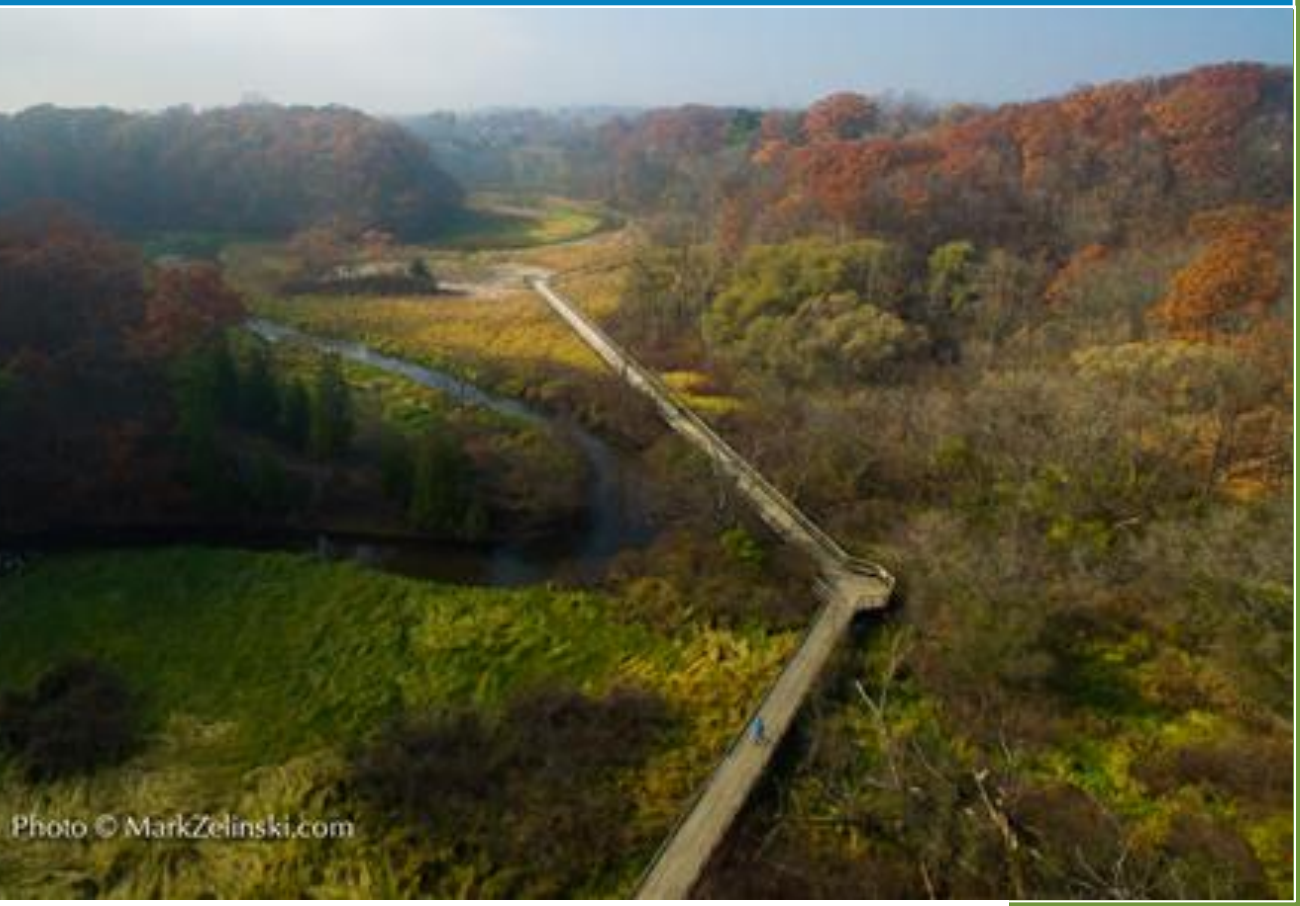
Hendrie Valley Forest Environmental Status Update 2023



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April 2024
RBG Report No. 2024-4

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Acknowledgements

This report would not have been possible without the guidance and assistance of Royal Botanical Gardens' Head of Natural Lands, Tys Theijsmeijer, as well as members of the Terrestrial Ecology Team: Lindsay Barr, Mallory Peirce, and Ashley Cramer. Forest and bird monitoring was completed by Lindsay Barr, Mallory Peirce, and Ashley Cramer.

Front cover photo: Mark Zelinski 2017. Overview image of Hendrie Valley

Recommended Citation

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

Document Description

This report from the Natural Lands Department of Royal Botanical Gardens has been reviewed internally. Its contents have not yet been subject to an independent peer review. The report represents a status update to a previous Environmental Status Report for Hendrie Valley. It is authorized for release by Royal Botanical Gardens subject to acknowledgment that it is being provided for information purposes only, and that its contents may be subject to revision following independent review. References to other agencies, organizations, or officials do not constitute endorsement of this report by those or any other agency.

Executive Summary

Hendrie Valley Nature Sanctuary features forested ravines along Grindstone Creek, as well coastal and floodplain marshes, creating diverse plant and animal life. At only 100 hectares in size, it remains a biodiversity hotspot amid the stressors of a highly urbanized Hamilton-Burlington landscape. The long narrow valley and the lack of interior forest leaves it more susceptible to impacts from non-native invasive species and ecological disturbances. Visitors experience the valley through the 4.5 km of woodland walking trails and large boardwalks that cross the floodplain. The valley is the most intensely visited site of Royal Botanical Gardens and with sensitive habitat abutting all the trails. Extensive marsh and land habitat restoration efforts have been undertaken to remediate the many stressors that continue to threaten the ecological function and biodiversity, with substantial improvements in marsh habitat ongoing supported by the Hamilton Harbour Remedial Action Plan process. Long-term forest monitoring, breeding bird surveys, Ecological Land Classification, Marsh Monitoring Program, and Species-at-Risk monitoring provides data to track changes in biodiversity and inform ecological status and assist in guiding management decisions.

Forest plant condition for the old growth forest is the primary measure of environmental status, and secondarily bird populations. To track changes in plant community multiple 20m x 20m forest monitoring plots have been surveyed since 2009, with additional plots added in 2018. The forest has experienced change since monitoring began. Canopy tree surveys assessed 53 individual trees of 13 different species including one invasive species Norway Maple (*Acer plantinoides*). The most abundant tree is the Red Maple (*Acer rubrum*) with a relative abundance of 25%, followed by Red Oak (*Quercus rubra*) - 20% relative abundance and Black Maple (*Acer nigrum*) - 15% relative abundance. By basal area, Red Oak dominated representing 53% of the tree species, followed by Red and Black Maples. Forest plant ground cover was dominated by native species (82%) including Blue-stemmed Goldenrod (*Solidago caesia*) and Wild Sarsaparilla (*Aralia nudicaulis*), with tree seedlings of Green Ash (*Fraxinus pennsylvanica*) and Black Maple also abundant. Among the 9 invasive species found, Amur Honeysuckle (*Lonicera maackii*) was most abundant, and Common Buckthorn (*Rhamnus cathartica*) and Tartarian Honeysuckle (*Lonicera tatarica*) appeared as a new plot species. Recent management activities of Spongy Moth (*Lymantria dispar dispar*) as well as outreach efforts to remain on the trails have notably increased forest floor leaf litter, despite the recent appearance of an invasive worm species, the Jumping Worm.

The invasion of Emerald Ash Borer (*Agrilus planipennis*) (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 including ash trees but also Norway Maple. Lesser Celandine (*Ficaria verna*) is also an issue. At the same time Garlic Mustard (*Alliaria petiolata*) has significantly declined. Norway Maple understory coverage increased from 12% of trees (2012), to 23% in 2023. During the fall of 2023 a large-scale Norway Maple removal project support though a Parks Canada Ecological Corridor Pilot funding facilitated removal of many invading trees, including most of the large seed producing Norway Maples trees at the valley edges.

Hendrie Valley habitat for birds is limited by the valley's smaller size and is the least diverse avian community of the RBG properties. As with all RBG sites, Red-winged Blackbird is the most common species (27% of all observations), with 37 bird species found during June monitoring. Other abundant bird species are Song Sparrow, American Robin, Northern Cardinal, and Black-capped Chickadee, and

when combined with blackbirds represent 50% of all the birds present. The bird populations were dramatically impacted by the extreme visitor numbers to the valley during COVID (2020), with bird species numbers recovered to a stable number since 2021, but with total numbers in decline, also noted across all the RBG sites. The decline in common bird species resulted in an increase in the diversity index, with Black-capped Chickadee declining and the Red-bellied Woodpecker emerging in abundance. The average abundance at a monitoring plot is 26 birds/plot and the average species count is 14 species/plot. Species-at-Risk classified birds are limited in number and dominated by the Wood-Pewee, while Wood Thrush not noted during breeding season since 2019.

Monitoring of migrating bird populations (both during spring and fall) was initiated in 2015 through a volunteer led program (RBG Long Watch). Since Long Watch transects began, 184 species have been recorded in Hendrie Valley, including 13 Species-at-Risk. The most species recorded during a single year occurred in 2019, with 143 unique species being seen/heard. Unfortunately, species richness has been declining since 2019. 2023 had the fewest number of species recorded (124) vs the 9-year average of 133 species. The top 5 most abundant species detected are Red-winged Blackbird (relative abundance of 15%), Mallard (12%), Black-capped Chickadee (8%), Canada Goose (5%) and Blue Jay (5%). All other species account for 55% of all records. This is comparable to the results found during RBG's staff-led bird surveys that occur in the month of June. Of the four sites in the Long Watch, Hendrie Valley hosts the fewest birds and species reflective of the smaller size of the area and the surrounding stresses and disturbances.

Separately for other wildlife, just 4 amphibian species continue to be recorded during Marsh Monitoring Program (MMP). Since 2018, monitoring has been limited, but as with other RBG properties the earliest spring species are absent despite appropriate habitat. Green Frog remains the most common. For Species-at- Risk plants and wildlife, 39 species have been observed in Hendrie Valley. Turtles continue to experience pressure from predated nests by opportunistic mammals and road mortality. Extensive roadside barriers have been installed in recent years to prevent roadkill.

A factor significantly impacting the valley ecosystem is visitors feeding the birds and animals. The valley has been impacted by wildlife feeding for several decades despite ongoing efforts to discourage this activity. With the aid of volunteer monitoring in 2023, this activity was noted at an all-time high with 95% of visitor groups noted as undertaking some form of wildlife feeding, with feeding unique to only the Hendrie Valley property at RBG. Despite numerous stressors such as wildlife feeding, recent canopy loss due to Emerald Ash Borer (EAB, caterpillar defoliations, and the recent arrival of Jumping Worms, the avian community has shown some resilience. Common species are adjusting as forest canopy recovers and smaller trees transitions back to forest. Ongoing efforts to stabilize the forest ecosystem including invasive woody plant removal, marsh restoration, and introduced insect management will continue. Due to unregulated access, changes to access and how parts of Hendrie Valley and Garden are used are a priority in RBG's approved 25-Year Master Plan.

To maintain the health of Hendrie Valley Nature Sanctuary the top three recommendations are:

1. Change access conditions to stop wildlife feeding by visitors.
2. Continue to undertake a program to remove invasive plant species, focusing on Norway Maple and Amur Honeysuckle.
3. Undertake research to address the lack of amphibians.

A full list of recommendations can be found at the end of this report.

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Introduction

Hendrie Valley Nature Sanctuary, located within the city of Burlington, Ontario, features forested ravines, Grindstone Creek, coastal and floodplain marshes, and diverse plant and animal life. The nature sanctuary is 100 hectares in size with 4.5 km of popular hiking trails, including the longest boardwalk within the Royal Botanical Gardens (RBG) properties. Hendrie Valley also represents the most significant concentration of native species within RBG's nature sanctuaries and is among the most biodiverse places in Canada (Galbraith et al., 2011). Adjacent to the nature sanctuary are RBG's cultivated spaces including Hendrie Park, Laking Garden, and RBG Main Centre, along with the major road corridors of Plains Road West and Highway 403, residential areas, and the City of Burlington's Hidden Valley Park (Figure 1).

Figure 1. Map of Hendrie Valley and surrounding properties. This map can be found at trailheads to Hendrie Valley (Cherry Hill Gate and Valley Inn).

This report examines the current environmental status of the valley through various ongoing ecological monitoring programs and provides and updates the first status report completed in 2018. Hendrie Valley and the surrounding lands have a rich history tied to our natural and cultural heritage. Before European settlement in the 1790s, Hendrie Valley contained footpaths, landings and water routes connecting indigenous peoples from Burlington Bay to the Niagara Escarpment (Royal Botanical Gardens, 2018). Some of the footpaths were expanded into transportation routes, which are known today as Old Guelph Road and Snake Road.

Prior to RBG's ownership of the property, Hendrie Valley and Park had a number of owners, most notably William Hendrie, who owned the Valley Farm and Hendrie Stables until his passing in 1906. Here, famous racehorses, including Martimas, trained and lived – putting Valley Farm on the international map following track victories in the United States and Canada (Henley, 1992; Henley 1996). The property was donated by George M. Hendrie, the surviving son of William, in 1931 to the

Hamilton Parks Board to be preserved as a nature sanctuary and park. In 1941, the property was officially acquired by RBG (Henley, 1992; Royal Botanical Gardens, 2018). Over the years, RBG acquired more land from the Carroll, Flatts, and Filman families, which led to the creation of the current property as it is today.

Historically, redevelopment of the landscape in and surrounding Hendrie Valley Nature Sanctuary dates back over 200 years, and which lead to the introduction of many Eurasian invasive species like Common Carp (*Cyprinus carpio*) and decimated much of the marsh system. Tablelands were cleared and altered to crop lands while floodplains became pastures, however, the steep ravine slopes in the valley, dominated by Carolinian tree species like oak (*Quercus* spp.) and hickory (*Carya* spp.) mostly remained intact. Today some of the largest trees found within RBG's properties are now found on these slopes, with the area currently having 42 native trees species and 25 non-native species based on Ecological Land Classification (ELC). To improve habitat, water quality and restore ecological function, restoration of the marsh began in 1994 in the floodplain ponds and expanded downstream to the coastal marsh by 2001 (Johnston et al., 2001). Carp barriers and artificial embankments (called berms) were installed to improve marsh conditions and provide habitat for wildlife. Recycled Christmas trees have been donated annually from local communities and businesses to be used in constructing the berms along Grindstone Creek. More recent restoration activities within the forests have focused on managing non-native invasive plants, erosion mitigation, establishing a protected zone (South Pasture Swamp), and improving impaired forest habitat with native seed dispersal and vegetation plantings.

However, there are still many stressors that threaten the ecological function and biodiversity in Hendrie Valley Nature Sanctuary. Large canopy tree loss has been an ongoing concern, with oaks, ash (*Fraxinus* spp.) and Black Cherry (*Prunus serotina*) trees observed to be most susceptible to mortality from various stressors in recent years. Over the past 20 years alone, stressors include long periods of drought, multiple years of defoliation (when trees are stripped of their leaves) from caterpillars [invasive Spongy Moth (*Lymantria dispar dispar*) and native Fall Cankerworm (*Alsophila pometaria*)], non-native invasive species (example Emerald Ash Borer -*Agrilus planipennis*)), introduced diseases (Hall & Preston, 2008), and more recently, the detection of Hemlock Woolly Adelgid (*Adelges tsugae*) within RBG's nature sanctuaries. Tree seedlings are susceptible to increased mortality from unbalanced populations of seed eating wildlife, such as chipmunks and squirrels, and trampling by visitors when wandering off trails. In 2004, a significant loss of canopy trees occurred when dozens of Red Oak (*Quercus rubra*) trees died following conditions of drought, extreme temperatures, and defoliation. If the aforementioned stressors do not cause quick tree mortality, then they can cause affected trees to become more susceptible to dieback, diseases, and blow downs during major storm events. Changes in frequency and intensity of major storm events is another concern regarding tree loss as climate change progresses.

Due to the high forest edge to interior forest ratio in Hendrie Valley, the typical human-caused impacts on the edge of the forest, that usually don't reach the interior forest, have been found to impact the interior forest in Hendrie Valley. Approximately 5 kilometers of forest edge are adjacent to roads, residential areas, and horticultural gardens. Impacts include the spread of invasive plants (via ornamental escapees from neighbouring gardens and yard waste dumping behind residential homes), erosion from urban surface water runoff, soil nutrient loading from fertilizers and dumped yard waste, and the spread of human garbage. The steepness of slope, lack of ground vegetation, and lack of leaf

litter in ravine portions of the Hendrie Valley forest may also be the result of surface water runoff and backyard pool drainage into the nature sanctuary.

A balance between visitors using the property and maintaining ecological integrity is crucial in nature sanctuaries, particularly where there is a high volume of visitor activity. Hendrie Valley offers an ecological oasis for native flora and fauna in an urban environment. However, anywhere from a few individuals to many hundreds of people use these trails every day. In 2023, Hendrie Valley remains the most-visited nature sanctuary of RBG's four protected areas despite being the smallest, estimated at approximately 157,800 people in 2023 (Theijsmeijer and Barr 2023). As addressed in Radassao et al. (2019), there were many human-induced impacts that were negatively affecting the plant and wildlife communities in Hendrie Valley. Thus, human caused impacts are often observed within the nature sanctuary. Such impacts include slope erosion, soil compaction and destruction of vegetation growing along trails from trampling, accidental spread of invasive plants when visitors travel off trail or from off-leash dogs, picking wildflowers, littering (including fishing lines and associated hooks and other equipment), wildlife harassment and/or injury from off-leash dogs or people (catching smaller animals like frogs and snakes), wildlife injury or death from entanglement in litter (especially fishing line), and feeding wildlife.

In addition to known stressors, there are activities that occur within Hendrie Valley that have minimal or unknown impact on the ecological community, with one example being invasive earthworms. What is known about European earthworms is that they consume leaf litter at a high rate and can deplete the natural "mulch" that is needed in our forested communities. Hendrie Valley is one of the few locations in Ontario to have a confirmed population of invasive Jumping Worms species (from multiple Genera including *Amynthas*, *Metaphire*, and *Pheretima*). In addition to Jumping Worms, it is likely that other species of introduced earthworms are present in Hendrie Valley, but further study is required to confidently identify species present.

Wildlife, water quality, and vegetation monitoring have been and will continue to be conducted to monitor long term plant, fish, bird, and amphibian presence and abundance in the nature sanctuary. This information provides guidance for restoration and conservation activities in Hendrie Valley. Despite improvements made through restoration efforts in the marsh and forests, various pressures continue to threaten the ecological integrity and biodiversity in the nature sanctuary. This report provides an update to the 2018 Environmental Status of Hendrie Valley Report produced by Radassao et. al in 2019 and presents data collected primarily from long term forest and bird monitoring programs in Hendrie Valley. Historic and emerging issues observed within the valley are discussed. Actions taken to date based on the recommendations from the previous report are summarized along with further recommendations for future actions RBG and its surrounding community can undertake to assist in preserving the biodiversity, ecological functions, and natural beauty within the nature sanctuary.

Methods Long Term Forest Monitoring

This report includes data collected through forest monitoring and bird monitoring surveys, of which methods for each are described below. There are currently eighteen 20 x 20 metre permanent long term forest monitoring plots established across RBG's nature sanctuaries. Six plots can be found in Hendrie Valley (the focus of this report), two on the Escarpment Properties, five on the north shore of Cootes Paradise, and five are located on the south shore of Cootes Paradise. A seventh plot also exists in the valley for breeding bird survey plot.

Vegetation Monitoring

Forest monitoring surveys follow the Ecological Monitoring and Assessment Network (EMAN) protocols and have been conducted in Hendrie Valley in 2009, 2010, 2012, 2018, and 2023. Data is collected from all forest's layers (canopy tree/tree, understory, ground vegetation, and forest floor) to track any changes to the forest over a long period of time. Tree inventory and tree health data was collected from within the entire 20 by 20 metre plots; ground vegetation and forest floor composition data were collected from four 1 by 1 metre quadrats that are within each forest monitoring plot; tree regeneration sampling occurred in five 2 by 2 metre sub-plots, with 4 outside and 1 inside each 20 by 20 metre plot. Tree regeneration surveys record the number of all tree seedlings (16-200 cm tall) and tree saplings (>200 cm tall) within the sub-plots. In 2023 RBG shrubs were included in the 2 by 2 sub-plots to better quantify changes in species of that plant form over time. Additional data was collected using the Vegetation Sampling Protocol (VSP), where all plants that occur within the 20 by 20 meter are identified and their percent cover estimated for each species. VSP classifies forest structure differently than EMAN. Under VSP, plants are categorized based on their height at the time of the survey. Hight classes are as follows: 0-0.5 meters, 0.5-2 meters, 2-10 meters and greater than 10 metres. For more details on the forest monitoring survey methods, refer to the *2009 Forest Monitoring Report* (Burtenshaw, 2010) and *Ecological Monitoring and Assessment Network: Terrestrial Vegetation Monitoring Protocols* (Roberts-Pichette & Gillespie, 1999). For more details on VSP methods search Vegetation Sampling Protocol on the University of Toronto Faculty of Forestry webpage. By combining these protocols, RBG can obtain more robust data that is valuable when looking into forest vegetation trends over time.

Prior to 2018, there had been two plots surveyed in Hendrie Valley: HV-1 and HV-2. Canopy tree surveys were conducted in 2009, 2012 and 2018. To acquire more data from Hendrie Valley it was decided that an additional four temporary plots be set up and surveyed in 2018 in order to gain a clearer picture of the environmental status of the sanctuary. Thus, forest monitoring occurred at a total of six plots in 2018 (HV-1 to HV-6). In 2023 three plots were surveyed. This third plot (HV-4) will become a permanent plot and surveyed along with HV-1 and HV-2 every 5 years which will help provide a better picture of vegetation communities in Hendrie Valley. When comparing data between years, only plots with comparable date were looked at for this report.

Bird Monitoring Procedure

Monitoring Sites

Monitoring sites were initially chosen to correspond with forest monitoring plots which undergo additional vegetation assessments under RBG's Forest Monitoring Program. The purpose was to assess the impact of Btk application to control Spongy Moth outbreaks, but surveys have since evolved to represent the health of terrestrial birds at RBG. As with the forest monitoring plots, in 2018, five

temporary plots in HV were surveyed for one season for an in-depth assessment of Hendrie Valley. These sites focus on terrestrial habitats, including forests with edge effects. Some plots have wetland influence, but this habitat type is not the focus. Together, the monitoring plots are scattered amongst RBG's nature sanctuaries. During winter 2012, names of the forest monitoring plots and bird monitoring plots were standardized to unify them; each was given a new name and ID number.

Point Count Surveys

The sampling window ranged from May 31st- July 1st and all plots were visited twice. 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. Identification aids and other equipment were used at this time. In rare instances a smartphone could be used to make audio recording of the call of a rare and/or unknown bird. On the data sheet, species were mapped out on a circle, where the centre represented the data recorder, and the edge of the circle represented the plot boundary. Species were placed in the circle based on their direction and approximated distance from the surveyors. If several individuals could be heard, surveyors assumed that multiple birds of the same species were calling only if they were consistently heard calling from distinctly different points (or at the same time). Any species which were visually confirmed were marked with a "v" on the data sheet. Notes were made on breeding behaviour of observed birds and if any nests were present. For more information on Methodology and associated data-collecting biases, please review the Data Collection section in Hamilton (2023).

Table 1. An overview of plots visited in Hendrie Valley since 2018, including the 2023 methodology change.

2018	2019-2022	2023
• HV-1 and HV-2 visited 4 times each. • HV-3 through HV-7 visited 2 times each.	• HV-1 and HV-2 visited four times each.	• HV-1, HV-2, HV-4, HV-5 and HV-6 visited two times each.

Every year HV-1 and HV-2 (the original monitoring plots) are visited. In 2018, site visits were also conducted at some of the additional plots in preparation for the *2018 Environmental Review of Hendrie Valley* (Radassao et al., 2019). Additionally, the methodology for breeding bird surveys at RBG was changed in 2023. Previously, each site was visited four times, but starting in 2023, each site will be visited only twice. On top of this, HV-1,2,4, 5 and 6 will be surveyed every year going forward in order to better capture all habitats within the Hendrie Valley. See Table 1 below for a summary of these

changes. Additional plots were also added to the other nature sanctuaries with the 2023 methodology change; however, these will not be detailed in this report.

To capture species composition and diversity during the migratory season, the volunteer-led Long Watch program was created. For this program, the sampling window occurs primarily in April-May and from September-October, though routes occurring in the shoulder months (March, June and August, November) occasionally happen. Each route is done three times a week, weather depending, and begins at least one hour after sunrise and is completed before noon. There are routes completed on the north and south shores of Cootes Paradise, as well as Hendrie Valley. The Hendrie Valley transect route, named after Cherry Hill Gate, can be seen below (Figure 22)

Figure 2. Cherry Hill transect route (source www.longwatch.ca/regular-morning-transects-maps*)*

Amphibian Monitoring

The Marsh monitoring Program coordinated by Birds Studies Canada supports amphibian status. In summary, spring breeding frog and toad populations are indexed by volunteers through listening for calling adults at habitat sites. As such salamander species are not inventoried. The protocol requires volunteers to listen for numbers and species at a site within a 100m radius of a shoreline area after dusk. Species and numbers are estimated inside and outside this radius. The protocol is repeated 3 times throughout the spring to capture the different groups of amphibian species. The 3 visits are tied to

progressing nighttime temperatures of 5C, 10C and 15C as thresholds for surveys and be separated by a minimum of two weeks. Survey #1 typically occurs in early April, while survey #3 is completed by mid-June. Grindstone Marsh in Hendrie Valley is part of the initial set of monitoring sites established across the Great Lakes in support of AOCs, piloted in 1994 and starting in 1995. There are 3 long term sites at Grindstone Marsh. At the outset of the program RBG sites without marsh habitat had no survey sites established as no breeding amphibians were present (RBG unpublished observations). Surveying sites lacking in any appreciable habitat continues to not occur at the lower reaches of Hendrie Valley.

Grindstone Marsh has two sub-route groupings totaling 5 sites. RBG staff have consistently completed some of the monitoring stations to ensure continuity of data. Species IDs issues occur for some species with volunteers particularly tied to Chorus Frog for which confirmation work occurs by Tys Theijsmeijer by evening secondary surveys since 2011 (Western Chorus Frog a Species at Risk). In addition, due to changing personnel and volunteers associated with the program over the years current site names and historical station names have changed multiple times. The monitoring protocol is detailed by Birds Studies Canada the coordinating organization for the overall program. In summary, spring breeding frog and toad populations are indexed by volunteers through listening for calling adults at habitat sites. As such salamander species are not inventoried. The protocol requires volunteers to listen for numbers and species at a site within a 100m radius of a shoreline area after dusk. Species and numbers are estimated inside and outside this radius. The protocol is repeated 3 times throughout the spring to capture the different groups of amphibian species. The 3 visits are tied to progressing nighttime temperatures of 5C, 10C and 15C as thresholds for surveys and be separated by a minimum of two weeks. Survey #1 typically occurs in early April, while survey #3 is completed by mid-June. Grindstone and Cootes Paradise Marsh are part of the initial set of monitoring sites established across the Great Lakes in support of AOCs, piloted in 1994 and starting in 1995. This included 6 sites at Cootes Paradise and 3 sites at Grindstone Marsh. Sites without marsh habitat had no survey sites established as no breeding amphibians were present (RBG unpublished observations). Surveying sites lacking in any appreciable habitat continues to not occur.

Cootes Paradise was originally Great Lakes marsh site 4 and Grindstone Creek Marsh was site 5. Cootes Paradise currently has four sub-route groupings totaling 16 sites while Grindstone Marsh has two sub-route groupings totaling 5 sites. Special project sites have also occurred over the years.

Results

Vegetation Monitoring

Canopy Tree Layer

Table 2 displays the canopy tree results for the 2023 sampling window, including information such as abundance, relative abundance (%), basal area (m^2), percent basal area, and tree density per hectare. In total, 53 trees were tagged, measured, and examined for biological and stem defects. There were 13 species found within the three monitoring plots, with only one non-native species (Norway Maple, *Acer platanoides*) detected. The most abundant tree species was Red Maple (*Acer rubrum*), followed by Red Oak (*Quercus rubra*), and Black Maple (*Acer nigrum*). However, the percent basal area of Red Maple was not the highest, as Red Oak accounted for 52.95% basal area compared to 24.93% for Red Maple. This can be explained by the sheer size of the Red Oaks measured within the plots compared to the smaller Red Maples.

Examining the relative abundance of canopy trees since monitoring began in 2009 provides a glimpse at how the Hendrie Valley Forest has changed over 14 years (Table 3). Most notable is the increase in Norway Maple presence beginning in 2018 and persisting through 2023. Despite not being identified in 2009 and 2012, it is likely that the Sugar Maple (*Acer saccharum*) that has not been observed since 2009 was possibly mis-identified and has now properly been identified as Norway Maple, as it can be difficult to distinguish between the two species based on the abilities of the surveyor. Similarly, White Oak (*Quercus alba*) has not been observed since 2009, but the addition of Bur Oak (*Quercus macrocarpa*) observations in 2018 and 2023, which may account for the missing White Oak. Overall, Red Maple maintains the most abundant tree species within the monitoring plots, ranging from 50% - 60% relative abundance over the course of the four sampling windows. Species richness has increased since 2009 by two species, with 11 species observed in-plot in 2023.

Table 2. Summary of assessed canopy tree species in three forest monitoring plots across Hendrie Valley in 2023 using EMAN protocol, organized by relative abundance. Results for basal area, percent basal area, and density per hectare are also shown. Non-native species are marked with an asterisk.

Species Name	Basal Area (m^2)	Percent Basal Area	Abundance	Density (trees/ha)
Red Maple (*Acer rubrum*)	7.46	24.93%	22	92
Red Oak (*Quercus rubra*)	15.85	52.95%	9	38
Black Maple (*Acer nigrum*)	4.38	14.64%	8	33
Black Cherry (*Prunus serotina*)	0.69	2.29%	4	17
Norway Maple (*Acer platanoides*)*	0.39	1.29%	2	8
Smooth Serviceberry (*Amelanchier laevis*)	0.01	0.03%	1	4
White Birch (*Betula papyrifera*)	0.03	0.09%	1	4
Shagbark Hickory (*Carya ovata*)	0.27	0.89%	1	4
Green Ash (*Fraxinus pennsylvanica*)	0.01	0.03%	1	4
Ironwood (*Ostrya virginiana*)	0.01	0.03%	1	4
White Pine (*Pinus strobus*)	0.28	0.93%	1	4
Bur Oak (*Quercus macrocarpa)*	0.42	1.40%	1	4
Eastern Hemlock (*Tsuga canadensis*)	0.15	0.50%	1	4
Species Richness: 13	**Native Species: 12**		**Non-native Species: 1**	

Table 3. Relative abundance for four survey years of inventoried canopy trees in forest monitoring plots (HV-1 and HV-2), using EMAN protocol. Species richness is also displayed. Non-native species are marked with an asterisk.

	Relative Abundance (%)			
Species Name	**2009**	**2012**	**2018**	**2023**
Norway Maple (*Acer platanoides*)*			5.0%	4.5%
Red Maple (*Acer rubrum*)	50.0%	60.0%	50.0%	50.0%
Sugar Maple (*Acer saccharum*)	2.4%			
Smooth Serviceberry (*Amelanchier laevis*)				2.3%
White Birch (*Betula papyrifera*)	7.1%	10.0%	2.5%	2.3%
Green Ash (*Fraxinus pennslyvanica*)				2.3%
Ironwood (*Ostrya virginiana*)	4.8%	3.3%	2.5%	2.3%
Eastern White Pine (*Pinus strobus*)	2.4%		2.5%	2.3%
Black Cherry (*Prunus serotina*)	9.5%	3.3%	10.0%	9.1%
White Oak (*Quercus alba*)	2.4%			
Bur Oak (*Quercus macrocarpa*)			2.5%	2.3%
Red Oak (*Quercus rubra*)	19.0%	16.7%	20.0%	20.5%
Black Oak (*Quercus velutina*)		3.3%	2.5%	
Eastern Hemlock (*Tsuga canadensis*)	2.4%	3.3%	2.5%	2.3%
Species Richness	**9**	**7**	**10**	**11**

Using VSP to look at canopy trees provides an opportunity to calculate the percent change in relative cover of a given species. Overall, 7 of the 12 identified canopy trees have declined since VSP was conducted in 2012 (Table 4), however none have lost more than 6% of their relative cover. Black Cherry has maintained its relative cover since 2012. There are four species (Eastern Hop-hornbeam, Red Oak, Smooth Serviceberry, and Sugar Maple) that have increased their relative cover over the last 11 years. The species with the largest increase in relative cover is the Red Oak with a 19% increase in cover since 2012. The reason is unclear, however as these trees are long-lived, this change in cover may simply be a result of tree maturation. Further monitoring of the Red Oak relative cover is required.

Table 4. Relative cover of all observed canopy tree species in 2012 and 2023, and their percent change in the eleven-year timeframe (VSP, trees greater than 10 metres tall).

Species Name	**2012**	**2023**	**Percent Change**
Black Cherry (*Prunus virginiana*)	5%	5%	0%
Black Oak (*Quercus velutina*)	6%	0%	-6%
Bur Oak (*Quercus macrocarpa*)	7%	2%	-5%
Eastern Hemlock (*Tsuga canadensis*)	5%	2%	-3%
Ironwood (*Ostrya virginiana*)	0%	1%	1%
Eastern White Pine (*Pinus strobus*)	2%	1%	-1%
Red Oak (*Quercus rubra*)	28%	47%	19%
White Birch (*Betula papyrifera*)	3%	1%	-2%
Red Maple (*Acer rubrum*)	21%	15%	-6%
Smooth Serviceberry (*Amelanchier laevis*)	0%	1%	1%
Sugar Maple (*Acer saccharum*)	21%	25%	4%
White Oak (*Quercus alba*)	2%	0%	-2%

Understory Layer

In 2023, 17 species were identified in the understory layer using VSP, with 12 native species and 5 non-native species (Table 5). These findings are not dissimilar to the number of species identified in 2012 when 18 species were identified in the understory layer, with 12 being native species and 6 non-native. The species that increased the most in the eleven-year period was Green Ash which increased its relative cover by 14%. Two other species that increased dramatically were Sugar Maple and Norway Maple, each increasing in relative cover by around 10%. The increase in Norway Maple is concerning, as Norway Maple now accounts for nearly a quarter (23.34%) of the cover in the understory layer.

Table 5. Relative cover of understory species (sum of 0.5-2.0m and 2-10m) using VSP across all Hendrie Valley monitoring plots in 2012 and 2023. Non-native species are marked with an asterisk.

Species	2012	2023	Percent Change
Norway Maple (*Acer platanoides*)*	12.61%	23.34%	10.72%
Sugar Maple (*Acer saccharum*)	7.24%	17.50%	10.26%
Green Ash (*Fraxinus pennslyvanica*)	7.93%	14.00%	6.07%
Red Maple (*Acer rubrum*)	23.42%	14.00%	-9.42%
Choke Cherry (*Prunus virginiana*)	18.74%	11.67%	-7.07%
Amur Honeysuckle (*Lonicera maackii*)*	4.36%	5.83%	1.47%
Black Cherry (*Prunus Serotina)*	8.65%	3.50%	-5.15%
American Witch-hazel (*Hamamelis virginiana*)	2.52%	2.33%	-0.19%
Maple-leaved Viburnum (*Viburnum acerifolium*)	1.80%	2.33%	0.53%
American Basswood (*Tilia americana*)	1.08%	1.28%	0.20%
Eastern Hop-hornbeam (*Ostrya virginiana*)	0.00%	1.28%	1.28%
Multiflora Rose (*Rosa multiflora*)*	0.04%	1.28%	1.25%
Round-leaved Dogwood (*Cornus rugosa*)	5.77%	1.17%	-4.60%
Common Buckthorn (*Rhamnus cathartica*)*	0.00%	0.12%	0.12%
Purple-flowering Raspberry (*Rubus odoratus*)	0.00%	0.12%	0.12%
Red Elderberry (*Sambucus racemosa*)	0.00%	0.12%	0.12%
Tartarian Honeysuckle (*Lonicera tatarica*)*	0.00%	0.12%	0.12%
Manitoba Maple (*Acer negundo*)*	2.52%	0.00%	-2.52%
Smooth Serviceberry (*Amelanchier laevis*)	2.16%	0.00%	-2.16%
Alternate-leaved Dogwood (*Cornus alternifolia*)	0.72%	0.00%	-0.72%
Musclewood (*Carpinus caroliniana*)	0.36%	0.00%	-0.36%
Horse Chestnut (*Aesculus hippocastanum*)*	0.04%	0.00%	-0.04%
Oriental Bittersweet (*Celastrus orbiculatus*)*	0.04%	0.00%	-0.04%
Species Richness	17	17	
Native Species	12	12	
Native Species Relative Cover	80.43%	69.31%	
Non-native Species	6	5	
Non-native Species Relative Cover	19.60%	30.69%	

Five new species were identified in the understory layer in 2023 that weren't observed in 2012 including: Ironwood, Common Buckthorn, Purple-flowering Raspberry, Red Elderberry, and Tartarian Honeysuckle. However, there were six species that were identified in the understory in 2012 that were not observed in that layer in 2023: Manitoba Maple, Smooth Serviceberry, Alternate-leaved Dogwood, Musclewood, Horse Chestnut, Oriental Bittersweet.

Ground Vegetation Layer

Abundance

A total of 39 species were identified and recorded during vegetation surveys using the EMAN protocol in 2023. Of those 39 species 9 were non-native. The most abundant species observed during 2023 ground vegetation surveys was Blue-stemmed Goldenrod (*Solidago caesia*), which accounted for 17% of all individuals counted (Figure 3). Wild Sarsaparilla (*Aralia nudicaulis*), Black Maple, Jack-in-the-pulpit (*Arisaema triphyllum*), and Green Ash rounded out the top five most abundant species.

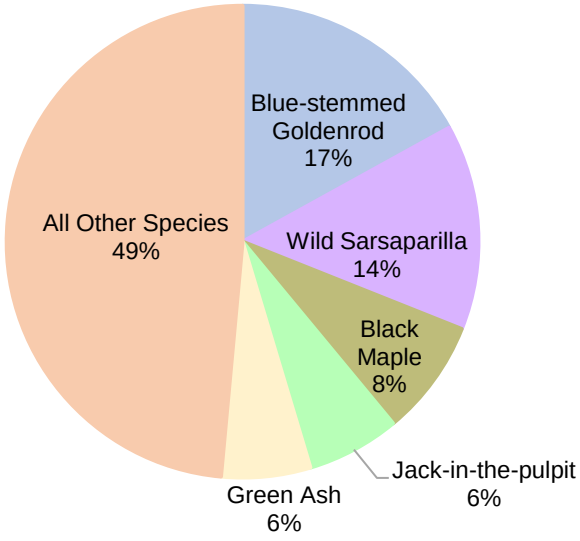

Figure 3. Top five most abundant species, and their associated relative abundance, observed during ground vegetation surveys (twelve 1m x 1m plots) in 2023 across three forest monitoring plots in Hendrie Valley using EMAN protocols.

In comparison to 2018, the disappearance of Garlic Mustard (*Alliaria petiolata*) as the most abundant species (38% relative abundance) in ground vegetation monitoring is very much welcomed. Garlic Mustard not only dropped out of the top five most abundant species in 2023, but relative abundance dropped below 4%.

As presented in Table *6*, the minimum and maximum number of plant stems or clumps can be viewed for the most common plants observed during ground vegetation surveys in 2023. Wild Sarsaparilla, only detected in HV-1 (in all four quadrats), and the highest number of stems of one species detected across all sites, with 21 stems counted in one quadrat. Garlic Mustard and Green Ash were detected at all three monitoring plots, however at lower maximum values than Wild Sarsaparilla.

Blue-stemmed Goldenrod was observed at two out of three monitoring plots, in all four vegetation quadrats at each site. HV-2 had a quadrat that contained 16 individual stem counts of Blue-stemmed Goldenrod, which was the highest across all twelve vegetation quadrats.

Black Maple only occurred in HV-4, and was detected in all four vegetation quadrats, with the maximum count being 9 individuals, and the minimum count being 6 individuals. Likewise, Broad-leaved Enchanter's Nightshade (*Circea canadensis*) only was detected at HV-4, but once again, was detected in all four vegetation quadrats. On the other hand, Pennsylvania Sedge (*Carex penslyvanica*) was only detected within one forest monitoring plot (HV-1) and had a maximum stem count of 8 individuals.

Table 6. Minimum and maximum stem/clump counts from all ground vegetation surveys (twelve 1m x 1m quadrats) across three forest monitoring plots in Hendrie Valley for 2023 for the top ten most abundant species by stem/clump count. Non-native species are bolded.

	HV-1		HV-2		HV-4	
Species Name	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Black Maple (*Acer nigrum*)	-	-	-	-	6	9
Blue-stemmed Goldenrod (*Solidago caesia*)	5	12	2	16	-	-
Broad-leaved Enchanter's Nightshade (Circaea canadensis)	-	-	-	-	2	5
Carex species (*Carex sp.*)	-	-	1	6	-	-
Garlic Mustard (Alliaria petiolata)	1	3	0	1	0	2
Green Ash (Fraxinus pennsylvanica)	0	3	0	8	0	1
Jack-in-the-pulpit (*Arisaema triphyllum*)	-	-	0	9	0	4
Pennsylvania Sedge (*Carex penslyvanica*)	0	8	-	-	-	-
Sugar Maple (*Acer saccharum*)	-	-	0	4	0	2
Wild Sarsaparilla (*Aralia nudicaulis*)	6	21	-	-	-	-

Relative Cover

Figure 4 displays the amount of space (a plant's percent cover) occupied by a species. Wild Sarsaparilla had the largest amount of cover within the ground vegetation monitoring sub-plots, accounting for 29% of the occupied space, followed by Blue-stemmed Goldenrod (11%), Green Ash (10%), Black Maple (6%), and Amur Honeysuckle (4%). In comparison to the relative abundance of species' stem counts, Wild Sarsaparilla bumped into the top spot from second in relative abundance to first in relative cover across the ground vegetation monitoring plots (Figure 2). Wild Sarsaparilla accounted for 29% of the relative cover of all species observed during the vegetation surveys, followed by Blue-stemmed Goldenrod (11%), Green Ash (10%), Black Maple (6%), Amur Honeysuckle (4%), and all other species accounted for 40% relative cover. Having Wild Sarsaparilla and Blue-stemmed Goldenrod switch places when referring to relative cover makes sense due to the sheer size of Wild Sarsaparilla. The same could be assumed for Green Ash and Black Maple, with the Green Ash seedlings simply being larger and taking up more space than the Black Maple seedlings. The addition of Amur Honeysuckle into fifth place for relative cover is not overly concerning, as it did not appear in the top five species for number of stems/individuals. Therefore, there were likely few Amur Honeysuckle observed within the ground vegetation quadrats, but they might have been moderately-sized seedlings.

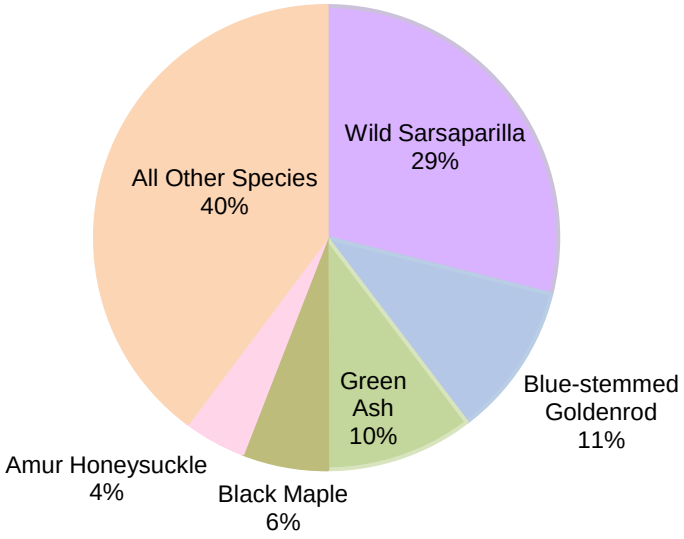

Figure 4. Top five species observed during ground vegetation surveys (twelve 1m x 1m plots) reflected as relative cover of each species within forest monitoring plots in Hendrie Valley (using EMAN protocols).

Non-native Species

In total, only 9 non-native species were observed during the 2023 ground vegetation quadrat surveys. Of the 9 species, Amur Honeysuckle dominated relative cover, accounting for 73% of the relative cover of all non-native species observed. Herb-Robert (*Geranium robertianum*) and Norway Maple were tied for the second-highest species, in terms of relative cover, each accounting for 8% relative cover, followed by Common Buckthorn with 5% relative cover, and then European Wood-sorrel (*Oxalis acetosella*) with 3% relative cover (Figure 5). All other species combined accounted for 3% relative cover.

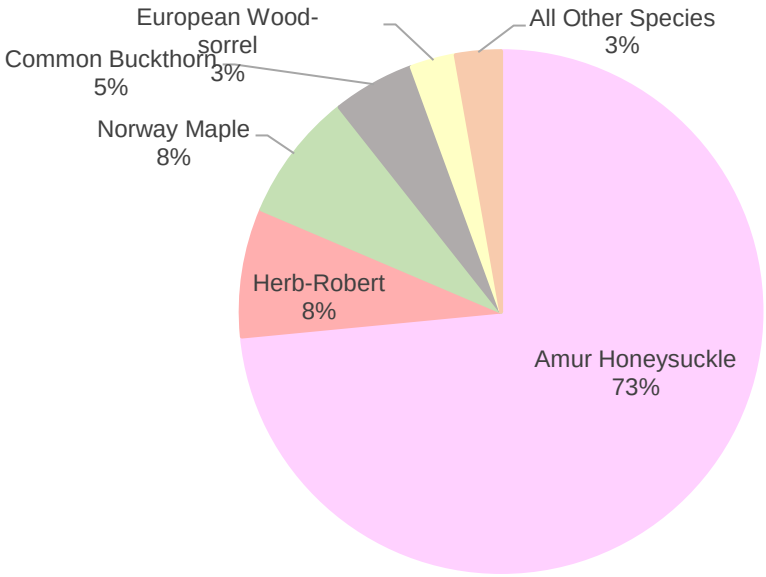

Figure 5. Total non-native species percent cover for 2023 Hendrie Valley ground vegetation surveys from all twelve quadrats (HV-1, HV-2, and HV-4).

When examining the non-native species found within the ground vegetation quadrats of each forest monitoring plot, it is interesting to note the composition of native versus non-native species present in the quadrats. Figure 6 displays the ratio of the number of native versus non-native individuals/clumps present within each forest monitoring plot. HV-4 had the highest percentage of native species (by stem count) present in the ground vegetation surveys, with 85% of the stems accounting for native species compared to 15% for non-native species. This is followed closely by HV-1, which had 82% native species and 18% non-native species, and HV-2 with 78% native species and 22% non-native species.

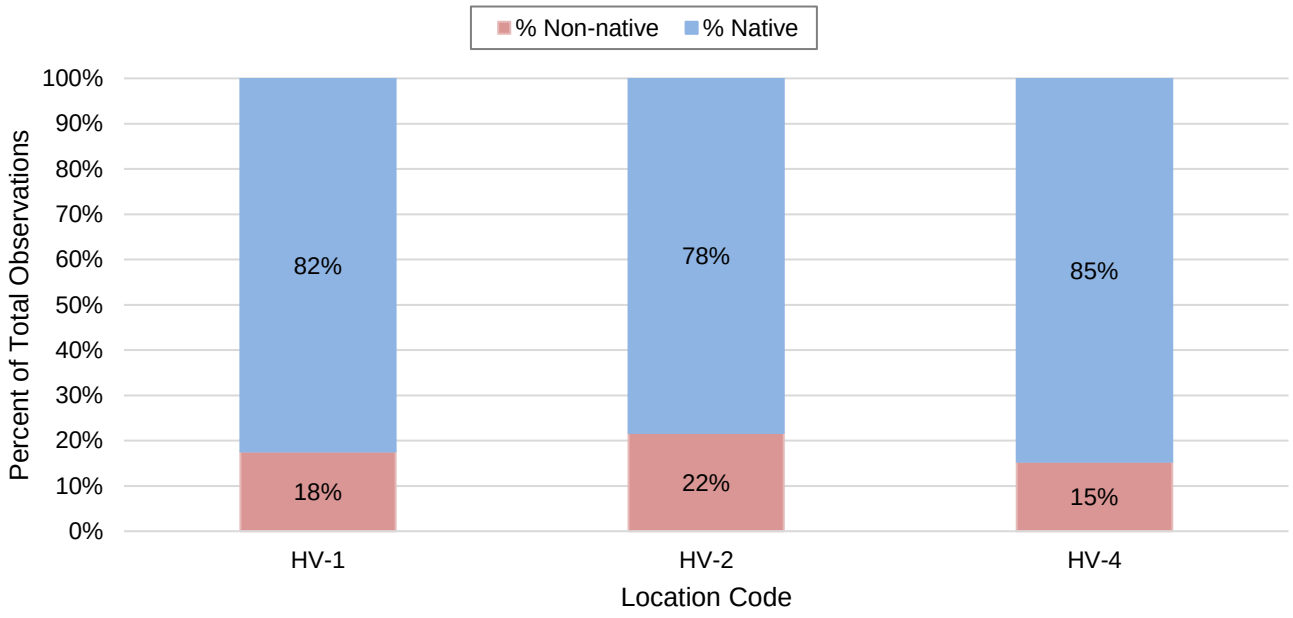

Figure 6. Percent native versus non-native species present in ground vegetation quadrats for each forest monitoring plot in Hendrie Valley, using total individual stem/clump counts for 2023.

Garlic Mustard has generally experienced a decrease within forest monitoring plots across RBG's nature sanctuaries since monitoring began in 2012, despite no active management or removals within the plots (Figure 7). Historically, Hendrie Valley had the lowest relative cover of Garlic Mustard (0% cover) when monitoring started in 2012, which then slightly increased in 2018 to 4%, and then decreased to 2% cover in 2023. Even though Garlic Mustard increased by 4% relative cover in 2018, it has been followed by a 2% decrease in 2023, and coupled with the fact that these are still very low values, there is no large cause for concern at this time for Garlic Mustard numbers in Hendrie Valley.

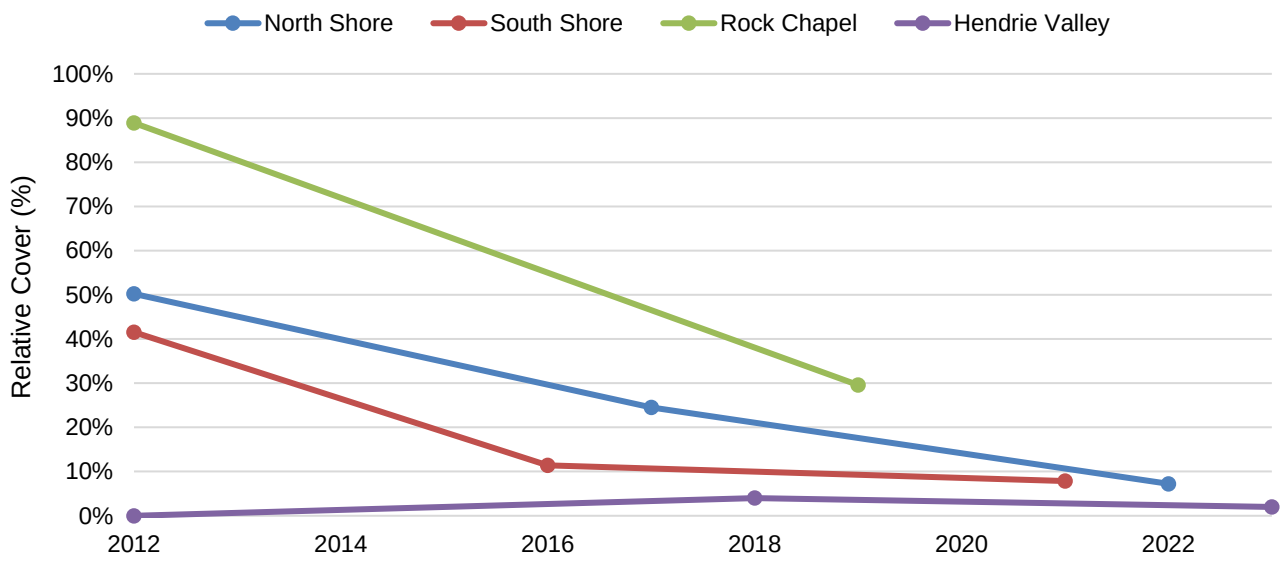

Figure 7. Relative cover (%) of Garlic Mustard across ground vegetation plots (EMAN) for all four nature sanctuaries since monitoring began in 2012. NOTE: Each nature sanctuary has a unique number of long-term forest monitoring plots, and therefore, the sampling effort varies from nature sanctuary to nature sanctuary.

Forest Floor Composition

It has been observed in forest floor layers of forest monitoring plots across RBG property that there is a relationship between the amount of leaf litter and bare ground cover (Burtenshaw 2010; Vincent, 2018; Radassao, 2019). This pattern is also displayed in Figure 8below. In HV-1 and HV-2 (the plots with more than ten years' worth of data), when leaf litter cover is high, bare ground cover is low, and vise-versa. Leaf litter has increased significantly since 2012 and 2018, respectively.

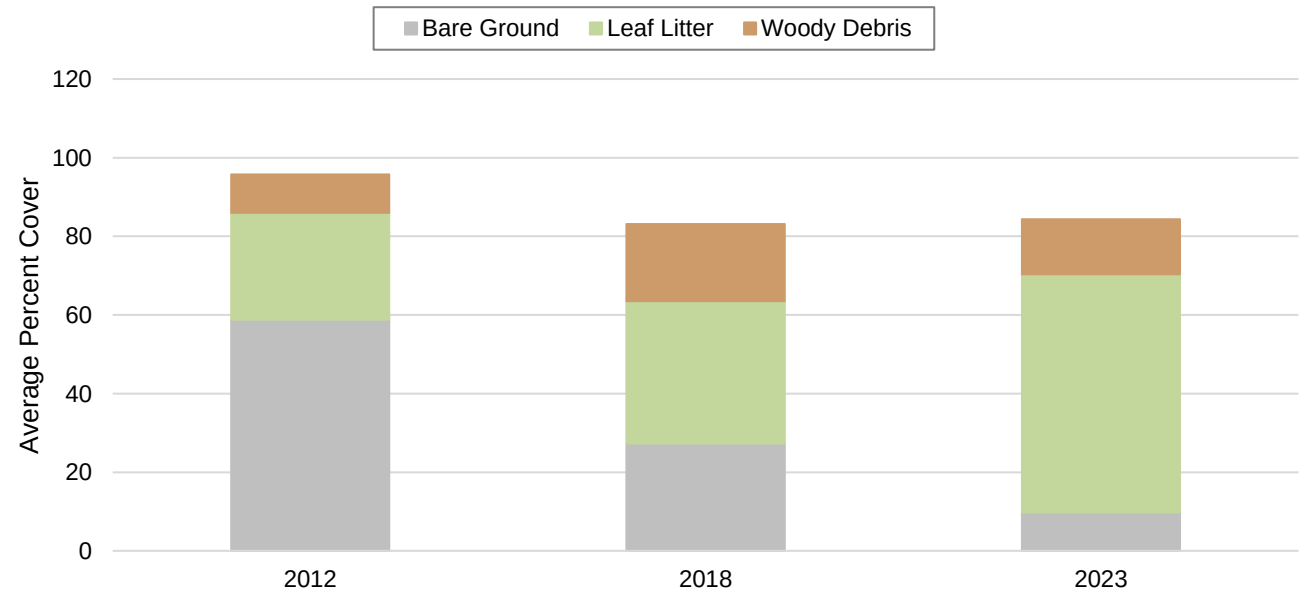

Figure 8. Average percent cover per 1m x 1m ground vegetation survey quadrat (four per plot) of forest floor composition in Hendrie Valley during monitoring years for HV-1 and HV-2.

Note: Forest floor percent cover does not always equal 100%, as the forest floor is composed of multiple vertical strata. For example, plants take up ground space on the forest floor that would otherwise be covered by leaf litter or bare ground.

Tree Regeneration Surveys

Tree regeneration surveys are part of the EMAN protocol, and consist of five 2m x 2m sub-plots, four of which are located outside of the official 20m x 20m monitoring plot. This may result in additional species records. Overall, Black Maple had the highest count of seedlings across all three forest monitoring plots –31 seedlings counted, totalling 41% relative abundance at HV-4. At HV-4, Sugar Maple followed closely behind with 28 seedlings, and Green Ash, Bitternut Hickory (*Carya cordiformis*), Common Buckthorn, Amur Honeysuckle, and Choke Cherry were also found in HV-4. A total of 75 individual seedlings were counted, of 7 unique species, 2 of which were non-native and 5 native species.

Saplings were also counted in the regeneration plots, however only 3 saplings were observed across all 15 regeneration plots. One Green Ash was found at both HV-1 and HV-2, and HV-2 also had a Norway Maple in its regeneration plots.

Bird Monitoring

During the month of June, RBG staff conduct breeding bird surveys across the properties. In Hendrie Valley Nature Sanctuary, there are seven breeding bird survey plots, six of which coincide with forest monitoring plots. In 2023, five of these plots were surveyed (HV-1, HV-2, HV-4, HV-5 and HV-6). In the summary below, trends presented from Hendrie Valley over time are from the original monitoring plots – HV-1 and HV-2, as these are the plots that have consistently been surveyed every year. Additionally, these analyses often exclude 2023, as the sampling effort (number of visits) changed. If 2023 is included in an analysis, the data was standardized using detections per hour.

Species Richness

In 2023, across the five surveyed breeding bird plots in Hendrie Valley, there was a total of 37 bird species detected with an average of 15 bird species per visit. The top five most abundant species detected were the Red-winged Blackbird (with a relative abundance of 27% (Figure 9), Song Sparrow, American Robin, followed by the Northern Cardinal, and Black-capped Chickadee. For a more in-depth comparison of common birds based on relative abundance between the Escarpment Properties (Rock Chapel and Berry Tract), Hendrie Valley, and the north and south shore of Cootes Paradise, refer to the *Upland Area Bird Monitoring 2010-2022 RBG Data Review* (Hamilton et al., 2023).

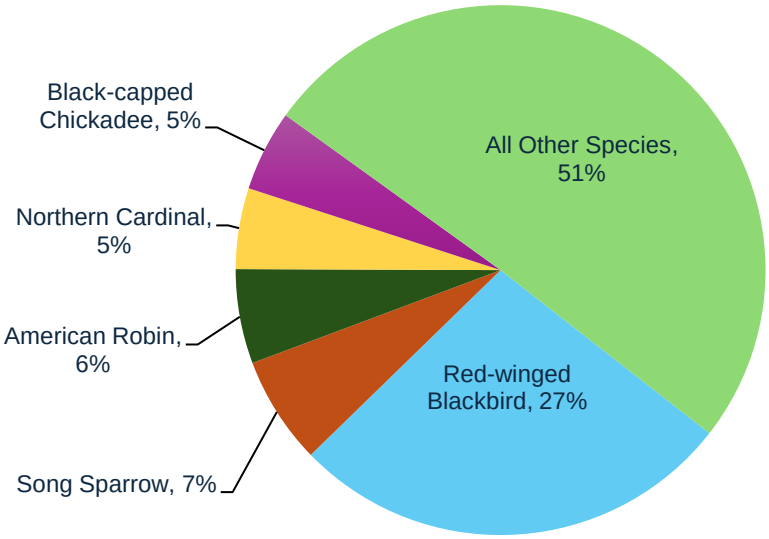

Figure 9. Relative Abundance of the top 5 bird species from 2023 bird surveys in Hendrie Valley (5 plots).

Looking at species richness across all survey plots in Hendrie Valley since 2018, it has remained relatively stable (a decreasing trend of only 5.81%) (Figure 10). Note that species richness peaked in 2018 with 44 species. This is possibly due to the increased number of plots completed that year, and therefore greater representation of Hendrie Valley was obtained. However, additional plots were also completed in 2023, which saw no change in species richness since 2022.

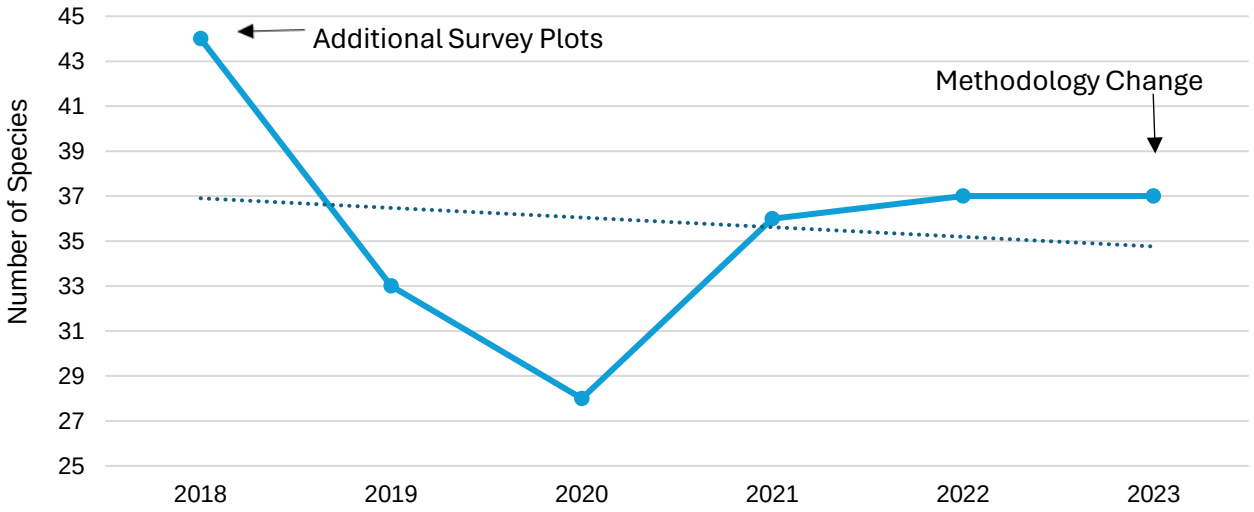

Figure 10. Number of species detected across all Hendrie Valley plots from 2018 - 2023.

When comparing species richness across nature sanctuaries, Hendrie Valley consistently has lower species richness than the north shore and south shore of Cootes Paradise (CP-NS, CP-SS, respectively), as well as the Escarpment Properties (EP) (Berry Tract and Rock Chapel) (Figure 11). However, species richness has been relatively stable in Hendrie Valley while it has decreased in every other nature sanctuary. The most notable decline in species richness occurred in 2023, a possible reason for which will be discussed later.

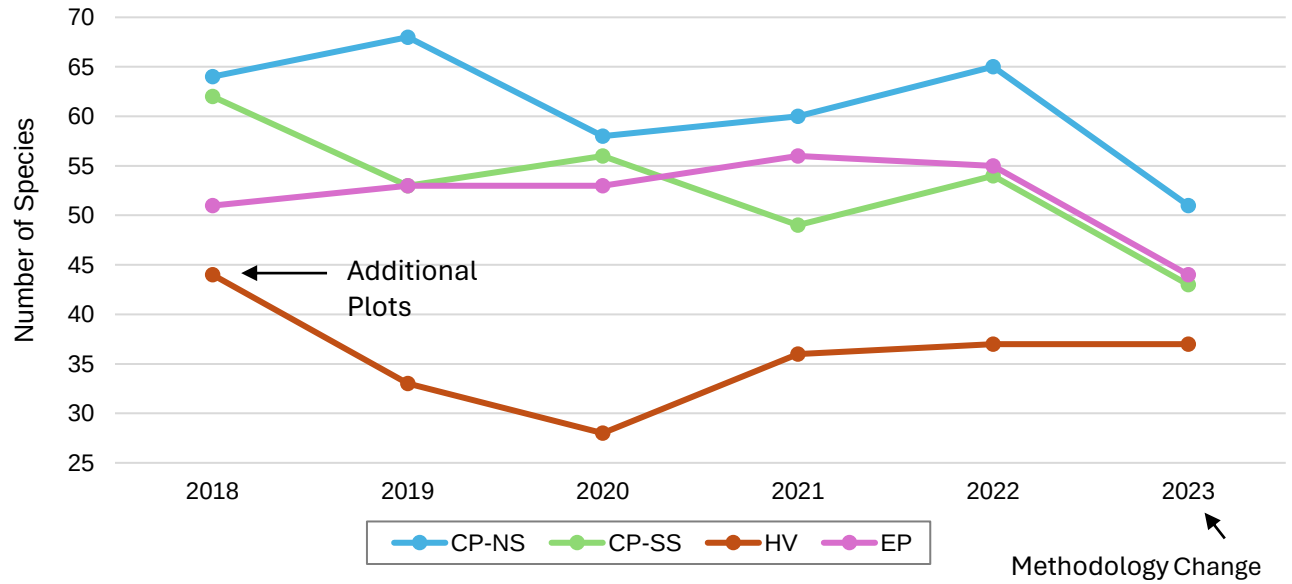

Figure 11. Species richness across nature sanctuaries from 2018-2023. Note that additional plots were completed in Hendrie Valley in 2018, and a methodology change occurred in 2023.

Detections

In this section, detections per hour were used as the metric for comparison in order to standardize the data across variable sampling efforts. Detections per hour in Hendrie Valley increased from 2018-2021, peaking at about 140 detections per hour (Figure 12). Since then, it has been declining, reaching about 97 detections per hour in 2023.

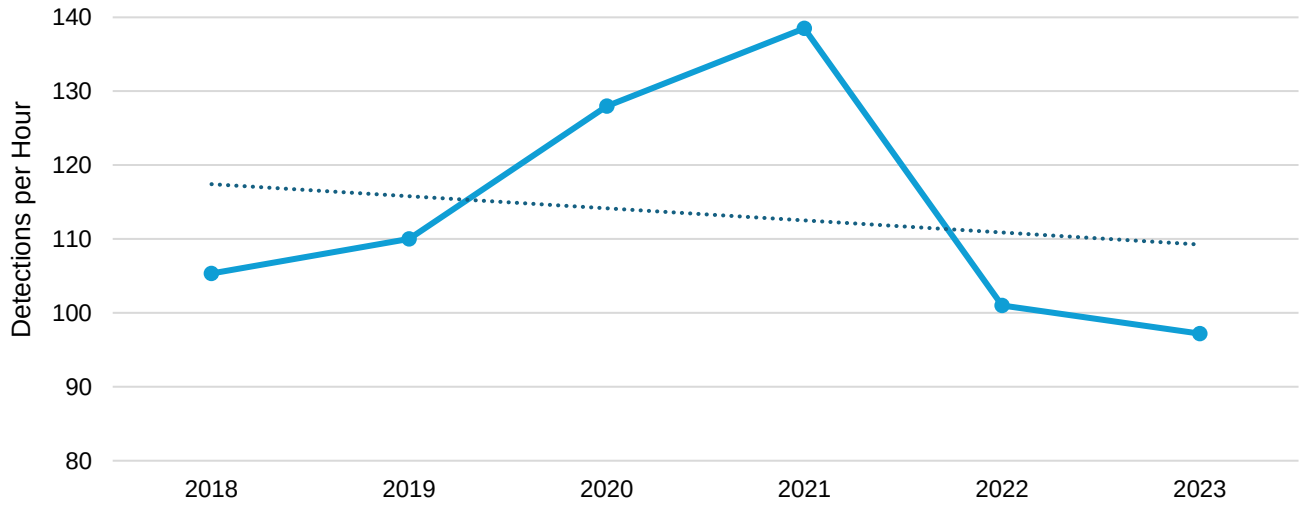

Figure 12. Detections per hour across all Hendrie Valley survey plots from 2018-2023.

Detections per hour across the rest of RBG have been variable since 2018. However, there is a common theme that detections per hour have been, on average, declining between 2018 and 2023 (Figure 13). Most notably, 2023 saw a 16.2% decrease in average detections per hour from 2022. These results are mirrored by migratory Long Watch surveys at RBG, which will be discussed later in this report (Hamilton & Cramer, 2024).

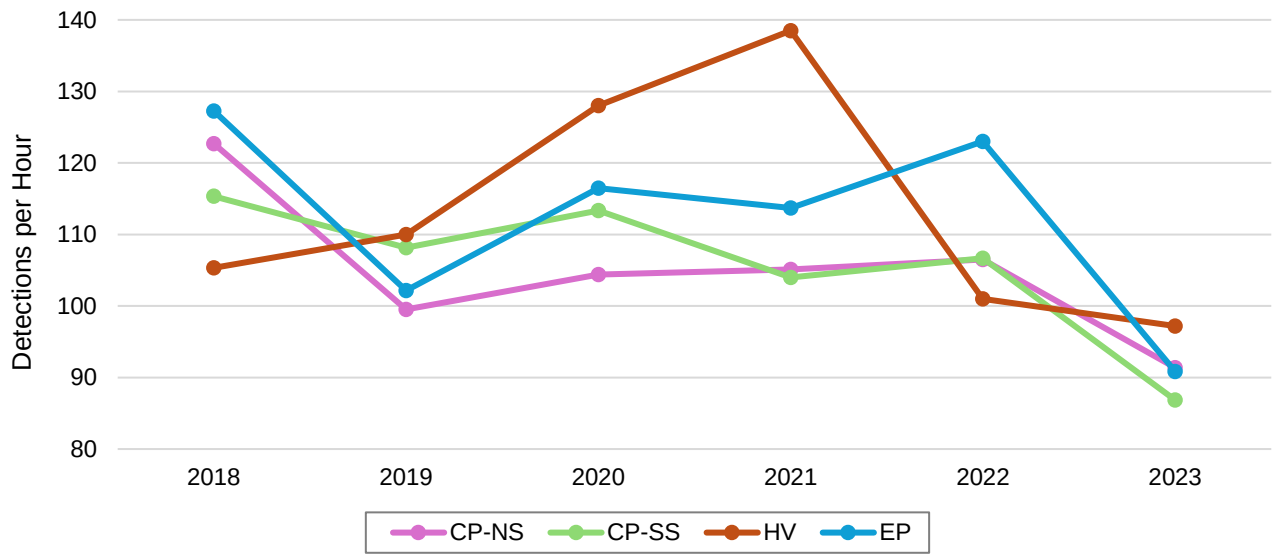

Figure 13. Detections per hour across all survey plots from 2018 - 2023.

Diversity

The Shannon-Wiener Index value represents overall species diversity in a given location, while accounting for species abundance and evenness (Molles and Cahill, 2014). Generally, Shannon-Wiener values fall between 1.5 and 3.5, with values rarely reaching over 4.0. The Shannon-Wiener Index is better suited to comparing diversity between sites or measuring change in one site across years than declaring how diverse one specific site is. Usually, only the same plots which received the same amount of effort would be used to compare diversity across time, however all sites have been added in Figure 14 below to show an interesting result. Diversity in 2018 and 2023 are higher than most years, likely due to the increased number of plots surveyed. This could indicate that adding additional plots is beneficial to studying breeding birds, as it captures more of the total area and diversity of habitat in Hendrie Valley.

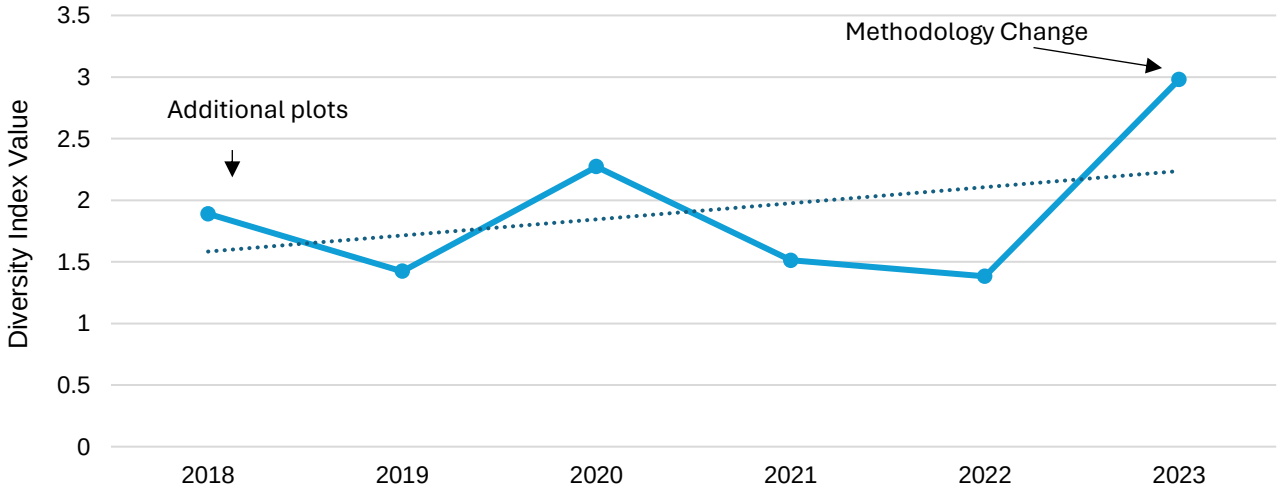

Figure 14. Diversity index including all survey plots across Hendrie Valley from 2018 - 2023. Note that additional plots were completed in 2018 and a methodology change occurred in 2023.

In Hendrie Valley, diversity has been variable, averaging 1.7 from 2018-2022. This is the lowest average diversity out of all of the nature sanctuaries (CP-NS=2.5, CP-SS= 2.4, EP=2.4 for the same time period). However, there was a 116% increase in the diversity index after 2022, reaching 3.0 in 2023. Interestingly, the same number of species were detected in both years, however the evenness of these species must have significantly increased as a larger area was surveyed. Species that may have been detected on the edges of their habitats previously, are now more represented as more area is covered. The large positive jump in diversity in 2023 is echoed across all the nature sanctuaries, however Hendrie Valley experienced the largest change (Figure 15).

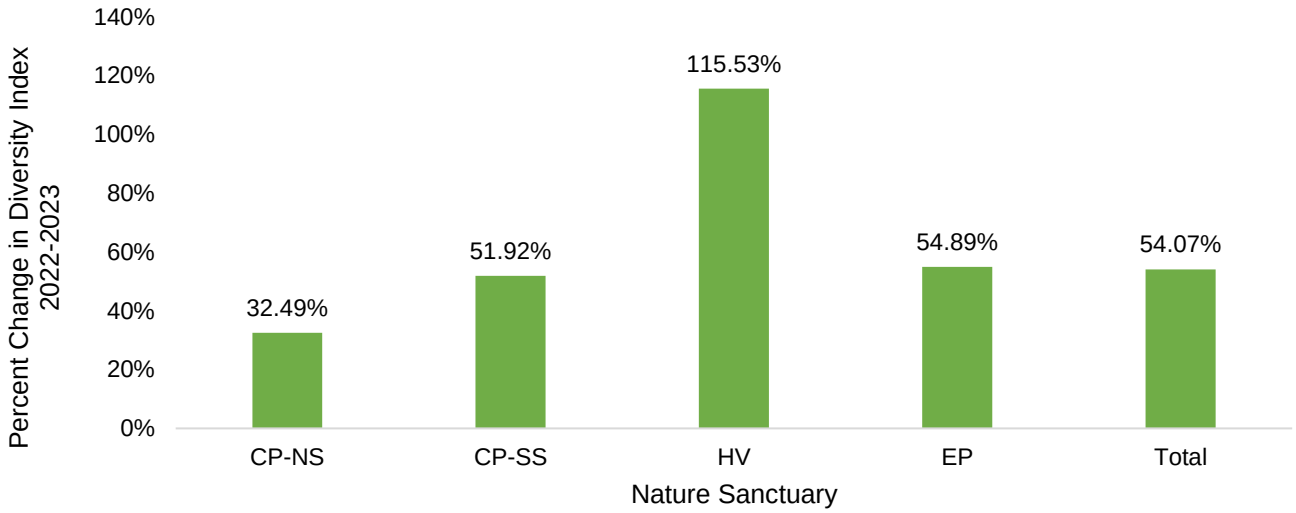

Figure 15. Percent change in diversity index across all nature sanctuaries between 2022 and 2023, including the methodology change that occurred in 2023.

Species-at-Risk

Since bird surveys began at RBG, four Species-at-Risk have been detected in the Hendrie Valley. These are the Barn Swallow, Chimney Swift, Eastern Wood-pewee, and Wood Thrush. Between 2018 and 2023, detections per hour of species-at-risk in the Hendrie Valley have, on average, gone up (Figure 16). This is largely due to the increasing detections of Eastern Wood-pewee, which has comprised 83% of all Species-at-Risk detections in Hendrie Valley since 2018.

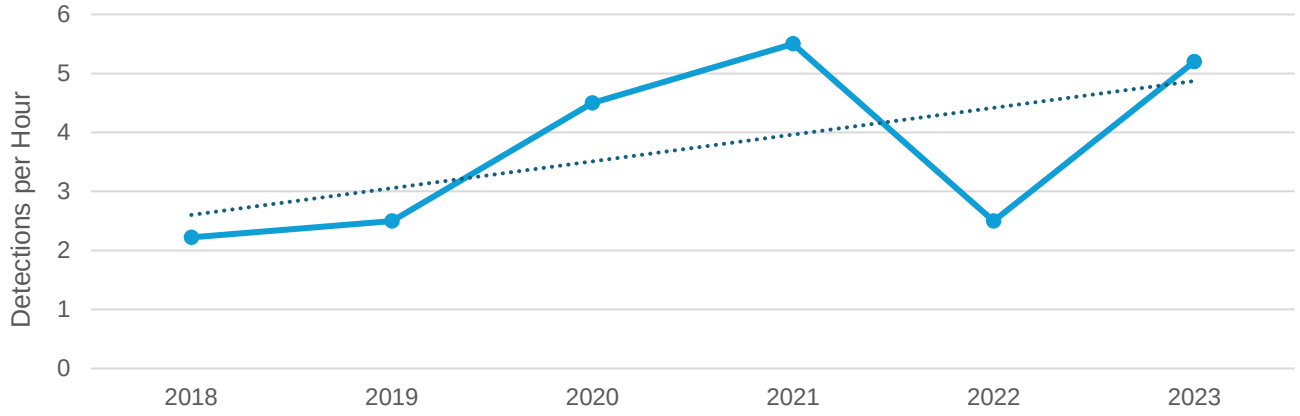

Figure 16. Species-at-Risk detections between 2018 and 2023 in Hendrie Valley.

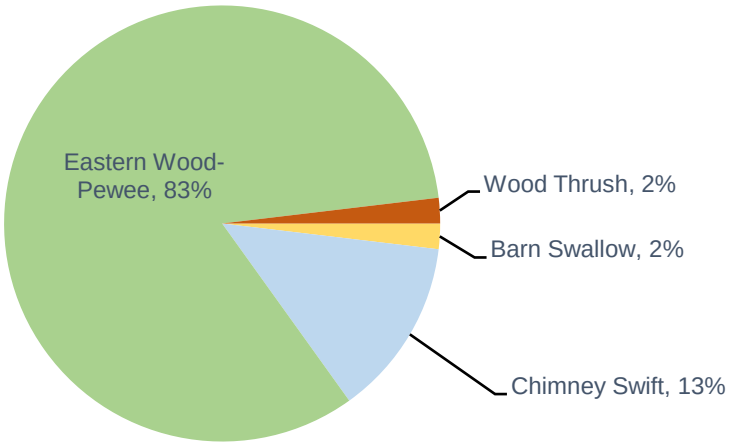

Figure 17. Composition of Species-at-Risk detections in Hendrie Valley since 2018.

Eastern Wood-pewees

Eastern Wood-pewees are seen every year in Hendrie Valley, whereas the first time a Chimney Swift was seen was 2020, and 2023 was the first time a Barn Swallow was detected. At least one Wood Thrush was detected each year from 2011-2014, however, after 2014 only one additional Wood Thrush was heard in 2019. See the *Wood Thrush* section below for more information.

Table 7. Species-at-Risk detected in Hendrie Valley from 2018 - 2023.

Species/Year	2018	2019	2020	2021	2022	2023
Barn Swallow						✓
Chimney Swift			✓	✓	✓	✓
Eastern Wood-pewee	✓	✓	✓	✓	✓	✓
Wood Thrush		✓				

Wood Thrush

As mentioned previously, Wood Thrush detections peaked in the early years of breeding bird surveys and have been a rare occurrence since (Figure 18). While already at risk in Ontario, the Wood Thrush is experiencing additional predation pressures in Hendrie Valley. As documented by Peirce (2018), Cherry Hill and much of the Hendrie Valley experience large amounts of wildlife feeding by trail users. This creates an unnatural abundance of species such as squirrels, chipmunks, racoons, and jays in the areas with supplemental food, all of which are nest predators to the low-nesting Wood Thrush (All About Birds, n.d.a). In The Supplemental Feeding of Wildlife in Hendrie Valley report, Peirce (2018) notes that one study found that rodent abundance over 20 individuals/hectare was responsible for a negative relationship between Wood Thrush population growth and rodent abundance (Schmidt & Ostfeld, 2008, as cited in Peirce, 2018).

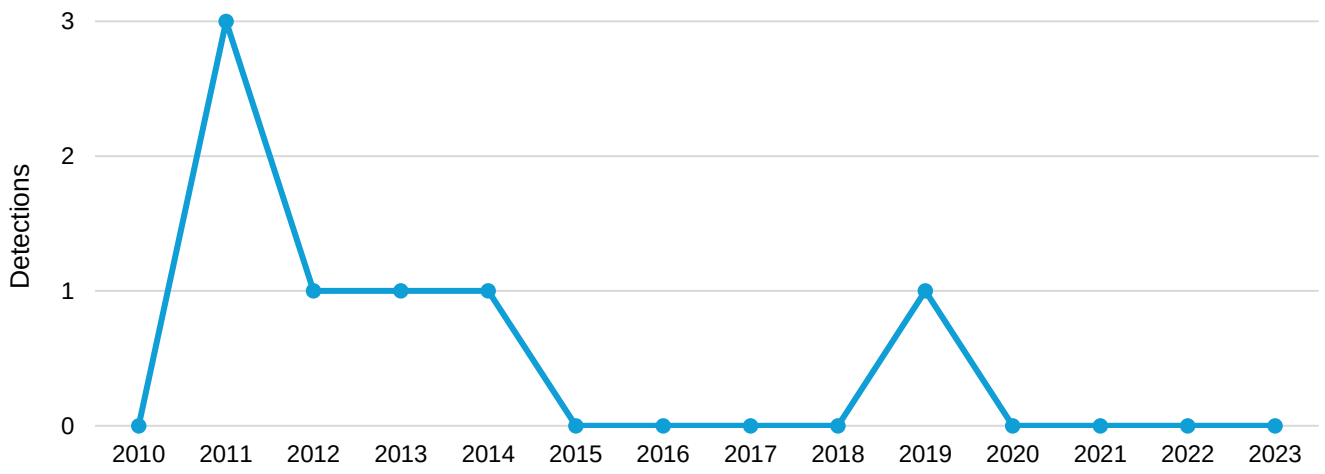

Figure 18. Wood Thrush detections in all surveyed plots in Hendrie Valley since 2010.

Black-capped Chickadee

Detections of Black-capped chickadees have been declining, on average, across all nature sanctuaries since breeding bird surveys began at RBG (Figure 19). However, this decline is particularly alarming in Hendrie Valley, seeing as it is a feeding hotspot for the species (Peirce, 2018). This decline is even more severe during the migratory season, with Long Watch surveys of Cherry Hill seeing a decreasing trend in detections of 37.5% since 2015 (Hamilton & Cramer, 2024).

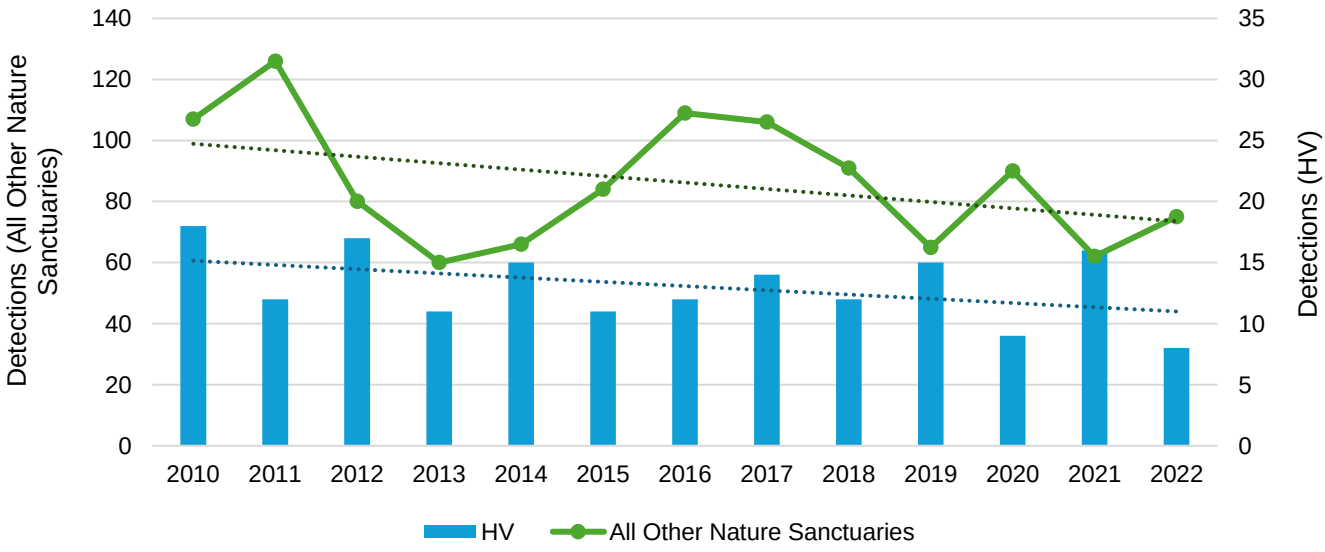

Figure 19. Detections of Black-capped Chickadees in HV-1 and HV-2 (right axis) compared to total Black-capped Chickadee detections across all other nature sanctuaries (left axis) from 2010 - 2022. In the other nature sanctuaries, only original plots that have been consistently surveyed every year are included.

Yellow Warbler

Yellow Warbler populations have experienced a 20% decline in North America between 1966 and 2019 (North American Breeding Bird Survey, as cited in All About Birds, n.d.b). This is due to a number of factors, including habitat loss and nest-parasitism by the Brown-headed Cowbird (All About Birds, n.d.b). In Hendrie Valley, Yellow Warbler detections have, on average, increased since the start of

breeding bird surveys (Figure 20). This makes sense, as Hendrie Valley has the largest amount of riparian habitat, which is a requirement of the species. Additionally, since 2010, only 12 Brown-headed Cowbirds have been detected during surveys in Hendrie Valley, while a total of 400 have been detected across the other nature sanctuaries. This could be a contributing factor to Yellow Warbler declines throughout the rest of RBG.

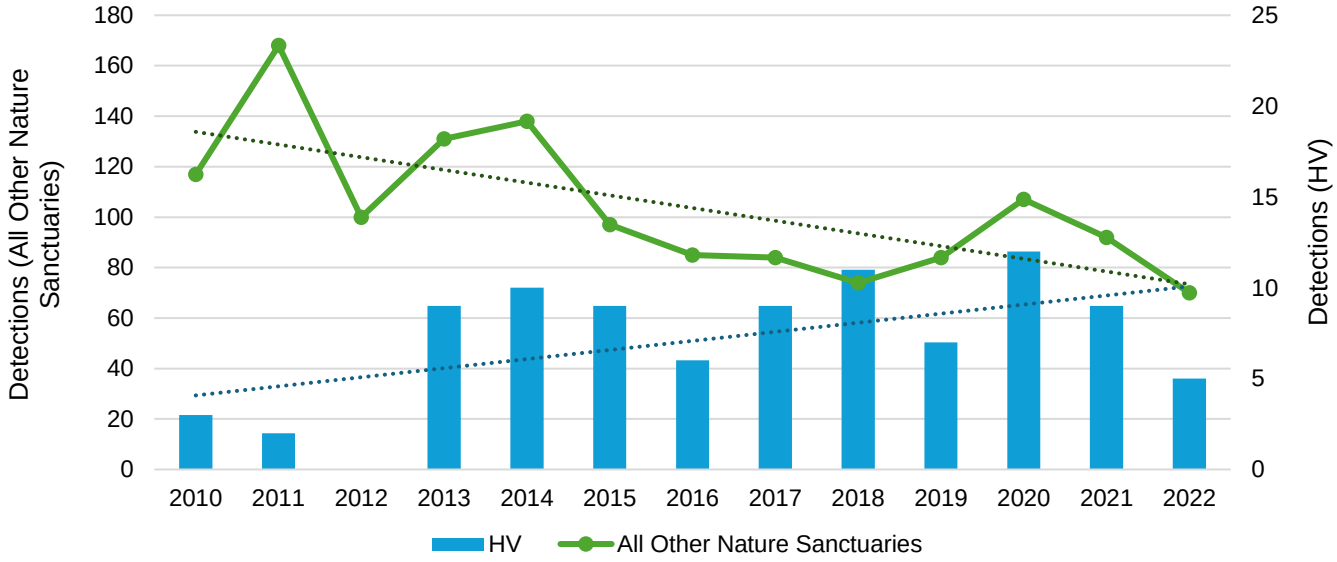

Figure 20. Detections of Yellow Warbler in HV-1 and HV-2 (right axis) compared to total Yellow Warbler detections across all other nature sanctuaries only original plots that have been consistently surveyed year are included.

Canada Goose

In the *2018 Environmental Review of Hendrie Valley* (Radassao et al., 2019), there was what appeared to be an increasing trend in Canada Goose detections at the time of writing the report. Possible reasons were given including increased visibility and the halting of the goose egg-oiling program in 2014. However, the number of detections of Canada Geese swiftly returned to zero (Figure 21). Therefore, while a temporary population boom in Hendrie Valley is possible, coincidence in timing of flock presence is much more likely.

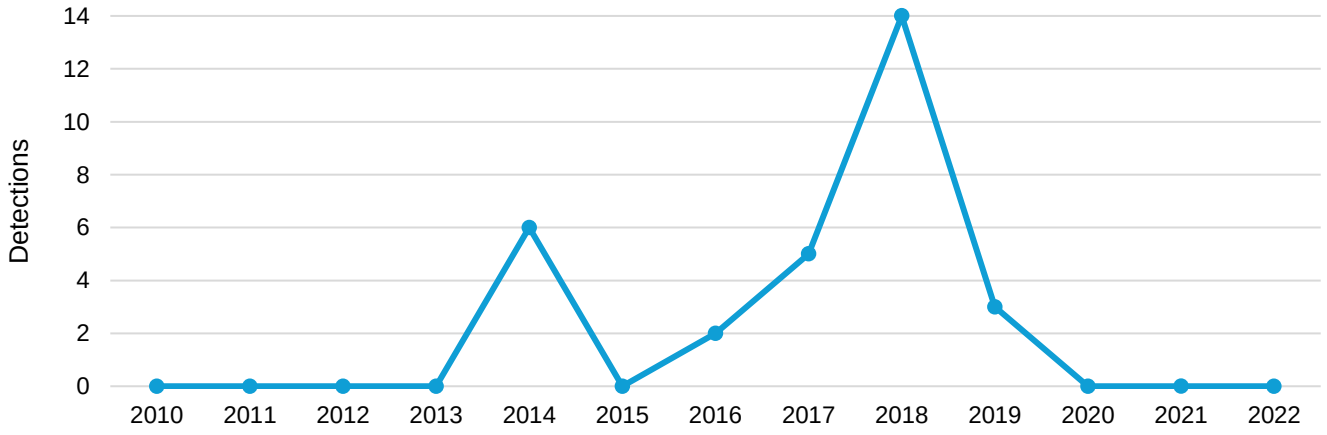

Figure 21. Canada Goose detections in HV-1 and HV-2 from 2010 - 2022.

Red-bellied Woodpecker

Red-bellied Woodpecker detections were very rare in Hendrie Valley from 2010-2016 (Figure 22). Since 2017, detections in this nature sanctuary remain low, however they have consistently been seen/heard during surveys. Detections have also been increasing, on average, across RBG property since surveys began. One reason for this may be the increased abundance of standing snags created by the effects of Emerald Ash Borer on the ash population in the area. Additionally, the range of the Red-bellied Woodpecker has been expanding its range northward from the southeastern US since the 1950s, and while still one of the rarest woodpeckers in Ontario, its population is expanding greatly (Kirchman & Schneider, 2014; Government of Canada, 2019).

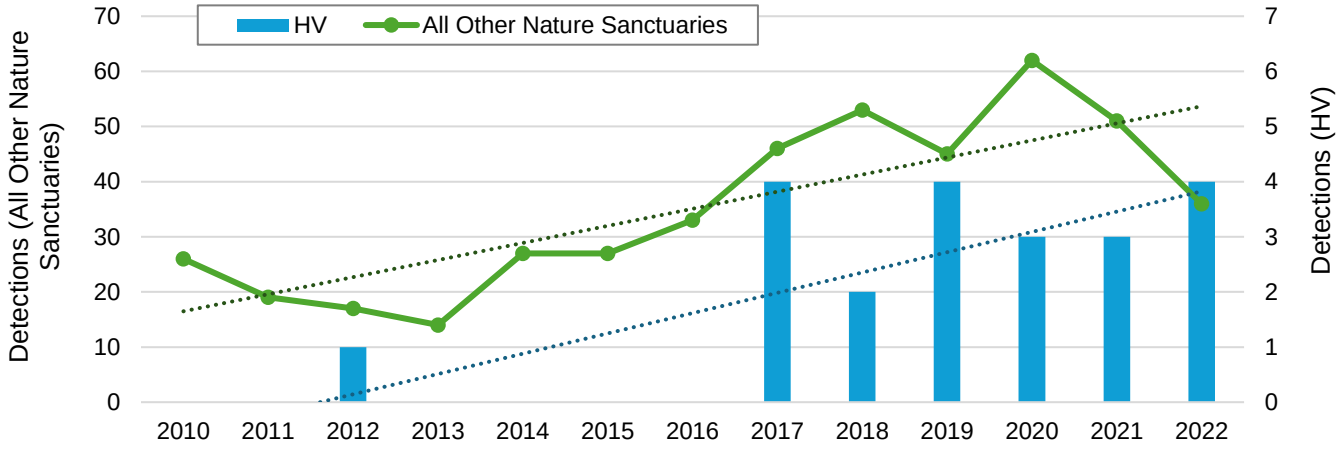

Figure 22. Detections of Red-bellied Woodpecker in HV-1 and HV-2 (right axis) compared to total Red-bellied Woodpecker detections across all other nature sanctuaries (left axis) from 2010 - 2022. In other nature sanctuaries, only original plots that have been consistently surveyed every year are included.

Long Watch Bird Monitoring

Since Long Watch transects began, 184 species have been recorded in Hendrie Valley, including 13 species-at-risk. The most species recorded during a single year occurred in 2019, with 143 unique species being seen/heard (Figure 23). Unfortunately, species richness has been, on average, declining. 2023 saw a dip which the fewest number of species was recorded, with 124. On average, 133 species are detected in Hendrie Valley annually.

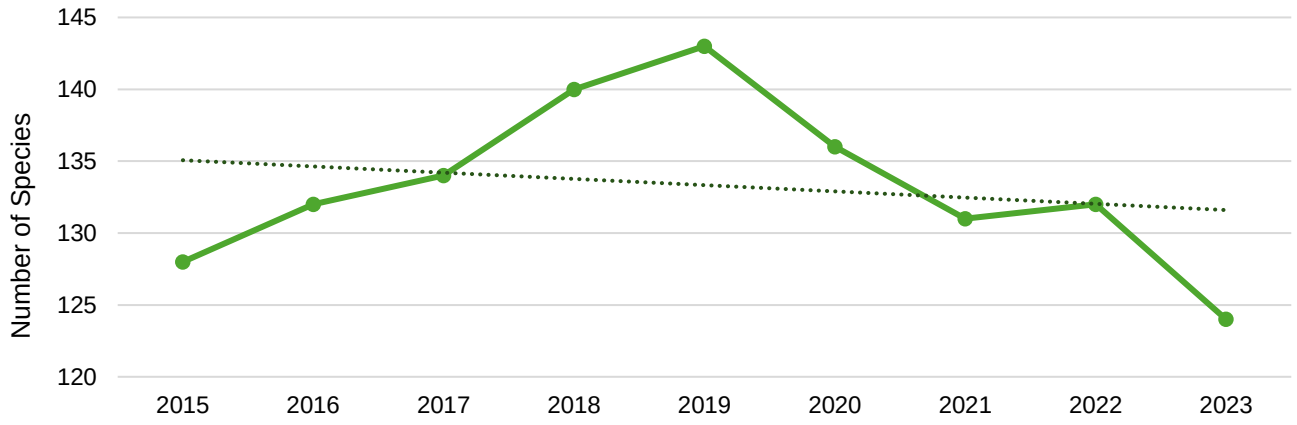

Figure 23. Species richness of birds for Cherry Hill transect from 2015 - 2023.

Since 2015, the top 5 most abundant species detected on the Cherry Hill transect are the Red-winged Blackbird (relative abundance of 15%), Mallard (12%), Black-capped Chickadee (8%), Canada Goose (5%) and Blue Jay (5%). All other species account for 55% of all records. These are similar to results found during RBG's staff-led bird surveys that occur in the month of June.

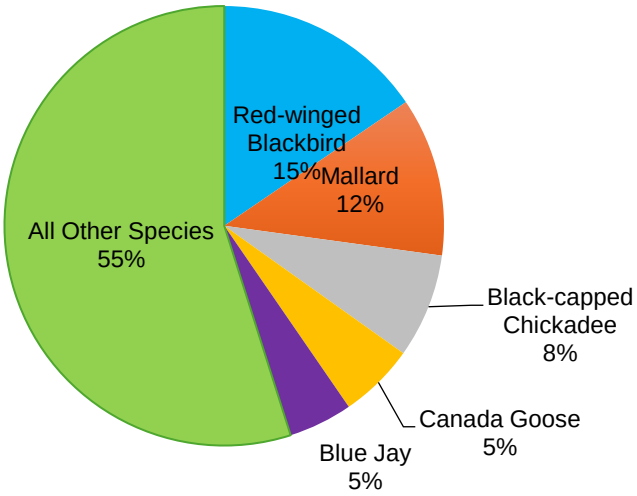

Figure 24. Top five most abundant bird species detected on the Cherry Hill transect 2015 - 2023.

Sampling effort is not always equivalent as multiple observers may go out on a transect. A rise in the number of observers increases detections and species richness, so effort hours are used in order to determine the rate of detections. An effort hour is the number of hours spent completing the transect, multiplied by the number of observers. However, as the number of observers continues to increase, the number of birds detected will reach a plateau. Therefore, while effort hours attempt to standardize the data to some degree, there are limitations to this methodology.

As seen in **Error! Reference source not found.** below, while detections per effort hour are variable, they have been, on average, increasing over time. The peak occurred in 2017, with about 86 detections per effort hour. In 2023, there were about 73 detections per effort hour. There is a large dip in 2020, likely due to the only spring transects being completed during June, due to the COVID-19 pandemic, which is past peak migration.

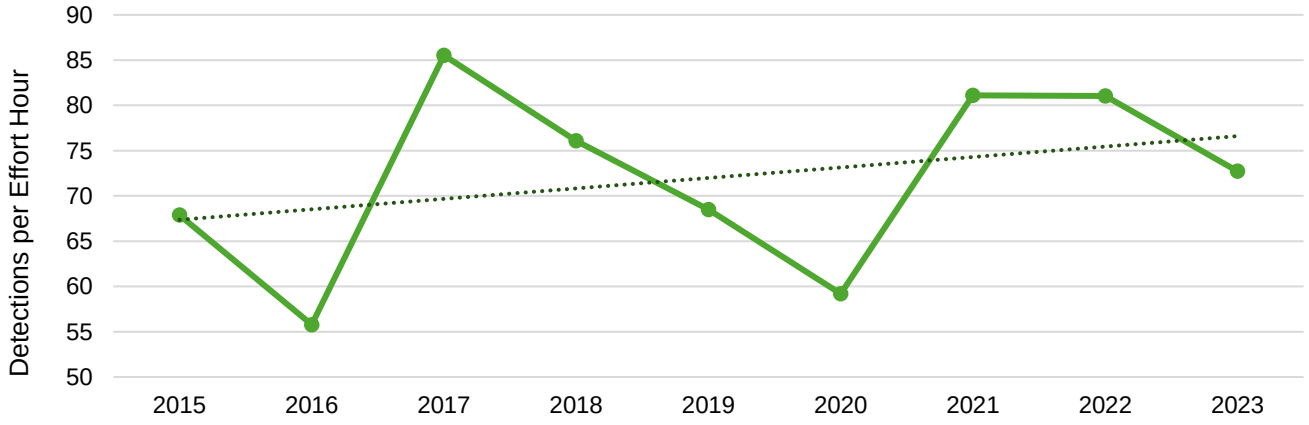

Figure 25. Detections of birds per effort hour for the Cherry Hill transect, 2015 - 2023.

Amphibians

Monitoring was originally restricted to sites with remnants of habitat with 9 sites surveyed at the outset of the Hamilton Harbour Remedial Action Plan in 1994 (Table 8. Amphibian species counts for Grindstone Marsh Monitoring Program. Standard annual monitoring includes 3 visits per site.

Species	1992*	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
No Calling Amphibians	-	4	1	1		1		1					7	6	1	2			6		3	4	6			7		**50**
Wood frog *Lithobates sylvaticus*	P												2		1		1											**4**
Spring Peeper *Pseudacris crucifer*	P					4				6	2	3	1		1	3	50		3	4			1		1	2		**81**
Western Chorus Frog *Pseudacris triseriata*	P																											**2**
Copes Gray Tree Frog *Dryophytes chrysoscelis*											1																	**0**
Northern Leopard Frog *Lithobates pipiens*	P		16	17	10	8	14	15	35	11	13	26		7	88	22	20	35	25	25	5	21	31	11	5	1	5	**466**
Pickerel Frog *Lithobates palustris*	P																											**0**
American Toad *Anaxyrus americanus*	P		2	1	4	2	6	1	16	27	10	12	50		22	15	3	5	19	16	7	14	9	2	6	2	4	**255**
Gray Treefrog *Dryophytes versicolor*	P														5					4		1		8				**18**
Green Frog *Lithobates clamitans*	P	24	18	39	18	36	29	49	21	54			1	29	55	30	48		59	30	68	41	8	14	21	11		**703**
Total Heard	-	24	36	57	32	50	49	65	72	98	26	41	54	36	172	70	122	40	106	79	80	77	49	35	33	16	9	**1,528**
Total Species	8	1	3	3	3	4	3	3	3	4	4	3	4	2	6	4	5	2	4	5	3	4	4	4	4	4	2	**7**
Total Sites Visited	-	9	9	9	6	9	9	9	12	12	6	7	15	15	15	15	9	6	17	12	12	15	17	8	9	14	3	**279**
Stations Active		3	3	3	3	3	3	3	4	4	3	4	5	5	5	5	3	3	6	4	4	6	6	3	3	5	3	**7**
Sites Dry	-																											**0**

Table 9). Since that time and addition 6 sites have been added to track progress of amphibian recolonization across Grindstone marshes. A subset of the monitoring stations have been surveyed almost every year since 1995. Large areas continue to lack any suitable habitat and as a result have no survey activity or calling amphibians. Reestablishment of calling amphibians has occurred at many sites where habitat is again found. Amphibians have now reestablished in middle zone areas of Grindstone Creek Marsh restoration below RBGs Laking Garden.

Amphibian abundance is generally low. No stations achieve a call code of 3, referring to a full chorus (an inestimable number). Total species richness of the past five years for Grindstone Marsh is reduced to 4 species. A total of 3 species are extirpated since the outset of the program in 1995 including Western Chorus Frog, Pickerel Frog and American Bullfrog. In addition, Spring Peeper are essentially extirpated from the valley, with the occasional individuals heard suspected to be washed down from upstream habitats. The last Wood Frog was recorded in 2017 and so may also be considered extirpated. During recent surveys most remaining species have demonstrated a slight decline in number, with Green Frog still commonly heard and overall the most abundant species. The Northern Leopard Frog and American Toad are also locally somewhat numerous at a subset of sites. No locations of large populations exist for any species at any site.

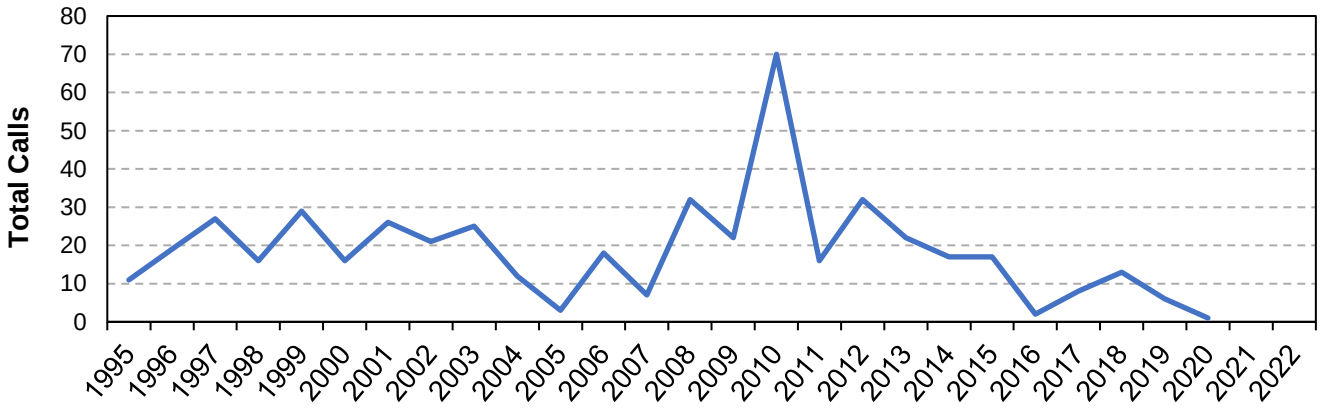

Figure 26. Trend total calls heard for 3 visits annually in the Marsh Monitoring Program at the highest quality habitat stations for amphibians at South Pasture Swamp (Grindstone Creek Marsh Hendrie Valley).

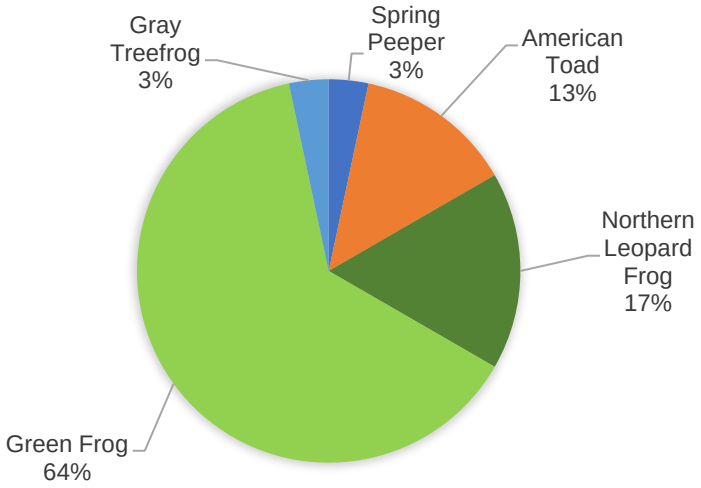

Figure 27. Amphibian species MMP at the highest quality habitat station - South Pasture Swamp (30 total calls).

Table 8. Amphibian species counts for Grindstone Marsh Monitoring Program. Standard annual monitoring includes 3 visits per site.

Species	1992*	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
No Calling Amphibians	-	4	1	1		1		1					7	6	1	2			6		3	4	6			7		**50**
Wood frog *Lithobates sylvaticus*	P												2		1		1											**4**
Spring Peeper *Pseudacris crucifer*	P					4				6	2	3	1		1	3	50		3	4			1		1	2		**81**
Western Chorus Frog *Pseudacris triseriata*	P																											**2**
Copes Gray Tree Frog *Dryophytes chrysoscelis*											1																	**0**
Northern Leopard Frog *Lithobates pipiens*	P		16	17	10	8	14	15	35	11	13	26		7	88	22	20	35	25	25	5	21	31	11	5	1	5	**466**
Pickerel Frog *Lithobates palustris*	P																											**0**
American Toad *Anaxyrus americanus*	P		2	1	4	2	6	1	16	27	10	12	50		22	15	3	5	19	16	7	14	9	2	6	2	4	**255**
Gray Treefrog *Dryophytes versicolor*	P														5					4		1		8				**18**
Green Frog *Lithobates clamitans*	P	24	18	39	18	36	29	49	21	54			1	29	55	30	48		59	30	68	41	8	14	21	11		**703**
Total Heard	-	24	36	57	32	50	49	65	72	98	26	41	54	36	172	70	122	40	106	79	80	77	49	35	33	16	9	**1,528**
Total Species	8	1	3	3	3	4	3	3	3	4	4	3	4	2	6	4	5	2	4	5	3	4	4	4	4	4	2	**7**
Total Sites Visited	-	9	9	9	6	9	9	9	12	12	6	7	15	15	15	15	9	6	17	12	12	15	17	8	9	14	3	**279**
Stations Active		3	3	3	3	3	3	3	4	4	3	4	5	5	5	5	3	3	6	4	4	6	6	3	3	5	3	**7**
Sites Dry	-																											**0**

Table 9. Amphibian count totals of Grindstone Marsh Monitoring Program by station. Standard annual monitoring includes 3 visits per site

Station Summary	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Visit 1	**0**	**16**	**17**	**14**	**8**	**19**	**15**	**35**	**28**	**11**	**22**	**13**	**23**	**92**	**23**	**72**	**34**	**47**	**25**	**1**	**25**	**36**	**11**	**5**	**3**	**9**	**604**
ON658B												0	5	2	0			0			0	0			0		**7**
ON658C								6	8	2	7	0	0	5	2			6			11	25			0		**72**
ON867A	0	8	7	4	5	6	6	10	7	6	2	6	5	7	6	56	14	9	3	0		0	3	1	2	1	**174**
ON867B	0	3	0	3	1	6	3	6	6		6	1	2	18	5	10	5	8	5	0	7	6	3	2	1	3	**110**
ON867C	0	5	10	7	2	7	6	13	7	3	7	6	11	60	12	6	15	12	7	1	7	3	5	2	0	5	**219**
ON867D																		12	10	0		2					**24**
Visit 2	**21**	**14**	**9**	**18**	**9**	**21**	**11**	**17**	**27**	**15**	**19**	**40**	**2**	**22**	**33**	**32**	**6**	**32**	**27**	**16**	**28**	**9**	**4**	**15**	**2**		**449**
ON658B												0	0	5	1			0			0	1			0		**7**
ON658C								3	8	8	8	10	0	5	1			0			10	0			0		**53**
ON867A	10	9	7	12	8	9	5	5	4	6	1	12	0	5	11	12	2	12	4	1	9	2		5	2		**153**
ON867B	2	1	1	3	1	4	0	5	7			10	2	1	4	9	1	9	8	3	5	5	2	4	0		**87**
ON867C	9	4	1	3	0	8	6	4	8	1	10	8	0	5	16	11	3	11	6	3	4	1	2	6			**130**
ON867D																		0	9	9							**18**
Visit 3	**3**	**6**	**31**		**33**	**9**	**39**	**20**	**43**			**1**	**11**	**58**	**14**	**18**		**27**	**27**	**63**	**24**	**4**	**20**	**13**	**11**		**475**
ON658B												0	0	3	1		1	0			0	0			0		**6**
ON658C								3	8			1	3	0	1		2	0			0	0			1		**21**
ON867A	1	2	13		16	1	15	6	14			0	2	20	5	2		11	15	16	8	0	5	7	2		**161**
ON867B	0	0	6		7	5	8	2	9			0	3	5	2	8		4	2	14	5	1	7	4	1		**93**
ON867C	2	4	12		10	3	16	9	12			0	3	30	3	8		12	7	26	9	2	8	2	7		**185**
ON867D																			3	7	2	1					**13**
Grand Total	**24**	**36**	**57**	**32**	**50**	**49**	**65**	**72**	**98**	**26**	**41**	**54**	**36**	**172**	**70**	**122**	**40**	**106**	**79**	**80**	**77**	**49**	**35**	**33**	**16**	**9**	**1,528**

Parks Canada Project 2023

In 2023, Cootes to Escarpment EcoPark System, received funding from Parks Canada for work focused on assessing and improving ecological corridors within the local Ecopark system. As a member of this alliance and one of the largest landowners, RBG received funds to improve habitat and connectivity between its nature sanctuaries. The major themes of this project were to:

1. Remove invasive species surrounding significant species on RBG property.
2. Improve the ecological integrity of interior forest habitat at RBG.
3. Install wildlife barriers along areas of high wildlife road mortality at RBG (Appendix 1).

These main themes were undertaken across all four of RBG's nature sanctuaries with great levels of success. Each of these three themes and their project summaries for Hendrie Valley can be found in the following sections.

Invasive Species Removal

Forest monitoring efforts have indicated that a risk to Hendrie Valley is the encroachment of Norway Maples (*Acer platanoides)* and other non-native trees. Regeneration surveys have shown the majority of new growth is non-native species (Radassao et al. 2018). This project aimed to reduce regeneration by targeting removal of non-native trees through the use of herbicide.

Table 10. Hendrie Valley invasive species work summary, 2023 with larger trees removed by contractor.

Species	Removal Method	RBG Staff	Contractor
Norway Maple (*Acer platanoides*)	Basal Bark - Garlon	45	350
Norway Maple	Cut Stump	0	45
Tree of Heaven (*Ailanthus altissima*)	Basal Bark - Garlon	0	30
Tree of Heaven	Cut Stump	0	6
Manitoba Maple (*Acer negundo*)	Basal Bark - Garlon	0	10
Manitoba Maple	Cut Stump	0	13
English Walnut (*Juglans regia*)	Cut Stump	0	1
Bird Cherry (*Prunus avium*)	Cut Stump	0	4
European Alder (*Alnus glutinosa*)	Basal Bark - Garlon	0	15
European Spindle Tree (*Euonymus europaeus*)	Basal Bark - Garlon	0	10
Burning Bush (*Euonymus alatus*)	Basal Bark - Garlon	1	10
Multiflora Rose (*Rosa multiflora*)	Basal Bark - Garlon	0	10
Common Buckthorn (*Rhamnus cathartica*)	Basal Bark - Garlon	2	100
Amur Honeysuckle (*Lonicera maackii*)	Basal Bark - Garlon	1	225
Horse Chestnut (*Aesculus hippocastanum*)	Basal Bark - Garlon	15	12
Total		64	841

Much of the work was contracted out for herbicide removal, and in some cases the manual felling of trees. Trees that were deemed a hazard, such as those on the roadside or next to a property line, were

felled and then had herbicide applied to the cut stump. Trees that were safe to leave dead standing had a basal bark application of triclopyr. Non-native trees were the primary target, and some non-native shrubs were also removed. 13.2 hectares were treated with 529 trees, and 349 shrubs treated. Of these, 109 trees were felled prior to application.

Figure 28. Hendrie Valley invasive species area sprayed in 2023.

Discussion

Plant Community

Canopy Tree Layer

The canopy tree layer within Hendrie Valley's Forest monitoring plots are composed primarily of Red Maple and Red Oak, all of which account for a combined 70.5% of the relative abundance. Even though Red Maple is the most abundant tree, Red Oak surpasses Red Maple when it comes to percent basal area. This is likely because the Red Oaks within Hendrie Valley are mature trees that are quite large in comparison to the Red Maples that are found within the forest. It is likely that Red Oaks are representative of some of the oldest trees within the Hendrie Valley Forest community.

Since the first round of forest monitoring began in Hendrie Valley in 2009, Red Maple has consistently been the most abundant tree found within monitoring plots. This pattern continued in 2023, where Red Maple accounted for 50% of all trees surveyed using the EMAN protocol. As mentioned in Peirce et al. 2022, there has been an on-going relationship between Red Maple and various species of Oak trees. Until the 1800s, Red Maple was rarely found in eastern North American forests (Fei and Steiner, 2007). In this area, hardwood forests were typically dominated by hickories and oaks. Clearing of untouched forests on the eastern half of the continent allowed for the expansion and proliferation of White-tailed Deer in disturbed areas. Interestingly, White-tailed Deer may have aided in the expansion of Red Maples in eastern North America over the last two centuries. Acorns account for a large portion of the White-tailed Deer diet, and therefore due to this increased pressure, oak regeneration in hardwood forests have been under stress (Fei and Steiner, 2007), allowing Red Maple to increase its abundance. Continuing to monitor Red Maple and Oak fluctuations over time as climate change progresses, White-tailed Deer populations continue to rise (unless successful predators infiltrate the area), and forest pests and diseases continue to threaten the integrity of forested ecosystems.

Comparing between 2009, 2012, 2018 and 2023, in the canopy tree layer, the composition has remained relatively stable with Red Maple, Red Oak, and Black Cherry comprising most of the layer. White Birch has declined since 2009 but this is likely due to tree mortality. White Birch is slightly shade intolerant, and it can be assumed that it was likely due to suppression by larger canopy trees. One difference observed within the Oaks is that Bur Oak was first observed in 2018 and then again in 2023, and Black Oak was present in 2012 and 2018, but was not re-located in 2023. This is possibly due to slightly shifting plot boundaries, as plots are not monitored annually and there is often a challenge in finding the plot markers when the monitoring team returns 5 years later. The absence of Norway Maple in 2009 and 2012 was possibly due to misidentification at the time. The absence of White Oak since 2012 is due to the death of the single tree that accounted for 2.4% relative abundance in 2009. The addition of Smooth Serviceberry in 2023 was due to that individual reaching appropriate size (10cm DBH) to be included in the canopy tree analysis.

The only invasive tree observed in plots in HV-1 and HV-2 since 2009 has been Norway Maple. It is not a surprise that Norway Maple has been present in forest monitoring plots in Hendrie Valley as it is a common species along the forest edge of Hendrie Valley – both in neighbouring properties and within RBG's horticultural garden collections. Norway Maple is a well-known invasive tree species present across RBG's nature sanctuaries and is managed by RBG staff as per the Invasive Plant Strategy for the Natural Lands. The areas that are typically highlighted as priority areas are often areas nearby to or

associated with critical habitat for Species-at-Risk and restoration projects. In 2023, there was a large initiative in Hendrie Valley to remove Norway Maple. Please see Environmental Stewardship Recommendations at the end of this report for more details.

Oak trees in Hendrie Valley, and across RBG property, have continued to experience stressors since monitoring last took place in 2018. The largest and likely most impactful stressor was the Spongy Moth outbreak that began in 2020, just 3 years after the Fall Canker Worm outbreak. Spongy Moth defoliation pressure was observed across Ontario, and Hendrie Valley was no exception. Across RBG property, the two areas with the highest defoliation forecast for 2021 were the South Shore of Cootes Paradise and Rock Chapel. Therefore, due to limited capacity, they were prioritized that year for aerial treatment of this forest pest. With that being said, Hendrie Valley was treated aerially in 2022 but therefore experienced an extra season of pressure from the defoliation of Spongy Moth. Despite the outbreak, up until this point, no noticeable death or dieback has been observed within monitoring plots in Hendrie Valley. A high precipitation year in 2023 played an important role for oak recovery, however, further monitoring will be required to determine if the stress of past insect outbreaks has impacted oak survival or growth.

Understory Layer

Two species of Maple have also increased since 2012. Both Sugar Maple and Norway Maple have increased by 10.26% and 10.72%, respectively. The increase in Sugar Maple is a positive addition for the forest monitoring plots, however a similar increase in Norway Maple is concerning. Norway Maple, as mentioned previously, has been a troublesome invasive tree in Hendrie Valley since monitoring began. In late 2023, herbicide treatment of 395 Norway Maples in Hendrie Valley was completed (Table 9). Therefore, a decrease in Norway Maple presence might be noted during the next sampling window in Hendrie Valley. However, not all trees within the nature sanctuary were treated, so further spread will likely continue. Additionally, with the removal of the Norway Maples within the treatment area, this may allow for the invasion of non-native shrubs (i.e. Common Buckthorn, Multiflora Rose, or non-native Honeysuckle species). Restoration plantings will occur in 2024 in an effort to offset this possibility.

Red Maple has declined nearly 10% in the understory layer since 2012. There was also a 6% decline in Red Maple cover in the canopy layer during surveys in 2023. Reasons for loss in cover are unknown, especially Red Maple continues to be the most abundant tree in Hendrie Valley in terms of density and relative abundance. Perhaps there are more Red Maple trees within the plots, but the size of the trees might be smaller as they are competing for resources.

Six new species were detected in the understory layer in 2023 that weren't previously detected in 2012 (Green Ash, Ironwood, Common Buckthorn, Purple-flowering Raspberry, Red Elderberry, and Tartarian Honeysuckle). The two new non-native species, Common Buckthorn and Tartarian Honeysuckle, detected have relatively low relative cover (both with 0.12% relative cover). This is promising, as this does not appear to be a fast invasion of these species. Additionally, the increase in relative cover of the new native species (15.52%) is much larger than the combined increase in non-native species (0.24%). Oppositely, six species that were present in 2012 were not observed during the 2023 monitoring window: Manitoba Maple, Smooth Serviceberry, Alternate-leaved Dogwood, Musclewood, Horse Chestnut, and Oriental Bittersweet, which were all observed with low relative cover. Therefore, it is possible that there was only one or two individuals of each of these species that might have either died since 2012 or been excluded due to slight shifts in plot boundaries over the years.

Species richness since 2012 has not changed dramatically, with 18 species detected in 2012 and 17 species detected in 2023. The composition of native species and non-native species has remained consistent since that time too. Therefore, despite disappearances and additions of select species over the years, the relative composition of native versus non-native species has remained relatively constant.

Ground Vegetation Layer

For 2023, when all data from all three monitoring plots is combined, there was a total of 39 species observed during ground vegetation surveys (EMAN). Of the 39 species, 9 were non-native. Therefore, nearly 77% native ground vegetation was observed during ground vegetation surveys versus 23% for nonnative species. These results are comparable to 2018's results for native versus non-native species in ground vegetation surveys (Radassao et al. 2019), despite more forest monitoring plots being surveyed in 2018. Interestingly, the top five most abundant species observed during ground vegetation surveys were all native species (Figure 1). However, this does not hold true for the top five species, when referring to relative cover, since Amur Honeysuckle has the 5th largest relative cover at 4% (Figure 2). This could be due to even one or two larger seedlings being observed in a single quadrat.

Unlike 2018, when examining the minimum and maximum stem counts (Table 5), not one species appears to outright dominate in terms of sheer presence. The species with the highest stem count was Wild Sarsaparilla, where 21 stems were counted. Compared to 2018, when 182 stems of Garlic Mustard were counted at HV-4, 2023's highest stem count is relatively low. (Radassao et al. 2019). Garlic Mustard was detected at every forest monitoring plot in 2023, as well as Green Ash.

One of the longest on-going invasive species projects on RBG property is the management of invasive Garlic Mustard. In 2018, Garlic Mustard was the most abundant species in total stem count and was the second highest in average cover (Radassao et al. 2019) – however, it should be noted that these results include an additional three monitoring plots than what was surveyed in 2023. In 2023, only 9 stems of Garlic Mustard were found across 12 ground vegetation plots in Hendrie Valley. Despite the difference in sampling effort from 2018, 2023's Garlic Mustard findings are still incredibly low compared to 2018. This trend has been observed in recent Forest Monitoring results in other RBG nature sanctuaries (Figure 5). Recent research has suggested that Garlic Mustard populations can exponentially increase in abundance during the initial stages of invasion, but experience decreasing population growth rates over time (Blossey et al. 2021). The reasoning behind the negative population growth rates is currently unknown but have been hypothesized to be related to unique regional climates, soil, and vegetation characteristics (Blossey et al. 2021). Further monitoring will be required to determine if this trend continues long-term. Additionally, when Forest Monitoring is conducted at Rock Chapel in 2024, it will provide another glance into Garlic Mustard and its presence across the nature sanctuaries.

Leaf litter has increased significantly since 2018, despite Hendrie Valley, amongst the rest of Ontario, experiencing an intense Spongy Moth outbreak in 2020 and 2021. RBG aerially treated all four of its nature sanctuaries, with Hendrie Valley receiving treatment in May 2022. Therefore, all trees in Hendrie Valley would have had full foliage cover again in 2022, resulting in plenty of leaves falling to the forest floor that autumn for surveyors to see in the vegetation quadrats in July 2023. Prior to 2018, there was a Fall Cankerworm outbreak that would have impacted the amount of leaf litter during 2018 surveys.

Therefore, the average percent cover of leaf litter in 2023 is likely more representative of robust canopy cover in Hendrie Valley for the first time in many years.

Another hypothesis as to why there may be increased leaf litter is that there have been undetected changes in invasive earthworm populations in Hendrie Valley. In 2020, the invasive Jumping Worm was confirmed at RBG in numerous locations, with Hendrie Valley being a hot spot for the species. It is unknown how long Jumping Worms have been present on RBG property; however, Jumping Worms have been present in North America since the late 1800s, but have more recently begun an invasion into natural areas through horticultural trade and transportation of plant material. Jumping Worms shed their castings within the soil profile which creates the space inhabitable for many native plants, and thus further susceptible to erosion (Invasive Species Centre, 2023). Having intense feeding habits, Jumping Worms consume, and essentially remove, the top layer of organic matter in the soil profile, which results in difficulty for plants to remain rooted in soil and allowing soil nutrients to wash away. Further investigation into the extent of Jumping Worm infestation in Forest Monitoring plots in Hendrie Valley should be conducted to provide context for changes in leaf litter presence.

Non-Native Invasive Plants

The sample of non-native plants observed during forest monitoring does not accurately reflect the intensity and extent of the non-native plants that inhabit Hendrie Valley Nature Sanctuary. Incidental observations and observations by way of Ecological Land Classification (ELC) surveys throughout the nature sanctuary provide a deeper understanding of the extent of the invasive species issue in Hendrie Valley. Some examples of non-native invasive species not captured in forest monitoring data include but are not limited to: Winged Euonymus (*Euonymus alatus*), Porcelain Berry (*Ampelopsis glandulosa*), Amur Cork Tree (*Phellodendron amurense*), Lily-of-the-Valley (*Convallarria* majalis), Oriental Bittersweet (*Celastrus* orbiculatus), Chocolate Vine (*Akebia quinata*), and Black Jetbead (*Rhodotypos scandens*). Some non-native invasive plant species found in Hendrie Valley are highlighted below.

Lesser Celandine (*Ficaria verna*) is a non-native perennial spring ephemeral that has been spreading throughout Hendrie Valley, among other areas of RBG's nature sanctuaries. In Hendrie Valley, the primary area of spread is from the Rifle Range area through Cherry Hill Gate to South Bridle Trail. Chemical treatment and manual removal of this ornamental ground cover has been on-going for many years at RBG with varying levels of success. There is fear that the chemically treated populations might become semi chemical-resistant with consistent treatment. Therefore, occasional pauses in chemical treatment of Lesser Celandine in Hendrie Valley have been conducted. In the past few years, other populations of Lesser Celandine have occurred on both the North and South Shore of Cootes Paradise, as well as Rock Chapel. The populations on the South Shore are likely from yard waste dumping, but the other spots at Rock Chapel and the North Shore of Cootes Paradise are concerning too. The location at Rock Chapel was found directly alongside the trail, where a tuber was likely deposited from a hiker's boot tread. Further spread of Lesser Celandine throughout Hendrie Valley is certainly possible as the population occurs alongside the Cherry Hill trail. Therefore, it is not unlikely that tubers could be spread along the trail system through Hendrie Valley. Due to the on-going threat of spread, RBG should prioritize a Lesser Celandine Management Plan specific for RBG. Further research into appropriate treatment timing and methodology may improve efficacy, as treatment for Lesser Celandine is still in early stages.

Yard Waste Dumping: Spreading Invasive Non-native Plants

Hendrie Valley has a large border that abuts many private residences, which results in challenging opportunities for community engagement. However, due to RBG's lack of resources and outreach programs, there is a large gap in ecological communication with neighbours. The disheartening result of this is that neighbours are not well educated in how to be a responsible neighbor when living next to a nature sanctuary. Therefore, there are many problems that arise from the education gap, with one of the main issues being yard waste dumping into nature sanctuaries. Since yard waste is generally seen as "organic material", there appears to be no threat of dumping yard waste into a nature sanctuary. However, this is a primary source of invasive species introduction into nature sanctuaries. In addition to the threat of invasive species introduction, there is often garbage (plastic plant tags and pots, etc.) included in the dumped material. Therefore, RBG should effectively engage with neighbours to provide them with proper protocol and information on how to be eco-friendly neighbours to nature sanctuaries.

Wildlife Community

Breeding Bird Surveys

Decline in Bird Detections in 2023

There was a notable decline in species richness and detections across RBG in 2023, but interestingly, this trend was not observed in Hendrie Valley. However, the decline in species richness was also mirrored by the results of migratory Long Watch surveys on RBG property (Hamilton & Cramer, 2024). A possible reason for the sharp decline seen this season was the smoky conditions which plagued not only Ontario but much of the migration routes.

Climate change is likely to increase the frequency and severity of wildfires, which can have substantial impacts on migratory and breeding birds (Haider et al., 2019; Irannezhad et al., 2022). Timing of migration, resource acquisition and navigation can all be altered by smoke and fire, meaning some birds are forced to flee an area before they are ready to make the journey. Lack of nutrition combined with smoke inhalation causing respiratory distress can mean that birds are either dying before they can complete their migration, or they arrive to the breeding grounds and face delays in breeding due to a necessary recovery period (Sanderfoot & Holloway, 2017; Irannezhad et al., 2022). Canada's wildfire season in 2023 was claimed to be the most destructive on record (NRC, 2023a). As of November 2nd 2023, 6,623 wildfires had been recorded in Canada, over 1,000 more than the 10 year average (NRC, 2023b). The smoke not only plagued much of Canada and the United States during the tail end of the spring migration, but fires in Quebec continued to rage on into July, extending into September in western Canada. Smoke can be seen by satellite covering much of eastern Canada right into October (NASA, 2023).

Amphibians

Status as summarize in HHRAP Stage 1 Report (1992) is as follows; Grindstone Marsh (Hendrie Valley/Carrolls Point), the area is characterized by regionally rare species. Bull Frog and Pickerel Frog occur in backwater ponds of Hendrie Valley in restricted numbers. As of the end of 2022 populations and distributions have changed both positively and negatively for frogs and toads. The distribution of several species of amphibians has expanded with associated with increases in habitat. Areas without habitat continue to lack amphibians. The overall abundance of several species has also increased, particularly the Gray Treefrog. Green Frog, Northern Leopard Frog, and American Toad are regularly encountered at low numbers, and at higher numbers than at the outset of the HHRAP. However,

amphibian populations continue to be very low with a particular seasonal issue demonstrated for the earliest season breeding species (ie Spring Peepers). Long-standing high-quality habitat locations in both marshes hold only moderate to very low populations of all species. Three species are now extirpated including Western Chorus Frog, American Bullfrog and Pickerel Frog. In addition, Wood Frog and Spring Peeper are essentially extirpated. Adjacent upstream populations of these continue to exist upstream/up watershed (unpublished Marsh Monitoring Program data). The most striking situation is the lack of amphibians at a long-standing restored habitat location in Grindstone Creek Marsh were in the past 5 years only 30 individual frogs have been heard representing predominantly 2 species. Roadkill has been a theory for lack of population increases and as a result an ongoing project to establish roadside barriers was initiated in 2019. As of the end of 2023 substantial roadside barriers now exists along Hendrie Valley although not fully complete at South Pasture Swamp area.

Due to ongoing concerns with frog abundance and distribution and potential issues with reproduction, Environment and Canada and Climate Change undertook a specific study at Cootes Paradise Marsh, focusing on Northern Leopard Frog with a multiyear project undertaken between 2014 & 2016 (Hughes et al.2020). This involved in-situ growth from egg to frog to determine survivability at multiple sites across the marsh. Only one site did not show severely impaired survivability, Upper Paradise Pond (an interior pond), where results were like the control site. Several sites had total loss of all individuals before transformation to frog. The potential issues and compounds were so numerous in the supporting water quality monitoring information completed that determining the specific limiting issues was not possible.

Wildlife Feeding

Peirce (2018) conducted a baseline survey of visitor-wildlife interactions in Hendrie Valley. It was found that approximately 65% of visitors to Cherry Hill were feeding wildlife. The status has increased in 2023 based of RBG Volunteer Trailwatcher monitoring (Theysmeyer et al. 2024). Monitoring the number of visitors observed feeding wildlife became part of the RBG Volunteer Trailwatchers in 2020. The early trends were positive with much reduced but still overwhelming wildlife feeding activity consistent in 2020 and 2021 (~70% of groups), declining in 2022 (~64%), and in 2023 dramatically rising to ~95% of reports noted people feeding the wildlife although with only smaller amounts of seed.

In 2018 it was impossible to quantify the sheer volume of supplemental food (mainly bird seed) entering the nature sanctuary, however the implications of feeding wildlife were well known in the literature. The main negative implications of feeding wildlife are the congregation of a higher-than-normal density of wildlife in a given area (i.e. on the periphery of the trail), introduction of non-native food sources to native birds, and increased risk of disease spread within the wildlife community.

In 2020, the Education Department and its volunteers ran a station with a table display at Cherry Hill Gate to engage with and educate visitors on the impacts of feeding wildlife to local ecosystems. This program continued in 2021. In total, 35 of RBG’s volunteers received training on effective techniques to discuss this topic with visitors. Eventually the decision was made to switch from an interactive stationary display to getting on the trail and directly chatting with visitors in-situ. 2,457 engagements with visitors at Cherry Hill were recorded in 2021. Listed in the table below (Table 11) are polled questions and feedback provided by volunteers who assisted in this program in 2021.

Table 11. Summary of some observations of volunteers that were on the trails in 2021, educating visitors on the impact of feeding wildlife in a nature sanctuary.

Survey Question 1	Survey Question 2	Survey Question 3
How did you feel about your role as a Wildlife Feeding Station Volunteer today?	*Did you have any meaningful or any challenging interactions? If so, please describe.*	*Other comments*
"Generally, I felt comfortable engaging with people, but 1 couple just ignored my greeting and would not engage with me saying (in a rude way) they didn't have time."	*"Members were glad to get educated as they didn't realize the consequences of wildlife feeding."*	*"Having a presence on the trails is a big improvement. After talking to so many people feeding wildlife, being off trail, picking greenery, I am not the most liked person. However, it needs to be done, if we are to preserve Hendrie Valley. The soft approach didn't work."*
"I felt useful."	*"Only 1 person showed her discontent. Her family was carrying peanuts, and she said that it wasn't her responsibility to worry about other children."*	*"I spoke at length to a woman who was incredibly interested in the topic even though she knew little about it at first. She suggested a handout would give more people time to understand the topic more fully and think about it more deeply. "*
"A little less positive. People I spoke with about not feeding were later found feeding. Giving more information about the effects of feeding were accepted. Found a large pile of peanuts and sunflower seeds beside a sign "Please do not feed wildlife". Cleaned it up with another volunteer's help. Volunteers should bring bags for seeds and garbage."	*"One young man was very upset. After I explained the bad consequences of feeding wildlife, he said SO!!! He asked me if I was going to tell everyone not to feed wildlife. I answered: Yes, that's what I'm here for. He asked me why I was following him down the trail. I said that's where I was going. He said that he didn't want me to follow him, so I asked him to let me go ahead. He kept grumbling to the people who were with him. Other groups on the trail were understanding. One woman even asked me how to become an RBG member."*	*"Another disappointing day, lots people coming just to feed the animals bringing tons of food. It seems the soft approach is not working, and harsher measures may be required. Just read in the paper that a couple in Vaughn, were fined $ 615.00 for feeding squirrels."*
"I felt that most visitors responded to the message. I enjoyed talking to visitors and engaging them in the discussion."	*"About 25% of people said they knew not to feed the wildlife and that they didn't feed (and they couldn't understand why people were feeding). About 8 people wanted bigger signage and more signage (I explained why RBG was trying to avoid doing that). The trails were the busiest of the season today - parking lots were overflowing and constant flow of people, especially in large groups of multi-generational families - more difficult to try and talk to since there were many under 5-year-old children who demanded adult's attention. A number of new visitors who seemed to appreciate and respect my*	*"For the last time doing this, I must admit that I feel some sense of accomplishment - there were no piles of food on the hill coming down from Cherry Hill Gate and on the way back up (around 12:30 pm) people were just walking on the hill and not stopping to feed. Also, the area where the ducks gather - there were less people feeding the ducks. I think there's been some success in the program, but visitors told me that they see people feeding all over the place on the trails, so still much more work be to done."*

	comments about the harm in feeding wildlife."	
"I felt that most visitors responded to the message. I enjoyed talking to visitors and engaging them in the discussion."	*"2 conversations where people said "Oh I didn't think of that, thank you"*	*"Absolute mayhem down here today. Hundreds of people invaded the trails. It was like pushing your way through a crowded subway platform. Half of them were feeding the animals, small amounts mostly. Only one family I talked to had a large bag. I think the only way to restore order is to keep people out."*

In addition to volunteers on the trail, RBG's Education and Natural Lands departments filmed educational videos on the impacts of wildlife feeding at RBG, which have over 1,000 views on YouTube. Topics such as how wildlife feeding impacts forested ecosystems, to impacting native turtles, and effects on wetland communities were covered.

Environmental Stewardship Recommendations and Updates

Recommendations to improve the health and sustainability of Hendrie Valley Nature Sanctuary were presented in two former reports: "2018 Environmental Review of Hendrie Valley" (Radassao et al. 2019) and "Mitigating the Impacts of Increased Visitation on Hendrie Valley Nature Sanctuary" (Killingbeck 2021). The recommendations from these reports fit into the following thematic categories:

- Visitor Use and Wildlife Feeding
- Non-native Invasive Plant Management
- Amphibians
- Species at Risk protection
- Reforestation and Slope Rehabilitation
- Land Defragmentation

Recommendations are listed under each category below along with RBG's associated follow-up actions taken to date.

Visitor Use and Wildlife Feeding

In 2018, nearly 65% of all visitors to Cherry Hill were feeding wildlife (Peirce, 2018), and due to the known negative ecological impacts of supplemental feeding, RBG undertook an educational approach to mitigating this activity.

1. *Resolve RBG's stance on wildlife feeding in Hendrie Valley (Killingbeck, 2021)*
   - RBG no longer supports the feeding of wildlife of any kind on our properties.
2. *Cease the advertising of feeding wildlife at RBG, including chickadees. This includes RBG's social media accounts and if possible, tourism websites (Radassao et al. 2019)*

- Although not written in RBG's Social Media Protocol, staff involved with communications are aware and cognizant of not posting photos of visitors or staff feeding wildlife, either on social media outlets or in RBG newsletters or advertising.

3. *Supervision and management for areas of high visitor traffic during popular visiting times be implemented. For example, more frequent guided hikes by RBG staff and/or volunteers with public visitors or implementation of an ambassador program where staff and volunteers engage the public on the trails (Radassao et al. 2019). Increase education on visitor behaviour and initiate enforcement strategies (Killingbeck, 2021).*

   - As mentioned previously, RBG implemented a program utilizing volunteers to engage with visitors at Cherry Hill and provide background information and education on the negative impacts of feeding wildlife. It cannot be determined if this program was effective, and therefore a replication of Peirce's 2018 study should be conducted and compared to results prior to volunteer engagement.
   - Enforcement was requested through the City of Burlington Bylaw enforcement team. Limited time to assist RBG has been available and as such few occasions of enforcement has occurred.

4. *Any group or club programs that take place on RBG property that including any bird feeding opportunities follow the same practices – feeding only birds in cultural land use areas (examples include: Woodland Garden in Hendrie Park, head of the Anishinaabe waadiziwin Trail in the Arboretum on the north shore of Cootes Paradise) and not leaving any seed piles behind (Radassao et al. 2019).*
   - RBG's Education and Customer Programs department has completely ceased all wildlife feeding in its programming. Pre-school programming occasionally involves making bird feeders using spruce cones, sunflower butter, and black oil sunflower seeds. These feeders are often taken home, but occasionally one might be hung up behind the NIC.
   - Interpreters and Camp Staff are encouraged to discuss the potential impacts of feeding wildlife with visitors who continue to partake in the activity. They are asked to discourage feeding, but if the visitor is adamant about continuing to feed, then responsible feeding is recommended (only **a few** black oil sunflower seeds to only birds – no mammals, no seed left behind, and no peanuts).
   - For RBG's Wildlife Rescue Exhibit, a Discovery Table was created with tangible educational materials related to RBG's messaging surrounding Wildlife Feeding. Volunteers interacted with visitors sharing the findings of RBG's Wildlife Feeding study and how visitors are expected to interact with wildlife going forward.

5. *Establish a threshold for environmental degradation and maximum visitor capacity and consider the implementation of an advanced ticket system for parking and/or entrance fees (Killingbeck, 2021).*
    - No advanced ticketing and user system has been resolved for this locations access, however the access changes are incorporated in the RBG 25 year Masterplan for updates.
    - The Unsworth Ave parking was closed/eliminated in 2023 reducing access to local users.
    - The main parking access Cherry Hill Parking lot was reduced from 2 to 1 entrance/exit, and a gate and fence were installed to contain access into the valley through this access.
    - A threshold for environmental degradation has not been established, however within the RBG 25-Year Masterplan the parking lot access is to be eliminated, changing access to regulated access through RBG to control user types and numbers access the valley.

New Objectives:

- Repeat the study by Peirce, 2019 to collect tangible data that will identify whether the actions listed above have made an impact on visitor use and wildlife feeding in Hendrie Valley needs to be taken as well. – *I don't think this provides any new help… and the valley will change, thus perhaps if we had in "after changes to valley access by the masterplan…"*
- Continue to monitor Black-capped chickadee decline using data from breeding bird monitoring and Long Watch census. Seek research opportunities within the academic

Invasive Species Management

Efforts to manage invasive species, specifically invasive plants, throughout key areas of Hendrie Valley have been undertaken as a result of recommendations from previous reports.

1. *A Norway Maple removal project be initiated in the valley, starting with the South Pasture Swamp Special Protection Area, and address seed sources in Hendrie Park and along Plains Rd where possible (Radassao et al. 2019).*
    - In 2023, a large project to remove Norway Maple, among other invasive trees and shrubs, was implemented in Hendrie Valley. The treatment area spanned 13.9 hectares from the edge of South Pasture Swamp up to the edge of the ravine, and across to behind RBG's Teahouse. During this project, approximately 529 invasive trees (primarily Norway Maple) and 349 invasive shrubs were treated with a basal bark application of triclopyr. In response to this project, RBG ecologists will be seeding and planting native trees and shrubs in the spring of 2024 to help reduce the possibility

Removal of invasive Norway Maples along the edge of Hendrie Valley.

of enhanced erosion due to the removal of the Norway Maples and other invasive species on the slopes.

2. *RBG staff and volunteers continue to develop and implement activities related to removal of invasive annual and biennial species of Garlic Mustard, Dame's Rocket, and Nipplewort in the valley, particularly in proximity to the trails (Radassao et al. 2019).*
   - RBG staff have continued to remove invasive herbaceous species in Hendrie Valley. Continued management of Garlic Mustard and other invasive herbaceous plants have continued, especially along trail edges, where slope restoration has occurred. *Ornamental non-native invasive plants continue to be removed, such as Common Butterbur and Lesser Celandine and a best management practice be developed for Lesser Celandine.*
   - Lesser Celandine has continued to receive herbicide treatments nearly every spring since Radassao et al. (2019) recommended treatment. While the area covered by Lesser Celandine has decreased significantly, the species is persistent and there is some concern that the plant could be developing resistance to glyphosate. A management plan for the species has not yet been developed, but populations of the plant have now been found in every RBG nature sanctuary from isolated patches that are smaller than two squared meters to large areas almost half a hectare in size.

Lesser Celandine escaping from RBG's cultivated gardens (Hendrie Park) into Hendrie Valley.

   - A management plan for lesser celandine has not yet been initiated.
   - Common Butterbur has received multiple herbicide treatments and has declined in area.
   - Additionally, herbicide treatments have occurred and continue as needed on Periwinkle along Kicking Horse Trail and Bridle Trail South.

     Populations of these invasive species have not been irradicated in Hendrie Valley, but significant control has been achieved. Visual monitoring during the growing season dictates weather herbicide treatments are required each year.

3. *The RBG Invasive Species Committee continue to work closely together and develop an organization wide strategy for reducing the spread of known and future non-native invasive plants (Radassao et al. 2018).*
   - The invasive species policy has been accepted by the RBG Board of Directors and a strategy is underway. The strategy highlights 4 main themes that relate to organization-wide goals which are as follows:
     i. Prevent: Prevent introduction of known invasive and potentially invasive species within RBG properties and through collaboration with others.

ii. Detect: Detect and report the presence of newly arrived invasive species and spread of introduced species already present at and near RBG.

iii. Manage: Protect the health and integrity of every level of biodiversity across RBG by managing invasive species.

iv. Educate: Improve the understanding of invasive species prevention, early detection and management internally and share our knowledge and expertise externally.

4. Continue invasive species management in key locations. Follow recommendations of RBG's invasive species management strategy once complete (Killingbeck, 2021).
    - While the invasive species strategy is not fully complete, several actions have been completed in response to objectives set within the strategy, specifically around the prevention theme. Several species of invasive species known to be present in Hendrie Valley have been removed from cultivation at RBG Center as well as Hendrie Park. Burning Bush (*Euonymus alatus*) was removed, and none remain in cultivation. Porcelain berry (*Ampelopsis glandulosa var. brevipendunculata* 'Elegans') was removed from RBG Centre yet remains planted in other areas of the gardens. ▪ There is also one plant that has matured and gone to seed at the base of Grindstone Marshes Trail that requires removal.

New Objectives:

As the forest canopy continues to change from environmental impacts to invasive species control, a surge of non-native invasive plant abundance is anticipated in the understory of Hendrie Valley, especially along the forest edges.

- Continue non-native invasive plant management in key locations throughout Hendrie Valley and Hendrie Park. Specifically, the valley lands surrounding South Pasture Swamp and north of Hendrie Park and the lands north of the parking lot known as the rifle range.
- Continue to implement priorities highlighted in the draft invasive species strategy that involve the removal of known invasive species from cultivated areas.
- Amur Corktree (*Phellodendron amurense*) fruit bearing trees should be prioritized for removal (PGSIP, 2023). It has been identified by the Public Gardens as Sentinels against Invasive Plants working group as a plant of concern due to a growing number of botanic gardens and arboreta reporting on its ability to escape cultivation. While this species hasn't shown up in any monitoring plot, known escapees are present in Hendrie Valley as well as both sides of the Cootes Paradise nature sanctuary. Efforts to remove the escaped plants from the valley needs to be taken as well.

Amphibians

Amphibians have long been the subject of increased vehicular mortality in, and around, Hendrie Valley. To protect amphibian populations in Hendrie Vally, the following actions have occurred.

1. During amphibian migration periods RBG staff and/or volunteers should survey adjacent roads for amphibian roadkill. Roads to survey would include Plains Road West, Patricia Drive, Unsworth Avenue, Sandcherry Drive, Grand View Avenue, Brook View Avenue, and Spring Gardens Road. It may be possible to engage members in the surrounding communities to participate in the study, particularly at Sandcherry Drive, Patricia Drive, Grand View Avenue, and

Brooke View Avenue. Local residents can report observations of live amphibians travelling across the road, road killed amphibians, and even send in pictures of amphibians for identification to a designated staff member(s) or volunteer(s). The INaturalist app may be very useful for this type of citizen science. Community involvement would not only increase awareness of the threats amphibians encounter but could also give RBG the opportunity to build a stronger partnership with residents. (Radassao et al. 2019)

- Since the time of publishing the *Environmental Review of Hendrie Valley* in 2019, no formal roadkill surveys have been conducted by RBG staff. However, the RBG roadkill project on iNaturalist (formally called “Road Kill Cootes Paradise”) has collected more than 480 observations by users documenting road kill along roads that line RBG’s nature sanctuaries. Although not specific to Hendrie Valley, across the boundaries of this project, 19 observers have contributed to the project and have identified 49 species of wildlife that have been killed by vehicles. The top three species that have been documented as roadkill in this project are Eastern Grey Squirrel (58 observations), Striped Skunk (57 observations), and American Toad (39 observations).
- Extensive wildlife barrier installation in key areas surrounding Hendrie Valley began in 2021. Over 2km of Animex fencing was installed in 2023 under the Parks Canada Eco-corridors Project. A summary of this Project can be found in Appendix 1. This fencing is imperative to the wellbeing of amphibians and wildlife whose habitat is Hendrie Valley.

New Objectives:

- Continue inputting roadkill information into the INaturalist project.
- Undertake a benchmark salamander population survey to determine status.
- Look for opportunities to enhance existing breeding ponds in the floodplain.

Species at Risk

Site Specific Plans for RBG’s species at risk are better sources for stewardship actions to be taken to help the recovery of species in Hendrie Valley Nature Sanctuary. However, some activities undertaken to date are worth noting based on recommendations from Radassao et al. 2019.

1. *A focus to improve turtle nesting in the vicinity of the Hendrie Park barn be undertaken.*
    - Two nesting piles were made in 2017, and a third was added in 2018 near the Hendrie Park Barn. Apart from those initiatives, no further amenities have been developed at this time.
    - As reported above, extensive wildlife barriers have been installed around the perimeter of Hendrie Park, the Esso Station on Plains Rd and Unsworth Avenue. The 2023 project under Parks Canada is summarized in Appendix 1.

2. *Continue bird surveys to determine future absence or presence of SAR birds, such as Wood Thrush. Additionally, targeted SAR bird surveys in Hendrie Valley be conducted periodically to monitor for presence and abundance of SAR birds.*

- Wood Thrush was heard at HV-1 in 2019, after the Radassao et al. (2019) report was published. However, further surveys have not been successful in detecting Wood Thrush at HV-1 since.
- There are currently 5 bird monitoring plots for Hendrie Valley. Three additional plots were re-established (based on the extra locations surveyed in 2018). Updates to the methodology can be found in the Bird Monitoring Procedure section of this report.

New Objectives:

- Evaluate new bird monitoring methodology after several years of data collection is obtained.
- Refer to SAR site specific plans for other actions related to Species-at-Risk recovery.

Reforestation and Slope Rehabilitation

Actions to address tree canopy loss due to forest disturbances such as Emerald Ash Borer and Oak Decline and rehabilitate trailside slopes from visitor pressures have been initiated in Hendrie Valley.

1. *Address slope erosion throughout Hendrie Valley with mitigation strategy (Killingbeck, 2021).*
    - In December 2021, erosion mitigation measures were undertaken along the trail edge at Cherry Hill. RBG staff added new topsoil to the eroded areas of the slope to replace the soil lost and reduce the steepness of the slope. The topsoil was then held in place with proper edging along the trail and coco fibre erosion blanket across the slope. Native herbaceous plants and shrubs were added to the slope to further stabilize the slope and replace vegetation lost from trampling and erosion. The coco fibre netting was held in place both with wooden and biodegradable plastic stakes. *Undertake reforestation initiatives in key locations to increase canopy cover, improve interior forest conditions, and extend buffer (Killingbeck, 2021).*

Before slope stabilization (left) and after coco fibre net installation and native plant restoration work (right).

- Some caliper-size trees (20) were planted along Grindstone Marshes Trail between the Cherry Hill Entrance and the Boardwalk. The intent was to replace some of the forest canopy lost to Oak Decline. Species planted include Red Oak, White Oak and Black Cherry.
- In response to the Parks Canada Eco-corridors project that initiated the control of invasive trees in Hendrie Valley, in the spring of 2024, 691 native trees and shrubs, and 17 kilograms of native seed will be added to areas where significant removals took place, specifically the valley slope south of South Pasture Swamp (aka Pond 4). RBG staff and volunteers will assist in the planting. More planting will be needed in this area in the future.

2. *South Bridle Trail – lowland area below the Tea House between Kippax Access Trail and Kicking Horse Trail. Prior to planting, any non-native trees and/or shrubs should be removed (Radassao et al. 2019).*
    - Non-native trees and shrubs were controlled using basal bark application of Garlon RTU in this area in the fall of 2023 as part of the Parks Canada Eco-corridors Pilot Project. Ongoing invasive species removal should occur as it is likely that some individuals were missed.
    - Tree planting has not occurred at this location.

New Objectives:

As sections of forest and treed floodplains once dominated by ash species and Norway Maple become bare, along with other tree mortalities experienced in the valley, changes to ecosystem community dynamics and functions are likely to occur.

- Continue tree replacement strategy throughout Hendrie Valley in key areas, specifically the lowland area below the RBG Tea House between the Kippax Garden access trail and Kicking Horse trail and where oak decline and ash have created holes in the canopy.
- Address trailside slope erosion from off trail activities in other locations (Bridle Trail South, Grindstone Marshes Trail by Snake Rd Trail). Refer to Killingbeck, 2021 for additional trail management recommendations.
- Continue to monitor and survey for invasive insects (Spongy Moth, Hemlock Woolly Adelgid).
- Improve our knowledge and understanding on the stewardship of forest ecosystems in a changing environment through participation in workshops, conferences, and other professional development opportunities.

Emerging Threats

As society continues to navigate the unknown impacts of climate change, it cannot be determined what Hendrie Valley might experience in the future. However, there are ecological threats at its doorstep that will place increased pressure on its ability to function as a thriving ecosystem. Threats can be placed into three main categories: Forest Pests and Diseases, Extreme Weather Events, and Increased Anthropogenic Pressures. These main categories are outlined in more detail below.

Forest Pests and Diseases

There are many pests and diseases that are moving closer to Southern Ontario at alarming rates. Hemlock Woolly Adelgid (*Adelges tsugae*) and Oak Wilt (*Bretziella fagacearum*) are the two most immediate threats to Hendrie Valley's Forest.

Hemlock Woolly Adelgid (hereafter referred to as HWA) was detected on the South Shore of Cootes Paradise in early March 2023. Despite further visual inspections of other Hemlocks on RBG property, no further spread of the initial infestation is thought to exist at this time. Eastern Hemlock is not overly common nor abundant in Hendrie Valley, however, this does not dispute the possibility of HWA arriving in the valley within the next few years. Continued monitoring by RBG staff and assistance from the Canadian Food Inspection Agency (CFIA) will provide understanding and detect spread of this deadly forest pest.

For Hendrie Valley, the most threatening forest pest is Oak Wilt, as the forest composition relies heavily on oaks. In 2023, Canada had its first detection of Oak Wilt, which was in the Niagara region. Oak Wilt is a vascular disease caused by the fungus *Bretziella fagacearum*, which grows on the outer sapwood of trees, thereby restricting the movement of water and nutrients throughout the tree. All oak species are affected by this disease; however Red Oak appears to be the species most seriously impacted by the fungus. Some oaks can die within a year after initial infection, but in severe cases, in red oaks, mortality can occur in as little as 2-6 weeks (Invasive Species Centre, 2023). RBG will continue to maintain best practices (i.e. not pruning oaks between April and October, when spore spread is most vulnerable) and monitor for symptoms of Oak Wilt in Hendrie Valley, as well as the other four nature sanctuaries and all garden collections.

Extreme Weather Events

All aspects of life on Earth will be impacted by Climate Change this century, and Southern Ontario is no exception to this fact. The major weather events that pose a threat to Hendrie Valley are increased precipitation intensity, increased frequency of storms, abnormally warm winters, increased intensity of windstorms and ice storms (Duinker 2008, Johnston et al. 2006). The predicted increase in precipitation increases the chance of erosion along hillsides that line the trails as water quickly flows over ground into the valley. This will create challenges with trail maintenance along some of RBG's busiest trails. However, this impact will not only be observed along trails, but also off-trail on steep slopes that line the edges of Hendrie Valley. The possibility of major erosion events is possible and will detrimentally impact the vegetation and wildlife community.

Increased frequency and intensity of windstorms not only threaten the safety of visitors to Hendrie Valley's trails, but also to the canopy health and integrity of the forest. Increased windstorms bring the possibility of increased risk of tree blowdowns and damage to the forested community. Blowdowns open the canopy, allowing more light to reach the forest floor, which can proliferate the spread of invasive species through the forest. This could increase the spread density of invasive species in Hendrie Valley.

Increased Anthropogenic Pressures

With the GTA's population projected to increase by 3.3 million residents by 2046, coupled with Hamilton's projected above- provincial-average growth rate of 44.1% by 2046 (Ontario, 2022), it can be predicted that RBG's visitation will increase significantly by that time. This will bring added anthropogenic pressures to RBG's nature sanctuaries. Increased visitation to nature sanctuaries increases challenges such as compaction on trails, possibility of off-trail use, wildlife feeding, litter, parking availability, and off-leash dogs. Each of these difficulties will likely increase with increased visitation.

RBG should prepare for increased visitation and take a proactive approach to increased pressure on its nature sanctuaries. RBG could learn from the Hamilton Conservation Authority who has dealt with dramatic increases in visitation over the last many years, as waterfall seekers have flooded the conservation areas. One of the main solutions to this problem was creating time-ticketed visitation using an online registration platform. RBG already uses a booking system with similar metrics for special events, so it would be an easy transition to add booking slots for Nature Sanctuary visits into the system. These discussions and possible solutions should occur before the increased visitation occurs so proactive measures can be taken before permanent damage is done.

Conclusion

Hendrie Valley Nature Sanctuary offers its visitors an opportunity to reconnect with natural ecosystems and escape from the city without long-distance travel. The valley itself provides important refuge for many of Ontario's native plants and wildlife, including those that are at-risk of extirpation and extinction. Long-term monitoring programs, such as RBG's bird monitoring and forest monitoring programs, detecting changes in ecological communities will help guide the management and ecological integrity of this nature sanctuary. As monitoring efforts continue, RBG's dataset will become more statistically robust, which will only provide a more accurate and detailed glimpse into the changes occurring within the nature sanctuary. With emerging threats such as climate change, the introduction of new invasive species and diseases, the increasing frequency of severe weather events, combined with the anthropogenic pressures of past and present, RBG's actions are more important now than ever. Through community engagement, partnerships, education, and collaboration with the surrounding community, Hendrie Valley will remain a preserved and ecologically diverse habitat for plants, wildlife, and people to prosper.

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Appendix 1: Wildlife Barriers

Wildlife barriers have been installed at four locations surrounding the Hendrie Valley Nature Sanctuary: Hendrie Park, Plains Rd West – beside the Esso, Plains Rd West – beside West Plains Church, and Unsworth Avenue.

Four-foot-high chain link fencing was installed at Plains Rd Esso and Unsworth. This work was contracted to and completed by King Fence. Vehicle and pedestrian access gates were installed at Unsworth to allow access to Creekside Walk. One-way access points have been installed at Plains Rd Esso and Unsworth, with ongoing plans to install one-ways at Hendrie Park. Turnaround treatments at fence ends, that don't connect to wildlife barriers, have been installed at Unsworth and Plains Rd beside the church, with hopes to further fencing efforts in the future to create a more continuous wildlife barrier system.

Animex was installed by a crew of invasive species technicians employed through the Parks Canada Ecopark Pilot Program grant. All processes associated with the barrier installation; trenching, stump removal, root clearing, leveling, backfilling, and securing the Animex to the permanent fencing, were completed manually by the technicians. On average it took 40 labour hours to install 100 ft of wildlife fencing. In total, 355 ft of new chain link fencing and 2,335 ft of wildlife barrier fencing (Animex) was installed roadside surrounding Hendrie Valley.

Table 12. Summary of labour hours and fence length for installation of wildlife barrier fencing in Hendrie Valley, 2023. Labour hours = number of staff x number of day hours worked (i.e. five staff working for four hours equals twenty labour hours)

Location	**Plains Rd W: Beside Esso**	**Plains Rd W: Beside Church**	**Hendie Park**	**Unsworth Ave**	**Total**
Total Day hours (Dhr)	16	22	70	24	132
Total Days (Dhr/6hr)	3	4	12	4	23
*Total Labour hours **	93	62	554	238	947
Total Animex (ft)	**180**	**375**	**1300**	**480**	**2335**
Total Chain Link (ft)	164			191	355
Labour Hours / 100 ft	52	17	43	50	Average = 40

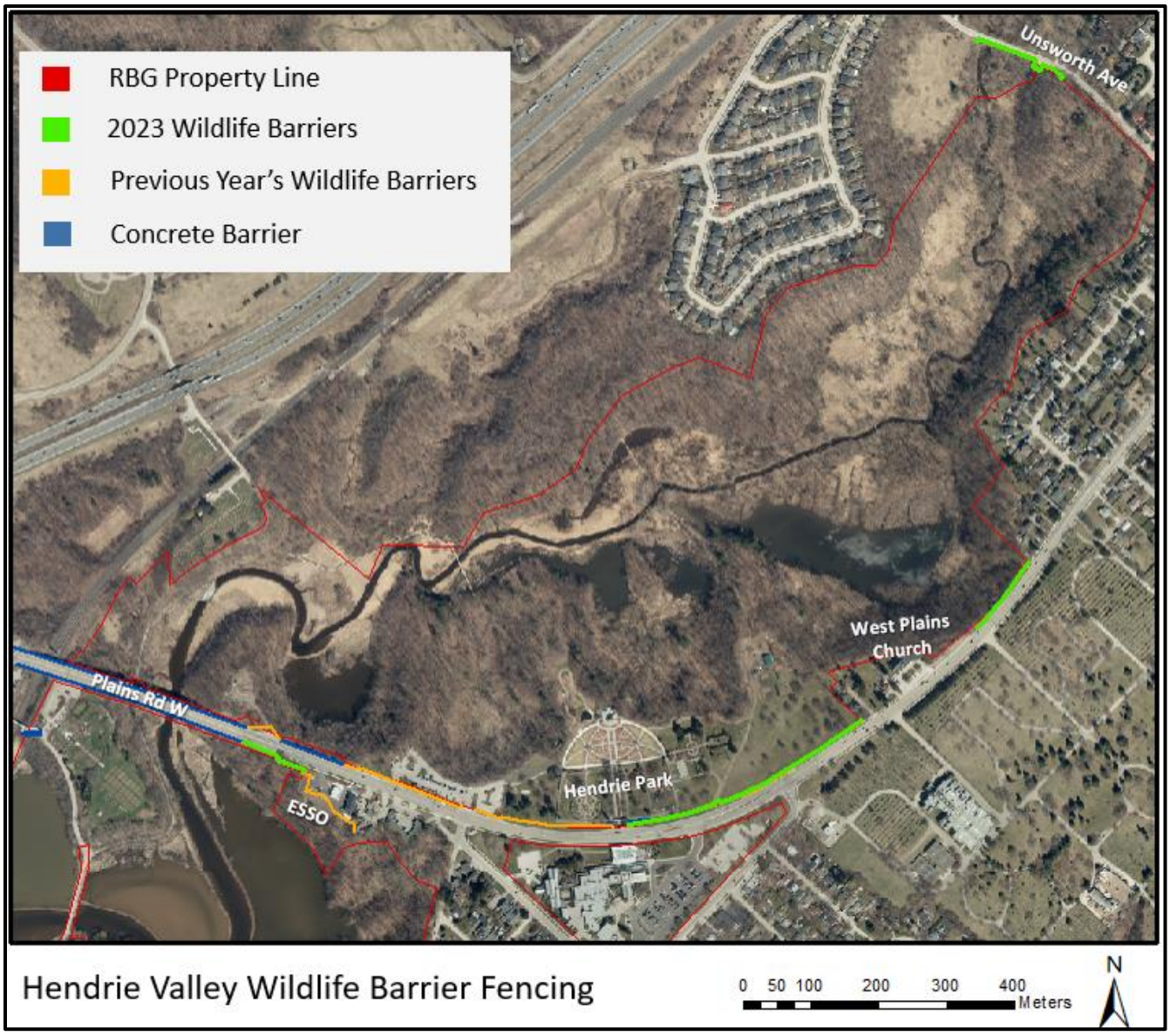

Figure 29. Wildlife barrier fencing installed around Hendrie Valley in 2023.