Royal Botanical Gardens
COOTES PARADISE

# Cootes Paradise North Shore Forest Environmental Status 2022

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**Document Description**

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# Executive Summary

The North Shore Forest of Cootes Paradise is located between the Niagara Escarpment and Cootes Paradise Marsh, and features long standing forested ravines, diverse plant and wildlife communities, locally rare species-at-risk, and several kilometres of nature trails. The table lands are almost all regenerating from agricultural or clay extraction activity, while tree species are in transition due to losses by introduced diseases and insects. The North Shore Forest remains a biodiversity hotspot of the Carolinian Zone, and an unusual landscape given its proximity to the urban communities of Hamilton and Burlington. Many stressors threaten the ecological integrity and function of this nature sanctuary. Long-term monitoring programs are of critical importance for tracking changes in the stressed forested community. The forest provides multiple different types of habitats, with the most vital tied to its central large block creating interior forest habitat and a refuge for sensitive plants and wildlife. The principal threat is currently invasive plant species replacing native species as well as ongoing loss of native canopy trees. Largely lost include American Chestnut, Elm species and Butternut, with ongoing decline of Oaks and Ash. Index monitoring of bird and plant communities to tract condition of the forest.

To tract changes in plant community four 20m x 20m forest monitoring plots have been surveyed since 2008 with one additional plot added in 2012. This report summarizes results from RBG most recent surveys (2022) and compares results to previous surveys (2012 and 2017) each capturing different habitat types. The forest has experienced change since monitoring began in 2012. Canopy tree surveys from 2022 plots resulted in the review of 75 individual trees of 14 different native species. The most abundant tree was the Red Maple (Acer rubrum) with a relative abundance of 24%, followed by Black Cherry (Prunus serotina) with 21% relative abundance, and Red Oak (Quercus rubra) with 20% relative abundance. Red Maple also covered the most basal area in the monitoring plots, representing 34% basal area. Although Black Cherry was the second most abundant tree, Red Oak took second place for coverage area with 32% basal area and Black Cherry was third with 15% basal area. Red Oak was also notable as filling in the canopy were formerly ash trees occurred.

The recent invasion of Emerald Ash Borer (2012) and its decimation of ash trees has dramatically changed the tree composition and understory plant community. The opening of the canopy has encouraged forest floor intense growth and spread of non-native honeysuckles, which has reduced species richness in the shrub layer. Eurasian Amur Honeysuckle (*Lonicera maackii*) was the most dominant species in the understory layer in 2022 accounting for 39% relative cover. This is a drastic change from 2012, when Amur Honeysuckle accounted for 7.2% relative cover. This invasion and intense spread of Amur Honeysuckle has reduced the species richness in the understory from 38 species to 22 species.

Interestingly, despite the increase in sunlight reaching the forest floor due to the loss of ash, Garlic Mustard appears to be declining in the number of stems present and relative cover in forest monitoring plots. This pattern was also reflected more drastically in the South Shore Forest in 2021. Replacing this species in 2022 was an explosion of Canada Clearweed (*Pile pumila*), specifically at one forest monitoring plot. The complete domination of this plant is visible when

examining the relative cover and relative abundance across all vegetation plots; Canada Clearweed accounted for 68% relative abundance and 25% relative cover across all plots. For relative abundance, Garlic Mustard, Nipplewort, Late/Canada Goldenrod, and Green Ash rounded out the top five most abundant species. For relative cover, Green Ash, White Ash, Black Raspberry, and **Amur Honeysuckle** followed Canada Clearweed and comprised the top five species for relative cover.

The North Shore of Cootes Paradise is the largest and includes interior forest habitat providing the overall and most diverse avian community with the Red-winged Blackbird the most common species. The top five most abundant bird species observed during RBG's bird surveys on the North Shore of Cootes Paradise are Red-winged Blackbird, American Goldfinch, Cedar Waxwing, Yellow Warbler, and Blue Jay representing 28% of the 60 species. Of all the RBG nature sanctuaries, guild representation is the most even indicating a robust avian community and varied habitat types. Species richness on the North Shore has increased 21% since 2010, and averages about 60 species observed per year. The average abundance at a monitoring plot is 26 birds/plot and the average species count is 14 species/plot. However, there has been a notable decline in relative abundance for American Goldfinch, Yellow Warbler, and Black-capped Chickadees.

Despite numerous stressors such as recent Emerald Ash Borer (EAB) and canopy loss, and an abundance of White-tailed Deer impacting the understory, the avian community has shown resilience, although fluctuation in species present. Common species are adjusting as forest canopy recovers and shrub transitions into forest. Overall, for RBG property interior forest species are best represented at Cootes Paradise North Shore but still make up a small percentage overall, highlighting the vulnerability of this guild. Ongoing efforts to maintain the forest including invasive woody plant removal and introduced insect management were possible will continue to occur.

# Introduction

Nestled between the Niagara Escarpment and westernmost tip of Lake Ontario in the municipality of Hamilton, Ontario, the largest of RBG's nature sanctuaries, Cootes Paradise, covers over 600 hectares of natural area. Included in the nature sanctuary is a 320-hectare river-mouth marsh under major restoration, 16 creeks, and 25 kilometres of shoreline. Its geographic location and expansive habitat has long made Cootes Paradise a vital migratory stopover for birds, which prompted the protection this area from ongoing development activities as a formal provincial wildlife sanctuary in 1927. The lands remained privately owned with RBG land acquisitions beginning in 1942, overtime acquiring more of the lands, with the latest addition in the 1980s associated farm fields in the northwest area in the area of the regional hydro corridors. In addition to the protection of migratory birds, the formalization of the area as a wildlife sanctuary allowed for the preservation of diverse and locally rare flora in the Carolinian zone. The Cootes Paradise Nature Sanctuary is divided into three sections: Cootes Paradise Marsh, a thin ribbon of urban forest on the South Shore of the marsh, and the larger, 279-hectare North Shore of which just over half is old forest with oaks, hickories, and occasion white pines as the largest trees. The adjacent lands are a more rural setting, including a nearby small residential area.

The lands have an ongoing history of people shaping the landscape. The history of the North Shore of Cootes Paradise goes well beyond RBG's stewardship of the land, as the property has extensive and significant cultural heritage as a seasonal landing point, trading site, farming area, and hunting ground for Indigenous peoples. Occupation of the North Shore spans at least 10,000 years, attracting many historical studies, including on-going research by McMaster conducted at the principal landing site by the current RBG boathouse. Similar use of the land has been confirmed on the South Shore of Cootes Paradise at Princess Point. European agricultural practices have also occurred on essentially all the flat lands of the North Shore since the early 1800s, with a large central block also used for large scale clay extraction until the 1930s. People have shaped Cootes Paradise and its plant community and forests for thousands of years and as a result a relatively small proportion has stood as forest constrained to the steeper ravine slopes.

An expanse of nature trails and outstanding views of Cootes Paradise Marsh make the North Shore Forest a highly desired destination today for photography, birding, hiking, and reconnecting with nature. Adjacent to RBG's Arboretum and Nature Interpretive Centre, the nature trails on the North Shore of Cootes Paradise are often used for educational programming and teachings by RBG Staff. In parallel with the rising regional population, a significant increase trail use in certain areas of the North Shore Forest has occurred resulting in access management updates to maintain core areas of habitat protection including the Hopkins Woods Special Protection area. The visitor use pressures on the surrounding forested ecosystem are noticed through the introduction and establishment of robust populations of invasive species, off-trail use, and general poor trail etiquette by some users. This is troubling for the forested ecosystem, and especially for efforts to retain Species-at-Risk plants such as American Chestnut (*Castanea dentata*), Butternut (*Juglans cinerea*), Flowering Dogwood (*Cornus florida*) and Few-flowered Club-rush (*Trichophorum planifolium*).

In addition to pressure from trail users, there are many other environmental stressors affecting the ecological function and integrity of the North Shore Forest. Stressors such as ongoing and

new forest pest outbreaks, changes in precipitation regimes, and intense windstorms have impacted the nature sanctuary. Recent introduced pests include Gypsy month particullary affecting oak species, Emeral Ash Borer eliminating ash trees, while long standing issues exist with Chestnut Blight, Dutch Elm Disease, and Butternut Canker. It can only be predicted that in the future, existing stressors will persist, and new sources of hardship will increase the struggle for survival of native plants and wildlife. Disruption of forested habitats will also continue fragmented by regional hydro corridors through forested habitat.

In order to track changes and examine the resilience of an ecosystem, long-term monitoring programs are conducted annually by RBG staff across RBG's nature sanctuaries. The findings in this report will focus on the environmental condition of the North Shore Forest. Two themes will be examined including forest plant community and springtime bird community composition.

One overarching program conducted by RBG staff is the Long-Term Forest Monitoring Program. Initiated in 2008, the main priority of this study is to collect high-quality floristic data which overtime can act as baseline data to identify and monitor threats and stressors to the terrestrial ecosystem. Since the program's inception, plots on the North Shore Forest have been added and modified to better reflect the entirety of the nature sanctuary. Since the second round of monitoring in 2012, five plots have been examined on a rotation of either five or six years. A combination of protocols including Environment Canada's Ecological Monitoring and Assessment Network (EMAN) and Vegetative Sampling Protocol (VSP) are used to compile an accurate representation of floristic truth. The protocols vary slightly in their data collection methods. The protocol for EMAN surveys the diversity of plants in a vertical sense from the forest floor to the tree canopy. The forest layers are labelled as: the canopy tree layer, the small tree and shrub layer, and the ground vegetation layer. VSP is different in that its main goal is to determine overall plant cover for the 20m x 20m forest monitoring plot. The combination of these two protocols allows RBG staff to monitor species richness, plant composition, dominance, tree regeneration, and tree health throughout a given forest community over time (Burtenshaw, 2010; Roberts-Pichette & Gillespie, 1999).

The development of a robust plant community monitoring program provides the opportunity to identify changes in the vegetative community, with one vital aspect being changes in native and non-native plant communities. An additional benefit of monitoring is the early detection of new forest pests and disease management strategies. Monitoring the forest regeneration allows for a snapshot of how the forest is succeeding and changing its species composition, in addition to determining whether the forest is naturally regenerating. Over continued surveying, the data can be used to determine ecosystem status and holistically can be used in conjunction with faunal surveys, which can help guide future restoration work.

Another vital long-term monitoring study conducted by RBG staff bird point count surveys. The initiation of this study was timed to align and compliment the beginning of long-term forest monitoring that started in 2008, with 2023 being the sixteenth year of monitoring birds across RBG property. The goal of the point count surveys is to collect long-term data on the bird community that uses RBG's forests, grasslands, and edge habitats during the breeding season. Habitat quality can be reflected by observing trends in the bird community since breeding birds are dependent on the resources of the local ecosystem (Ellis, 2017). Therefore, the decline or disappearance of certain bird species across RBG property could indicate poor habitat quality, in terms of resources and nesting habitat. Oppositely, this study has the ability to also detect increasing trends in bird populations, which can be the rebound of native populations, or the establishment and proliferation of non-native species.

This report will amalgamate data from RBG's Long-term Forest Monitoring program and Bird Monitoring Program to produce an idea of the ecological status on the North Shore of Cootes Paradise.

# Monitoring

## Long-term Forest Monitoring

Across RBG's nature sanctuaries, there are fourteen 20m x 20m long-term forest monitoring plots. Five are located on the South Shore of Cootes Paradise, two in both Hendrie Valley and the Escarpment Properties, and five on the North Shore of Cootes Paradise, which is the focus of this report, represented in Figure 1.

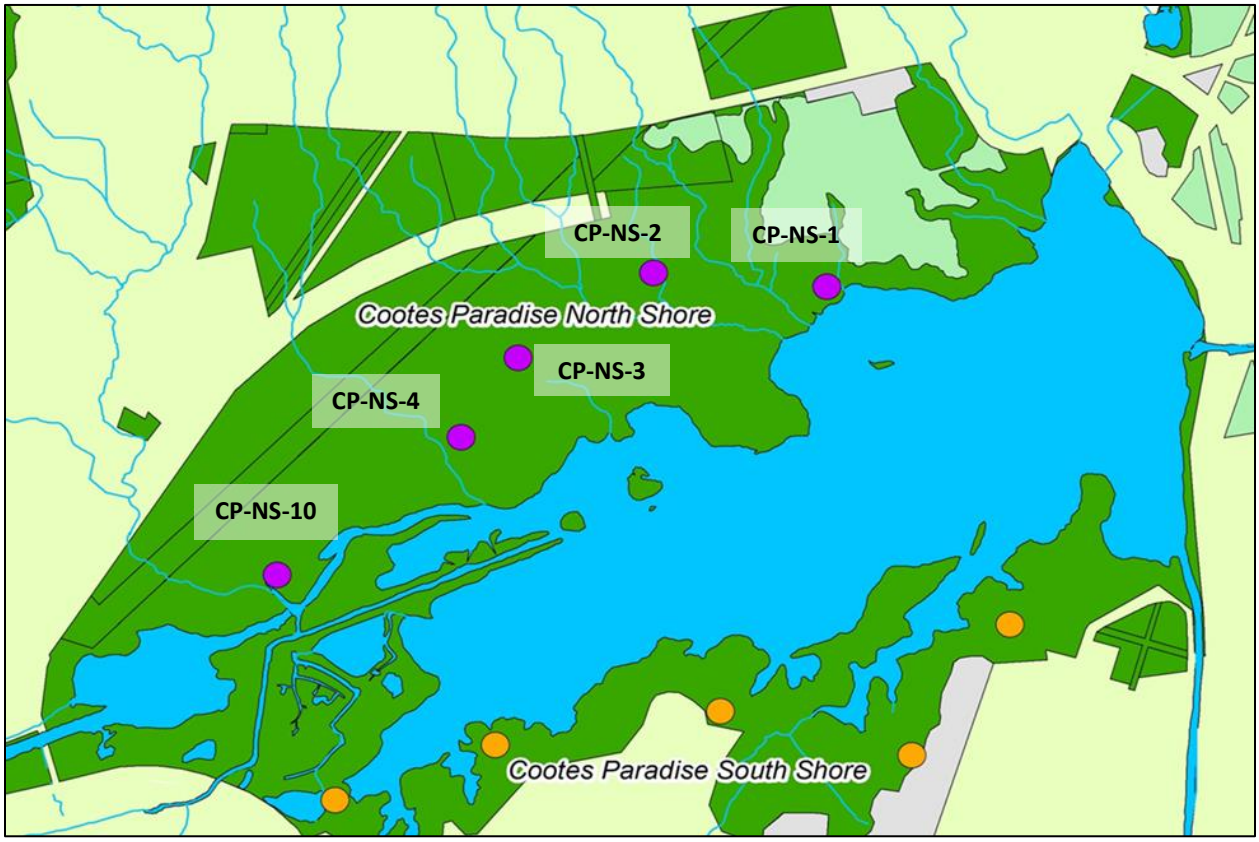


**Figure 1. Map of RBG's Forest Monitoring Plots on the North Shore of Cootes Paradise**.

**Cootes Paradise North Shore (CP-NS) Forest Monitoring Plots:**

- CP-NS-1 Captain Cootes
- CP-NS-2 Grey Doe
- CP-NS-3 Interior East
- CP-NS-4 Interior West
- CP-NS-10 Borer's Creek

Forest monitoring protocols follow the Ecological Monitoring and Assessment Network (EMAN) and have been conducted in most plots on the North Shore during 2008. 2012, 2017, and 2022. Data is collected for three layers observed in the forest community: the canopy tree layer, understory layer, and ground vegetation. The collection of canopy tree information includes the tracking of all trees growing within the 20m x 20m plot, including tree health data. The understory layer was collected using the Vegetative Sampling Protocol (VSP), with all trees and shrubs in the plot identified, recorded, and the percent cover of their occupation of space in the plot

recorded. The ground vegetation, as well as the forest floor composition data, was collected from four 1m x 1m plots within each 20m x 20m forest monitoring plot. Tree regeneration data was collected from five 2m x 2m quadrats; four quadrats are outside the 20m x 20m plot and one is within the plot. For tree regeneration data collection, tree seedlings between the heights of 16cm – 200cm and saplings over 200cm were recorded within the quadrats. More information on protocols and procedures for data collection, please refer to the *2009 Forest Monitoring Report* (Burtenshaw, 2010) and *Ecological Monitoring and Assessment Network: Terrestrial Vegetation Monitoring Protocols* (Roberts – Pichette and Gillespie, 1999). Fore more details on VSP methodology search Vegetation Sampling Protocol on the University of Toronto Faculty of Forestry webpage.

Prior to 2017, there were some inconsistencies in data collection due to time and staffing pressures. Notably CP-NS-10 was added in 2012, and the canopy tree data was not fully collected across all plots in 2012.

## Bird Monitoring

### Monitoring Sites

Several of RBG's bird monitoring plots are aligned with plots from other vegetation monitoring programs, such as forest monitoring or grassland monitoring. Overall, 30 sites that focus on terrestrial habitats, including interior forest, forests with edge effects, secondary forests, grasslands, garden, and plantations. A portion of these plots have wetland influence, but this habitat type is not the focus. Monitoring plots are scattered across RBG's four nature sanctuaries (see Appendix).

### Point Count Surveys

The sampling window ranged from May 31$^{st}$- July 1$^{st}$ and all plots were visited 4 times, with at least three days in-between samples. Point count surveys were conducted between 5:10 am and 10:45 am. Generally, between six and eight plots were visited per day, with fewer or no plots surveyed on days with inclement weather. Point count methodology was based on protocols set by the Ontario Breeding Bird Atlas (OBBA, 2001).

The time of day during which a given plot was visited was intentionally varied during repeat visits to eliminate biases associated with time-of-day bird activity levels. A five-minute period of silence upon arrival at the site allowed for nearby birds to adjust to the disturbance caused by surveyors. This time was also used to record the appropriate site information on the monitoring sheet, including the date, time, study plot code, temperature (°C), percent cloud cover, wind strength (Beaufort scale), surveyors present, noise code (with "1" meaning very low noise level and "5" being extremely loud), and other relevant notes. A compass on a smartphone was used to orient the field data sheet towards magnetic north. Following this time of silence was a ten-minute period where all species detected by song/call or visual observation within a 100-metre circular radius from the centre of the plot were recorded.

# Results

## Forest Monitoring

### Canopy Tree Layer

Table 1 displays the canopy tree results for the 2022 sampling window, including information such as abundance, relative abundance (%), basal area ($m^2$), percent basal area, and tree density (per hectare). In total, 75 trees were tagged, measured, and examined for any biological defects. There were 14 species observed in the plots, with zero non-native species being identified. The most abundant tree, and the species with the largest basal area, observed was Red Maple (*Acer rubrum*) with 18 individuals identified and a percent basal area of 34%. In terms of abundance, the Black Cherry (*Prunus serotina*) was the second most abundant tree with 16 individuals identified, followed by 15 identified Red Oak (*Quercus rubra*). However, these two species switch places in terms of basal area, with Red Oak having the second largest basal area (32%) and Black Cherry having the third largest (15%).

**Table 1. Summary of assessed canopy tree species in five forest monitoring plots in 2022 using EMAN protocol, organized by relative abundance. Results for basal area, percent basal area, and density per hectare are also displayed.**

| Common Name | Abundance | Relative Abundance | Basal Area ($m^2$) | Percent Basal Area | Density (trees/ha) |
|---|---|---|---|---|---|
| Red Maple | 18 | 24% | 25.51 | 34% | 75 |
| Black Cherry | 16 | 21% | 10.93 | 15% | 67 |
| Red Oak | 15 | 20% | 24.01 | 32% | 63 |
| White Oak | 6 | 8% | 8.30 | 11% | 25 |
| Ironwood | 4 | 5% | 0.29 | 0% | 17 |
| Smooth Serviceberry | 3 | 4% | 0.11 | 0% | 13 |
| White Pine | 3 | 4% | 3.61 | 5% | 13 |
| Black Oak | 2 | 3% | 0.99 | 1% | 8 |
| Sassafras | 2 | 3% | 0.12 | 0% | 8 |
| Sugar Maple | 2 | 3% | 0.32 | 0% | 8 |
| American Beech | 1 | 1% | 0.11 | 0% | 4 |
| Black Walnut | 1 | 1% | 0.01 | 0% | 4 |
| Bur Oak | 1 | 1% | 0.14 | 0% | 4 |
| Blue Beech | 1 | 1% | 0.02 | 0% | 4 |
| | **75** | | | | **313** |
| **Species Richness: 14** | | **Native Species: 14** | | **Non-native Species: 0** | |

Examining the relative abundance of canopy trees since monitoring began in 2008 provides a glimpse at how the North Shore Forest has changed over 15 years. Most notably was the complete disappearance of any ash (*Fraxinus sp.*) species in 2022 (Table 2). This is due to the impact of the EAB, which has now taken its complete toll across RBG property. The dominant tree across the North Shore Forest has varied from year to year, there have been two constant species in the top three dominant trees: Red Maple (*Acer rubrum*) and Black Cherry (*Prunus serotina*). Red Oak (*Quercus rubra*) also appears in the top three for three out of four monitoring years. Species richness has decreased since 2012 by two species. Not surprisingly the two species unaccounted for in 2022 were Green Ash (*Fraxinus pennsylvanica*) and White Ash (*Fraxinus americana*). It should be noted that not all plots were surveyed in 2008, explaining the discrepancy between species richness from 2008 to 2012.

**Table 2. Relative abundance for four survey years of all surveyed canopy trees in long-term forest monitoring plots. Species richness is also displayed, using EMAN protocol.**

| | Relative Abundance | | | |
|---|---|---|---|---|
| **Common Name** | **2008** | **2012** | **2017** | **2022** |
| Red Maple (*Acer rubrum*) | 33% | 16% | 20% | 24% |
| Black Cherry (*Prunus serotina*) | 12% | 16% | 18% | 21% |
| Red Oak (*Quercus rubra*) | 5% | 17% | 25% | 20% |
| White Oak (*Quercus alba*) | 10% | 5% | 4% | 8% |
| Ironwood (*Ostrya virginiana*) | 2% | 1% | 4% | 5% |
| Smooth Serviceberry (*Amelanchier laevis*) | | 3% | 4% | 4% |
| White Pine (*Pinus strobus*) | 7% | 4% | 5% | 4% |
| Black Oak (*Quercus velutina*) | 2% | 2% | 2% | 3% |
| Sassafras (*Sassafras albidum*) | | 2% | 2% | 3% |
| Sugar Maple (*Acer saccharum*) | 3% | 2% | 2% | 3% |
| American Beech (*Fagus grandifolia*) | 2% | 1% | 1% | 1% |
| Black Walnut (*Juglans nigra*) | | 1% | 1% | 1% |
| Bur Oak (*Quercus macrocarpa*) | | 1% | 1% | 1% |
| Blue Beech (*Carpinus caroliniana*) | | 2% | | 1% |
| Green Ash (*Fraxinus pennsylvanica*) | | 15% | 5% | |
| White Ash (*Fraxinus americana*) | 24% | 12% | 5% | |
| **Species Richness** | **10** | **16** | **15** | **14** |

Using VSP to look at canopy trees provides an opportunity to calculate the percent change in relative cover of a given species. Even though Black Cherry (*Prunus serotina*) has increased in relative abundance by 5.0%, the relative cover in the plot has decreased 5.0% since 2012 (Table 3). A similar trend is detected in White Oak (*Quercus alba*), where the relative cover has dropped by 9% but the relative abundance has increased by 3%. Not surprisingly, both White Ash (*Fraxinus americana*) and Green Ash (*Fraxinus pennsylvanica*) have decreased significantly in relative cover from 6.9% and 10.4% respectively in 2012 to 0% in 2022. This information is also reflected in EMAN protocol (Table 2).

The relative cover of two species has increased considerably since 2012. Black Oak (*Quercus velutina*) has increased by 7.5% in relative cover but has increased by only 1% in relative abundance. Similarly, Red Oak (Quercus rubra) has also increased by 10% relative cover and 3% in relative abundance. Both species are typically relatively large canopy trees and can have extensive canopy cover, which may not be reflected in the relative abundance of the species. This could be a response to loss of ash in the canopy.

**Table 3. Relative cover of all observed canopy tree species and climbing grapes in 2012 and 2022, and their percent change in the ten-year time period (VSP, trees over 10m).**

| | 2012 | 2022 | Percent Change |
|---|---|---|---|
| **American Beech** | 2.8% | 4.6% | 1.8% |
| **Black Cherry** | 16.7% | 11.7% | -5.0% |
| **Black Oak** | 3.5% | 10.9% | 7.5% |
| **Bur Oak** | 1.4% | 1.5% | 0.1% |
| **Eastern Hop-hornbeam** | 1.4% | 5.5% | 4.1% |
| **White Pine** | 4.2% | 4.0% | -0.2% |
| **Green Ash** | 10.4% | | -10% |
| **Northern Red Oak** | 17.4% | 27.4% | 10% |
| **Red Maple** | 18.8% | 23.2% | 4% |
| **Riverbank Grape** | 0.7% | | -1% |
| **Sugar Maple** | 0.7% | 4.0% | 3% |
| **White Ash** | 6.9% | | -7% |
| **White Oak** | 15.3% | 6.8% | -9% |
| **Total Layer Cover*** | 418 | 413 | -5 |
| **Species Richness** | **13** | **10** | **-3** |

*Total Layer Cover is the estimated vegetation cover for the entire 20x20m plot of all species within a given height class. It is calculated for each vegetation height class at each monitoring plot. For the purposes of this table, the total cover for vegetation height class >10m was added together for all plots for each monitoring year and presented as a sum.

## Understory Layer

In 2022, 21 species were identified in the understory using VSP, with 16 native species and 5 non-native species (Table 4). This is similar to the 20 species found in 2012 during VSP monitoring, with 14 native species and 6 non-native species. The largest change in relative cover from 2012 was the 16.9% increase in Amur Honeysuckle (*Lonicera maackii*) cover in the understory of the North Shore Forest plots. Decrease in cover was seen most noticeably in White Ash (*Fraxinus americana*) which dropped in coverage by 11.86%. Interestingly Nannyberry, a native shrub occasionally found throughout the North Shore Forest, has disappeared from the monitoring plots altogether (previously found in 3, no longer found in any). Careful consideration and attention to detail will be required during the next round of VSP to detect Nannyberry. Other notable declines in cover (between three and five percent) include Eastern Hop-Hornbeam (aka. Ironwood), Blue Beech and Red Maple, however, when compared to relative abundance results from EMAN we see that Blue Beech is the only notable species that is of concern with a

decrease in relative abundance while the other 2 species have in fact increased in abundance since 2012. New native species reported were Allegheny Blackberry (which appeared throughout all 5 north shore forest monitoring plots), Black Rasberry, and White Oak. Non-native species that were no longer reported include Morrow's and Tartarian Honeysuckle (which are difficult to tell apart from each other but not from Amur Honeysuckle).

**Table 4. Relative cover of understory species (sum of 0.5m-2m and 2-10m) using VSP across all North Shore Forest Monitoring plots in 2012 and 2022.**

| Species | 2012 | 2022 | Percent Change |
|---|---|---|---|
| Amur Honeysuckle | 22.79% | 39.69% | 16.90% |
| Black Cherry | 12.46% | 12.45% | -0.01% |
| American Witch-hazel | 6.99% | 10.00% | 3.01% |
| American Beech | 7.80% | 7.93% | 0.14% |
| Sugar Maple | 4.40% | 6.90% | 2.49% |
| Allegheny Blackberry | | 6.21% | 6.21% |
| White Ash | 15.31% | 3.45% | -11.86% |
| Magnolia Kobus | 0.26% | 2.07% | 1.81% |
| Green Ash | 2.07% | 1.72% | -0.35% |
| Sassafras | 2.59% | 1.72% | -0.87% |
| Eastern Hop-hornbeam | 4.95% | 1.45% | -3.50% |
| Blue Beech | 6.24% | 1.38% | -4.86% |
| Multiflora Rose | | 1.07% | 1.07% |
| Black Raspberry | | 1.03% | 1.03% |
| Japanese Barberry | 1.30% | 1.03% | -0.26% |
| Red Maple | 4.40% | 1.03% | -3.37% |
| European Privet | 0.80% | 0.69% | -0.11% |
| Common Buckthorn | 0.78% | 0.07% | -0.71% |
| Maple-leaved Viburnum | 2.12% | 0.03% | -2.09% |
| Virginia Creeper | 0.03% | 0.03% | 0.01% |
| White Oak | | 0.03% | 0.03% |
| Morrow's Honeysuckle | 0.03% | | -0.03% |
| Nannyberry | 4.17% | | -4.17% |
| Tartarian Honeysuckle | 0.52% | | -0.52% |
| **Total Layer Cover*** | **335** | **266** | **-69** |
| **Species Richness** | **20** | **21** | **1** |
| **Native Species** | **14** | **16** | **2** |
| **Native Species Relative Cover** | **73.5%** | **55.4%** | **-18** |
| **Non-Native Species** | **6** | **5** | **-1** |
| **Non-Native Species Relative Cover** | **26.5** | **44.6** | **18** |

***Total Layer Cover** is the estimated vegetation cover for the entire 20x20m plot of all species within a given height class. It is calculated for each vegetation height class at each monitoring

plot. For the purposes of this table, the 0.5-2m and 2-10m height classes were added together and a sum for all plots was calculated for each monitoring year.

## Ground Vegetation Layer

### Abundance

A total of 35 identified species were recorded during ground vegetation surveys using the EMAN protocol in 2022. Of those 35 species, 10 were non-native. The most abundant species observed during surveys was Canada Clearweed (*Pilea pumila*) accounting for 68% of total stems counted (Figure 2). Garlic Mustard (*Alliaria petiolata*), Nipplewort (*Lapsana communis*), Green Ash (*Fraxinus pennsylvanica*), and Late/Canada Goldenrod (*Solidago altissima/canadensis)* round out the top five most abundant species. It should be noted that due to the difficulty in identifying Canada Goldenrod (*Solidago canadensis*) and Late Goldenrod (*Solidago altissima*), especially with the lack of flowers during the time of survey, the two species were lumped together. All other species combined accounted for 19% of the observations.

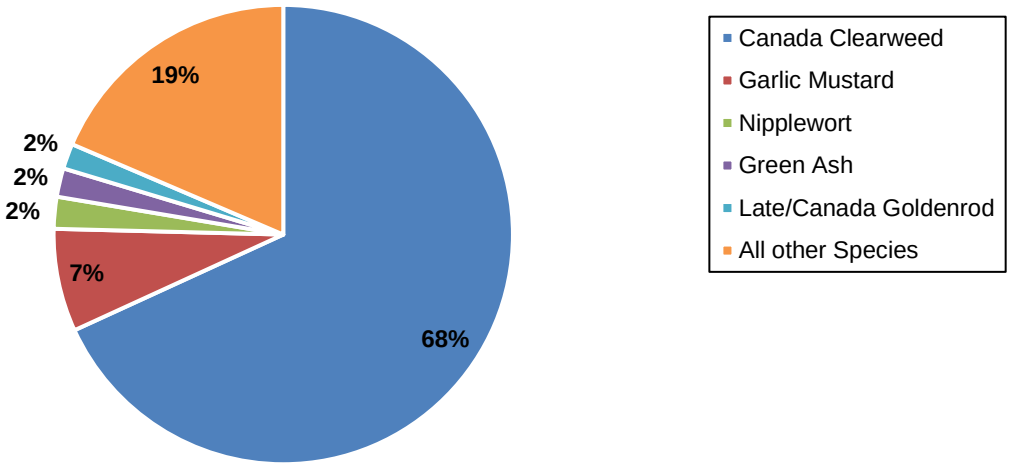


**Figure 2. Relative abundance of top five most abundant species during ground vegetation surveys in 2022.**

### Relative Cover

Figure 3 displays the amount of space (a plant's percent cover) occupied by a species. Canada Clearweed (*Pilea pumila*) was the most abundant species observed with 25% of the total cover, followed by Green Ash (*Fraxinus pennsylvanica*), White Ash (*Fraxinus americana*), Black Raspberry (*Rubus occidentalis*), and Amur Honeysuckle (*Lonicera maackii*) rounding out the top five. This is quite a difference from previous monitoring years where Garlic Mustard was consistently in the top five species for relative specifically in 2012 when Garlic Mustard accounted for 51% of all ground vegetation cover.

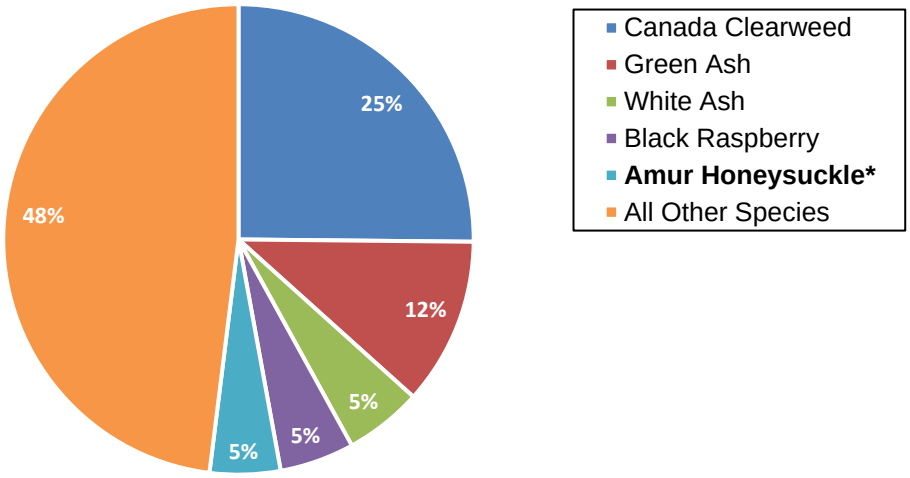


**Figure 3. Relative percent cover of top five observed species during ground vegetation surveys (20 quadrats) in 2022 *EMAN)**

VSP shows a slightly different composition of ground vegetation, in terms of relative cover. As observed in Table 6, Garlic Mustard is still the species with the greatest relative cover in 2012, followed by White Ash and May-apple. However, the fourth and fifth species with the highest cover in 2012 is different for EMAN and VSP. Using EMAN protocols, Black Cherry (Prunus serotina) and Jack-in-the-pulpit (*Arisaema triphyllum)* are the fourth and fifth species with highest cover (Table 5). However, using VSP Amur Honeysuckle and Virginia Creeper (*Parthenocissus quinquefolia*) round out the top five.

**Table 5. Relative percent ground cover of top five species for previous monitoring years on the North Shore of Cootes Paradise (EMAN).**

| | Species | Scientific Name | Relative Cover |
|---|---|---|---|
| **2009** | Ash (White and Green) | *Fraxinus americana and pennsylvanica* | 17% |
| | **Garlic Mustard** | ***Alliaria petiolata*** | **12%** |
| | Broad-leaved Enchanter's Nightshade | *Circaea canadensis* | 11% |
| | Black Raspberry | *Rubus occidentalis* | 10% |
| | Maple-leaved Viburnum | *Viburnum acerifolium* | 10% |
| | All Other Species | | 40% |
| **2012** | **Garlic Mustard** | ***Alliaria petiolata*** | **51%** |
| | Ash (White and Green) | *Fraxinus americana and pennsylvanica* | 24% |
| | May-apple | *Podophyllum peltatum* | 4% |
| | Black Cherry | *Prunus serotina* | 3% |
| | Jack-in-the-pulpit | *Arisaema triphyllum* | 3% |
| | All Other Species | | 15% |
| **2017** | Ash (White and Green) | *Fraxinus americana and pennsylvanica* | 28% |
| | May-apple | *Podophyllum peltatum* | 14% |
| | **Garlic Mustard** | ***Alliaria petiolata*** | **11%** |

| | | | |
|---|---|---|---|
| | **Common Nipplewort** | ***Lapsana communis*** | **7%** |
| | **Honeysuckle species** | ***Lonicera maakii/tatarica*** | **6%** |
| | All Other Species | | 35% |
| **2022** | Canada Clearweed | *Pilea pumila* | 25% |
| | Ash (White and Green) | *Fraxinus americana and pennsylvanica* | 17% |
| | Black Raspberry | *Rubus occidentalis* | 5% |
| | **Amur Honeysuckle** | ***Lonicera maackii*** | **5%** |
| | All Other Species | | 48% |

Similar trends can be observed in the comparison between the EMAN ground vegetation surveys and VSP data collected in 2022. The three species with the highest relative cover remain the same (despite some variation in their cover), and the fourth and fifth species are different from one another. Using EMAN, Black Raspberry (*Rubus occidentalis*) and Amur Honeysuckle (*Lonicera maackii*) are in fourth and fifth spot, respectively. Looking at the VSP relative cover for 2022, White Ash (*Fraxinus americana*) and Carex species account for the fourth and fifth species greatest relative cover. Additionally, using VSP, 94 species were identified across all North Shore plots. This is much greater than the 35 species documented using only EMAN protocols.

**Table 6. Relative percent ground cover of top five species in 2012 and 2022, using VSP protocol. Species richness, along with number of native and non-native plants, is displayed.**

| | Common Name | Scientific Name | Relative Cover |
|---|---|---|---|
| **2012** | **Garlic Mustard** | **Alliaria petiolata** | 52% |
| | White Ash | Fraxinus americana | 7% |
| | May-apple | Podophyllum peltatum | 7% |
| | **Amur Honeysuckle** | **Lonicera maackii** | 6% |
| | Virginia Creeper | Parthenocissus quinquefolia | 4% |
| | All Other Species | | 23% |
| | **Species Richness** | | **58** |
| | **Native** | | **45** |
| | **Non-native** | | **13** |
| **2022** | Canada Clearweed | Pilea pumila | 24.2% |
| | **Garlic Mustard** | **Alliaria petiolata** | 12.9% |
| | Green Ash | Fraxinus pennsylvanica | 10.3% |
| | White Ash | Fraxinus americana | 9.7% |
| | Carex species | | 3.7% |
| | All Other Species | | 39.2% |
| | **Species Richness** | | **94** |
| | **Native** | | **74** |
| | **Non-native** | | **20** |

## Minimum and Maximum Counts

As presented in Table 6 below, the minimum and maximum number of plant stems or clumps can be observed for the top ten most common species recorded in the ground vegetation surveys. Interestingly, CP-NS-2 had the highest maximum number of stems for four of the top ten species across the North Shore: White Ash, Garlic Mustard, Cleavers, and Canada Clearweed. The maximum number of Amur Honeysuckle stems was detected at CP-NS-1, with a count of 5. CP-NS-1 also held the highest count of Broad-leaved Enchanter's Nightshade and Poa species (Table 6).

Apart from Canada Clearweed, which was recorded in all plots except one, non-native Garlic Mustard was present in all forest monitoring plots. With that being said, the presence of Garlic Mustard did not mean that it was present at high numbers. In fact, at two plots, the maximum number of Garlic Mustard stems was below 5 and the maximum number across all North Shore plots was 27 stems.

As mentioned previously, Canada Clearweed was present in all but one forest monitoring plots on the North Shore. CP-NS-2 had the massive maximum count of 508 stems of Canada Clearweed in one sub-plot. Even more astonishing is the minimum count at CP-NS-2 was 157 stems. This provides further understand as to why Canada Clearweed accounted for 25% of the relative cover across the North Shore plots, despite the plant being considered relatively small.

**Table 7. Minimum and maximum count of stems/clumps from all ground vegetation surveys (20 quadrats) in all North Shore Forest monitoring plots. Non-native species are bolded (EMAN).**

| | CP-NS-1 | | CP-NS-2 | | CP-NS-3 | | CP-NS-4 | | CP-NS-10 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species Name** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** |
| **Amur Honeysuckle** | 0 | 5 | - | - | - | - | 0 | 1 | 0 | 1 |
| Black Raspberry | - | - | - | - | 0 | 1 | 0 | 1 | - | - |
| Broad-leaved Enchanter's Nightshade | 0 | 10 | - | - | 0 | 1 | - | - | - | - |
| Canada Clearweed | 3 | 62 | 157 | 508 | 0 | 3 | 0 | 1 | - | - |
| **Cleavers** | 1 | 2 | 0 | 11 | - | - | - | - | 0 | 3 |
| **Common Speedwell** | - | - | - | - | - | - | 0 | 2 | 0 | 14 |
| **Garlic Mustard** | 0 | 1 | 10 | 27 | 0 | 15 | 0 | 4 | 0 | 11 |
| Green Ash | 0 | 1 | - | - | 1 | 14 | - | - | - | - |
| **Poa species** | 0 | 19 | - | - | 1 | 14 | - | - | - | - |
| White Ash | - | - | 0 | 3 | - | - | 0 | 1 | 0 | 2 |

## Non-native Plants

In 2022, during ground vegetation surveys 10 non-native species were identified. Amur Honeysuckle (*Lonicera maackii*) had the highest relative cover of non-native species, accounting for 25% of all non-native plant cover (Figure 4). This is followed closely by Garlic Mustard, at 24% of all non-native ground cover, and Poa species at 20%, Cleavers (*Galium aparine*) at 14%, and Erect Hedge-parsley (*Torilis japonica*) at 9%. All other non-native species make up 13% of the remaining cover. This was the first time Erect Hedge-parsley (*Torilis japonica*), Multiflora Rose (*Rosa multiflora*), Norway Maple (*Acer platinoides*), and Poa species have been identified in vegetation monitoring sub-plots.

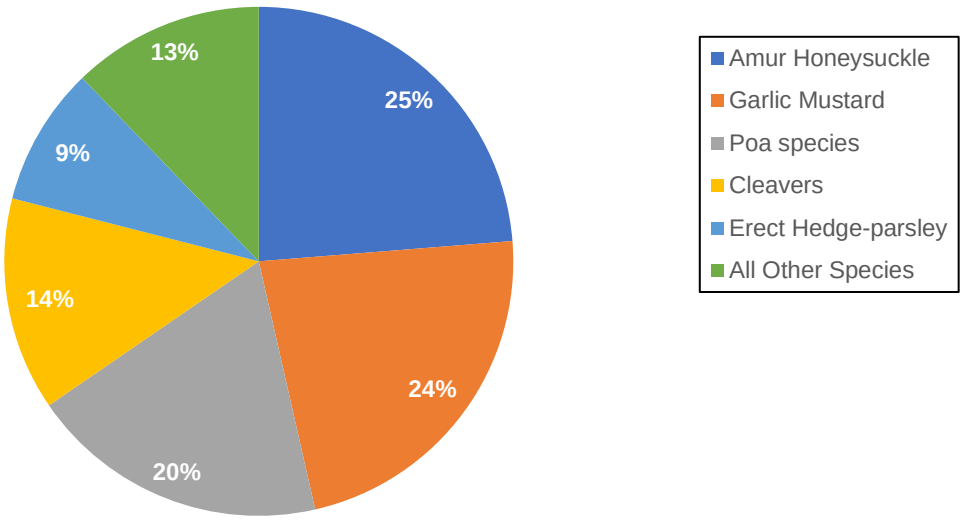


**Figure 4. Composition of relative non-native plant cover across all monitoring sub-plots on the North Shore (EMAN).**

All sub-plots contain 30%, and under, non-native stem counts, with the lowest being 3% non-native stem count at CP-NS-3 (Figure 5). CP-NS-4 had the highest non-native count of total observations at 30%. Both CP-NS-1 and CP-NS-2 and CP-NS-4 and CP-NS-10 have very similar native and non-native plant composition.

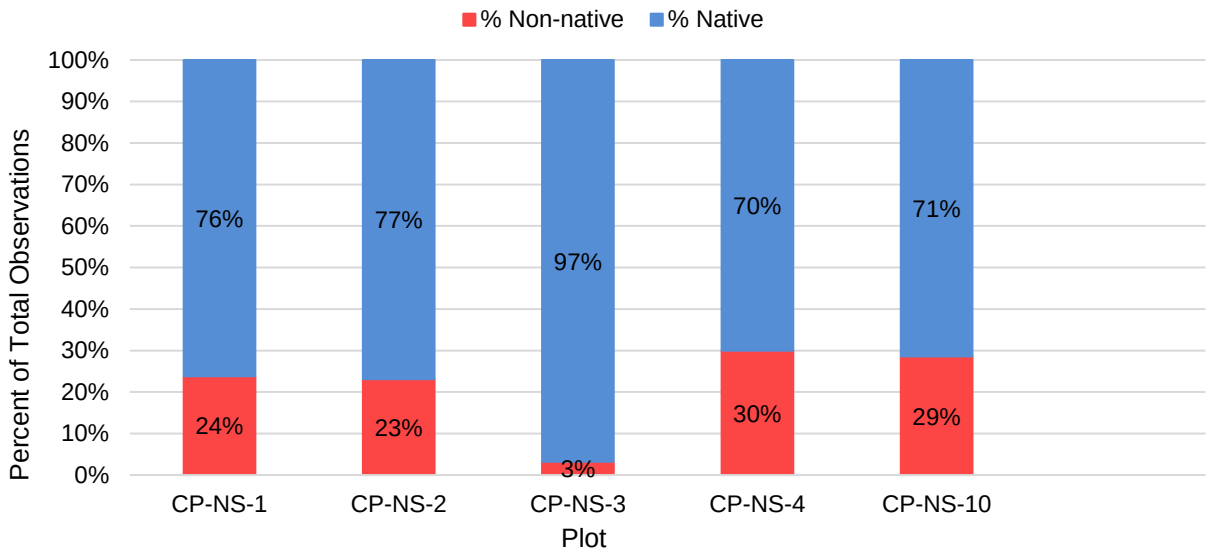


**Figure 5. Percent native and non-native stem count for each monitoring plot on the North Shore of Cootes Paradise during 2022 ground vegetation surveys (EMAN).**

One of the most widespread non-native herbaceous species in the North Shore Forest is Garlic Mustard. Figure 6 displays the total stem count of Garlic Mustard since monitoring began in 2009. 2022 had the lowest total stem count since 2009, at 126 total stems across 20 1m x 1m sub-plots. The highest number of stems counted occurred in 2012, which compliments the data displayed in Table 5, where Garlic Mustard accounted for 51% of total cover. The decrease in stem count in the forest monitoring plots on the South Shore of Cootes Paradise was also observed and calculated during monitoring in 2021 (Figure 7).

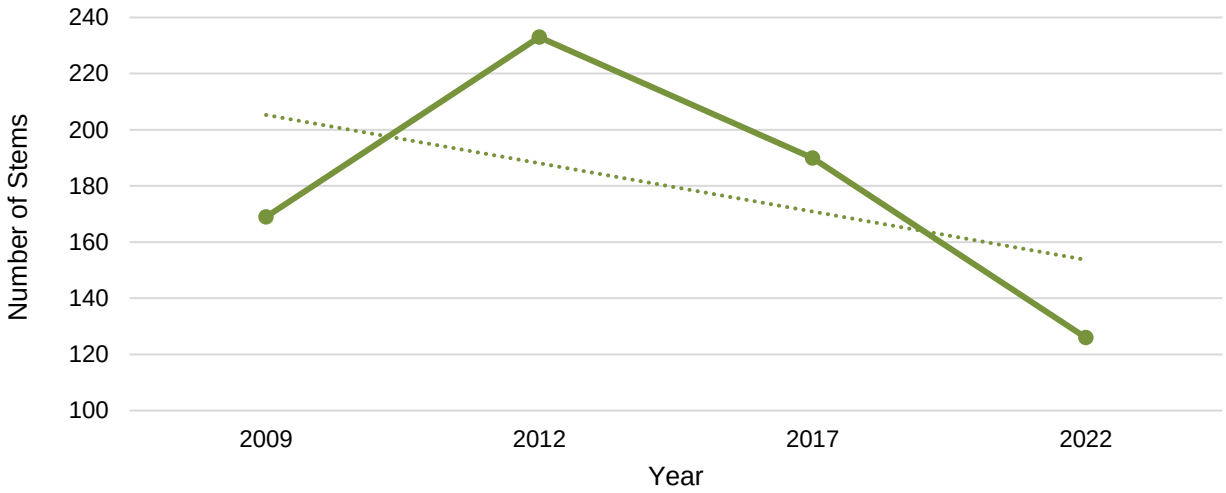


**Figure 6. Total number of Garlic Mustard stems across all twenty ground vegetation sub-plots on the North Shore of Cootes Paradise (EMAN).**

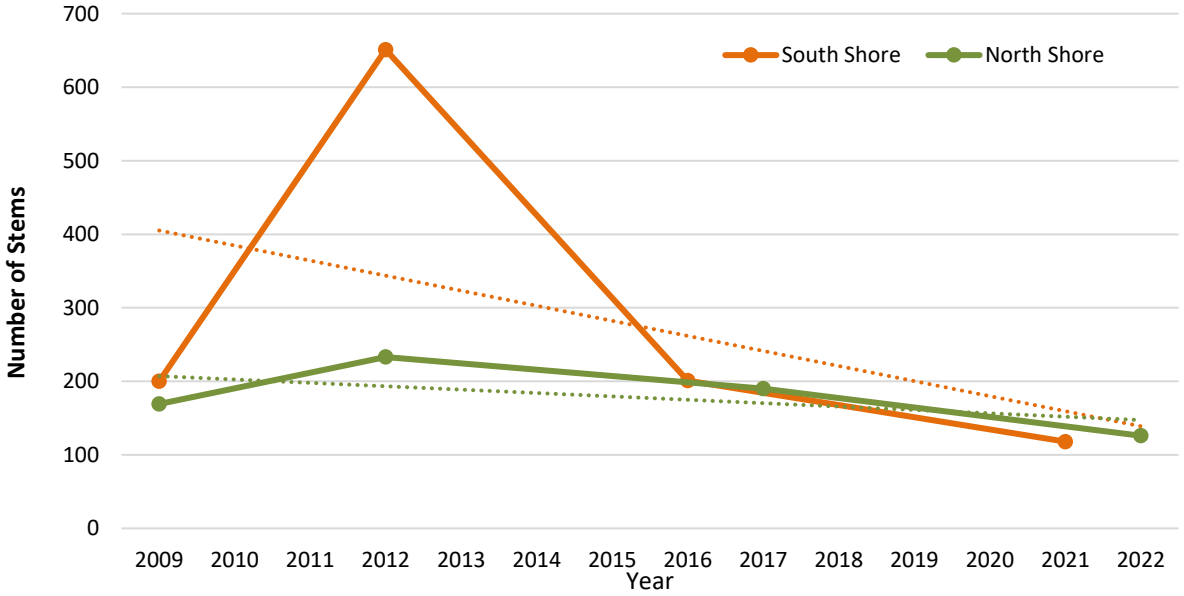


**Figure 7. Total number of Garlic Mustard stems across all North Shore and South Shore forest monitoring ground vegetation plots (EMAN).**

## Forest Floor Composition

A trend that has been observed in other nature sanctuaries on RBG property and determined a relationship between bare ground and leaf litter (Burtenshaw 2010, Vincent 2018, and Radassao 2019). However, that trend is less evident on the North Shore. Previous investigations into such relationship have discovered that with low leaf litter there is more bare ground present at the site, and vice-versa. It is hard to determine that relationship when looking at the North Shore forest floor composition (Figure 8). The study year that best fits this relationship would be 2017, however the other monitoring years do not provide any meaningful correlations.

The presence of moss in ground vegetation quadrats wasn't recorded until 2017, and only dropped by 1% from 2017 to 2022. Oppositely, woody debris has been recorded in every

monitoring year, and appears to be on the rise. Since 2009, woody debris has increased very steadily by approximately 4%. This could be due to multiple factors including stressed and/or dying trees, pest outbreaks (like Emerald Ash Borer and Spongy Moth), and/or intense windstorms. This will be important to monitor in the future as forests continue to face increased environmental pressures.

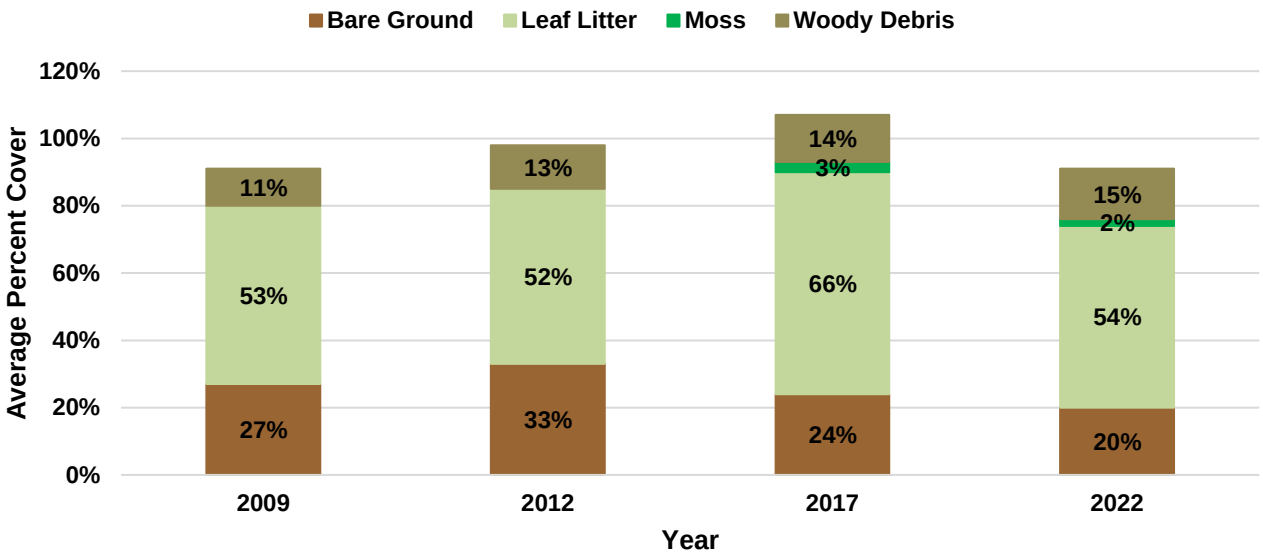


**Figure 8. Forest floor composition; average percent cover per 1m x 1m ground vegetation quadrats (n = 20 for 2022) on the North Shore during monitoring years.** *NOTE: The percent cover of the forest floor composition does not always equal 100%, since the forest floor is composed of multiple layers. For instance, living plants occupy space on the forest floor that would have otherwise been taken up by any of the four components listed above.*

## Bird Monitoring

### Species Richness and Detections at Coote Paradise North Shore

Species richness on the North Shore of Cootes Paradise (CP-NS) has increased 21% since 2010 and averages 60 species a year (Figure 9). While a change in observer skill could contribute to this increase, there is not enough data between observers to determine if this is the case. It is likely that species richness and detections are increasing due to restoration efforts, stability of habitat and perhaps observer skill.

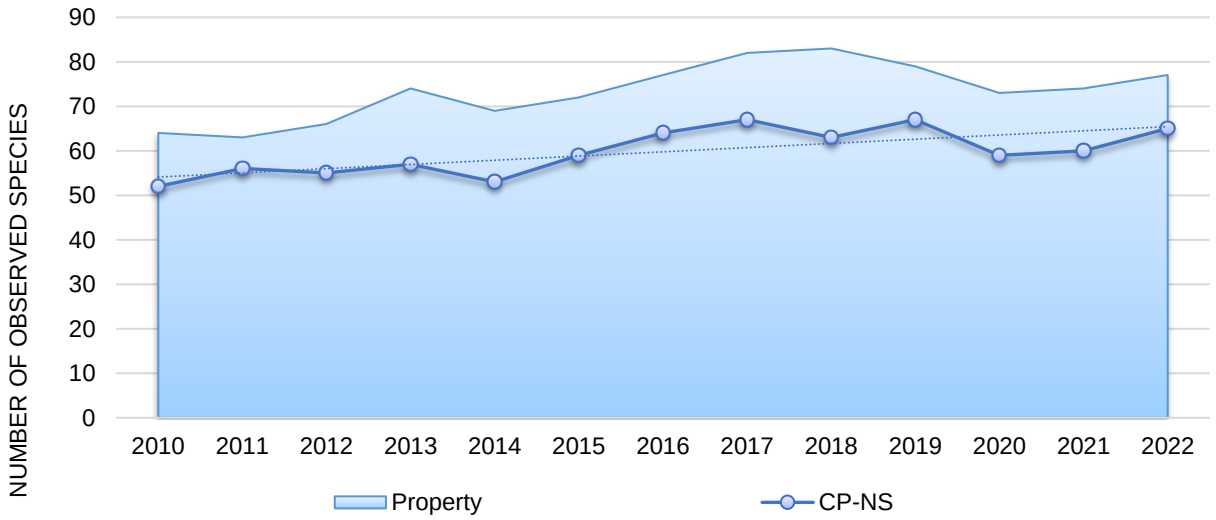


**Figure 9. Species richness across the North Shore of Cootes Paradise, and species richness across all RBG bird monitoring plots from 2010 - 2022.**

Detections have increased property wide and in each nature sanctuary (Figure 10). Property wide the average number of detections per plot is 99 birds per year. CP-NS averages 102 detections per plot per year, exceeding the property average. Since 2010 detections have increased by 26% and on average 1020 birds are detected each season.

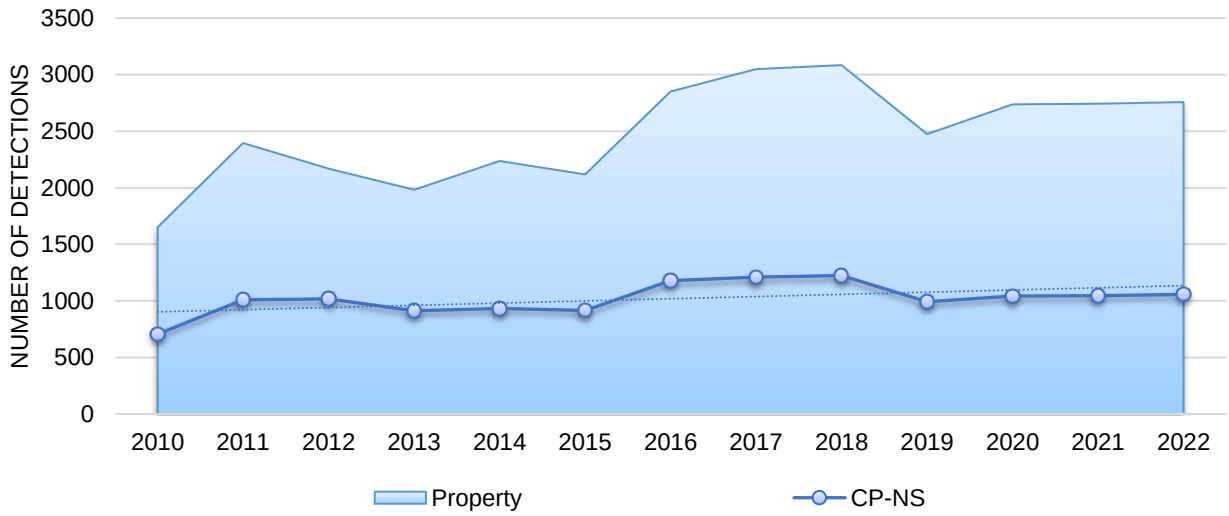


**Figure 10. The number of bird detections on the North Shore of Cootes Paradise, and all bird monitoring plots across RBG property from 2010 - 2022.**

## Diversity

The north shore (CP-NS) is the most diverse nature sanctuary but has only seen a slight increase in diversity of 5% since 2010 (Figure 11).

Diversity is high at CP-NS and indicative of a resilient avian community despite major forest health impacts such as Spongy Moth and EAB. Common birds are remaining common throughout much

of the CP-NS. As restoration efforts continue species richness and diversity should remain stable or slightly increase.

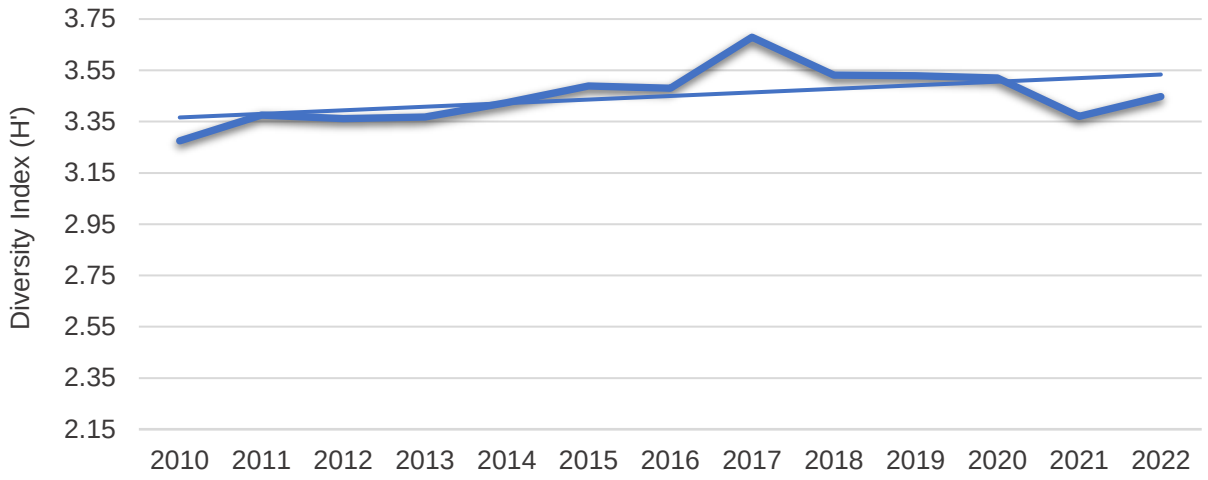


**Figure 11. The diversity index of the North Shore of Cootes Paradise form 2010 - 2022.**

## Relative Abundance and Common Species

The relative abundance of the most common species has changed significantly between 2010 and 2022 (Figure 12). There is a noticeable decline in relative abundance for American Goldfinch, Yellow Warbler, and Black-capped Chickadees, which is matched by a decline in detections.

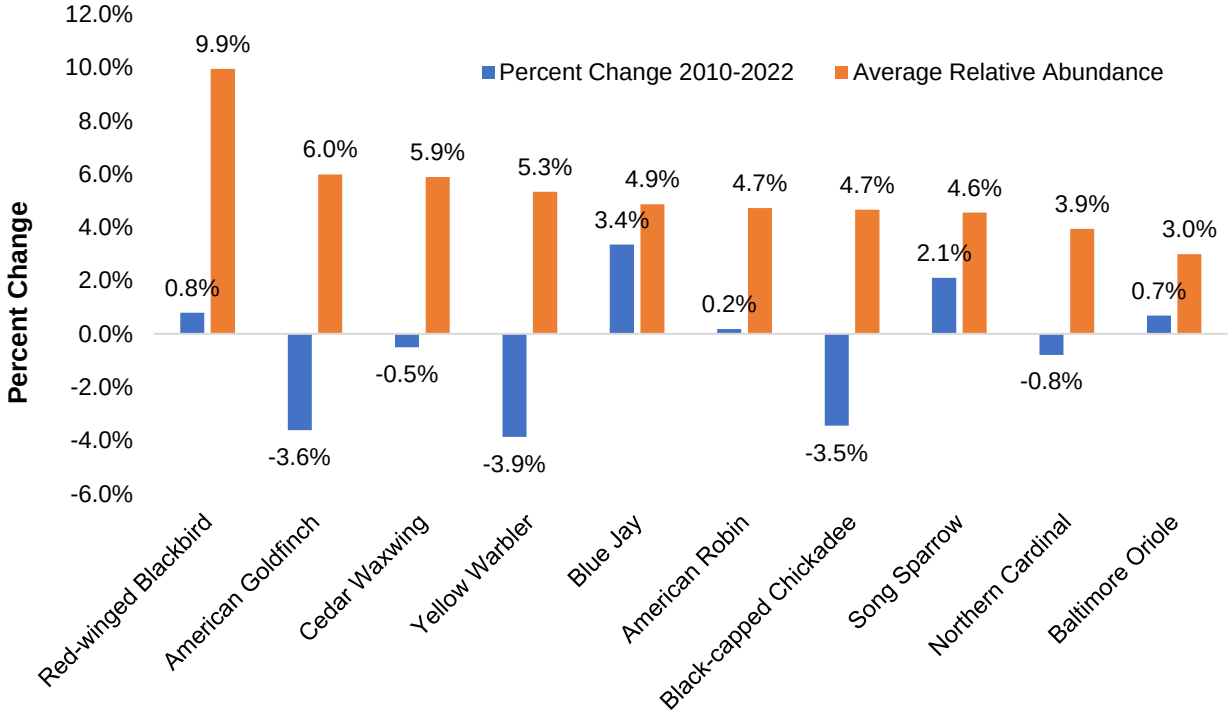


**Figure 12. Top ten most abundant bird species at CP-NS and their percent change from 2010 - 2022.**

American Goldfinch have been found in every plot on the North Shore of Cootes Paradise but are concentrated in plots with regenerating forests and shrubland. Goldfinches are nomadic during bird surveys as they search for food and roosting sites prior to their breeding season. As shrublands and secondary forests mature, goldfinches are likely seeking out new food sources at CP-NS. Despite the decline, this species is still common throughout CP-NS, and averages 61 detections a year.

The most abundant bird observed during bird surveys since 2010 is the Red-winged Blackbird (Figure 13) accounting for nearly 10% of all observations, followed by American Goldfinch (6%), Cedar Waxwing (5.9%), Yellow Warbler (5.3%), and Blue Jay (4.9%). All other species accounted for 68% of all observations.

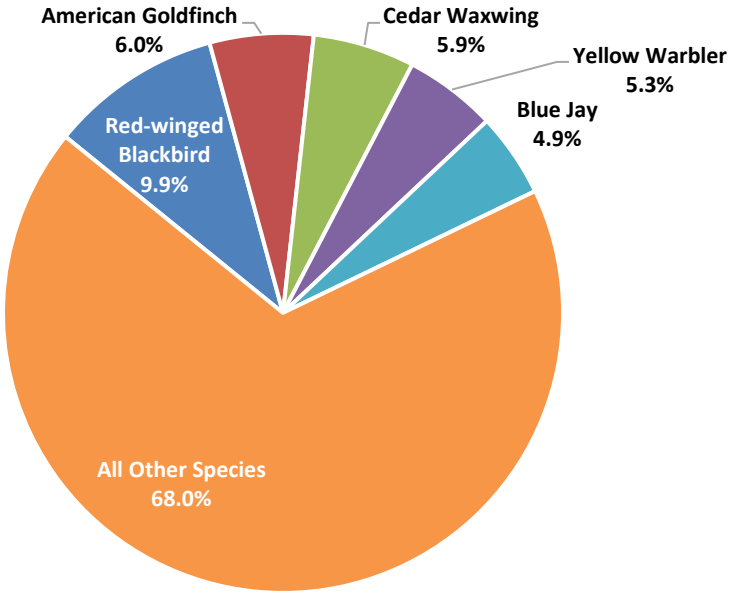


**Figure 13. Top five most abundant species observed during bird surveys on CP-NS from 2010 - 2022.**

Yellow Warblers have declined throughout the North Shore, notably at CP-NS-6, CP-NS-7, CP-NS-8, CP-NS-9, and CP-NS-10 where they were previously common (Figure 14). The decline can likely be attributed to loss of nesting habitat through invasive species, deer browse, and forest maturation, though the impact of each is difficult to tell. Yellow Warbler is also experiencing continent wide decline, with a decrease of 20% between 1966 and 2019 (Lowther et al. 2020).

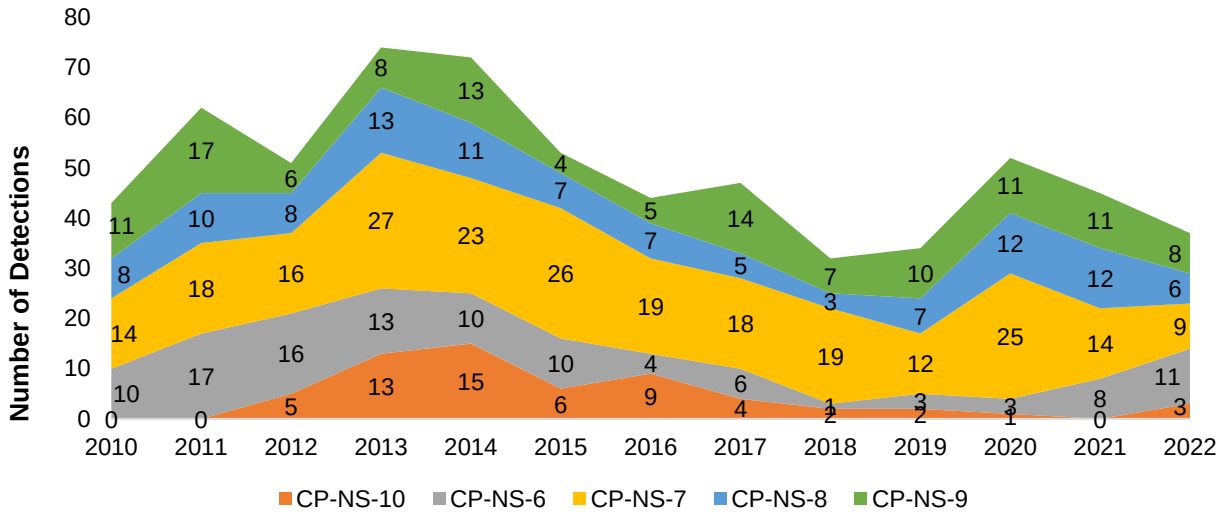


**Figure 14. Yellow Warbler detections at terrestrial bird survey plots where they have appeared from 2010 - 2022. NOTE: CP-NS-10 was not surveyed until 2012.**

Black-capped Chickadees are noticeably declining throughout the North Shore of Cootes Paradise (Figure 15). Reasons for decline are varied and can include supplemental feeding by RBG visitors which concentrates chickadees in non-surveyed locations, reduction of suitable nesting habitat, as chickadees prefer birch, aspen, and sugar maple, are uncommon across the North Shore, and other unknown factors.

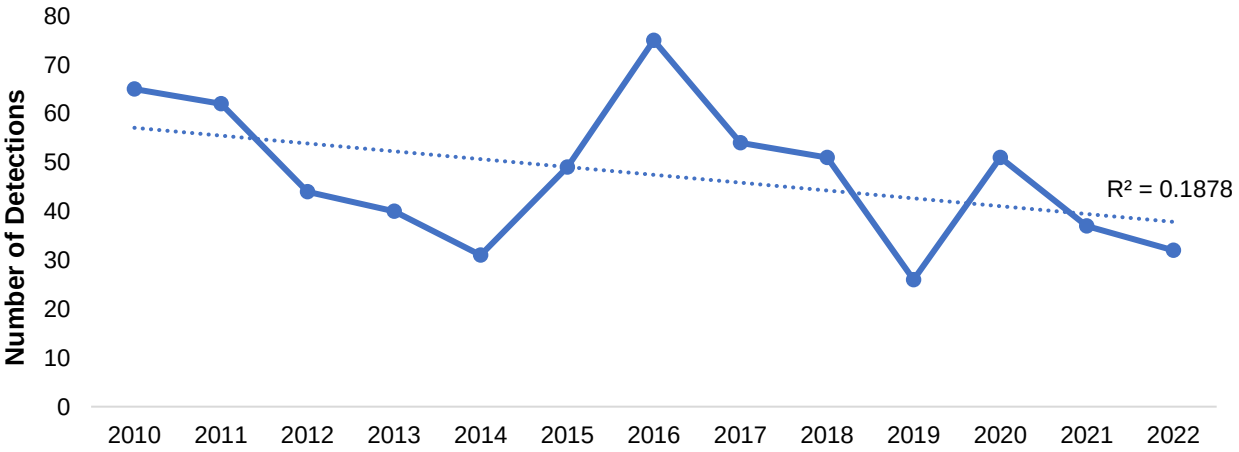


**Figure 15. Detections of Black-capped Chickadee at CP-NS from 2010 -2022.**

Blue Jays are common on the North Shore averaging around 50 detections a year, and the increase in detections indicates a minor population increase. Blue Jays have spread throughout the North Shore and are present in all plots surveyed. In 2010, Blue Jays were detected in 5 out of 9 plots, by 2015 they were detected in every plot and have been ever since. Noticeable increases in Blue Jay detections are at CP-NS-1, CP-NS-2, and CP-NS-6. Blue Jays are prevalent in the interior forest where average detections are highest.

## Guilds

### Nest Location

The greatest change in nesting location is the decline of shrub nesting birds and the increase of lower-canopy nesters Figure 16. This may be due to the reduction of the shrub layer across the North Shore due to maturation of trees, reduced recruitment of native species due to invasives and increased browsing pressure by deer, and manual removal of invasive shrubs.

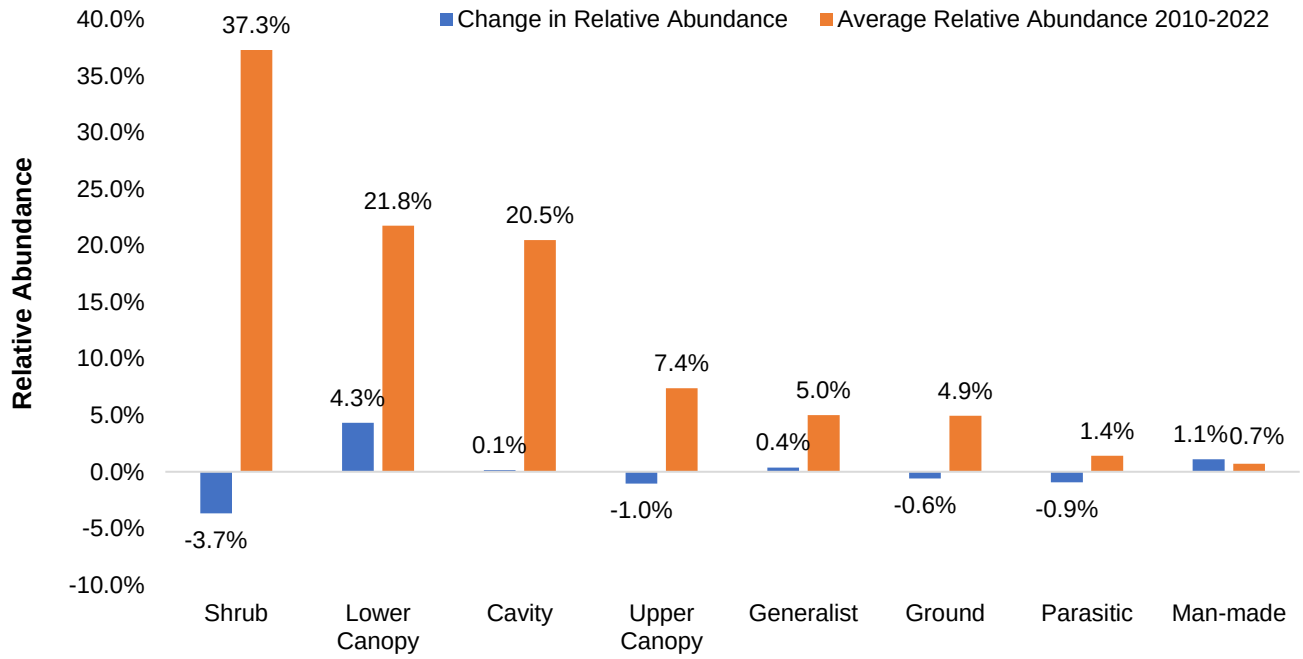


**Figure 16. Nest location relative abundance and change in relative abundance at CP-NS from 2010 to 2022.**

### Habitat

Forest usage is stable or slightly increasing across the four forest habitat guilds (Figure 17). Interior forest species remain fairly restricted to CP-NS-2, CP-NS-3, and CP-NS-4 with only intermittent detections in other plots. Forest edge species are uncommon and restricted to a few plots which have strong delineation between habitat types, such as CP-NS-7, CP-NS-8, and CP-NS-9.

Forest-generalists and secondary forest birds are slightly increasing and are prevalent across the property. Habitat for these groups remains abundant throughout the North Shore and as CP-NS-7 and CP-NS-8 undergo succession these guilds are likely to expand further.

Generalists have declined in relative abundance, but overall detections are stable. The decline in relative abundance is due to the increased representation of forest guilds, rather than the decline of generalist species.

Shrubland species are restricted to a few plots, CP-NS-6, CP-NS-7, CP-NS-8, and CP-NS-9. Detections at other plots are intermittent which is likely contributing to an overall decline in abundance. As succession continues at CP-NS-7 and CP-NS-8 this guild is likely to decrease over time.

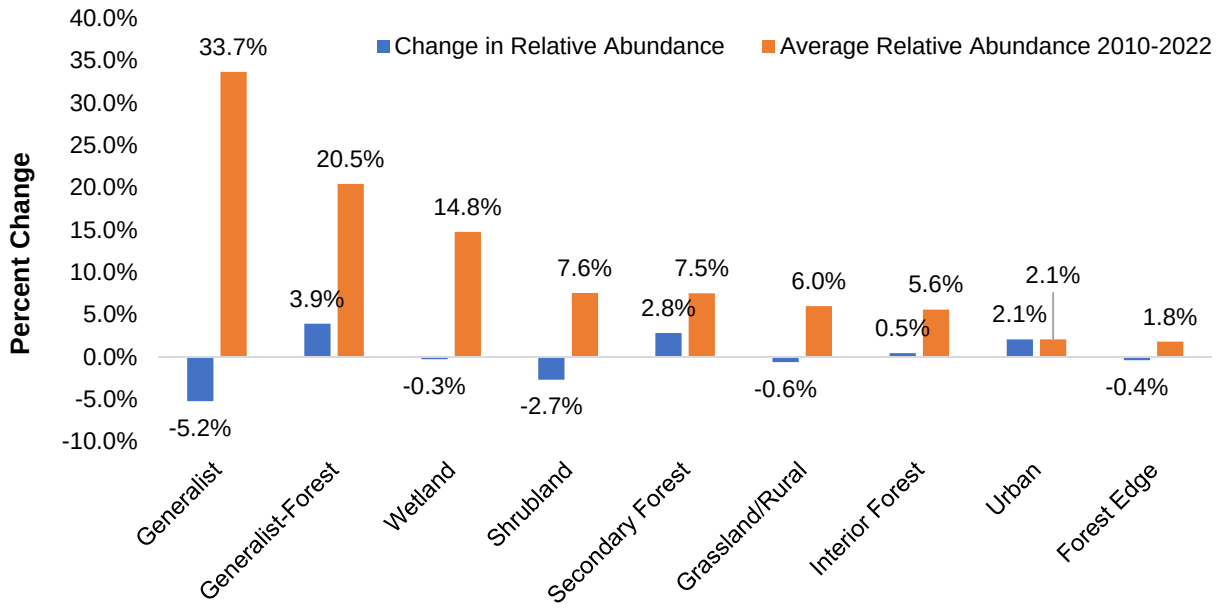


**Figure 17.Habitat relative abundance and change in relative abundance at CP-NS from 2010-2022.**

## Foraging

The most notable change is the increase in lower aerial insectivores (Figure 18). This guild relies heavily on the gap between shrubs and upper canopy layer to forage and nest in, and often declines when invasive shrubs dominate the understory. The data shows that invasive shrub and ground cover species are falling on the North Shore, and that the shrub layer itself is shrinking. This lack of shrubs is likely facilitating some expansion of this guild into the interior forest.

Granivores are almost entirely American Goldfinch and waterfowl species. As described previously American Goldfinch are declining across the North Shore, and waterfowl are only incidentally recorded, so a reduction of this guild is unsurprising.

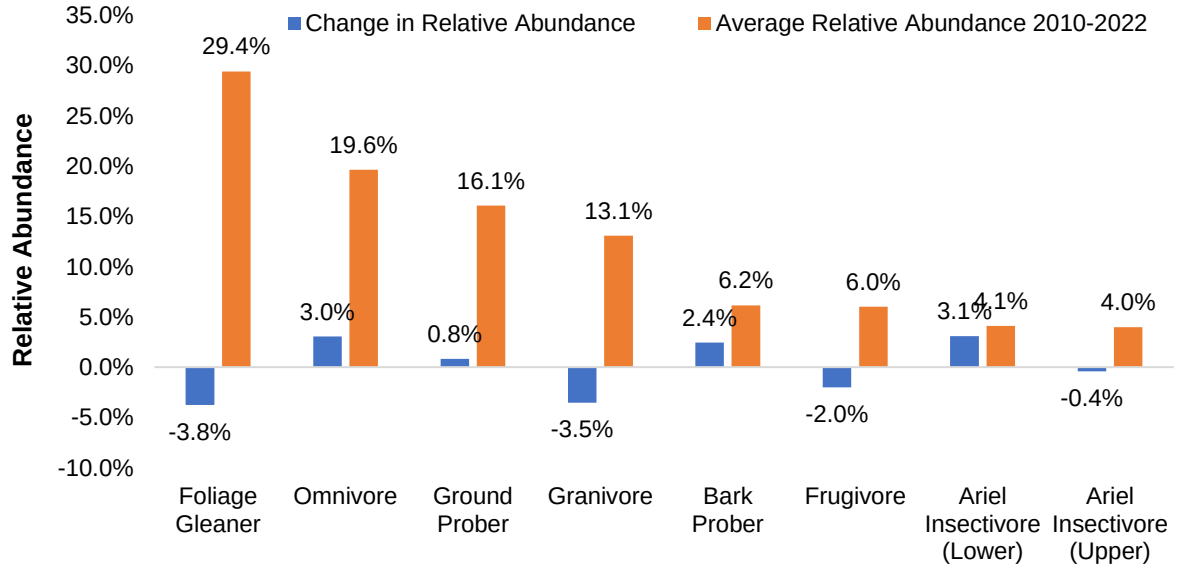


**Figure 18. Foraging relative abundance and change in relative abundance at CP-NS from 2010-2022.**

Foliage gleaners have declined in relative abundance but are stable in detections (Figure 19). *The* decline in relative abundance then is associated with an increase in detections for other guilds, rather than a decline in foliage gleaners.

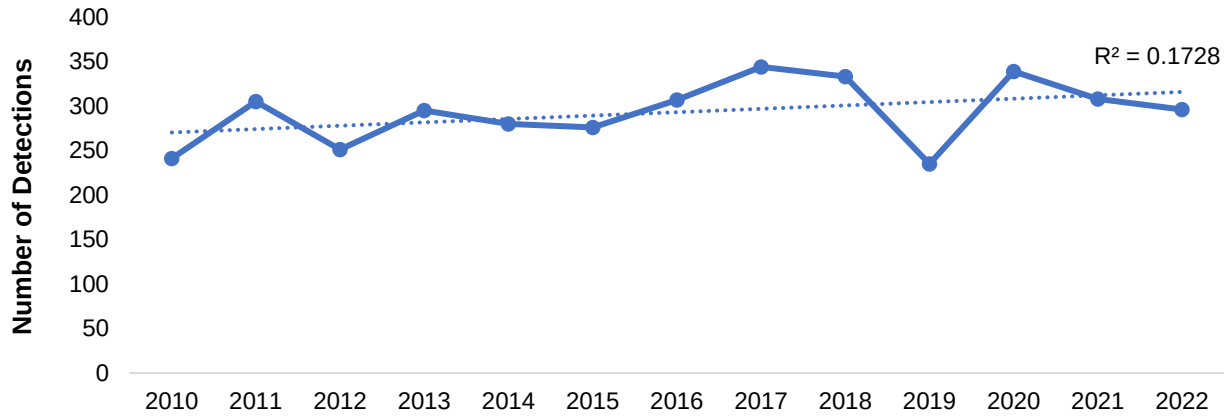


**Figure 19. Detections of all Foliage Gleaner species at CP-NS from 2010-2022.**

## Species-at-Risk

Species-at-risk (SAR) work across RBG property is intensive, extensive, and continual throughout the year. Several SAR use the habitat found in North Shore Forest, and are therefore monitored by RBG's SAR team. 2022 provided some new highlights and updates to SAR that can be found across the North Shore Forest.

- A new population of the Endangered Few-flowered Clubrush (*Trichophorum planifolium*) was discovered by staff. This expands the known range of the population and allows for further monitoring and protection of this plant.
- Two different genetic groupings ('strains') of American Chestnut (*Castanea dentata*) was confirmed on the property. One group aligns with Chestnuts found in Canada, and the other aligns more closely with the genetic population in the U.S.
- Several Endangered Cucumber Magnolia (*Magnolia acuminata*) trees were planted in RBG's natural lands, including 6 within the North Shore Forest.
- A Yellow-banded Bumblebee (*Bombus terricola*) was recorded for only the third time at RBG at a restoration site along Hickory Valley trail, according to iNaturalist.

# Discussion

## Forest Monitoring

### Canopy Tree Layer

The canopy tree layer in the North Shore Forest monitoring plots is composed of primarily Red Maple, Black Cherry, and Red Oak, all of which account for a combined 65% of the relative abundance. Even though Black Cherry is the second most abundant tree, Red Oak surpasses Black Cherry when it comes to percent basal area and relative canopy cover. This is likely due to the fact that the Red Oaks found in the North Shore Forest are quite large in comparison to Black Cherry. It is likely that the Red Oaks are representative of some of the oldest trees in the North Shore Forest community.

Since the beginning of Forest Monitoring in 2008, Red Maple has always been either the most, or second most, abundant species. This pattern continued in 2022, when Red Maple accounted for nearly one-quarter of all trees surveyed using the EMAN protocol. A the same time essentially all of these trees are younger. The species that has been nearly equally in abundance to Red Oak, for which many large individuals found. Looking back through time, it is interesting to examine the relationship between Red Maple and oak trees. Until the 1800s, Red Maple was found to be relatively rare in eastern North American forests (Fei and Steiner, 2007). Hardwood forests were typically dominated by oaks and hickories (source). However, the clearing of land for agricultural purposes increased the White-tailed Deer population in the part of the continent. Looking at today's forested ecosystem, it is not uncommon to find multiple Red Maples in a typical hardwood forest. Interestingly, White-tailed Deer may be responsible for the expansion of Red Maple over the last century, as acorns account for a large portion of White-tailed Deer diet. Therefore, the regeneration of oak has been under stress also due to the increasing abundance of White-tailed Deer in eastern North America (Fei and Steiner, 2007), allowing Red Maple to increase its abundance. It will be interesting to observe future changes to Red Maple and oak abundance over time as increased pressures from a changing climate, continued elevated deer populations, and future forest pests continue to threaten the integrity of forested ecosystems.

Tracking changes over the last decade in the canopy layer provides insight as to how the tree composition in the canopy layer is changing over time. It comes as no surprise that Green Ash and White Ash experienced the greatest loss, calculated as percent change, since 2012, due to the infestation of the Emerald Ash Borer (*Agrilus planipennis*), which started to take hold in 2012. Another species that has lost a large portion (9%) of its canopy tree layer is White Oak. This could be due to more frequent windstorms, the Spongy Moth outbreak which would have impacted trees from 2020 until 2022, the trees slower growth rate making it more susceptible to stress, or older White Oaks dying off and smaller trees being recruited.

Interestingly, Black Cherry has increased in relative abundance since monitoring began in 2009 but has decreased in relative cover since 2012. An explanation for this would be that larger Black Cherry are dying out and being replaced by smaller Black Cherries. However, this should be monitored going forward to ensure stability in the species' population.

Red Oak and Black Oak have both increased by 10% and 7.5% respectively in their relative cover since 2012. This is an interesting discovery since Red Oak have increased in relative abundance by only 3%, and Black Oak by 1%. The increase in relative canopy cover likely reflects the maturing and growth of medium-sized trees into large, old-growth trees. It is also likely that oak species are increasing their canopy growth in response to gaps in the canopy that were created when the ash trees died.

Another potential reason for changes in relative cover of certain species could be due to the fact that forest monitoring plots are not surveyed annually. Which leads to the possibility of the exact borders of the plots altering and shifting over time. Additionally, the plots are marked using spray paint, which can fade over time. Leading to the inability to correctly identify the edges of the plots. This could produce variability in the collection of data over time. An example of this defect can be observed in the relative abundance of Blue Beech (*Carpinus caroliniana*) from 2012 to 2022. In 2012, the relative abundance is 2%, then the species was absent in 2017, but then in 2022 the relative abundance was 1%. There is one individual Blue Beech found in-plot across the North Shore plots. However, it is on the edge of the plot. This means that in some years, the tree would have been counted as “out”, and in other years, the tree was counted as “in”. To prevent errors such as this in the future, this year we made notes on the data sheets as to which trees are the corner trees. This will make it easier to identify the edges of the plot in future monitoring years. In-plot trees along the perimeter were also re-painted to ensure any faded markings are better seen. In addition to these measures, trees greater than 10cm in diameter received a tag number which is now nailed into the tree using best management practices for marking. This will help minimize time taken to find in-plot trees in future years.

Species richness maintains consistent over the monitoring window, despite the major loss of ash trees in the forested canopy. In 2008, during EMAN canopy tree monitoring, there were 10 species identified, which is the lowest species count on record. With that being said, CP-NS-10 had not been established as a Long-Term Forest Monitoring plot, therefore resulting in a lower sampling effort across the nature sanctuary. Not surprisingly, species richness increased from ten species to sixteen in 2012 likely due to the addition of CP-NS-10 as a monitoring plot. Since that time, species richness has remained relatively stable, losing one species per monitoring year. As stated earlier, this is not surprising as there was a loss of two native ash species over that time. Additionally, the inconsistency of the delineation of monitoring plots, as mentioned earlier, has resulted in one species (Blue Beech) being either included or excluded, depending on the year. With more consistent monitoring and proper techniques (GPS coordinates of corner trees and permanent corner markers), this can hopefully be avoided in the future.

While conducting data analysis, there was discrepancy discovered between the identification of some canopy trees over time. Therefore, it is recommended that RBG’s Botany team assist the Terrestrial Ecology Team to determine proper identification of some difficult to identify species. Therefore, consistency and confidence can be achieved going forward.

## Understory

Comparing understory relative cover between the 2012 and 2022 monitoring season provides an insight into how the understory has changed over the last decade. Notable increases in species includes Amur Honeysuckle and Allegheny Blackberry (new species observed in the forest layer).

Species that have decreased in plant coverage and abundance include White Ash, Nannyberry and Blue Beech. Black raspberry is another new species observed this year.

The aforementioned changes in the understory plant community is concerning and could possibly be due to the dramatic increase in relative cover of the Amur Honeysuckle in the understory layer. Non-native Amur Honeysuckle (*Lonicera maackii*) has increased alarmingly from 22.8% in 2012 to 39.7% in 2022, a change of 16.9%. Removal of Amur Honeysuckle on the North Shore has been a prime target of RBG's Shrub Removal Program for a decade. Despite this tremendous effort by RBG staff, the prolific spread of this species has prevailed. Unfortunately, Amur Honeysuckle is known to be tolerant of extreme summer droughts and very cold winter temperatures (Hartman, 2005). With the unknown intensity and severity of a changing climate, this could mean that this non-native species might have the ability to persevere through drastic alterations to the weather regime of southern Ontario.

Amur Honeysuckle has also been known to have allelopathic impacts on both native and non-native seed germination in laboratory studies (McNeish et al., 2016). In addition to producing dense thickets that block sunlight from reaching the forest floor, the allelopathic impact of Amur Honeysuckle assist in its establishment as a monoculture when left to proliferate across the landscape. Therefore, it is of utmost importance to continue, and increase, RBG's shrub removal program the North Shore to ensure the spread of honeysuckle remains contained to its current extent.

Understandably, White Ash (*Fraxinus americana*) and Green Ash (*Fraxinus pennsylvanica*) have decreased in understory coverage by 11.9% and 0.35% respectively. The majority of canopy and sub-canopy ash trees are now dead from Emerald Ash Borer. It could be assumed that the loss of ash in the canopy has allowed increased light to penetrate through, however, total canopy cover for the north shore forest plots has remained stable. An increase in canopy coverage of oak species was observed and it is likely that oak branch growth has filled in some of the gaps left by ash species in the canopy layer. Gains in red maple abundance and cover were also noted in the canopy layer suggesting understory recruitment to the canopy. A decrease in total layer canopy cover, however, was observed in the understory which can be attributed to ash dieback in the sub-canopy layer. It is hypothesized that this changed is allowing more filtered light to penetrate through the canopy to the forest floor despite the minimal change in canopy cover, resulting in the observed introductions of blackberry and raspberry. It is also suspected that these vines were also benefited by increased light penetration in 2021 due to the Spongy Moth caterpillar outbreak which resulted in severe defoliation of oak species.

## Ground Vegetation

Of the 35 species identified during ground vegetation surveys in 2022, one plant was tremendously dominant in its abundance and cover over other species. Canada Clearweed (*Pilea pumila*) accounted for 68% of the total number of stems counted during ground surveys and accounted for 25% of the total surveys space. This result has not been observed during Forest Monitoring in years past. Typically, either an ash species or Garlic Mustard account for the plant with the highest percent cover or number of stems. However, Canada Clearweed completely dominated one monitoring plot, CP-NS-2, this year. This result is present in both the ground surveys, which offer a micro-sample of the larger plot, and the overall VSP ground cover, which

samples the entire plot. Therefore, Canada Clearweed was not just found in great abundance in one area of the CP-NS-2 plot, but it was abundantly spread across the entire 20 metre x 20 metre plot.

Canada Clearweed is an herbaceous annual that grows half an inch to two inches tall. Typically inhabiting light shaded, moist to wet conditions, it has the ability to develop large colonies by producing large amounts of seed. CP-NS-2 has experienced heavy ash dieback due to the EAB infestation, which has created gaps in the canopy. Therefore, the light regime within the plot has likely changed from mostly shaded to lightly shaded, which would create ideal growing conditions for Canada Clearweed, prompting its dominance at the site.

One interesting trend observed in 2022's ground vegetation surveys is that Garlic Mustard is declining, when looking at the total number of stems counted. The impacts of Garlic Mustard on the native plant community are well known and documented thoroughly. Despite continued removal effort by RBG staff, Garlic Mustard is still well-established across RBG's nature sanctuaries and continues to threaten the survival of spring wildflowers.

Garlic Mustard coupled with deer herbivory can have intense effects on native species. However, studies have shown that by excluding deer or reducing their population, decreases in Garlic Mustard populations have been observed. In other words, Garlic Mustard spreads and dominates the landscape more easily when there are high population numbers of White-tailed Deer, due to the intense browse on native plants by deer. Therefore, it could be possible that past intense browsing of native plants could have increased the ability of Garlic Mustard to proliferate throughout the North Shore Forest. However, as demonstrated in Figure 7, the presence of Garlic Mustard within both the South Shore and North Shore forests has declined since monitoring began. Thus, it is possible that the deer population in the Cootes Paradise Nature Sanctuary could be declining and relieving pressure on native plants, while simultaneously reducing the presence of Garlic Mustard. However, further study is needed to provide support for this hypothesis.

In addition to Garlic Mustard, ten non-native species were identified during ground vegetation surveys. Of those ten species, four were found for the first time in 2022 (Erect Hedge-parsley, Multiflora Rose, Norway Maple, and Poa species). It is known that Multiflora Rose is present across the North Shore Forest, as well as the occasional Norway Maple. However, the findings of Erect Hedge-parsley and Poa species is concerning.

As noted in Barr et al. 2022, Poa species are a large threat to the ecological integrity of the ground vegetation on the South Shore of Cootes Paradise. This species has the ability to produce dense monocultures across the forest floor, thereby reducing native species richness. It has also been identified as a large threat to Few-flowered Clubrush (*Trichophorum planifolium*), a highly endangered plant at RBG. Although known to be present, but not overly abundant, across the North Shore, discovering that Poa species are spreading into Forest Monitoring plots is worrisome. Management and removal strategies should be implemented before this invasive species continues to spread across the North Shore and threaten the ecological integrity of the ground vegetation community.

With regard to Erect Hedge-parsley, this is a plant that has been present across the North Shore in varying degrees of abundance for a number of years. Efforts by RBG staff and volunteers in manual removal of this plant has been proven to be effective in management, as population levels significantly drop the following year. However, these areas of removal in the past have been along trails. Therefore, targeted searches and removals should be conducted across the North Shore to reduce the possibility of further establishment and spread.

Look at the composition of the forest floor, in terms of woody debris, leaf litter, moss, and bare ground, the overall composition has remained relatively similar since the first year of monitoring in 2009. When looking at the average cover of leaf litter, there was a decrease of 12% from 2017 to 2022. This could possibly be explained due to the Spongy Moth outbreak that spanned from 2020-2022. The increase of defoliation across the North Shore during that time could have impacted the amount of leaf drop and therefore build-up of leaves on the forest floor. There has been a slight increase in woody debris that could be reflective of the loss of Ash due to the Emerald Ash Borer. What is noticeable is the decline of bare ground from 2009/2012 (27% and 33% respectively) to 2017 (24%) and even more in 2022 (20%). The increase in woody debris is a factor that would influence the amount of bare ground exposed. Also, an increase in ground vegetation cover could account for less bare ground due to increased light filtering through to the forest floor and allowing for more plant germination and growth. The canopy loss of the previous year's Spongy Moth outbreak or from a 17% decreased in the amount of canopy cover due to Ash loss. Long-term trends in leaf litter and bare ground are important to track. Decreased leaf litter and increased bare ground can reflect physical disturbances to the forest floor. Disturbance could be from people walking off trail, dogs off leash, abundant wildlife populations (such as white-tailed deer), exotic worm infestations etc. The disturbed conditions of the forest floor often lean to invasive species infestations where their highly competitive and opportunistic properties take advantage of the bare soil and lack of leaf litter to proliferate and spread. It would be valuable to record the total ground vegetation cover for 1x1 meter plots along with bare ground, leaf litter and woody debris moving forward.

# Birds

## Impacts to the Avian Community

### Invasive species

Invasive plant species are present property wide, with each sanctuary dealing with different infestations and varying severity. Many invasive shrubs are present across the North Shore Forest, including Multiflora Rose (*Rosa multiflora)*, Common Buckthorn (*Rhamnus cathartica)*, and non-native honeysuckle species (*Lonicera spp*.). In particular, Multiflora Rose and non-native honeysuckle are known to expand when ash die back from EAB infestations (Dosanjh, 2022) and is occurring within the North Shore Forest.

After the devastation of EAB, many areas experienced canopy thinning which permitted increased light to reach the forest floor. This increase of light causes non-native shrubs to rapidly expand and grow, and many non-native species spread into the interior forest. Non-native shrubs are known to reduce nesting success of several species, provide poor forage for others, and can even exclude native species from nesting altogether (Bakermans and Rodewald, 2006). Continuing invasive

species removal as indicated by the Honeysuckle and Buckthorn management plans, will be beneficial to protecting the ecological integrity of the North Shore Forest.

### White-tailed Deer

White-tailed deer are prevalent throughout CP-NS and indirectly impact birds through intense browsing. White-tailed deer can significantly reduce native tree survival through intense browse, reducing habitat and preventing recruitment into the shrub and lower canopy layer (Loomis et al. 2015; Waller and Alverson, 1997). High densities of deer reduce ground nesting forest birds at the landscape level, and impact interior forest species greater than successional species (Tymkiw et al. 2013). Tymkiw et al. found that neotropical migrants had lower species richness and density in areas with deer greater than twenty individuals per square kilometer and that sensitive species such as Ovenbird were greatly impacted. In 2013, a ground survey of White-tailed Deer was conducted on RBG property, with 110 deer observed, which resulted in 0.33 deer/ha (Radassao et al. 2013). While current measurements for deer density at RBG are unavailable, the prevalence of deer and known issues with browse is likely impacting the avian community. RBG should complete a follow-p deer density survey when conditions allow.

### Methodology Limitations and Bias

As with all surveys there are inherit limitations. Point counts are limited in detecting diurnal raptors, owls, nocturnal species, very quiet species, and species which require playback to elicit calls. They are also impacted by ambient noise, observer skill, number of observers, weather, and time of count.

The terrestrial bird monitoring surveys at RBG are focused solely on terrestrial species and point count locations are in terrestrial habitats. High flying aerial insectivores, such as swifts and swallows, may also be underrepresented as they are above the canopy and can be hard to see and hear.

The surveys are restricted to the month of June, when most species have arrived and started breeding. Prescence of early and late breeders may be observed, but definitive proof of breeding will be missed. Only through extensive surveys, territory mapping, or nest searching could a definitive list of breeding birds be made.

Distance sampling is not done during bird monitoring surveys. This makes defined population estimates impossible due to the imprecision and bias of the data collected. Instead, relative abundance and detections are used as a metric to determine if a species or guild is common, uncommon, or rare, and what the trends are. Adjustments to methodology can ensure more accurate population estimates in the future.

## Invasive Shrub Removal Program

For over a decade, RBG has developed and implemented an intensive invasive shrub removal program across the property. The primary purpose of the program is to remove as many invasive shrubs from the interior forest as possible during the fall months. Specialized staff are hired to assist with the manual and chemical removal of three primary invasive shrubs: Common Buckthorn, Amur Honeysuckle, and Multiflora Rose.

In 2022, 19,934 shrubs were removed at the edge and in the interior of the North Shore Forest, with more than half of the total shrubs removed being Amur Honeysuckle individuals. Common Buckthorn and Kobus Magnolia were the second and third most removed species. Compared to years prior, staff experienced great success in the ability to remove Kobus Magnolia and successfully removed 2,313 of these invasive ornamentals.

**Table 8. Number of invasive shrubs removed in 2022 in the North Shore Forest (both edge and interior habitat represented).**

| Species | Total Removed |
|---|---|
| **Amur Honeysuckle** | 11,021 |
| Common Buckthorn | 4,813 |
| Kobus Magnolia | 2,313 |
| Common Privet | 1,329 |
| Multiflora Rose | 392 |
| Japanese Knotweed | 23 |
| Black Locust | 16 |
| Common Barberry | 9 |
| Euonymus species | 9 |
| Japanese Barberry | 6 |
| Katsura Tree | 2 |
| White Mulberry | 1 |
| **Total Shrubs Removed** | **19,934** |

## Forest Pests and Diseases

### Spongy Moth

In the summer of 2020, it had been anecdotally noted by RBG staff that the number of Spongy Moth (*Lymantria dispar dispar*) caterpillars was noticeably higher than previous years. This prompted intense surveying of RBG property during the winter of 2020/21. Results predicted severe levels of defoliation across most of the property, with the highest predicted defoliation forecasted to occur on the South Shore of Cootes Paradise and in the Escarpment Properties, specifically at Rock Chapel. This forecast resulted in RBG hiring Zimmer Air Ltd. to conduct an aerial spray of Btk (*Bacillus thuringiensis kurstaki*) to control the population. The spray was highly successful in eliminating the threat of defoliation in the two aforementioned nature sanctuaries. However, severe defoliation occurred across the North Shore Forest and Hendrie Valley, which proved the need for treatment at those nature sanctuaries too.

Monitoring the entire property to forecast defoliation continued in the winter of 2021/2022. As expected, the South Shore of Cootes Paradise and Rock Chapel were forecasted to have light defoliation (as the application of Btk does not guarantee 100% mortality of caterpillars). Oppositely, the North Shore of Cootes Paradise and Hendrie Valley, along with a strip of forest across the Escarpment Properties, was forecasted to have severe defoliation during the growing season of 2022. Although not the outcome RBG was hoping for, it did not come as a surprise that

in 2022 the North Shore Forest and Hendrie Valley would need the same aerial treatment of Btk that the two other nature sanctuaries received the year prior. In May of 2022, Zimmer Air Ltd was contracted to apply Btk to the areas that were at risk of severe defoliation. Although it is a difficult decision to apply a non-targeted biological insecticide, it was necessary to protect the integrity of RBG's oak-dominated forest.

Early results from the winter of 2022/2023 monitoring shows that the application of Btk across all four nature sanctuaries has kept Spongy Moth numbers low and the defoliation forecast for much of the property for 2023 is predicted to be "light". It is assumed that these protective measures have saved the lives of many trees, and its positive impact will last for years to come.

### Emerald Ash Borer

Since the last vegetation monitoring window in 2017, the impact of Emerald Ash Borer (*Agrilus planipennis*; hereafter referred to as EAB) has been felt at its greatest. Since 2017, EAB has completed its decimation of ash trees within RBG. Even large ash that were injected with a protective insecticide (TreeAzin) have succumbed to the invasive pest. The dieback of the ash has left massive gaps in the forest canopy, allowing more sunlight to reach the forest floor and potentially cause large shifts in the composition of the native plant community. Some smaller ash trees are currently clinging to life, but any significantly large ash have died. As RBG enters the afterglow of EAB, further restoration plantings in previously ash-dominated habitats should be conducted to increase the canopy cover.

### Jumping Worms

In 2021, it was confirmed that RBG was one of the few known sites in Ontario to have invasive Jumping Worms present in the nature sanctuaries. First reported in Hendrie Valley, and then discovered in the Arboretum Garden (adjacent to the North Shore Forest), these worms focus their activities in the top layer of soil and consume nearly all leaves and seeds found in that layer, which impacts the soil and its conditions. Although currently unknown, and therefore uncommon, in Ontario, it is likely that this species will spread in coming years as it is easily transported by humans through plant movement and the horticulture industry, and by birds.

Unfortunately, there are not any current eradication methods that would be applicable to a nature sanctuary such as the North Shore Forest. At this time, the goal of management is to reduce spread and educate the public about how they can stop the spread. Therefore, caution should be used when transporting material from one area to another, as well as importing plant material from suppliers.

### Hemlock Woolly Adelgid

Hemlock Woolly Adelgid (hereafter referred to as HWA) has been a forest pest that has been inching its way closer to Southern Ontario in the last few years. HWA was confirmed in the Niagara region last fall, and therefore has been top of mind of RBG staff since then. An intense forest pest that intensively feeds on exclusively native hemlock, essentially starving the tree of water and nutrients. An HWA infestation kills native hemlock between 4 and 15 years after the infestation begins on a tree (Invasive Species Centre, 2023).

In the late winter of 2023, RBG staff identified Hemlock Woolly Adelgid on the South Shore of Cootes Paradise along Caleb's Walk. Although not yet present on the North Shore of Cootes Paradise, HWA is approximately 1 kilometre away, as the crow flies. It can be likely deduced that infestation on the North Shore will ensue in the next few years, if not already present, due to the fact that this forest pest is mainly spread via wind or birds. RBG's forests, including the North Shore Forest, contain stands of Eastern Hemlock (*Tsuga canadensis*) in pockets of the forest. Most of these stands occur on slopes with sandy soil. Not only a threat to the vitality and survival of Hemlocks, but HWA poses a threat for increased erosion on slopes where Hemlocks reside. Also, Hemlocks are a host plant for many species and provide critical cooling factors for nearby creeks and streams, as the dense foliage of Hemlocks nearly block out sunlight entirely (source – notebook with presentation).

There is a treatment option are available to manage HWA, and current research is examining whether dual injections of TreeAzin and IMA-JET (Imidacloprid) could act as a joint force to provide up to a five-year period of protection for a tree. Nova Scotia currently has two basal bark treatments (Xytect-2F and Starkel-Diontefuran) available for use under emergency registration. Early research and conversations with experienced professionals state that these two basal bark sprays begin working faster than the IMA-Jet and are the preferred treatment for foresters in Nova Scotia. As RBG experienced with the Emerald Ash Borer and the TreeAzin treatments, these are not always the solution for saving infested trees. However, these chemical treatments could act as a band-aid solution until a successful biocontrol is discovered. A safe biocontrol would be the most effective measure to protect hemlock trees in the future.

RBG staff will continue to remain up to date on the status of HWA in Ontario, work with the Canadian Food Inspection Agency (CFIA) and explore various treatment options. RBG should begin to plan and account for the financial impact of this forest pest, both in the treatment stage and in the hazard tree management phase.

### Oak Wilt

A serious threat to the survival and vigor of oaks in Ontario is the dispersal of Oak Wilt across Eastern North America. Oak Wilt is a fungi-induced disease that is spearheaded by the *Bretziella fagacearum* fungus. The fungus develops in the outer wood of the stem, which in turn halts the movement of nutrients and water (source – inspection Canada website). The speed at which this disease can kill a tree is remarkable, with most trees being killed in a single growing season.

The vector of spread is typically through root grafting or through bark beetles that transfer spores from infected trees to healthy trees. Current research suggests that red oaks become infected first and die faster than white oaks (source – inspection Canada website).
Although not yet present at RBG, this disease poses a serious threat to RBG's forests. As most of RBG property is dominated by Quercus species, the inevitable arrival of this disease will have extraordinarily detrimental impacts to RBG's forests. RBG should be prepare an emergency response plan which highlights management techniques and strategies for dealing with Oak Wilt.

## Climate Change

A changing climate is a constant and serious threat to the ecological integrity of the North Shore Forest. Intense wind and rainfall events, along with droughts and heatwaves, threaten the survival and flourishment of the plant and wildlife community. As intense storms become normalized, and wind warnings are more frequently issued by Environment Canada, the impact and damage to trees will continue to rise.

With the summer of 2022 being listed as "Abnormally Dry" by Environment Canada (Environment Canada, 2022), and the continuation of that condition into mid-winter of 2023, we can only predict that with a changing climate, changes in the amount and type of precipitation should be expected. If some of the aforementioned forest pests do not cause the death of native trees, their impact on native trees will only increase the stress and inability of a tree to withstand droughts. Therefore, one distinct factor may not cause the death of a tree; it could be a variety of different impacts that push a tree to its biological limits, leading to the demise of the tree.

## Recommendations and Updates

### Non-native Plant Control

- Continued removal of invasive shrubs in the interior forest. With focus on the perimeter of spread to reduce spread into untouched areas.
- Removal of all invasive honeysuckle within and 20 metres surrounding the CP-NS-3 forest monitoring plot. 2022 monitoring shows decreased diversity at this plot, due to the formation of a thick layer of invasive honeysuckle. Using this monitoring plot as a test site for complete removal will allow for observation of forest regeneration. Due to the size and location of the current thicket of honeysuckle, both manual and chemical removal will be necessary.
- With the decrease in Garlic Mustard in Forest Monitoring plots, it is recommended that RBG staff and volunteers continue to remove this invasive plant in the spring. Even though removals occur outside of Forest Monitoring plots, it is encouraging to know that the seed bank might be depleted if efforts by staff and volunteers continue, especially in areas of new invasion.
- Due to the spread of *Magnolia kobus*, efforts during fall invasive shrub removal should continue to focus on removing this invasive shrub. 2022 provided success in removing this species, but there is still more work to be done. Enlisting volunteers at the major site of spread would be helpful to tackle this problem. To prevent further spread into the forest, all specimens in RBG's curated collection should be removed. Completion of RBG's Invasive Species Strategy will provide solid grounds for removal of *Magnolia kobus* from RBG's collections. At that time, a collaborative effort should be made by the Natural Lands and Horticulture departments to remove this invasive species from the collections and natural areas.
- RBG's Horticulture staff should continue the removal of invasive species in garden areas, especially in regions neighbouring natural areas. Additionally, these invasive species should be disposed of using the proper disposal techniques.
- New and/or satellite invasive plant populations should be identified and removed in a timely manner before the inevitable expansion of their range. Regions where this might occur would be the area surrounding the Arboretum, Hopkin's Loop (via yard waste dumping and

backyard escapees), and at the Homestead Plantation (north of Rasberry House). To assist in spreading awareness of invasive species, RBG is encouraged to continue with their educational content for Invasive Species Week and similar recognition events throughout the year. Additionally, expanding the outreach potential of RBG would be beneficial through the assistance of a stewardship technician position. This employee's main goal would be to connect with neighbouring landowners to discuss invasive species and their potential impact on the surrounding nature sanctuary. This would be extremely important in creating a respectful and strong community connection with neighbours to RBG.

- Monitoring and removal of invasive *Poa* species should be conducted. The impact of this invasive grass has been observed in the South Shore of Cootes Paradise (see Vincent, 2018) and is known to proliferate through the forested ecosystem. It poses a major threat to populations of Few-flowered Clubrush, as observed on the South Shore. Therefore, immediate action is needed to stop the spread of this grass through the North Shore Forest.

### Invasive Forest Pests

- Determining the extent of Hemlock Woolly Adelgid spread across RBG property. With the confirmation of HWA at RBG, the organization should take extensive measures to reduce the risk of human-induced spread. This is the only way staff and visitors can protect and do their best to conserve the Hemlock stands on RBG property. Collaboration with local organizations to educate and train RBG staff on monitoring protocols and treatment methods would be exceptionally useful.
- A known invasive forest pest, Spotted Lanternfly (*Lycorma delicatula*; hereafter referred to as SLF) is not yet in Ontario but is bordering the province and establishing well in Western New York State and Eastern Michigan. It is only a matter of time before Ontario's ecosystems are dealt yet another threat. SLF feeds preferentially on non-native Tree of Heaven (*Ailanthus altissima*), however the nymphs will attack a wide range of native trees and horticultural trees. SLF poses a large threat to the fruit and wine industry, as the insect can kill grape vines and destroy fruit orchards (source, invasive species centre). Currently, the impact on native grape vines is unknown. However, it has been noted that most native trees will prevail in the presence of SLF and the pest will be more of an aesthetic irritant. RBG staff should be aware and be on the lookout for this pest.
- Although the North Shore Forest has just experienced a Spongy Moth outbreak, with a changing climate and unknown climatic future, it is impossible to predict when the next outbreak will occur. Therefore, continued monitoring and prediction of Spongy Moth defoliation is required to monitor the presence and abundance of this forest pest.
- The extent of Jumping Worms (*Amynthas agrestis*) on the North Shore is not known. Therefore, inviting research scientists and experts to the property to sample and inventory for the worms would be beneficial.

### Species-at-Risk

- Targeted surveys for Few-flowered Clubrush on the North Shore of Cootes Paradise would be extremely valuable to map the extent of the known population, as a new population was identified in 2022. However, it is acknowledged that staff time is limited, and priorities may fall elsewhere at certain times of the year. With that being said, a combined effort from the

Species-at-risk, Terrestrial Ecology, and Botany teams would be helpful in the smooth operation of surveys on the North Shore.

### Wildlife

- It would be beneficial for RBG Terrestrial Ecology staff to conduct an aerial survey of the White-tailed Deer population across RBG property if no updates are expected from OMNRF, with specific attention to the North Shore nature sanctuary. A deer count has not been conducted on the property since 2013, which resulted in an estimated population of 110, or 1 deer/0.39 hectares (Radassao, 2013). It is well studied and known that an inflated White-tailed Deer population can have detrimental impacts on the native plant community. Therefore, if the estimated population number is elevated beyond the expected or acceptable number, then deer mitigation techniques and practices should be considered.
- Chronic Wasting Disease (CWD) is a fatal disease that attacks the nervous system of all members of the cervid family. Although not yet detected in Ontario, it has been found in farmed populations of elk and deer in Western Canada and has been detected in wild moose and deer in Manitoba (Government of Manitoba, 2022). RBG staff should educate themselves on the symptoms of CWD and should take note of any sick deer on the property.

### Visitor Behaviour

- Off-trail use in the North Shore Forest has been problematic year over year. The disturbance caused by trail users wandering through the interior forest has negative impacts on the plant and wildlife community. Discouraging and educating trail users as to the property etiquette of behaviour while visiting nature sanctuaries is encouraged, along with increased presence of RBG Trailwatchers and Trail Ambassadors, along with staff, on the trails. It is also critical that this understanding of off-trail use be communicated to visitors in terms of human behaviour and dog behaviour. Off-leash dogs are one of the biggest culprits of going off-trail. Although pet owners may see this activity as harmless, off-leash dogs can reek havoc on the local ecosystem by tormenting wildlife and destroying sensitive plants in the process. Continued promotion of keeping dogs on-leash is strongly encouraged.
- Poaching has been an on-going problem for years in the North Shore Forest, both for wildlife and plant material. It is known that poachers access the areas surrounding the North Shore Forest for illegal deer hunting. Over the past few years, RBG staff have found and collected many arrows from the North Shore Forest, as well as across other nature sanctuaries. Therefore, continued awareness of such activity should be addressed for safety measures. As well as collaborating with local law enforcement organizations, such as the Hamilton Police Force and local Conservation Officers to ensure the behaviour stops.
- Supplemental visitor wildlife feeding occurs across all of RBG's nature sanctuaries. The impacts of feeding can negatively affect wildlife populations – both avian and mammalian. Therefore, the continued discouragement (through educational material – factsheets, webinars, social media posts, etc.) of this activity, along with enforcement would result in the cessation of feeding.
- Erosion of slopes alongside trails has been an on-going issue for many years. Erosion mitigation measures were installed along Grindstone Marshes Trail in Hendrie Valley in late 2021 using coco-fibre netting, additional soil, and native plants to stabilize the slope and

prevent further damage. A similar technique was used on the North Shore of Cootes Paradise, beneath a Sugar Maple along the Hickory Valley Trail in the spring of 2022. As trail usage continues, and likely increases over the next decade, further measures may be required along additional trails to reduce erosion.
- Reduce trail expansion across the North Shore to create areas of “wilderness protection” where visitors and their associated behaviours are excluded. This will provide plants and wildlife with the seclusion needed to support sensitive species.

### Herptiles

- Formal surveys for ephemeral ponds and salamander populations should be conducted, as this area of knowledge is currently unknown.
- The continuation and growth of RBG’s Turtle Monitoring Program should be greatly considered in the future. Growth of the program would require more staff and resources, however this would result in the protection of more turtle nests.

## Research Opportunities

There are endless opportunities for research on the North Shore of Cootes Paradise, however, there are certain topics that would provide staff with information that could help drive future ecological work. Future research topics could include:

#### Historical Indigenous Land Use

Given the presence and extent to which Indigenous peoples utilized the lands that are now referred to as the North Shore, further knowledge should be obtained to help guide future projects that require disturbing and digging through layers in the ground. Which areas of the North Shore are of historical indigenous significance? How should the land be treated when dealing with invasive species? Is there a certain depth that staff can dig? And to what extent across the landscape does this rule apply?

#### Chipmunks

Although supplemental wildlife feeding is not as widespread and intense in the North Shore Forest as in other RBG nature sanctuaries (Hendrie Valley), it is still impacting the wildlife community. One of the possible impacts is an unbalanced mammal population, specifically chipmunks, which can increase pressures on low and ground nesting birds as well as recruitment of trees. It would be beneficial to conduct a population study of chipmunks not only on the North Shore of Cootes Paradise, but across all of RBG’s nature sanctuaries. This would provide interesting information as the level of feeding varies across nature sanctuaries.

#### Wood Thrush

As outlined in Peirce et al (2018), the supplemental feeding of wildlife has the potential to be beneficial for opportunistic, potential non-target species, such as chipmunks. Although feeding chipmunks may be a goal of visitors, they can also be a non-target and benefitted species when piles of seed are left alongside trails for wildlife. Therefore, in conjunction with a population study of Chipmunks at RBG, it would be ideal to have a study that focuses on mammalian predation of low and ground nesting birds at RBG. As mentioned earlier, Wood Thrush have been declining at RBG over the past years. The current prediction is that wildlife feeding and Brown-headed

Cowbirds could be negatively impacting the Wood Thrush population. Collaboration with a nearby university could help answer this question.

### Magnolia kobus

The North Shore Forest is an ideal location for further study and examination of the spread and expansion of Magnolia kobus into natural areas. This is a highly understudied area of research, and therefore RBG should be collaborating with local universities to create a better understanding of the plant's ability to spread.

### Black-capped Chickadee Population Study

The population of Black-capped Chickadees has continued to be a question posed by RBG staff, volunteers, and visitors for many years. RBG staff do not have the capacity to conduct intensive population studies, such as mark-recapture. Therefore, enlisting the assistance of nearby universities to answer this question would be beneficial. Since Black-capped Chickadees are readily fed supplemental food by visitors, they are a species that could be experiencing impacts by this activity. Therefore, gathering baseline population information would be advantageous to track changes in population numbers along with changes in supplemental feeding behaviour by visitors.

### Jumping Worms

As mentioned previously, invasive Jumping Worms are present in the North Shore Forest. However, the extent of their population is not yet known. Therefore, this would be a valuable research opportunity for sampling across the North Shore Forest.

### Hemlock Woolly Adelgid

RBG is one of the few sites in Southern Ontario with a confirmed infestation of Hemlock Woolly Adelgid (HWA), it would be a great site for research opportunities as this pest continues its spread across the landscape. Although not yet noted or confirmed in the North Shore Forest, it would be a prime research control site in contrast to the infested study site on the South Shore of Cootes Paradise. It is recommended that RBG continues to work with the Canadian Food Inspection Agency (CFIA) and Canadian Forest Service (CFS) on potential research studies on the property.

## Conclusion

The North Shore Forests provides trail users with an escape from the concrete urban landscape and provides the feeling of being transported far way from the city into the remote wilderness. Despite its importance to the surrounding community for recreational use, the forest provides essential habitat and refuge for plants and wildlife, including species that are locally rare and at risk of extinction. The continuation of long-term monitoring programs for both plants and wildlife will be essential in tracking changes in the ecosystem, especially as the populations of Hamilton and Burlington continue to expand. Increased human pressures impacting the nature sanctuary can be expected in the future. This pressure in conjunction with changes in climate will push the ecological integrity of the forest to limits not experienced in the past. However, with community collaboration and strong partnerships, the North Shore Forest will continue to provide freedom from the city as well as remaining an ecological sanctuary for plants and wildlife.

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# Appendix A

**Table 9. Bird Monitoring plot names with corresponding identification codes, and the number of site visits in 2022.**

| Site ID # | New Site Name | Old Site Name | Visits |
|---|---|---|---|
| HV-1 | HV-1 Cherry Hill | HV1 Cherry Hill | 4 |
| HV-2 | HV-2 South Pasture Swamp | HV2 Brakenbrae | 4 |
| EP-BT-1 | EP-BT-1 Thornapple Loop | Berry Tract | 4 |
| EP-BT-2 | EP-BT-2 Berry Tract South | *New plot in 2017 | 4 |
| EP-RC-1 | EP-RC-1 Lower | RC1 lower | 4 |
| EP-RC-2 | EP-RC-2 Upper | RC2 upper | 4 |
| EP-RC-3 | EP-RC-3 Field | RC field | 4 |
| EP-RC-4 | EP-RC-4 Borer’s Field | *New Plot in 2018 | 4 |
| EP-RC-5 | EP-RC-5 Romar Field | *New Plot in 2018 | 2 |
| CP-NS-1 | CP-NS-1 Captain Cootes | 1B Captain Cootes | 4 |
| CP-NS-2 | CP-NS-2 Grey Doe | 2B Grey Doe | 4 |
| CP-NS-3 | CP-NS-3 Interior North | 4B plantation east | 4 |
| CP-NS-4 | CP-NS-4 Interior South | 4C Plantation south | 4 |
| CP-NS-5 | CP-NS-5 Homestead | Homestead | 4 |
| CP-NS-6 | CP-NS-6 Lilac Dell | Lilac Dell | 4 |
| CP-NS-7 | CP-NS-7YorkRoad Parkette | York Road Parking Lot | 4 |
| CP-NS-8 | CP-NS-8 Segato Field | Plantation Field | 4 |
| CP-NS-9 | CP-NS-9 Hopkin’s Loop | Hopkin’s Loop | 4 |
| CP-NS-10 | CP-NS-10 Borer’s Creek | * New plot in 2012 | 4 |
| CP-SS-1 | CP-SS-1 President's Pond | 1C President's Pond | 4 |
| CP-SS-2 | CP-SS-2 Mac Landing | 1A Mac Landing | 4 |
| CP-SS-3 | CP-SS-3 Ravine Road | 2A Ravine Road | 4 |
| CP-SS-4 | CP-SS-4 Churchill South | 3A Churchill South | 4 |
| CP-SS-5 | CP-SS-5 Churchill North | 4A Churchill Interior | 4 |
| CP-SS-6 | CP-SS-6 Princess Point | Princess Point Oak Savannah | 4 |

## Appendix B

Guild Definitions - Habitat, Foraging, Nest Placement

The purpose of assigning birds found at Royal Botanical Gardens to guilds is to help make more informed decisions about habitat quality and restoration efforts. Guilds allow for the examination restoration on a community scale rather than individual species-specific needs. The decline or increase in certain guilds is also indicative of habitat quality, surrounding land uses, and can highlight stressors before individual populations are impacted to a noticeable extent.

All species detected during terrestrial bird monitoring, and the Long Watch Migratory bird monitoring were assigned guilds. Birds were assigned guilds based on needs during the breeding season, regardless of if they breed in the Hamilton area.

Each bird has been slotted into multiple guilds, these are taxon, habitat, foraging, nest placement, and for species-at-risk, conservation status.

Research for each species was conducted using Birds of the World species accounts (https://birdsoftheworld.org/bow/home), and information from All About Birds (https://www.birds.cornell.edu/home). All information was retrieved between June 2022 – March 2023.

Birds were sorted taxonomically by using the groups provided by AllAboutBirds (https://www.allaboutbirds.org/guide/browse/taxonomy).

| **Guild**<br>**Habitat** | **Definition** |
|---|---|
| Forest Edge | Forest Edge birds rely on the transition between forested areas and open ones. They are found on the edges of blown-downs, fires, clearcuts, grasslands, or spruce/bog transitions. |
| Generalist | This bird will use and breed in a mix of woodlands, grasslands, and occasionally wetlands/urban areas so long as suitable vegetation is found. |
| Generalist - Forest | This bird will be readily in any wooded areas, from interior forest to forest edge. So long as trees are present in good numbers they can breed there. |
| Grassland/Rural | These birds require areas of open space such as pastures, farm-fields (non-row crops), restored meadows and grasslands, or other large open areas. |
| Interior Forest | Mature forest that is at least 100 metres away from major disturbance and edge effects such as roads, fields, and trails. Canopy is usually closed and diverse. Birds that occupy this area are typically shy of humans. |

| | |
|---|---|
| Open Water | Birds usually nest on islands or beaches with abundant access to open water such as large lakes and rivers for foraging. |
| Secondary Forest | Regenerating forest after blowdowns, fires, or other disturbance, and can include small openings in Interior Forest. Birds rely on the young trees and shrub layer to successfully nest and forage. |
| Shrubland | Represents thicket and shrubby habitats dominated by shrubs, with few trees. Often areas are regenerating from disturbance or are near riparian areas. |
| Urban | Suburban homes, skyscrapers, roadways, and other human made infrastructure dominate the landscape. Birds typically rely on these structures to nest in. |
| Wetland | Birds found in cattail marshes, vernal pools, ponds, wooded swamps, bogs, fens, and rivers. |
| **Foraging** | |
| Aerial Insectivore (Lower) | The bird forages for insects on the wing below the canopy, may also forage above small streams and wetlands. |
| Aerial Insectivore (Upper) | The bird forages for insects on the wing above the canopy, grasslands, open water, or shrublands. |
| Bark Prober | The bird will drill into bark for insects or spend most of it's time gleaning insects from bark crevices. |
| Carnivore | The bird hunts and consumes vertebrate prey such as mammals, birds, reptiles, and amphibians. |
| Foliage Gleaner | The bird picks insects off of leaves, grasses, twigs, bark, and the ground. |
| Frugivore | The bird almost exclusively consumes fruits such as berries, apples, grapes etc. |
| Granivore | The bird consumes a variety of seeds, nuts, grasses, or forbs. |
| Ground Prober | The bird hunts invertebrates in the ground or soft substrates, often by wedging their bill into the substrate. |
| Molluscivore | The bird mostly consumes molluscs, such as snails, mussels, and other aquatic benthics and invertebrates. |
| Nectivore | The bird almost exclusively consumes nectar from flowering plants. |
| Omnivore | The bird consumes most prey items from fruits, seeds, invertebrates, carrion, etc. |
| Piscivore | The bird hunts and consumes aquatic vertebrate prey such as fish and amphibians. May also consume freshwater invertebrates. |
| Scavenger | The bird almost exclusively eats carrion. |
| **Nest Placement** | |

| | |
|---|---|
| Burrow | Nest is built in a burrow that was excavated or found. Usually in a bank or cliff of soft substrate. |
| Cavity | Nest is built in a cavity that was excavated or found. Usually in trees but can also be in man-made structures. |
| Colonial | Nests are built in large groups of the same species, i.e terns, either in trees, shrubs, or on the ground. |
| Generalist | Nests in a variety of heights/locations and may reuse nests of birds or mammals. |
| Ground | Nest is built on or near (<30 cm) the ground. |
| Lower Canopy | Nest is built in upper branches of shrubs or lower branches of trees about 5 – 15 metres above the ground. |
| Man-made | Nests are mostly built in or on man-made areas such as barns, chimneys, telephone poles etc. |
| Parasitic | Lays eggs in another bird's nest. |
| Shrub | Nest is built in shrubs about 0.5 m – 5 metres above ground. |
| Upper Canopy | Nest is built in the upper branches or the top of tall trees 15 – 25+ metres. |