark Hickory, Downy Serviceberry, White Birch, Black Cherry, American Witch-hazel, American Hazelnut, Alternate Leaf Dogwood, Round-leaved Dogwood, Bush Honeysuckle, and Choke Cherry.
- Climate change resilient species currently within the southern fringe of Ontario (i.e. Carolinian species) include: Chestnut Oak, Hills Oak, Pin Oak, Shumard Oak, Overcup Oak, Sassafras, Tulip Tree, Black Gum, PawPaw, American Persimmon, Shellbark Hickory, Mockernut Hickory, Cherry Birch, River Birch, Cucumber Magnolia, Common Hoptree, Blue Ash, Honey Locust, Ohio Buckeye, Northern Hackberry, Pitch Pine, Virginia Pine, Red Mulberry, American Sycamore, Big-seeded Hawthorn.
- Species that currently do not exist in Southern Ontario, but are climate change resilient species: Sugar Hackberry, Loblolly Pine, Pitch Pine, Swamp Cottonwood, Swamp Locust, and Sweetbay Magnolia, with many further additional species not listed/potential. In addition, within the RBG property many collection trees have existed for decades and can provide useful information on hardiness.

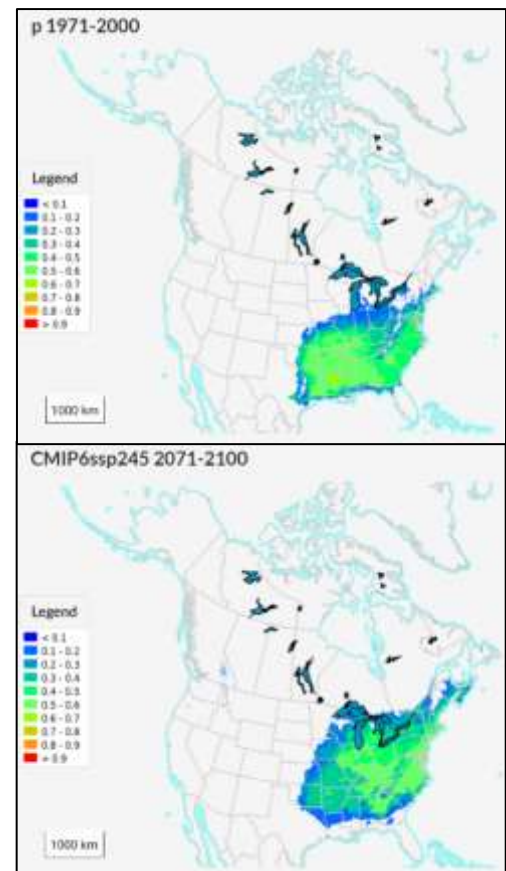


Figure 8. Example distribution maps under a moderate warming scenario SSP245. for a potentially common future species Shumard Oak (*Quercus shumardii*), currently an Ontario rare species-NRC Maps. Oak Wilt is of significant concern to future oak planting considerations.

Tree species no longer viable except within localized microclimate niches include;

- Eastern Hemlock, Eastern White Cedar, Red Pine, Balsam Fir, Spruce species, Tamarack, Trembling Aspen, White Birch, Yellow Birch, Large-tooth Aspen, Balsam Poplar, Black Ash, Canada Service Berry, and Smooth Serviceberry.

Rock Chapel, the most recently assessed forest site (Pierce et al 2024) provides an example of how the more common current species will adjust based on the changing climate under a moderate climate warming scenario. “Core” indicates the species is within in the core habitat and growing conditions, while range refers to the margins of a trees preferred habitat.

Table 2. Example of Canopy tree species present in Rock Chapel's forest monitoring plots in 2024, and their associated current and forecasted distribution based on climate model SSP245, italics identifying a notable shift.

Species Name	Basal Area (%)	In-plot Abundance	Density (trees/ha)	Current Distribution	Forecasted (2071-2100)
Sugar Maple <i>(Acer saccharum)</i>	40.9%	13	54	Core	Range
Ironwood <i>(Ostrya virginiana)</i>	4.7%	7	29	Core	Core
Black Cherry <i>(Prunus serotina)</i>	13.9%	6	25	Range	Range
Red Oak <i>(Quercus rubra)</i>	40.0%	5	21	Core	Core (Range in most extreme scenario)
Norway Maple <i>(Acer platanoides)</i>	0.2%	1	4	N/A	Not Present
Shagbark Hickory <i>(Carya ovata)</i>	0.3%	1	4	Range	Core
White Ash <i>(Fraxinus americana)</i>	0.1%	1	4	Core	Range

Conclusion

This Forest Canopy Stewardship Strategy aims to guide RBG's forest ecosystems through the challenges of climate change, invasive species, and growing human impact. By addressing these pressures with targeted actions, RBG can protect and transition its forest canopy to the new climate conditions, while supporting broader conservation efforts across Southern Ontario. The environmental growing conditions for this region can be anticipated to be that of a temperate deciduous forest similar to that of the Appalachian ecoregion, with ample evidence that this is already the case. Many southern deciduous forest species already survive in the existing garden collection plantings.

Through research, collaboration, and community engagement, RBG will help build resilient, sustainable forests for future generations to depend on and enjoy. This document is intended to provide broader regional leadership aided by both RBG's knowledge of plants, examples of and the many microclimates and diverse habitats found within the property. Due to the already existing collections of more southern species resulting in a potential of 32 additional tree species added into the forest ecosystem, but with only 10 of these currently not found on the RBG property, a result of past tree collections plantings. Habitat details of new species and their preferred growing conditions can be found in both in the U.S Forest Service website and in the Appendix of Trees of the Carolinian Forest (Waldron 2003).



Figure 9. RBG Arboretum Avenue of Trees #1, with examples of climate change appropriate species including Pin Oak (*Quercus palustris*) and Tulip Tree (*Liriodendron tulipifera*).

References

Barr, L., Peirce M., and L. Negrazis. 2022. Cootes Paradise South Shore Forest Ecological Condition Update 2021. RBG Report No. 2022-4 Royal Botanical Gardens. Burlington, ON.

Barr L., M. Peirce, T. Theijsmeyer, & A. Cramer. 2025. Royal Botanical Gardens' Hemlock Woolly Adelgid (*Adelges tsugae*) Management Strategy. Ecological Stewardship Department. 2025. Royal Botanical Gardens. Hamilton, Ontario.

IPCC, 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 184 pp., doi: 10.59327/IPCC/AR6-9789291691647.

Lee, H, Wasyl Bakowsky, John Riley, Jane Bowles, Michael Puddister, Peter Uhlig, Sean McMurray. 1998. Ecological Land Classification for Southern Ontario. First Approximation and Its Application. SCSS Field Guide FG-02. ISBN 0-7778-7263-3. OMNR# 51146. Published by Ontario Ministry of Natural Resources

Peirce, M., L. Barr, J. Hamilton. 2023. Cootes Paradise North Shore Forest Status. RBG Report No. 2023-4 Royal Botanical Gardens. Burlington, ON.

Peirce, M., L. Barr, A. Cramer & T. Theijsmeyer. 2024. Hendrie Valley Forest Status. RBG Report No. 2024-4 Royal Botanical Gardens. Burlington, ON.

Peirce, M. &. 2025. Rock Chapel Forest Status. RBG Report No. 2025-4. Royal Botanical Gardens. Burlington, ON.

Rothfels C. 2005. Why are all the Oak Trees Dying. RBG newsletter, Royal Botanical Gardens, Hamilton Ontario.

McKenney DW, Pedlar JP, Iverson LR, Hutchinson MF, Lawrence K, Campbell K. (2007) Potential impacts of climate change on the distribution of North American trees. Bioscience, Vol. 57 No. 11:939-948.

Smith, T.W. and C.J. Rothfels. 2007. Recovery Strategy for Few-flowered Club-rush/Bashful Bulrush (*Trichophorum planifolium* (Sprengel) Palla) in Canada. Prepared for the Ontario Ministry of Natural Resources by the Royal Botanical Gardens. Hamilton. vi + 22 pp.

Smith, T. 2003. Checklist of the vascular flora of Royal Botanical Gardens. Hamilton. Electronic Publication. Royal Botanical Gardens. [RBG Contribution 113]

Waldron G. 2003. Trees of the Carolinian Forest: A Guide to Species, Their Ecology and Uses. Boston Mills Press, 132 Main Street, Erin, Ontario N0B 1T0 Canada. 274 pages

Appendix 1. New Climate Adapted Species List

Trees - Assisted Migration and new climate adapted tree species for RBG's nature sanctuaries.

#	Common Name	Scientific Name	Existing	New	Collection Planted
1	Black Maple	<i>Acer nigra</i>	X		
2	Red Maple	<i>Acer rubrum</i>	X		
3	Silver Maple	<i>Acer saccharinum</i>	X		
4	Sugar Maple	<i>Acer saccharum</i>	X		
5	Yellow Buckeye	<i>Aesculus flava</i>			X
6	Ohio Buckeye	<i>Aesculus glabra</i>			X
7	Downy Serviceberry	<i>Amelanchier arborea</i>	X		
8	Pawpaw	<i>Asimina triloba</i>			X
9	Cherry Birch	<i>Betula lenta</i>			X
10	River Birch	<i>Betula nigra</i>			X
11	Blue Beach	<i>Carpinus caroliniana</i>	X		
12	Bitternut Hickory	<i>Carya cordiformis</i>	X		
13	Pignut/Red Hickory	<i>Carya glabra</i>	X		
14	Pecan	<i>Carya illinoensis</i>		X	
15	Shellbark Hickory	<i>Carya laciniata</i>		X	
16	Shagbark Hickory	<i>Carya ovata</i>	X		
17	Mockernut Hickory	<i>Carya tomentosa</i>		X	
18	American Chestnut	<i>Castanea dentata</i>	X		
19	Northern Catalpa	<i>Catalpa speciosa</i>	X		
20	Sugar Hackberry	<i>Celtis laevigata</i>			X
21	Northern Hackberry	<i>Celtis occidentalis</i>	X		
22	Eastern Redbud	<i>Cercis canadensis</i>	X		
23	American Yellowwood	<i>Cladrastis kentukea</i>			X
24	Flower Dogwood	<i>Cornus florida</i>	X		
25	Dunbar's Hawthorn	<i>Crataegus beata*</i>	X		
26	Large-thorn Hawthorn	<i>Crataegus macracantha*</i>	X		
27	Large-seeded Hawthorn	<i>Crataegus macrosperma*</i>		X	
28	Poplar Hawthorn	<i>Crataegus populnea*</i>	X		
29	American Persimmon	<i>Diospyros virginiana</i>		X	
30	Eastern Wahoo	<i>Euonymus atropurpureus</i>			X
31	American Beech	<i>Fagus grandifolia</i>	X		
32	White Ash	<i>Fraxinus americana</i>	X		
33	Green Ash	<i>Fraxinus pennsylvanica</i>	X		
34	Red Ash	<i>Fraxinus pensylvanica</i>	X		
35	Pumpkin Ash	<i>Fraxinus profunda</i>		X	
36	Blue Ash	<i>Fraxinus quadrangulata</i>			X
37	Honey Locust	<i>Gleditsia triacanthos</i>			X
38	Kentucky Coffeetree	<i>Gymnocladus dioica</i>			X
39	Butternut	<i>Juglans cinerea</i>	X		
40	Black Walnut	<i>Juglans nigra</i>	X		
41	Eastern Red Cedar	<i>Juniperus virginiana</i>	X		
42	American Sweet Gum	<i>Liquidambar styraciflua</i>			X

#	Common Name	Scientific Name	Existing	New	Collection Planted
43	Tulip Tree	<i>Liriodendron tulipifera</i>	X		
44	Cucumber Tree	<i>Magnolia acuminata</i>			X
45	Umbrella Magnolia	<i>Magnolia tripetala</i>			X
46	Sweetbay Magnolia	<i>Magnolia virginiana</i>			X
47	Sweet Crabapple	<i>Malus coronaria</i>	X		
48	Red Mulberry	<i>Morus rubra</i>	X		
50	Black Gum	<i>Nyssa sylvatica</i>			X
51	Eastern Hop-hornbeam	<i>Ostrya virginiana</i>	X		
52	Virginia Pine	<i>Pinus virginiana</i>			X
53	Pitch Pine	<i>Pinus taeda</i>		X	
54	American Sycamore	<i>Platanus occidentalis</i>	X		
55	Eastern Cottonwood	<i>Populus deltoides</i>	X		
56	Swamp Cottonwood	<i>Populus heterophylla</i>			X
57	American Plum	<i>Prunus americana</i>	X		
58	Wild Black Cherry	<i>Prunus serotina</i>	X		
59	Choke Cherry	<i>Prunus virginiana</i>	X		
60	Common Hoptree	<i>Ptelia trifoliata</i>	X		
61	White Oak	<i>Quercus alba</i>	X		
62	Swamp White Oak	<i>Quercus bicolor</i>	X		
63	Hills Oak	<i>Quercus ellipsoidalis</i>			X
64	Shingle Oak	<i>Quercus imbricaria</i>			X
65	Overcup Oak	<i>Quercus lyrata</i>		X	
66	Bur Oak	<i>Quercus macrocarpa</i>	X		
67	Swamp Chestnut Oak	<i>Quercus michauxii</i>		X	
68	Chestnut Oak	<i>Quercus montana</i>			X
69	Chinquapin Oak	<i>Quercus muehlenbergii</i>	X		
70	Pin Oak	<i>Quercus palustris</i>			X
71	Northern Red Oak	<i>Quercus rubra</i>	X		
72	Shumard Oak	<i>Quercus shumardii</i>		X	
73	Black Oak	<i>Quercus velutina</i>	X		
74	Black Locust	<i>Robinia pseudoacacia</i>	X		
75	Black Willow	<i>Salix nigra</i>	X		
76	Sassafras	<i>Sassafras albidum</i>	X		
77	American Basswood	<i>Tilia americana</i>	X		
78	American Elm	<i>Ulmus americana</i>	X		
79	Slippery Elm	<i>Ulmus rubra</i>	X		
	Total Species		47	10	22

*Note: The complexity of the Hawthorns (*Crataegus*) requires a more thorough investigation and lacks data due to identification challenges. Species significantly affected by Eurasian pests and diseases including elm, ash, Butternut, American Chestnut, and beech would occur as special trial projects.

Appendix 2. Current Tree Species List

Table 3. Spontaneous occurrence of tree species found in RBG's nature sanctuaries; non-native species are marked by italics (Smith 2003). Total 88 species including 23 Eurasian species.

#	Common Name	Scientific Name	Cootes Paradise	Hendrie Valley	Escarpment
1	<i>Field Maple*</i>	<i>Acer campestre</i>	X	X	
2	Manitoba Maple	<i>Acer negundo</i>	X	X	X
3	Black Maple	<i>Acer nigra</i>	X	X	X
4	<i>Norway Maple*</i>	<i>Acer platanoides</i>	X	X	X
5	<i>Sycamore Maple*</i>	<i>Acer pseudoplatanus</i>		X	
6	Red Maple	<i>Acer rubrum</i>	X	X	X
7	Silver Maple	<i>Acer saccharinum</i>	X	X	
8	Sugar Maple	<i>Acer saccharum</i>	X	X	X
9	Mountain Maple	<i>Acer spicatum</i>	X	X	
10	<i>Tartarian Maple*</i>	<i>Acer tataricum</i>			X
11	Ohio Buckeye	<i>Aesculus glabra</i>	X	X	
12	<i>Tree-of-heaven*</i>	<i>Ailanthus altissima</i>		X	
13	<i>European Black Alder*</i>	<i>Alnus glutinosa</i>	X	X	
14	Speckled Alder	<i>Alnus incana</i>	X	X	
15	Saskatoon Berry	<i>Amelanchier alnifolia</i>	X	X	X
16	Downy Serviceberry	<i>Amelanchier arborea</i>	X	X	
17	Inland Serviceberry	<i>Amelanchier interior</i>			X
18	Smooth Serviceberry	<i>Amelanchier laevis</i>	X	X	
19	Round-leaved Serviceberry	<i>Amelanchier sanguinea</i>	X		X
20	Pawpaw	<i>Asimina triloba</i>	X	X	
21	Yellow Birch	<i>Betula alleghaniensis</i>	X	X	
22	Cherry Birch - Planted	<i>Betula lenta</i>	X		
23	Paper Birch	<i>Betula papyrifera</i>	X	X	X
24	<i>Weeping Birch*</i>	<i>Betula pendula</i>			X
25	Blue beech	<i>Carpinus caroliniana</i>	X	X	X
26	Bitternut Hickory	<i>Carya cordiformis</i>	X	X	X
27	Pignut Hickory	<i>Carya glabra</i>	X	X	
28	Shagbark Hickory	<i>Carya ovata</i>	X	X	X
29	American Chestnut	<i>Castanea dentata</i>	X	X	
30	Northern Catalpa	<i>Catalpa speciosa</i>	X		
31	Eastern Redbud	<i>Cercis canadensis</i>	X	X	
32	Dunbar's Hawthorn	<i>Crataegus beata</i>	X		
33	Large-thorn Hawthorn	<i>Crataegus macracantha</i>	X	X	
34	Poplar Hawthorn	<i>Crataegus populnea</i>	X		
35	<i>Russian Olive*</i>	<i>Elaeagnus angustifolia</i>	X	X	
36	American Beech	<i>Fagus grandifolia</i>	X	X	
37	White Ash	<i>Fraxinus americana</i>	X	X	X
38	Black Ash	<i>Fraxinus nigra</i>	X	X	
39	Green Ash	<i>Fraxinus pennsylvanica</i>	X	X	
40	Red Ash	<i>Fraxinus pensylvanica</i>	X		
41	Honey Locust	<i>Gleditsia triacanthos</i>	X		
42	Butternut	<i>Juglans cinerea</i>	X	X	X
43	Black Walnut	<i>Juglans nigra</i>	X	X	X

#	Common Name	Scientific Name	Cootes Paradise	Hendrie Valley	Escarpment
44	<i>English Walnut*</i>	<i>Juglans regia</i>		X	
45	Eastern Red Cedar	<i>Juniperus virginiana</i>	X	X	X
46	<i>European Larch*</i>	<i>Larix decidua</i>	X		
47	Tulip Tree	<i>Liriodendron tulipifera</i>	X	X	
48	Sweet Crabapple	<i>Malus coronaria</i>	X	X	X
49	<i>Wild Apples*</i>	<i>Malus sp.</i>	X	X	X
50	<i>White Mulberry*</i>	<i>Morus alba</i>	X	X	X
51	Red Mulberry	<i>Morus rubra</i>			X
52	Eastern Hop-hornbeam	<i>Ostrya virginiana</i>	X	X	X
53	<i>Amur Corktree*</i>	<i>Phellodendron amurense</i>	X	X	
54	Red Pine	<i>Pinus resinosa</i>	X		
55	American Sycamore	<i>Platanus occidentalis</i>	X	X	
56	<i>White Poplar*</i>	<i>Populus albar</i>	X		
57	Balsam Poplar	<i>Populus balsamifera</i>	X	X	X
58	Eastern Cottonwood	<i>Populus deltoides</i>	X	X	X
59	Large-tooth Aspen	<i>Populus grandidentata</i>	X	X	X
60	Trembling Aspen	<i>Populus tremuloides</i>	X	X	X
61	American Plum	<i>Prunus americana</i>	X		X
62	<i>Sweet Cherry*</i>	<i>Prunus avium</i>	X		X
63	Pin Cherry	<i>Prunus pensylvanica</i>	X	X	
64	Wild Black Cherry	<i>Prunus serotina</i>	X	X	X
65	Choke Cherry	<i>Prunus virginiana</i>	X	X	X
66	<i>Common Pear*</i>	<i>Pyrus communis</i>	X		
67	White Oak	<i>Quercus alba</i>	X	X	X
68	Swamp White Oak	<i>Quercus bicolor</i>	X	X	
69	Bur Oak	<i>Quercus macrocarpa</i>	X		
70	Chinquapin Oak	<i>Quercus muehlenbergii</i>	X	X	X
71	Northern Red Oak	<i>Quercus rubra</i>	X	X	X
72	Black Oak	<i>Quercus velutina</i>	X	X	X
73	<i>White Willow*</i>	<i>Salix alba</i>	X		X
74	<i>Crack Willow*</i>	<i>Salix fragilis</i>	X		X
76	Black Willow	<i>Salix nigra</i>	X	X	
77	Sassafras	<i>Sassafras albidum</i>	X	X	X
78	Northern Mountain-ash	<i>Sorbus decora</i>	X		
79	<i>Peking Tree Lilac*</i>	<i>Syringa reticulata</i>	X		
80	Eastern White Cedar	<i>Thuja occidentalis</i>	X	X	X
81	American Basswood	<i>Tilia americana</i>	X		X
82	Eastern Hemlock	<i>Tsuga canadensis</i>	X	X	X
83	American Elm	<i>Ulmus americana</i>	X	X	X
84	<i>Siberian Elm*</i>	<i>Ulmus pumila</i>		X	
85	Slippery Elm	<i>Ulmus rubra</i>	X	X	
86	<i>Wayfaring-tree*</i>	<i>Viburnum lantana</i>	X	X	
Total Species			77	62	42

Note: Three addition trees species have begun colonization of the natural areas including Katsura (*Cercidiphyllum japonicum*), Japanese Walnut (*Juglans ailantifolia*), and Magnolia Kobus (*Magnolia Kobus*) since the 2003 Checklist was published.

Appendix 3. Trees Reviewed for Climate Change and Future RBG Plantings

Common Name	Species Name	Current Distribution	Forecasted Distribution	Currently Present in Ontario	Closest iNaturalist Observation	Soil Requirements	Light Requirements	Moisture Requirements
American Holly	<i>Ilex opaca</i>	Not present	Range	No	West Falls, New York	Acidic, well drained, consistently moist.	Part shade to full sun.	Medium
American Persimmon	<i>Diospyros virginiana</i>	Range	Range	Yes, in small numbers	Jordan, ON	Variable, grows best in moist, rich soil (sandy, sandy loam to clay)	Full sun to part shade	Low to Wet
Black Cherry	<i>Prunus serotina</i>	Range (very close to Core)	Range (very close to Core)	Yes	RBG	Rich, well drained.	Part shade to full sun	Medium
Black Walnut	<i>Juglans nigra</i>	Range	Range	Yes	RBG	Rich, well drained	Full sun	Moist
Blackjack Oak	<i>Quercus marilandica</i>	Range	Range and Core (most extreme scenario)	No	Just north of Lancaster, P.A. and south of Columbus, OH.	Dry	Part shade	Low
Chestnut Oak	<i>Quercus montana</i>	Not Present	Core Range	Yes	RBG collections	Variable well drained (gravel, sand)	Full Sun to part shade	Medium to Dry
Common Hackberry	<i>Celtis occidentalis</i>	Range	Range (almost Core)	Yes	RBG	Rich, well drained	Part shade to full sun	Medium to wet
Cucumber Magnolia	<i>Magnolia acuminata</i>	Range	Range	Yes	Waterdown, ON and RBG, North of Snake Road.	Rich, well drained.	Part shade to full sun	Moist
Eastern Redbud	<i>Cercis canadensis</i>	Range	Range (almost Core)	Yes	RBG	Moderately well drained, consistent moisture	Part shade to full sun	Medium
Florida Maple	<i>Acer barbatum</i>	Not present	Range	No	Allana Acres, Maryland	Occasionally wet, well drained. Variety of compositions	Part shade to full sun	Moist
Flowering Dogwood	<i>Cornus florida</i>	Range	Range (almost Core)	Yes	RBG	Well drained. Rich, acidic	Part shade to full sun	Medium
Honey Locust	<i>Gleditsia triacanthos</i>	Range	Range (very close to Core)	Yes	RBG North Shore.	Loam, clay, well drained, can tolerate a range	Full sun	Moist but drought & flood tolerant

Ironwood	<i>Ostrya virginiana</i>	Core	Core	Yes	RBG	Well drained	Part shade to full sun	Medium
Kentucky Coffeetree	<i>Gymnocladus dioica</i>	Range	Range	Yes	RBG North Shore.	Rich, well drained	Full sun	Medium
Laurel Oak	<i>Quercus laurifolia</i>	Not Present	Range	No	Central Park, New York, N.Y.	Rich, humusy, acidic, medium to wet, well drained soil	Full sun	Medium to wet
Live Oak	<i>Quercus virginiana</i>	Not Present	Range (most extreme scenario)	No	East of Richmond, V.A. near Chesapeake Bay	Dry to moist soils, gravelly, sandy, loamy, or clay.	Full sun to part shade	Medium
Loblolly Pine	<i>Pinus taeda</i>	Not Present	Range	No	Pittsburgh, P.A.	Prefers moist, sandy soils (sand, sandy loam)	Part shade	High
Mockernut Hickory	<i>Carya tomentosa</i>	Range	Range (but almost Core)	No	Syracuse, N.Y. (Research Grade) and observation near Point Pelee (needs ID).	Variety of types, but dry in the northern part of its range	Full sun	Low, but occasionally grows in bottomlands
Musclewood	<i>Carpinus caroliniana</i>	Range	Range (almost Core)	Yes	Hendrie Valley, Cootes Paradise	Rich, moist. Can tolerate clay	Part shade to full shade	Medium, moist
Ohio Buckeye	<i>Aesculus glabra</i>	Range	Range	Yes	RBG North Shore.	Well drained	Part shade to full sun	Medium
Overcup Oak	<i>Quercus lyrata</i>	Range	Range (but almost Core)	No	Just outside of Newark, N.J.	Poorly drained, clayey soils.	Full sun	Medium to wet
Pecan	<i>Carya illinoensis</i>	Range	Core	No	Slightly Northwest of Youngtown, O.H.	Best grown in humusy, rich, moist, well-drained soils	Full sun	Medium
Pignut Hickory	<i>Carya glabra</i>	Range	Range	Yes	RBG North Shore.	Moist to dry clay soils, can tolerate dry sand at low elevation	Part shade to full sun	Well drained, moist to dry during the summer

Pitch Pine	<i>Pinus rigida</i>	Range	Range (but close to Core)	Yes	Hamilton, ON and Fort Erie ON	Shallow soils over bedrock, but tolerates many soil types	Full sun	Moist, well-drained soils
Post Oak	<i>Quercus stellata</i>	Range (barely)	Range (almost Core)	Unknown, but not likely	Northwest of Columbus, O.H.	Soil can contain loam, clay, sand, or gravel.	Full sun	Dry to medium
River Birch	<i>Betula nigra</i>	Range	Range (very close to Core)	Yes	South of Ancaster; Duff's Corners	Acidic, fertile, cool, moist	Part shade to full sun	Medium to wet
Sassafras	<i>Sassafras albidum</i>	Range	Range (almost Core)	Yes	RBG	Well drained.	Part shade to full sun	Medium
Scarlet Oak	<i>Quercus coccinea</i>	Range	Range (almost Core)	Yes (planted at RBG)	Niagara Falls, N.Y.	Variety of soils	Full sun (extremely shade intolerant!)	Medium
Slippery Elm	<i>Ulmus rubra</i>	Range	Range	Yes	RBG	Rich, well drained.	Full sun	Medium
Southern Catalpa	<i>Catalpa bignonioides</i>	Range	Core	Yes	Strathroy, ON	Wide variety of soil types, such as acidic, loamy, moist, rich, sandy, clay.	Part shade	Wet
Sparkleberry	<i>Vaccinium arboreum</i>	Not present	Range	No	Ruther Glen, Virginia	Well drained	Part shade to full sun	Occasionally dry to moist
Sugar Hackberry	<i>Celtis laevigata</i>	Not Present	Range (but very close to Core)	No	Ann Arbor, MI (Needs ID)	Various: sandy, sandy loam, medium loam, clay, clay loam	Part shade	Medium to wet
Swamp Chestnut Oak	<i>Quercus michauxii</i>	Not Present	Range	No	Wantage, N.J. (just east of Delaware State Forest)	Well-drained, loam soils, as well-drained silty clay soils in bottomlands	Full sun	Dry to medium
Swamp Cottonwood	<i>Populus heterophylla</i>	Not present	Range	Yes	Near the St. Clair river in Ontario. Between Chatham and Sarnia	Heavy clay, edge of swamps	Full sun	Moist to saturated
Swamp Cypress	<i>Taxodium distichum</i>	Range	Range	No	Buffalo, New York	Moisture retentive but well drained	Full sun	Medium to saturated
Swamp Locust	<i>Gleditsia aquatica</i>	Not present	Range	No	Findlay, Ohio	Most soils	Part shade to full sun	Wet to saturated

Swamp Tupelo	<i>Nyssa biflora</i>	Not Present	Range	No	Near Pemberton Township, N.J. (~70km east of Philadelphia)	Organic mucks, heavy clay, wet sand	Full sun to part shade	Wet to continuously saturated
Sweetbay Magnolia	<i>Magnolia virginiana</i>	Not present	Range	No	Ithica, New York	Rich, acidic	Part shade to full sun	Medium to wet
Sweetgum	<i>Liquidambar styraciflua</i>	Range	Range	Yes	Hamilton, ON (entrance to Caleb's Walk, RBG)	Moist, well-drained soil. Tolerates clay soil, flooding, and road salt.	Full sun	Medium
Sycamore	<i>Platanus occidentalis</i>	Range	Range (almost Core)	Yes	RBG	Well drained. Prefers rich, well drained.	Full sun	Medium to wet
Tulip Tree	<i>Liriodendron tulipifera</i>	Range	Range	Yes	RBG	Rich, well drained loam	Full sun	Medium
Virginia Pine	<i>Pinus virginiana</i>	Range	Range	No	Erie P.A., Missisauga (Needs ID)	Poor, well-drained soils	Full sun	Low
Water Oak	<i>Quercus nigra</i>	Not Present	Range	No	Southeast of Harrisburg, P.A.	Rich, humusy, acidic soil	Full sun	Medium to wet
White Alder	<i>Alnus rhombifolia</i>	Core	Core	No	Boston, Massachusetts	Sand to clay, well drained, occasionally wet	Part shade to full sun	Medium to medium
Willow Oak	<i>Quercus phellos</i>	Not Present	Range	No	Just outside of Pittsburgh, P.A.	Variety of types (will tolerate clay soil with somewhat poor drainage)	Full sun	Medium to wet
Winged Elm	<i>Ulmus alata</i>	Range	Range (almost Core)	No	Near Oakland, M.D.	Variety of soils, best on terraces and bottomlands	Part shade	Medium