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Natural Lands Department

2018 Environmental Review of Hendrie Valley

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Document Description

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Front cover photo taken at South Pasture Swamp lookout June 2017 between breeding bird survey visits. Photo credit: Felicia Radassao.

Executive Summary

Hendrie Valley Nature Sanctuary features forested ravines, Grindstone Creek, coastal and floodplain marshes, and diverse plant and animal life. 100 hectares in size, it is a biodiversity hotspot amid the highly urbanized Hamilton-Burlington landscape. Its 4.5 km of walking trails, feature boardwalk and ecological landscapes attract local visitors and tourists alike. Despite marsh and land habitat improvements through ecological restoration efforts, there are many stressors that continue to threaten the ecological function and biodiversity in Hendrie Valley. 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, as well as increase our understanding of consequences from historic and current impacts and assist in guiding management decisions.

The forest in Hendrie Valley is both fragmented by the urban landscape and by Grindstone Creek which divides the valley. The lack of interior forest leaves it more susceptible to impacts from non-native invasive species and ecological disturbances. Forest monitoring is beginning to show compositional changes in the forest structure that are signs of these impacts. Six 20 by 20 meter plots were surveyed in 2018; four new plots and the two original plots previously surveyed in 2009 and 2012. Canopy tree surveys from 2018 examined 101 canopy trees consisting of 20 species. Red Maple (*Acer rubrum*) was most common (25.74% relative abundance) while Red Oak (*Quercus rubra*) was dominant overall by coverage representing 81.94% of basal area. Red Oak was second most common in relative abundance (23.76%), followed by Black Cherry (*Prunus serotina*) at 12.87% relative abundance. Non-native invasive Norway Maple (*Acer platanoides*) was fourth most abundant (8.91%). In the understory layer, 32 species were recorded with 9 being non-native. The dominant species in the understory was White Ash (*Fraxinus americana*) with 8.67% average cover and 18.11% relative cover. Norway Maple was second most numerous with 7.02% average cover and 14.66% relative cover, followed by Green Ash (*Fraxinus pennsylvanica*) with 5.33% average and 11.14% relative cover. When the two original forest monitoring plots are compared between years: ash species and Norway Maple show to have a competitive advantage in the understory layer; native shrub species appear to be in decline; non-native invasive shrubs are continuing to colonize and spread; forest floor leaf litter is limited, with bare ground and moss making up 42% of the ground cover. 2018 ground vegetation surveys from all six plots resulted in 67 species recorded with 15 being non-native. Non-native Garlic Mustard (*Alliaria petiolata*) was most abundant with 37% relative abundance, followed by Pennsylvania Sedge (*Carex pensylvanica*) at 19%, and Blue-stemmed Goldenrod (*Solidago caesia*) at 9% relative abundance. Comparing amount of space occupied, Wild Sarsaparilla (*Aralia nudicaulis*) had the most coverage (18% relative cover), followed by Garlic Mustard (10% relative cover). When ground vegetation is compared over time from the two original forest monitoring plots, native plant cover is remaining stable while

Hendrie Valley forest monitoring plot. Barr, 2018.

non-native plant cover is steadily increasing. Through tree regeneration surveys from all six plots in 2018, a total of 10 species were recorded, with 2 being non-native. The sapling data reflects the 2018 understory results; confirming that Green Ash, White Ash and Norway Maple are the most common understory species, making up over 80% of the 5 sapling species detected.

A total of 57.24 hectares of terrestrial (21.44), wetland (20.31) and aquatic (15.49) systems have been surveyed in Hendrie Valley through Ecological Land Classification (ELC), with approximately 18 hectares remaining to be surveyed. Thus far, 162 non-native species were recorded in the 22 polygons classified terrestrial. Garlic Mustard was found in all but one polygon. Common Buckthorn (*Rhamnus cathartica*), Nipplewort (*Lapsana communis*) and Common Privet (*Ligustrum vulgare*) were also among the more frequently recorded non-native species. A total of 359 native species were recorded in the 22 terrestrial polygons, with polygon HV-2016-6 having the most native species richness (107 species) and the highest Coefficient of Conservatism value (4.9). Further analysis of ELC data, once all of Hendrie Valley has been surveyed will help prioritize areas for management.

Bird surveys have shown relatively positive trends for Hendrie Valley. In 2018, 42 bird species were detected during surveys with an average of 12 bird species and an average of 24 individual birds seen/heard per visit. The most abundant bird was Red-winged Blackbird (*Agelaius phoeniceus*) with a relative abundance of 32%, followed by Black-capped Chickadee and Northern Cardinal with both tied at 6%. Species richness has been increasing overall at the two original survey plots since breeding bird surveys began in 2009, along with average individual bird detections per visit per plot since 2012. Notable abundance changes in detections for Wood Thrush (*Hylocichla mustelina*), Canada Goose (*Branta canadensis*) and Black-capped Chickadee (*Poecile atricapillus*) have been observed. Yellow Warbler (*Setophaga petechia*) average detections in Hendrie Valley have been rising since 2016, unlike in Cootes Paradise, with the greatest number in 2018 at 6 average detections per plot.

Peirce, 2018.

It is well known that there is an abundance of birds and other wildlife that will feed from visitors' hands in Hendrie Valley. A visitor wildlife feeding study resulted in 1,965 wildlife observations and 407 visitors using the trails, with 156 visitors documented feeding wildlife. The Mallard (*Anas platyrhynchos*) was detected most at Cherry Hill with a total of 45% of detections. Second most detected species was Eastern Chipmunk (*Tamias striatus*) at 13%, followed by non-native House Sparrow (*Passer deomesticus*) at 12%. The Cherry Hill section of Grindstone Marshes Trail had the most visitors and wildlife detections; 151 visitors out of 254 (65%) were observed feeding wildlife with feeding observed on 90% of the visits. Low quality feed, white proso millet (*Panicum miliaceum*), was the most popular type of supplementary feed used by visitors. Since 2015, Wood Thrush (*Hylocichla mustelina*) detections at the monitoring plot adjacent to Cherry Hill have dropped to zero during breeding bird surveys. These impacts are only just beginning to be understood and will require further study. Higher densities of wildlife formed by species congregating to feed, along with left behind food piles, may lead to increased stress levels, more frequent aggression and increased risk of disease transmission. The quality of seed that visitors bring, proso millet, lacks important nutrients and attracts undesirable non-native bird species. Additionally, seed piles left behind by visitors often attracts concentrations of turtle egg eating mammals, including raccoons and skunks.

A total of 4 amphibian species were recorded during the amphibian Marsh Monitoring Program (MMP) surveys in 2018 with a total of 33 individuals recorded. Green frog was the most common; virtually no forest frog species are present despite ample suitable habitat for reproduction.

Of the 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. Amphibians and turtles may potentially be at risk of mortality from a newly confirm virus known as Ranavirus. Confirmed case was from a Snapping Turtle (*Chelydra serpentina*) in Cootes Paradise Marsh.

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

1. Undertake a targeted program to stop wildlife feeding by visitors
2. Undertake a program to remove Norway Maple
3. Undertake research to address the lack of amphibians

A full list of recommendations for future land management, monitoring and restoration activities can be found at the end of this report. In addition, research questions that developed during the creation of this document are also summarized.

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Introduction

Hendrie Valley Nature Sanctuary, located within the municipality 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 walking trails, including the largest and longest boardwalk within the Royal Botanical Gardens (RBG) properties. Hendrie Valley also represents the most significant concentration of native species within RBG's properties and is among the most biodiverse places in Canada (Galbraith et al., 2011). Adjacent to the nature sanctuary are RBG's cultural spaces of 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 and information can be found at trailheads to Hendrie Valley (Cherry Hill Gate and Valley Inn) and on RBG's website.

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 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 mixture 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 the Valley Farm on the international map following track victories in the United States and Canada (Henley, 1992; Henley, 1996). George M. Hendrie, surviving son of William Hendrie, donated the property in 1931 to the Hamilton Parks Board to be preserved as a nature sanctuary and park. In 1941, the property became part of RBG (Henley, 1992; Royal Botanical Gardens, 2018). As time progressed RBG acquired more land from the Carroll's, Flatts' and Filman's to create the current property.

Historically, redevelopment of the landscape in and around Hendrie Valley Nature Sanctuary dates back over 200 years, and in combination with the introduction of many Eurasian invasive species like Common Carp (*Cyprinus carpio*), 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 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 (non-native Gypsy Moth (*Lymantria dispar*) and native Fall Cankerworm (*Alsophila pometaria*)), non-native invasive species (example Emerald Ash Borer (*Agrilus planipennis*)), and introduced diseases (Hall & Preston, 2008). Tree seedlings are susceptible to increased mortality from unbalanced populations of seed eating wildlife, such as chipmunks and squirrels, and trampling by visitors when wondering off trails. In 2004 a significant loss of canopy trees occurred when dozens of Red Oak (*Quercus rubra*) trees died following a combination 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 unfolds.

Due to the high forest edge to inner forest ratio of Hendrie Valley, human caused impacts along the forest edge that would not normally affect the inner forest have been observed in the inner areas. Approximately 5 kilometers of forest edge are adjacent to roads, residential areas and manicured gardens. Impacts include the spread of non-native invasive plants (ornamental collections from gardens, yard waste dumping behind residential homes), erosion from urban surface water runoff, soil nutrient loading from fertilizers and dumped yard waste, and spread of human garbage/litter. 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 visitor use and ecological integrity is crucial in a nature sanctuary, particularly where high visitor use occurs. Hendrie Valley Nature Sanctuary is a relatively small protected area that provides a place for plants and wildlife to thrive. However, anywhere from a few individuals to hundreds of people visit the trails in a day. In 2018 Hendrie Valley was the most popular of the RBG nature sanctuaries with over 200,000 visits. Thus, human caused impacts are often observed within the nature sanctuary. Such impacts include slope erosion and destruction of vegetation growing along trails from trampling, accidental spread of invasive plants when visitors venture off trail or from off-leash dogs, picking of wildflowers, garbage/litter including fishing lines and hooks, 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 of wildlife.

There are also stressors that influence Hendrie Valley where the extend of impacts are currently unknown. One example is introduced earthworms. It is known that European earthworms consume leaf litter and can deplete this natural mulch, however it is currently unstudied as to what extent earthworms are impacting the forest of Hendrie Valley. Even species present is unknown, thus until a thorough study is complete the impacts will remain unquantified. The forest is also affected by rushing surface runoff from surrounding urbanized areas following heavy rain or snow melt. This can also cause leaf litter on ravined slopes to be washed away. Another stressor that impacts wildlife is the surrounding network of roads and train tracks. Both can result in wildlife vehicle collisions, from amphibians and reptiles to birds and mammals. Currently it is unknown how many species and individual animals are ending up as road kill, especially for smaller wildlife like reptiles, amphibians and songbirds. Conducting road mortality surveys would be beneficial to determine the extent of road impacts on wildlife. Results may even indicate a potential link to a concerning observation that has been made regarding the lack of amphibian abundance in the Hendrie Valley marshes. Despite available habitat, the abundance of frogs and toads in Hendrie Valley is low and as of now it is unknown why. Potential reasons for the lack of amphibians could be due to diseases such as Ranavirus, which was identified in a Snapping Turtle (*Chelydra serpentina*) from Cootes Paradise marsh in 2018, as well as high levels of contaminants in marsh sediment, water and forest soils. However, it is unknown what contaminants are present and at what levels. Further research into detecting and preventing the spread of Ranavirus in Hendrie Valley is needed, along with research into soil, sediment, and water contaminants.

Wildlife and vegetation monitoring have been and will continue to be conducted to assess plant, fish, bird, and amphibian presence and abundance in the nature sanctuary. Water quality will also continue to be sampled. This information provides guidance for management in Hendrie Valley Nature Sanctuary. 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. In this report data collected from forest monitoring, Ecological Land Classification, breeding bird surveys, an internship project examining the feeding of wildlife, and amphibian marsh monitoring program in Hendrie Valley is analyzed and presented. Historic and emerging issues observed within the valley are discussed. Recommendations are presented regarding future actions RBG and the local community can take part in to assist in preserving the biodiversity, ecological functions and natural beauty within the nature sanctuary.

Methods

Below are the various monitoring methods used to acquire plant and wildlife data. This report includes data collected through forest monitoring, Ecological Land Classification, breeding bird surveys, an internship project on supplemental wildlife feeding, and the Marsh Monitoring Program. Methods for each are described below.

Long Term Forest Monitoring

There are currently eighteen 20 x 20 meter permanent long term forest monitoring plots established across RBG's nature sanctuaries. Two of these plots can be found on the Escarpment Properties, five are located on the north shore of Cootes Paradise, five are located on the south shore of Cootes Paradise, and six can be found in Hendrie Valley (the focus of this report); represented in Figure 2. The seventh plot in the figure is solely a breeding bird survey plot.

Forest monitoring surveys follow the Ecological Monitoring and Assessment Network (EMAN) protocols and have been conducted in Hendrie Valley in 2009, 2010, 2012, and 2018. Data is collected from a 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 and tree health data was collected from within the entire 20 by 20 meter plots; understory data was collected using the Vegetation Sampling Protocol (VSP), where all trees and shrubs are identified and percent covers are given to each species for the entire 20 by 20 meter plot; and ground vegetation and forest floor composition data was collected from four 1 by 1 meter quadrats that are within each forest monitoring plot. Tree regeneration sampling occurred in five 2 by 2 meter sub-plots, with 4 outside and 1 inside each 20 by 20 meter 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. 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.

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 plots be set up and surveyed in 2018. Thus, forest monitoring occurred at a total of six plots in 2018 (HV-1 to HV-6). Refer to Figure 2 for plot locations below.

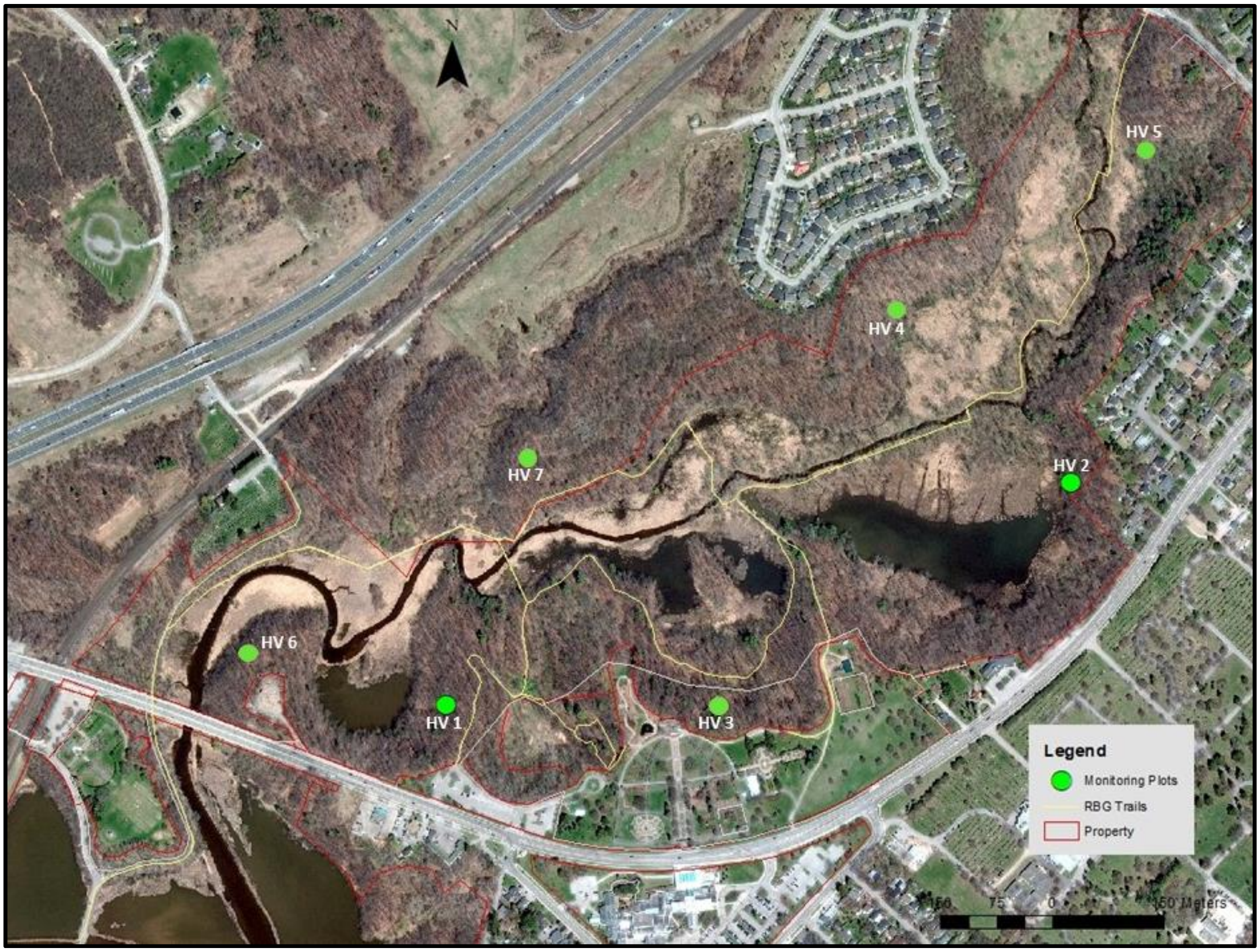


Figure 2. Locations of long term forest monitoring plots in Hendrie Valley; Note HV-7 is only a breeding bird survey plot.

Ecological Land Classification

Ecological Land Classification (ELC) was first conducted in Hendrie Valley around 2001. A more recent detailed survey of Hendrie Valley began in the wetland areas in 2012, followed by the terrestrial lands from 2015 to present with approximately 18 hectares still to complete. Through ELC, the ecological features on the landscape and plant community assemblages can be determined and mapped to assist with future planning, identifying ecological patterns, and species conservation. This information is determined based on climate, geology/soils, landforms, and vegetation communities. For more details outlining ELC survey methods, refer to *Ecological Land Classification of Royal Botanical Gardens' Natural Lands* (Barr, 2014) or visit: https://www.ontario.ca/page/introduction-ecological-land-classification-systems

The Coefficient of Conservatism (CC) was calculated for each ELC polygon. The native plant species of any particular area vary in their degree of tolerance to disturbance and display varying degrees of fidelity to specific habitats. The average CC is an evaluation based on species conservatism - the degree of reliability a plant displays to a specific habitat or set of environmental conditions (Oldham et al., 1995).

Each native plant has been assigned a numerical value (coefficient of conservatism). Introduced species are given a null value. In order to use the method to evaluate a site, a species list is compiled, and the coefficients of all native plants are summed and divided by the total number of native plants. This value yields a mean coefficient (C) for all the native plants in the assessment area.

Coefficients range from 0 (highly tolerant of disturbance, little fidelity to any natural community) to 10 (highly intolerant of disturbance, restricted to pre-settlement remnants). Conceptually this 10-point scale can be subdivided into several ranges:

Disturbed (0-3)	Species that provide little or no confidence that its inhabitance signifies remnant conditions. Plants that are found in a wide variety of plant communities, including disturbed sites.
Moderately Disturbed (4-6)	Species that are typically associated with remnant plant communities but tolerate significant to moderate disturbance.
Slightly Disturbed (7-8)	Species found in high quality remnant plant communities but appear to endure, from time to time, some disturbance. Taxa associated with a plant community in an advanced successional stage that has undergone minor disturbance.
No Disturbance (9-10)	Species restricted to remnant landscapes that appear to have suffered very little post-settlement trauma. Plants with high degrees of fidelity to a narrow range of ecological parameters.

Table adapted from Oldham et al. (1995) and Rothrock (2004).

Using the above criteria, in theory, an intact site accommodating a wide array of species characteristic of a pre-settlement plant community would have a mean C of 5 or greater (Rothrock, 2004). As an area becomes disturbed, the first plants to be lost would be those with a higher C value. The degradation might also facilitate the introduction of additional species with low C values or non-native species that have been assigned a null value. This would lower the mean C to below 5 (Rothrock, 2004). An old field or highly degraded sites might be expected to have mean C values of 2 or less (Rothrock, 2004).

Breeding Bird Surveys

Breeding bird surveys at RBG are conducted using passive listening point counts as described in the *Ontario Breeding Bird Atlas Guide for Participants* (Cadman, 2001) during the month of June. In Hendrie Valley there are seven breeding bird survey locations with six coinciding with RBG forest monitoring plots. The seventh breeding bird survey location in Figure 2 is HV-7.

Only HV-1 and HV-2 (the original monitoring plots) were surveyed four times for breeding birds while the other five plots were surveyed twice. This was due to time constraints; however, the two visits provided baseline bird data for the additional plots. During each visit, surveyors stand in the center of a 100 meter circle, wait five minutes in silence to allow any nearby birds to adjust to the surveyors, and record all birds heard and/or seen during a period of 10 minutes.

For a more detailed breakdown of the methods used to conduct breeding bird surveys at RBG, refer to the *2018 Bird Monitoring Summary* (Peirce, 2019a), and the *Atlas of the Breeding Birds of Ontario* (Cadman et al., 2007).

Visitor Wildlife Feeding Study

Trail transects were conducted on four sections of trails in Hendrie Valley – Grindstone Marshes Trail (from Valley Inn to Snake Road Trail), Cherry Hill (section of Grindstone Marshes Trail from Cherry Hill Gate parking lot across boardwalk to North Bridle Trail junction), Kicking Horse Trail, Creekside Walk Trail - on a weekly basis from July 30, 2018 to October 20, 2018 during various times throughout the day. Each trail was visited on twelve occasions (Cherry Hill and Creekside Walk were visited 13 separate occasions) with equal visits in the morning, afternoon, and evening. During the transects, observer(s) walked the trail and only stopped to identify wildlife species, food piles and observe visitor interactions with wildlife. No interaction with visitors was conducted during the transects. The information collected on each transect included abundance of wildlife species observed on the trail, number of visitors, number of visitors feeding wildlife, and various visit details. Wildlife observed along and on the trails were counted in the study. Please refer to *The Supplemental Feeding of Wildlife in Hendrie Valley* report for more information regarding the methodology of this study (Peirce, 2019b).

Marsh Monitoring Program

The Marsh Monitoring Program (MMP) surveys have been conducted at RBG since 1995 when the Great Lakes Marsh Monitoring Program (GLMMP) was first established. Two marsh monitoring routes have been established in Hendrie Valley with three sites each. Although the number of sites surveyed and type of surveys completed have varied based on the availability of surveyors and marsh conditions, three sites have been consistently surveyed for amphibians.

When conducting Amphibian Marsh Monitoring Program surveys, sites are visited a half hour after sunset three times between May and July 5^{th}. Estimating the number of frogs calling can sometimes be difficult to determine, thus a system of calling codes are used. Calling code 1 means individual calls do not overlap and can be discretely counted. A calling code 2 means calls of individuals sometimes overlap, but numbers of amphibians can still be roughly estimated. Calling code 3 represents a full chorus, meaning the number of individual calls cannot be differentiated or accurately estimated.

For a detailed list of GLMMP methods please refer to Bird Studies Canada's *Marsh Monitoring Program Participants Handbook.*

For information on the Grindstone Marsh aquatic plants and fish populations, please refer to *Project Paradise 2017* (Mataya et al., 2018).

Results

Long Term Forest Monitoring

Canopy Tree Layer

In 2018 four new forest monitoring plots were added in Hendrie Valley; Table 1 depicts relative abundance, tree density and basal area of canopy tree species from all six plots. A total of 101 trees were examined within the plots which consisted of 20 tree species. The most numerous tree species in 2018 are the same species from 2009 and 2012, with Red Maple (*Acer rubrum*) most common with a relative abundance of 25.74% while Red Oak (*Quercus rubra*) was dominant overall by coverage representing 81.94% of basal area (amount of area occupied by a trees trunk). Red Oak was second most common with a relative abundance of 23.76%, followed by Black Cherry (*Prunus serotina*) at 12.87% relative abundance. Norway Maple (*Acer platanoides*), a non-native invasive species, was the fourth most abundant tree species (8.91% relative abundance). A second non-native tree species recorded in 2018 was Horse Chestnut (*Aesculus hippocastanum*) with a relative abundance of 1.98%. Despite the 2 non-native tree species, there are 18 native tree species documented in 2018. The higher species diversity compared to previous monitoring years is attributed to the increased number of plots surveyed and thus species recorded. Based on basal area, Red Oak (*Quercus rubra*) occupied the largest area with 149.35 m^2 basal area, or 81.9%, followed by Red Maple (*Acer rubrum*) at 16.66 m^2, Black Cherry (*Prunus serotina*) at 4.08 m^2 and White Oak (*Quercus alba*) at 3.87 m^2.

When comparing 2009, 2012 and 2018 canopy tree data from the original two forest monitoring plots (HV-1 and HV-2) in Table 2, the most common canopy tree species were Red Maple (*Acer rubrum*) and Red Oak (*Quercus rubra*) based on relative abundance. Although Red Maple (*Acer rubrum*) was most abundant in all three years, Red Oak (*Quercus rubra*) occupied more area. The third abundant tree species was Black Cherry (*Prunus serotina*). Norway Maple was first recorded in the canopy layer in 2018 and White Birch decreased in abundance in 2018 (Table 2). There was a total of 9 species documented within the two monitoring plots in 2009, 11 species in 2012 and 10 species in 2018. The additional species recorded for 2012 – Bur Oak (*Quercus macrocarpa*) and Black Oak (*Quercus velutina*) – both had a relative abundance of 2.44%. The additional tree species were along the edge of the forest monitoring plots and in 2012 were recorded as being within the plots; most likely one of the four corners marking the plots was missing and had to be remeasured and remarked, thus incorporating some boarder trees within the plot. This illustrates that there are additional tree species found in Hendrie Valley that are present outside the forest monitoring plots. When comparing between Norway Maple (*Acer platanoides*) and Sugar Maple (*Acer saccharum*) below in Table 2, it is likely that either Sugar Maple had been mis-identified and was actually Norway Maple as they can be difficult to tell apart, or these trees are along the plot edges. The White Oak (*Quercus alba*) was dead in 2018, hence the absence for that year.

Table 1. 2018 Hendrie Valley tree summary for all **six** 20x20m forest monitoring plots, sorted by relative abundance; non-native species are bolded.

Species	Relative Abundance (%)	Density (trees/ha)	Basal Area (m2)	Percent Basal Area (%)
Red Maple, *Acer rubrum*	25.74	108	16.66	9.14
Red Oak, *Quercus rubra*	23.76	100	149.35	81.94
Black Cherry, *Prunus serotina*	12.87	54	4.08	2.24
Norway Maple, *Acer platanoides*	**8.91**	**38**	**3.30**	**1.81**
Black Maple, *Acer nigrum*	5.94	25	2.27	1.25
White Oak, *Quercus alba*	4.95	21	3.87	2.12
Sugar Maple, *Acer saccharum*	1.98	8	0.26	0.14
Horse Chestnut, *Aesculus hippocastanum*	**1.98**	**8**	**0.03**	**0.02**
Green Ash, *Fraxinus pennsylvanica*	1.98	8	0.05	0.03
Black Oak, *Quercus velutina*	1.98	8	1.24	0.68
White Birch, *Betula papyrifera*	0.99	4	0.03	0.02
Bitternut Hickory, *Carya cordiformis*	0.99	4	0.01	0.00
Shagbark Hickory, *Carya ovata*	0.99	4	0.25	0.14
White Ash, *Fraxinus americana*	0.99	4	0.03	0.02
Black Walnut, *Juglans nigra*	0.99	4	0.02	0.01
Ironwood, *Ostrya virginiana*	0.99	4	0.01	0.01
White Pine, *Pinus strobus*	0.99	4	0.22	0.12
Large-tooth Aspen, *Populus grandidentata*	0.99	4	0.08	0.04
Bur Oak, *Quercus macrocarpa*	0.99	4	0.38	0.21
Hemlock, *Tsuga canadensis*	0.99	4	0.14	0.08
Species Richness	**20**			
Shannon Diversity Index	**0.97902**			

Table 2. Hendrie Valley canopy tree relative abundance for HV-1 and HV-2 from 2009, 2012 and 2018 through forest monitoring plots; non-native species bolded.

Species	Relative Abundance (%)		
	2009	**2012**	**2018**
Red Maple, *Acer rubrum*	50.0	43.9	50.0
Red Oak, *Quercus rubra*	19.0	19.5	20.0
Black Cherry, *Prunus serotina*	9.5	12.2	10.0
Norway Maple, *Acer platanoides*			**5.0**
White Birch, *Betula papyrifera*	7.1	7.3	2.5
Ironwood, *Ostrya virginiana*	4.8	2.4	2.5
Sugar Maple, *Acer saccharum*	2.4	2.4	
White Pine, *Pinus strobus*	2.4	2.4	2.5
Bur Oak, *Quercus macrocarpa*		2.4	2.5
White Oak, *Quercus alba*	2.4	2.4	
Black Oak, *Quercus velutina*		2.4	2.5
Eastern Hemlock, *Tsuga canadensis*	2.4	2.4	2.5
Species Richness	**9**	**11**	**10**
Shannon Diversity Index	**0.684**	**0.765**	**0.670**

Shrubs and Small Trees Layer

Combining the data collected in 2018 from all six plots in the understory layer, a total of 32 species were recorded, with 9 species being non-native (Table 3). The dominant species in the understory layer was White Ash (*Fraxinus americana*) with an average cover of 8.67% and relative cover of 18.11%. Norway Maple (*Acer platanoides*) was second most numerous with 7.02% average cover and 14.66% relative cover, followed by Green Ash (*Fraxinus pennsylvanica*) with 5.33% average cover and 11.14% relative cover. In order of dominance, the non-native species recorded in 2018 were: Norway Maple (*Acer platanoides*), Amur Honeysuckle (*Lonicera maackii*), Common Privet (*Ligustrum vulgare*), Manitoba Maple (*Acer negundo*), Horse Chestnut (*Aesculus hippocastanum*), European Buckthorn (*Rhamnus cathartica*), Multiflora Rose (*Rosa multiflora*), Tartarian Honeysuckle (*Lonicera tatarica*), and White Mulberry (*Morus alba*). Non-native plants represented 27% of the understory cover, while native plants represented 73% cover in 2018.

Table 3. 2018 shrub and small tree (0.5-10 meters) summary for HV-1 to HV-6 based on percent cover; non-native species bolded. Data collected from six 20 by 20m plots using VSP.

Species	Average % Cover	Relative % Cover
White Ash, *Fraxinus americana*	8.67	18.11
Norway Maple, *Acer platanoides*	**7.02**	**14.66**
Green Ash, *Fraxinus pennsylvanica*	5.33	11.14
Black Cherry, *Prunus serotina*	3.87	8.08
Blackberry, *Rubus allegheniensis*	3.50	7.31
Red Maple, *Acer rubrum*	3.33	6.96
Black Maple, *Acer nigrum*	2.50	5.22
Choke Cherry, *Prunus virginiana*	2.50	5.22
Amur Honeysuckle, *Lonicera maackii*	**2.42**	**5.05**
Common Privet, *Ligustrum vulgare*	**2.20**	**4.60**
Witch Hazel, *Hamamelis virginiana*	1.33	2.79
Black Raspberry, *Rubus occidentalis*	1.00	2.09
Red Elm, *Ulmus rubra*	0.88	1.85
Currant/Gooseberry sp., *Ribes species*	0.83	1.74
Manitoba Maple, *Acer negundo*	**0.53**	**1.11**
Honeysuckle sp., *Lonicera species*	0.50	1.04
Horse Chestnut, *Aesculus hippocastanum*	**0.35**	**0.73**
Ironwood, *Ostrya virginiana*	0.33	0.70
European Buckthorn, *Rhamnus cathartica*	**0.20**	**0.42**
Sugar Maple, *Acer saccharum*	0.18	0.38
Roundleaf Dogwood, *Cornus rugosa*	0.17	0.35
Multiflora Rose, *Rosa multiflora*	**0.03**	**0.07**
Maple-leaved Viburnum, *Viburnum acerifolium*	0.03	0.07
Freeman Maple, *Acer x freemanii*	0.02	0.03
Dogwood sp., *Cornus species*	0.02	0.03
Tartarian Honeysuckle, *Lonicera tatarica*	**0.02**	**0.03**
Purple-flowering Raspberry, *Rubus odoratus*	0.02	0.03
Basswood, *Tilia americana*	0.02	0.03
Downy Arrowwood, *Viburnum rafinesquianum*	0.02	0.03
Large-tooth Aspen, *Populus grandidentata*	0.02	0.03
Black Walnut, *Juglans nigra*	0.02	0.03
White Mulberry, *Morus alba*	**0.02**	**0.03**
Species Richness	**32**	
Non-native Richness	**9**	

For 2012, a total of 17 species were identified in the understory layer at HV-1 and HV-2, with 5 species being non-native (Table 5). Comparing the two monitoring plots by survey year, the most dominant species in the understory layer was Red Maple (*Acer rubrum*) with an average cover of 32.5% and relative cover of 28.58%, however Norway Maple (*Acer platanoides*), which was third in 2012, became most dominant in 2018 with 20% average cover and 32.68% relative cover. Second most dominant species in 2012 was Chokecherry (*Prunus virginiana*) at 26% average cover and 22.87% relative cover, but the species was fifth most abundant in 2018. Overall, in 2012 non-native plants represented 20% cover in the understory, with native plants representing 80%; however, in 2018 non-native plants represented 38% cover and native plants had 62% cover.

Table 4. 2012 and 2018 shrub and small tree (0.5-10 meters) summary from HV-1 and HV-2 based on percent cover; non-native species bolded. Data collected from two 20 by 20m plots.

	2012		2018	
Species	**Average % Cover**	**Relative % Cover**	**Average % Cover**	**Relative % Cover**
Red Maple, *Acer rubrum*	32.5	28.58	8.5	13.89
Chokecherry, *Prunus virginiana*	26	22.87	6	9.80
Norway Maple, *Acer platanoides*	**17.5**	**15.39**	**20**	**32.68**
Black Cherry, *Prunus serotina*	12	10.55	1.6	2.61
White Ash, *Fraxinus americana*	11	9.67	10	16.34
Green Ash, *Fraxinus pennsylvanica*			9	14.71
Sugar Maple, *Acer saccharum*	10.05	8.84		
Round-leaved Dogwood, *Cornus rugosa*	8	7.04	0.5	0.82
Amur Honeysuckle, *Lonicera maackii*	**6.05**	**5.32**	**2.25**	**3.68**
Manitoba Maple, *Acer negundo*	**3.5**	**3.08**	**1.05**	**1.71**
Witch Hazel, *Hamamelis virginiana*	3.5	3.08	1	1.63
Smooth serviceberry, *Amelanchier laevis*	3	2.64		
Maple-leaved Viburnum, *Viburnum acerifolium*	2.5	2.20	0.05	0.08
Basswood, *Tilia americana*	1.5	1.32		
Alternate-leaved Dogwood, *Cornus alternifolia*	1	0.88		
Blue Beech, *Carpinus caroliniana*	0.5	0.44		
European Horse Chestnut, *Aesculus hippocastanum*	**0.05**	**0.04**		
Multiflora Rose, *Rosa multiflora*	**0.05**	**0.04**	**0.1**	**0.16**
Ironwood, *Ostrya virginiana*			1	1.63
Common Privet, *Ligustrum vulgare*			**0.05**	**0.08**
Common Buckthorn, *Rhamnus cathartica*			**0.05**	**0.08**
Purple-flowering Raspberry, *Rubus odoratus*			0.05	0.08
Species Richness	**17**		**16**	
Non-native Richness	**5**		**6**	

Ground Vegetation Layer

A total of 67 species were recorded in the ground vegetation surveys conducted in 2018. Note that this data is with the four additional plots included, relative to 2009 and 2012 when HV-1 and HV-2 were the only plots monitored. Of the 67 species, 15 were non-native. For a full species list, along with average number of individual plants and average percent cover, refer to Appendix A. Based on relative abundance, Garlic Mustard (*Alliaria petiolata*) was the most abundant plant with 37% relative abundance (Figure 3). It is important to note that most Garlic Mustard plants were small first year basal florets. The second most abundant species was Pennsylvania Sedge (*Carex pensylvanica*) with a relative abundance of 19%, followed by Blue-stemmed Goldenrod (*Solidago caesia*) at 9%. Canada Mayflower, non-native Japanese Hedge Parsley, and Wild Sarsaparilla were tied at 3% relative abundance.

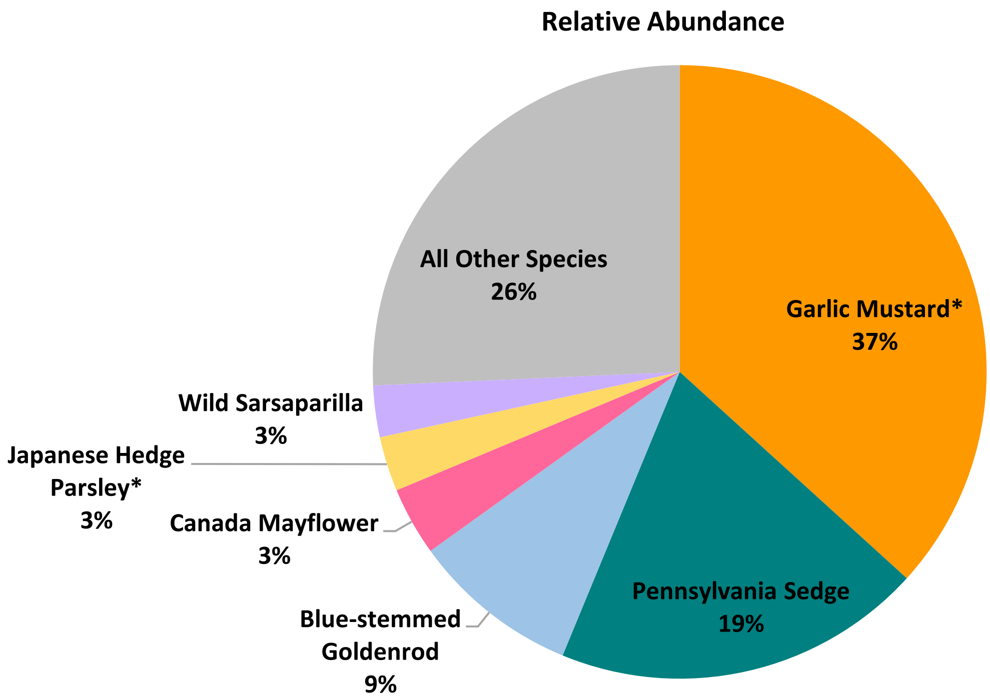


Figure 3. Top 6 species in ground vegetation surveys (24 quadrats) based on relative abundance from HV-1 – HV-6 for 2018 forest monitoring; Non-native plants marked with an asterisk (*).

As is presented in Table 5 below, the minimum and maximum number of plant stems or clumps can be viewed for the most common plants recorded from the ground vegetation surveys. Other than Avens (*Geum* sp.), which was detected at all plots except one, non-native invasive Garlic Mustard (*Alliaria petiolate*) was present across all forest monitoring plots. Garlic Mustard had the highest number of plants at HV-3 with a maximum of 241 stems recorded but was more abundant at HV-4 as it was detected in all four quadrats. At HV-4, there was a minimum of 40 stems and a maximum of 182 stems recorded. Similarly, Garlic Mustard was distributed across all four quadrats at HV-5 as well. HV-1 and

HV-6 had the least amount of Garlic Mustard with a maximum number of 10 and 4 stems respectively. Both Japanese Hedge Parsley (*Torilis japonica*) and Nipplewort (*Lapsana communis*) were most abundant at HV-4 with a maximum number of 30 and 28 stems detected, respectively. Blue-stemmed Goldenrod (*Solidago caesia*) and Dwarf Nightshade (*Circaea alpine*) were detected at three forest monitoring plots, while Canada Mayflower (*Maianthemum canadense*), Pennsylvania Sedge (*Carex pensylvanica*) and Wild Sarsaparilla (*Aralia nudicaulis*) were present at only two plots based on ground vegetation surveys.

Table 5. Minimum and maximum stem/clump counts from all ground vegetation surveys (24 1x1m quadrats) in all Hendrie Valley forest monitoring plots for 2018 for the top 10 most abundant species by stem/clump count; non-native species are bolded.

Species	HV-1		HV-2		HV-3		HV-4		HV-5		HV-6	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Avens Species *Geum* sp.	0	1	0	2	0	1	0	14	2	12	-	-
Blue-stemmed Goldenrod *Solidago caesia*	17	79	5	13	-	-	-	-	-	-	5	11
Canada Mayflower *Maianthemum canadense*	0	3	-	-	-	-	-	-	-	-	12	38
Dwarf Nightshade *Circaea alpina*	-	-	0	18	-	-	4	17	0	2	-	-
Garlic Mustard *Alliaria petiolata*	**0**	**10**	**0**	**14**	**0**	**241**	**40**	**182**	**16**	**72**	**0**	**4**
Japanese Hedge Parsley *Torilis japonica*	-	-	-	-	-	-	**0**	**30**	**1**	**7**	-	-
Maple Species *Acer* sp.	-	-	-	-	-	-	0	20	-	-	-	-
Nipplewort *Lapsana communis*	**0**	**1**	**0**	**1**	-	-	**0**	**28**	**0**	**7**	-	-
Pennsylvania Sedge *Carex pensylvanica*	0	42	-	-	-	-	-	-	-	-	0	149
Wild Sarsaparilla *Aralia nudicaulis*	13	24	-	-	-	-	-	-	-	-	0	0

Note: Wild Sarsaparilla (*Aralia nudicaulis*) was at HV-6 but was not growing within the ground vegetation plots; had percent cover recorded in a quadrat (plant was leaning in, thus contributed only to percent cover).

When comparing the amount of space occupied (a plant's percent cover), Wild Sarsaparilla (*Aralia nudicaulis*) had the most coverage with a relative cover of 18% (Figure 4), despite only being present in two forest monitoring plots (refer to Table 5). Although no Wild Sarsaparilla was growing within the ground vegetation quadrats at HV-6, they were growing just outside the quadrats and percent cover was recorded where the plant's leaves overlapped the quadrats. Garlic Mustard (*Alliaria petiolate*) and Pennsylvania Sedge (*Carex pensylvanica*) were tied, with both having a relative cover of 10%. White Ash (*Fraxinus americana*) had a relative cover of 8%, followed by Blue-stemmed Goldenrod (*Solidago caesia*) and Green Ash (*Fraxinus pennsylvanica*) both at 5% relative cover.

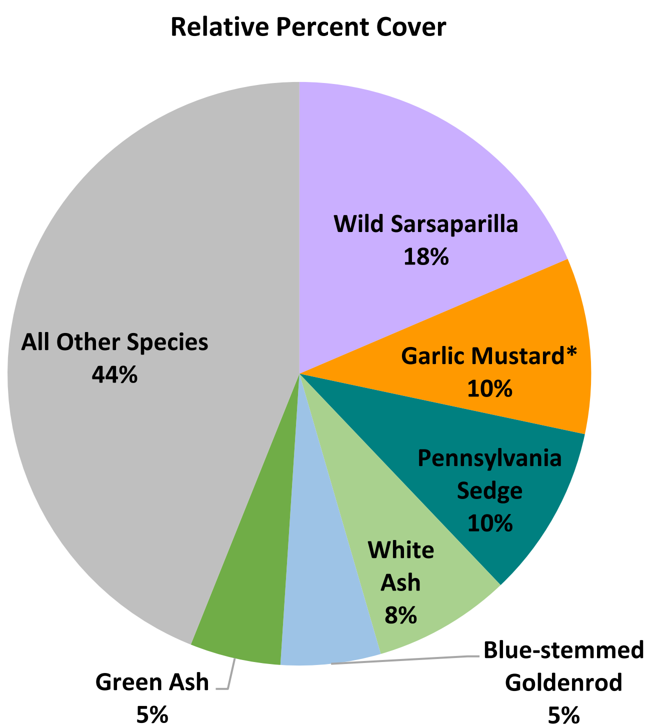


Figure 4. Top 6 species in ground vegetation surveys (24 quadrats) based on relative percent cover from HV-1 – HV-6 for 2018 forest monitoring; Non-native plants marked with an asterisk (*).

Comparing trends over monitoring years between 2009 to 2018, Figure 5 displays native verse non-native average percent cover from Hendrie Valley (HV-1 and HV-2), Cootes Paradise south shore, Cootes Paradise north shore, and the 2018 values for Hendrie Valley when all six plots are considered. Since monitoring began in 2009, the average percent cover of native plants in Hendrie Valley at the two monitoring sites has remained relatively stable. There was a slight increase in the average percent cover for native plants, with 56% in 2009 and 65.8% in 2018. When considering all six plots, native plant cover drops to 51.8%. Cootes Paradise north and south shore show similar trends to Hendrie Valley's, with slight increases in average native plant cover, as can be viewed below. A striking difference between the three nature sanctuaries is the large gap between average native and non-native plant cover. However, the strongest trend detected in Hendrie Valley is the increase in the average percent cover of non-native plants from HV-1 and HV-2. Non-native average percent cover in 2009 was 0.69%; in 2010 was 0.81%;

2012 was 1.31%; and 2018 was 4.75%. Although the overall average percent cover is small when compared to native plant cover per monitoring year, the trend foreshadows possible increases in non-native plant cover in the future at the two plots, and when all six plots are considered the relative abundance jumps up to 14.47%, just under the value for Cootes Paradise south shore. Comparing non-native plant cover to the other two nature sanctuaries, the south shore has significantly more non-native plant cover; however, when all six Hendrie Valley plots are considered there is little difference between the two nature sanctuaries. Another apparent difference between the nature sanctuaries is that Hendrie Valley consistently has higher native ground vegetation cover.

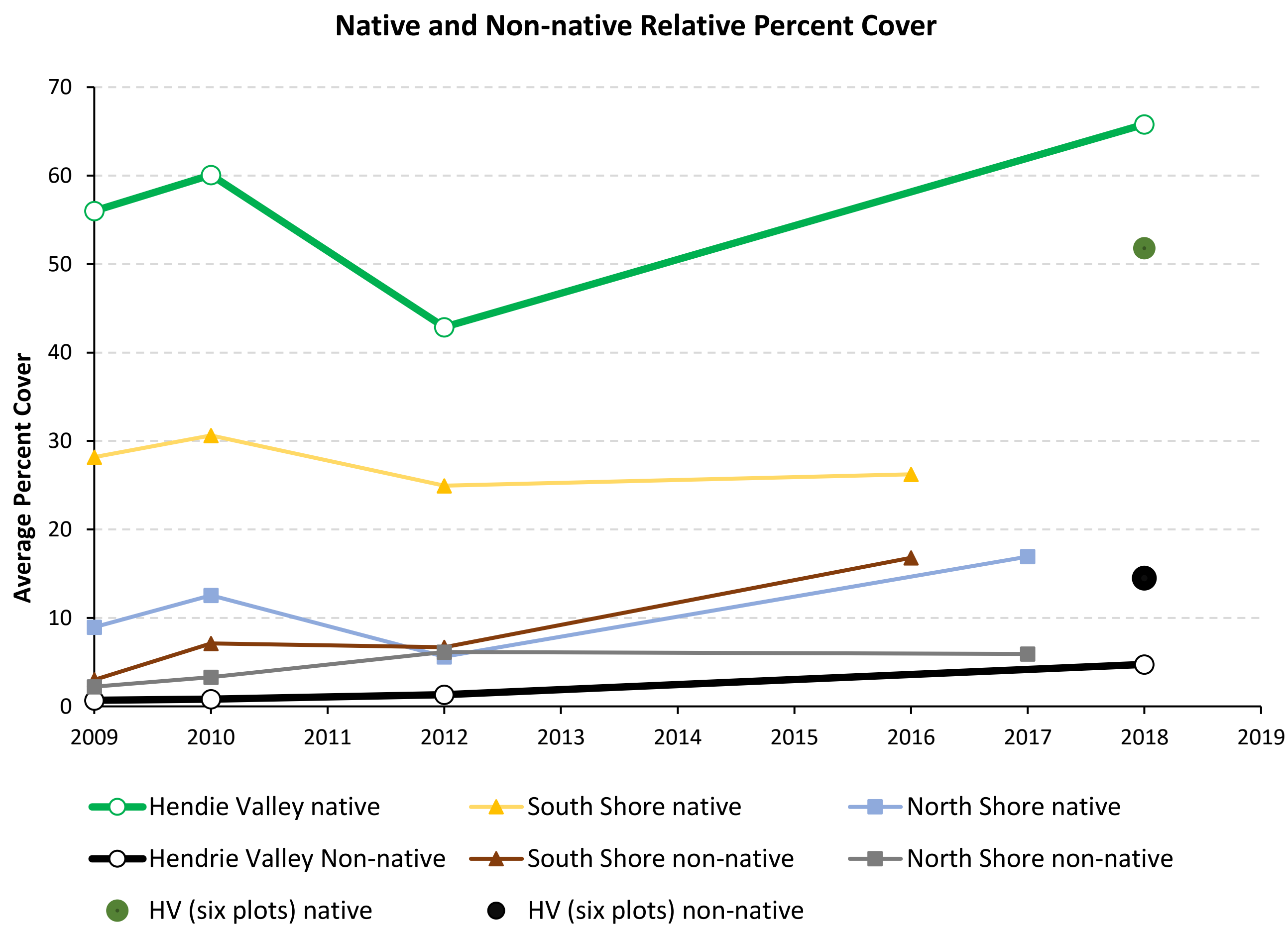


Figure 5. Average percent cover of native and non-native ground vegetation plants for Hendrie Valley, Cootes Paradise south shore and Cootes Paradise north shore forest monitoring plots.

In 2018 a total of 15 non-native plants were recorded from all ground vegetation quadrats in the six forest monitoring plots in Hendrie Valley. Comparing the average non-native plant cover occupied by individual non-native species, Garlic Mustard (*Alliaria petiolate*) occupied the most cover on average and was the dominant non-native ground plant (Figure 6). Second dominant species in the ground layer was Amur Honeysuckle (*Lonicera maackii*), followed by European Buckthorn (*Rhamnus cathartica*), Burdock (*Artium minus*), and Nipplewort (*Lapsana communis*). For a list of the non-native species that make up the “All other non-natives”, refer to Appendix A.

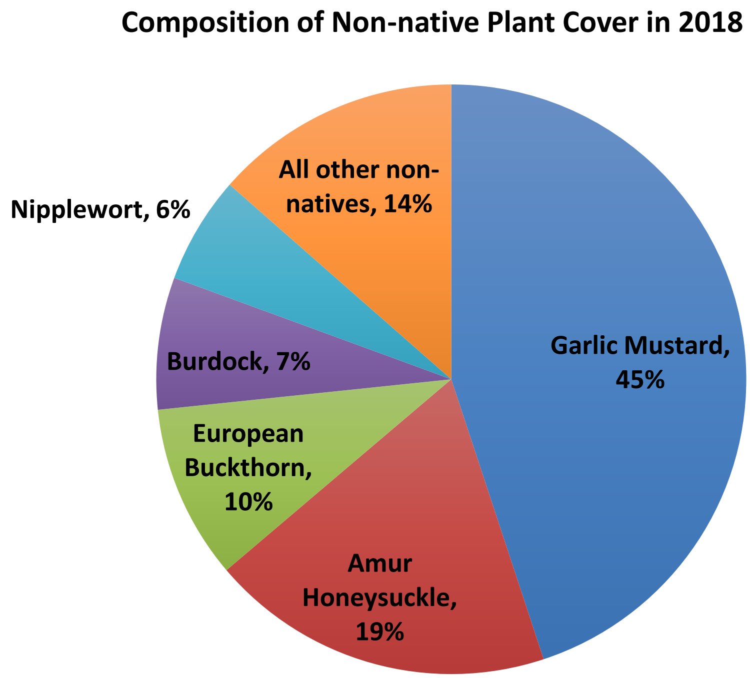


Figure 6. Total non-native species percent cover averaged from 2018 Hendrie Valley ground vegetation surveys from all 24 quadrats (HV-1 – HV-6); average percent cover based on total percent cover for all 15 non-natives recorded.

It has been observed in forest floor layers of other forest monitoring plots outside Hendrie Valley that there is a relationship between the amount of leaf litter and bare ground cover (Burtenshaw, 2010; Vincent, 2018), which appears to be present in Figure 7 (below). In HV-1 and HV-2, when leaf litter cover on average is high, bare ground cover is low and vise-versa. There also appears to be a possible relationship between moss cover and bare ground. Both moss and bare ground cover is similar between 2009 and 2010, with the average cover for moss at 4% and bare ground at 22% in 2009 and 4.2% for moss and 21.9% for bare ground in 2010. However, in 2012 no moss was recorded, and bare ground cover increased significantly. In 2018 moss cover is present again and bare ground cover lowered. For 2012 the relationship between leaf litter and bare ground cover was stronger but it is also possible that moss cover had been present but was missed during surveys. One thing to keep in mind when looking at the average cover of leaf litter and bare ground is that both forest monitoring plots are located on slopes, with HV-2 on a very steep slope. Thus, during rain, snow melt, or high wind events it is likely that leaves on the ground are moved further down the slope. The increase of woody debris in 2018 may reflect an increase in dead wood from stressed and dying trees. Regardless, further data collection is required before significant trends in forest floor cover can be observed.

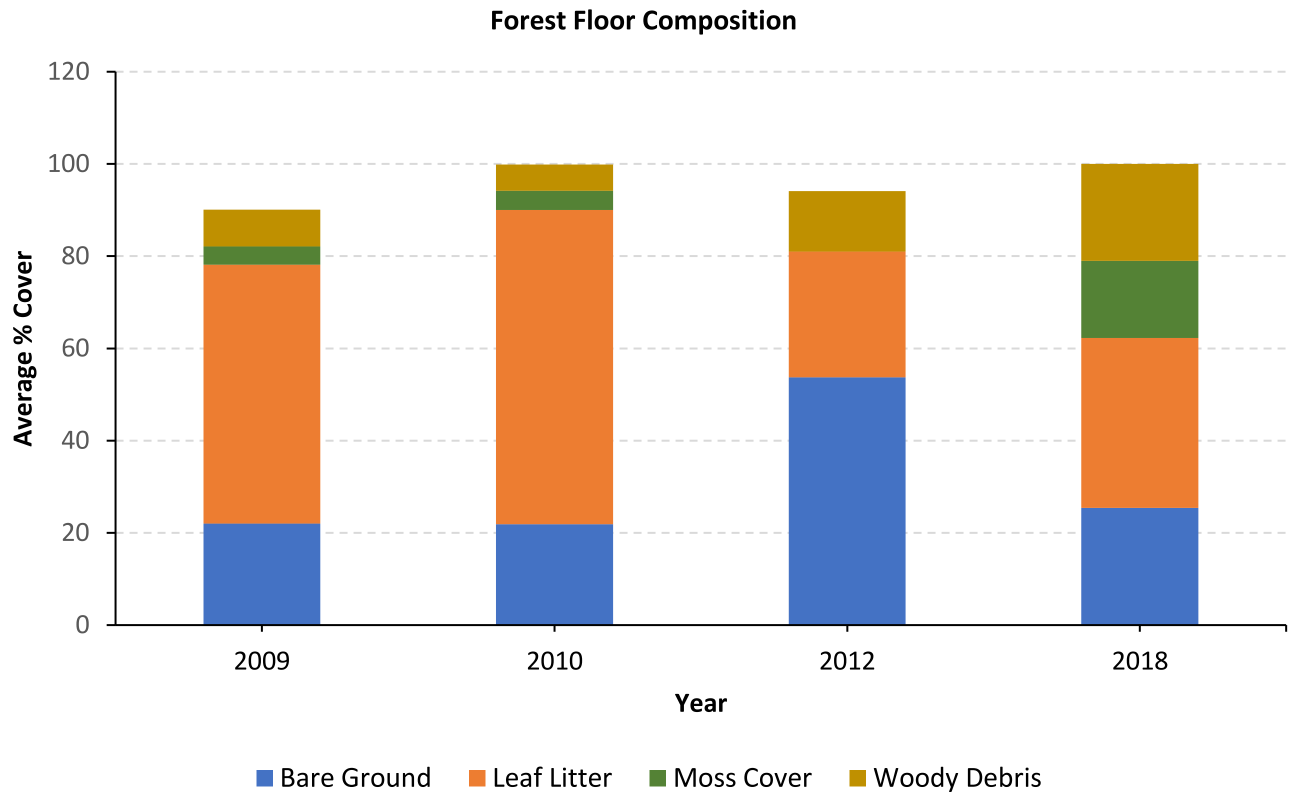


Figure 7. Average percent cover per 1 by 1m ground vegetation survey quadrate (4 per plot) of forest floor composition in Hendrie Valley during monitoring years for HV-1 and HV-2.

Note: Forest floor percent cover does not always equal 100 percent as the forest floor is composed of multiple layers. For example, live 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 2 by 2 meter sub-plots, four of which are located outside of the official 20 by 20 meter monitoring plots which may result in additional species records. Table 6 presents tree regeneration survey results from 2018 for all six forest monitoring plots which summarizes all tree seedlings (16 to 200 cm in height) and saplings (>200 cm in height) present.

Table 6. 2018 tree regeneration summary for seedlings (16-200 cm) and saplings (>200 cm) for HV-1 – HV-6 showing total number counted, relative abundance and number of forest monitoring plots each species occurred in. Non-native species are in bold.

Species	Seedlings (16-200cm)		Saplings (>200cm)		# plots
	total #	relative abundance	total #	relative abundance	
Sugar Maple	36	35.29%	0	0.00%	1
White Ash	29	28.43%	3	25.00%	3
Green Ash	20	19.61%	4	33.33%	2
Black Maple	8	7.84%	0	0.00%	1
Black Cherry	3	2.94%	0	0.00%	1
Manitoba Maple	**3**	**2.94%**	**0**	**0.00%**	**2**
Large-toothed Aspen	2	1.96%	0	0.00%	1
Norway Maple	**1**	**0.98%**	**3**	**25.00%**	**2**
Amelanchier species	0	0.00%	1	8.33%	1
Slippery Elm	0	0.00%	1	8.33%	1

Species Richness:	**10**
Non-native species:	**2**

A total of 10 species were recorded in the tree regeneration surveys, 2 of which were non-native. The results of the sapling (>200 cm) data reflects the 2018 understory results; confirming that Green Ash, White Ash and Norway Maple are the most common understory species, with the three species making up over 80% of the 5 sapling species detected in the tree regeneration surveys. There was greater species diversity (8) in the seedling (16-200cm) results where Sugar Maple had the greatest abundance (35.29%) followed by White Ash (28.43%) Green Ash (19.61%) and Black Maple (7.84). The native Maples, however, only occurred in the regeneration surveys at 1 forest monitoring plot out of the 6 which was HV-4 Quarry Forest on the north side of the valley. White Ash and Green Ash occurred at 3 and 2 forest monitoring plots, respectively.

Ecological Land Classification

A total of 57.24 hectares of terrestrial (21.44), wetland (20.31) and aquatic (15.49) systems have been surveyed in Hendrie Valley Nature Sanctuary. The portion of the valley that remains to be classified is approximately 18 hectares. About 95% of this is terrestrial and 5% wetland. Figure 8 shows the mapped ELC polygons within Hendrie Valley coloured by community class (ex. Forest, Woodland, Marsh, Swamp) and labeled by vegetation community type - the finest level of resolution in ELC. The area marked in semi-translucent white depicts the remaining area of RBG property to be classified. Forested areas outside of this (mostly along the north side of the valley) are not owned and managed by RBG. Table 7 lists all vegetation community types present in Hendrie Valley and shows the number of polygons associated per vegetation type and the total area covered.

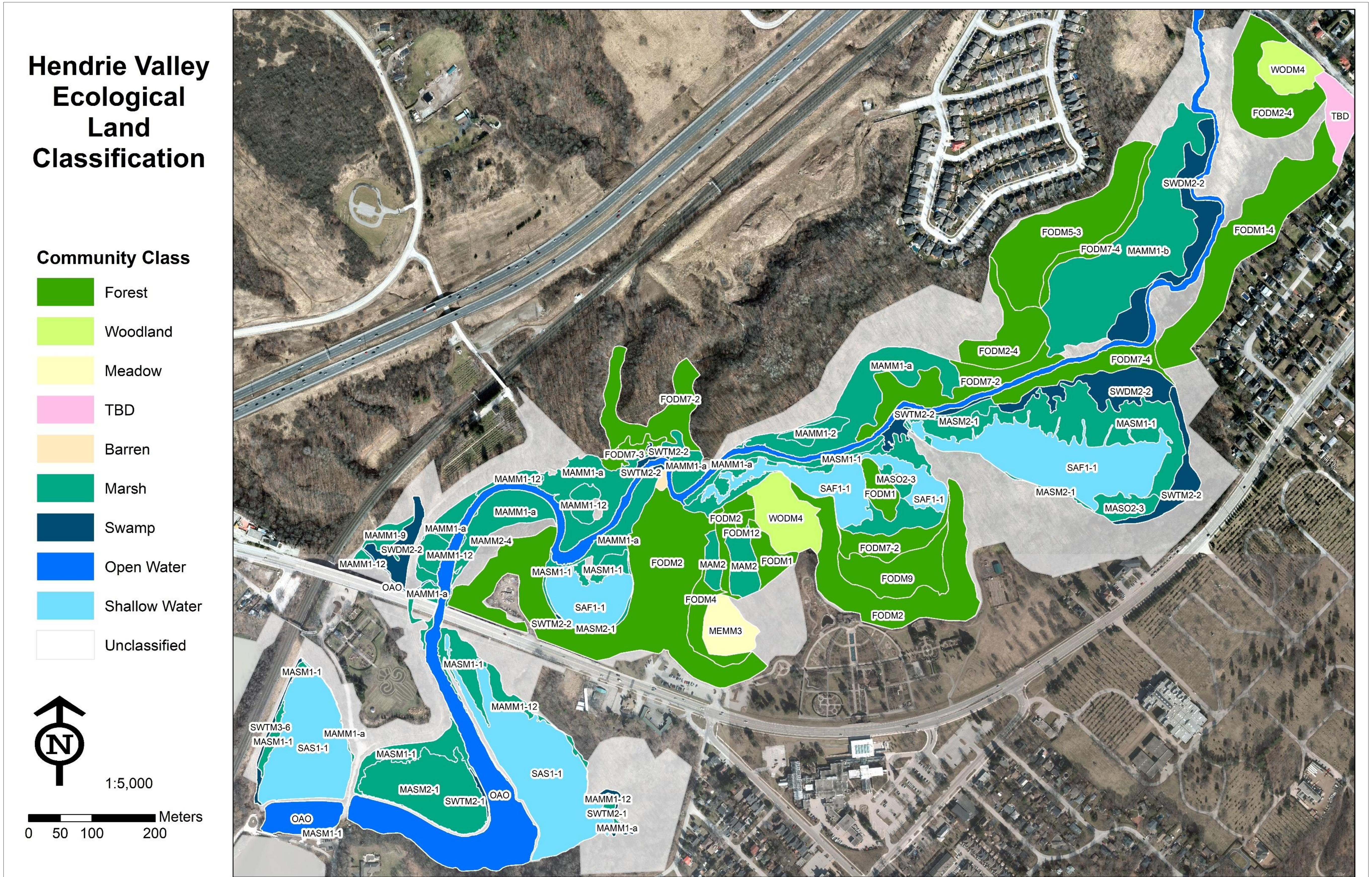


Figure 8. Map showing the updated Ecological Land Classification of Hendrie Valley; polygons coloured by Community Class and labeled by Vegetation Community Type

Table 7. Summary of updated ELC Vegetation Community Types for Hendrie Valley

TERRESTRIAL SYSTEM		**22 Polygons**	**Area (ha)**
Forest		**17**	**18.68**
FODM1-3	Dry-Fresh Black Oak Deciduous Forest Type	1	0.33
FODM1-4	Dry-Fresh Mixed Oak Deciduous Forest Type	1	0.36
FODM2-1	Dry-Fresh Oak - Red Maple Deciduous Forest Type	1	5.07
FODM2-2	Dry-Fresh Oak - Hickory Deciduous Forest Type	1	0.36
FODM2-4	Dry-Fresh Oak Hardwood Deciduous Forest Type	3	4.57
FODM4-8	Dry-Fresh Black Cherry Deciduous Forest Type	1	0.41
FODM5-3	Dry-Fresh Sugar Maple - Oak Deciduous Forest Type	1	2.30
FODM7-2	Fresh-Moist Green Ash - Hardwood Lowland Deciduous Forest Type	3	2.80
FODM7-3	Fresh-Moist Willow Lowland Deciduous Forest Type	1	0.22
FODM7-4	Fresh-Moist Black Walnut Lowland Deciduous Forest Type	2	1.14
FODM9-2	Fresh-Moist Oak - Maple Deciduous Forest Type	1	1.04
FODM12	Naturalized Deciduous Plantation	1	0.08
Woodland		**2**	**1.58**
WODM4-4	Dry-Fresh Black Walnut Deciduous Woodland Type	2	1.58
Meadow		**1**	**0.60**
MEMM3	Dry-Fresh Mixed Meadow Ecosite	1	0.60
TBD ***		**1**	**0.53**
Barren		**1**	**0.05**
WETLAND SYSTEM		**42 Polygons**	**Area (ha)**
Marsh		**32**	**16.82**
MAM2-9	Jewelweed Forb Mineral Meadow Marsh Type	1	0.63
MAMM1-12	Common Reed Graminoid Mineral Meadow Marsh Type *	6	0.91
MAMM1-2	Cattail Graminoid Mineral Meadow Marsh Type	1	0.23
MAMM1-5	Fowl Manna Grass Graminoid Mineral Meadow Marsh Type **	9	5.14
MAMM1-9	Narrow-leaved Sedge Graminoid Mineral Meadow Marsh Type	1	0.21
MAMM1-b	Pasture Grass Graminoid Mineral Meadow Marsh Type	1	3.68
MAMM2-4	Mixed Forb Mineral Meadow Marsh Type	1	0.02
MASM1-1	Cattail Mineral Shallow Marsh Type	5	3.53
MASM1-2	Bulrush Mineral Shallow Marsh Type	1	0.04
MASM2-1	Forb Mineral Shallow Marsh Type	4	1.99
MASO2-3	Water Willow Organic Shallow Marsh Type	2	0.46
Swamp		**10**	**3.49**
SWDM2-2	Green Ash Mineral Deciduous Swamp Type	3	2.39
SWTM2-1	Red-osier Dogwood Mineral Deciduous Thicket Swamp Type	2	0.17
SWTM2-2	Silky Dogwood Mineral Deciduous Thicket Swamp Type	4	0.82
SWTM3-6	Mixed Willow Mineral Deciduous Thicket Swamp Type	1	0.10

AQUATIC SYSTEM		8 Polygons	Area (ha)
Open Water		**2**	**5.55**
OAO	Open Water Aquatic	2	5.55
Shallow Water		**6**	**9.94**
SAF_1-1	Water Lily - Bullhead Lily Floating-leaved Shallow Aquatic Type	4	5.05
SAS_1-1	Pondweed Submerged Shallow Aquatic Type	2	4.89
	Total Classified	**72**	**57.24**
Unclassified	**Majority Dry-Fresh Oak and Oak - Maple - Hickory Deciduous Forest Ecosite**	**TBD**	**~ 18**

* TBD – this polygon represents where the RBG "Director's House" used to be. The area is a mix of historically planted ornamentals and restored meadow which makes it difficult to classify within the ECL system.

** Common Reed Graminoid Mineral Meadow Marsh Type polygons have since been treated with herbicide. Restoration efforts to encourage native plant communities are underway.

*** Fowl Manna Grass Graminoid Mineral Meadow Marsh Type actually represents Reed Mannagrass (*Glyceria maxima*), a non-native invasive species.

There are 12 deciduous forest vegetation community types represented in Hendrie Valley. Seven of the 12 vegetation types have oaks described as the dominant or co-dominant species. Dry-Fresh Oak -Red Maple and Oak – Hardwood Deciduous Forest Types make up over half of the classified Forest area (9.67 ha). Consulting the maps from the previous ELC in Hendrie Valley (which was completed in the early 2000's) the majority of the remaining 18 hectares of land to be surveyed is likely to be Oak and Oak Maple-Hickory dominant.

Non-Native Species – Terrestrial Polygons

Because this report primarily focuses on the forested lands of Hendrie Valley, only terrestrial polygons were looked at in depth for non-native species. A total of 162 non-native species were recorded in the 22 polygons classified terrestrial. Figure 9 shows the distribution of non-native species richness by polygon for Hendrie Valley. Polygons associated with the south side of the valley have a complete range of non-native species richness from under 10 to over 60 while the polygons on the north side of the valley have a range between 10 and 40 non-native species.

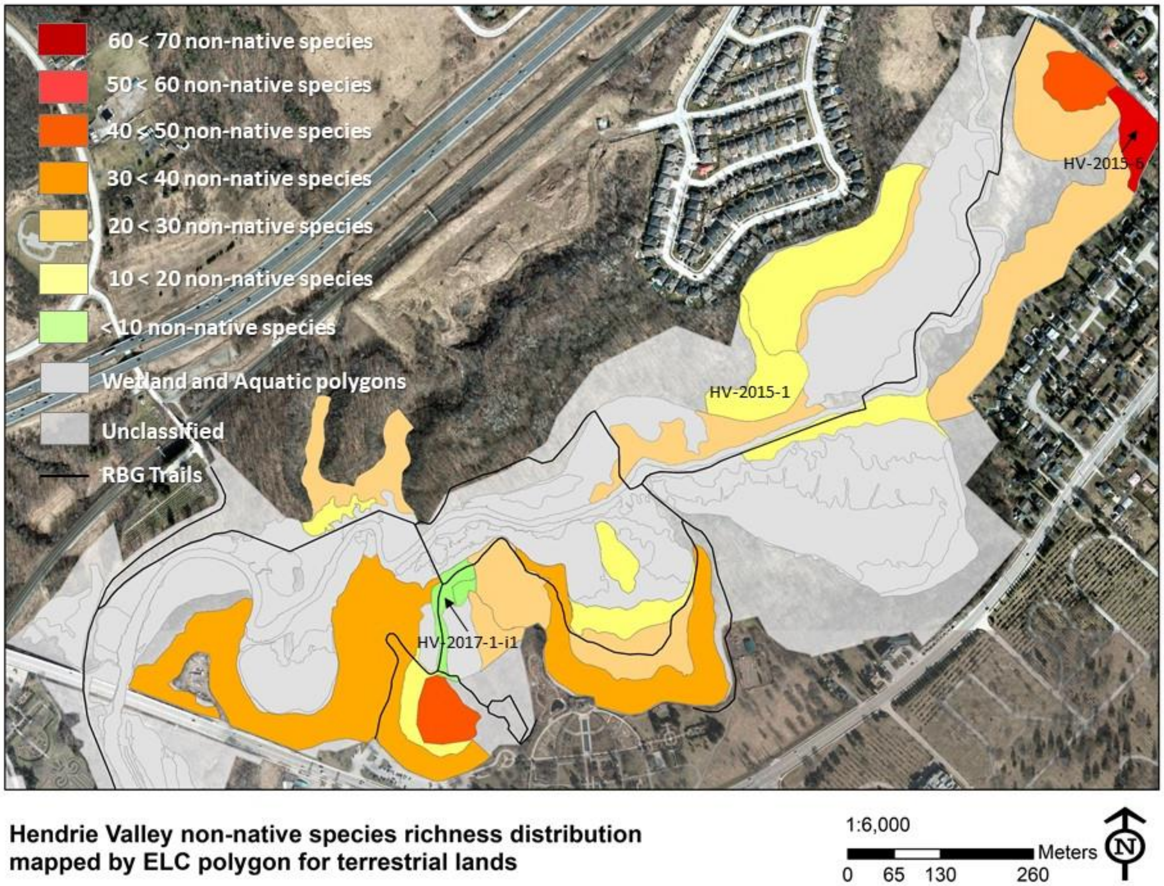


Figure 9. Map of Hendrie Valley terrestrial ELC polygons showing non-native species richness distribution.

The polygons coloured dark orange and red contain the largest numbers of non-native species. These polygons are located near the north-eastern edge of the property (which was previously associated with the old Director's House) and immediately west of the woodland garden (known as the Rifle Range). Polygon HV-2015-6 had the most non-native species richness (61).

The polygons with the lowest number of non-native species are mapped inclusions of a larger polygon. These inclusions are associated with management efforts to control non-native species and are much smaller in area compared to the other terrestrial ELC polygons. HV-2017-1-i1 had the lowest invasive species richness (6). The polygon with the lowest species richness of non-native plants was HV-2015-1 with 13 species recorded.

Table 8 lists the non-native species that were found to be present in 50% or more of the terrestrial polygons. Garlic mustard was found in all but one polygon. Common Buckthorn, Nipplewort and Common Privet were also among the more frequently recorded non-native species. The weediness index of the species in Table 8 are ranked -3 and -2 which indicates that they are known invasive plants in Ontario.

Table 8. List of non-native species present in 50% or more of the 22 terrestrial polygons

Species Common	Species Scientific	Weediness index (-1 to -3)	# polygons
Garlic Mustard	*Alliaria petiolata*	-3	21
Common Buckthorn	*Rhamnus cathartica*	-3	19
Nipplewort	*Lapsana communis*	-2	18
Common Privet	*Ligustrum vulgare*	-2	15
Common Dandelion	*Traxacum officionale*	-2	13
Japanese Hedge Parsley	*Torilis japonica*	-3	14
Multiflora Rose	*Rosa multiflora*	-3	14
Amur Honeysuckle	*Lonicera maakii*	-2	13
Bittersweet Nightshade	*Solanum dulcamara*	-2	13
Dame's Rocket	*Hesperis matronalis*	-3	12

Native Species and Coefficient of Conservatism – Terrestrial Polygons

Because this report mostly focuses on the lands of Hendrie Valley Nature Sanctuary, only terrestrial polygons were looked at in depth for native species. A total of 359 native species were recorded in the 22 polygons classified under the terrestrial system. Polygon HV-2016-6 had the most native species richness with 107 species recorded while HV-2017-1-i2 had the fewest native species recorded with 11. These polygons are identified in Figure 10.

Table 9. List of native species present in 50% or more of the 22 terrestrial polygons

Common Name	Scientific Name	Coefficient of Conservatism	# of polygons
Riverbank Grape	*Vitis riparia*	0	19
Manitoba Maple	*Acer negundo*	0	17
Green Ash	*Fraxinus pennsylvanica*	3	16
Black Cherry	*Prunus serotina*	3	14
Black Raspberry	*Rubus occidentalis*	1	13
Black Walnut	*Juglans nigra*	5	12
Canada Goldenrod	*Solidago canadensis*	1	12
Eastern White Pine	*Pinus strobus*	4	12
Jack-in-the-pulpit	*Arisaema triphyllum*	5	12
Virginia Stickseed	*Hacklia virginiana*	5	12
White Vervain	*Verbena urticifolia*	4	12
Red Oak	*Quercus rubra*	6	11
White Avens	*Geum canadense*	3	11

The species listed in Table 9 are those present in 50% or more of the 22 terrestrial polygons. Riverbank Grape occurred in the most polygons (19) and Manitoba Maple was the tree most frequently present in each polygon (17), followed by Green Ash (16). Canada Goldenrod, Jack-in-the-pulpit, Virginia Stickseed and White Vervain were all herbaceous plants present in 12 of the 22 terrestrial polygons. There was no single native shrub species that was recorded in over 50% of the terrestrial polygons. Compared to the list of non-native species in Table 8, it is evident that some of the non-native shrubs are well distributed. The average Coefficient of Conservatism (CC) was calculated for each individual polygon and again for all terrestrial polygons. The average CC for the terrestrial system in Hendrie Valley was 4.0 which places it into the lowest end of the moderately disturbed category. Figure 10 illustrates the distribution of polygons that averaged between 0 and 4 (disturbed) and 4 and 7 (moderately disturbed). No polygons were found to have an average CC in the slightly disturbed (7-8) or the undisturbed (8-10) categories

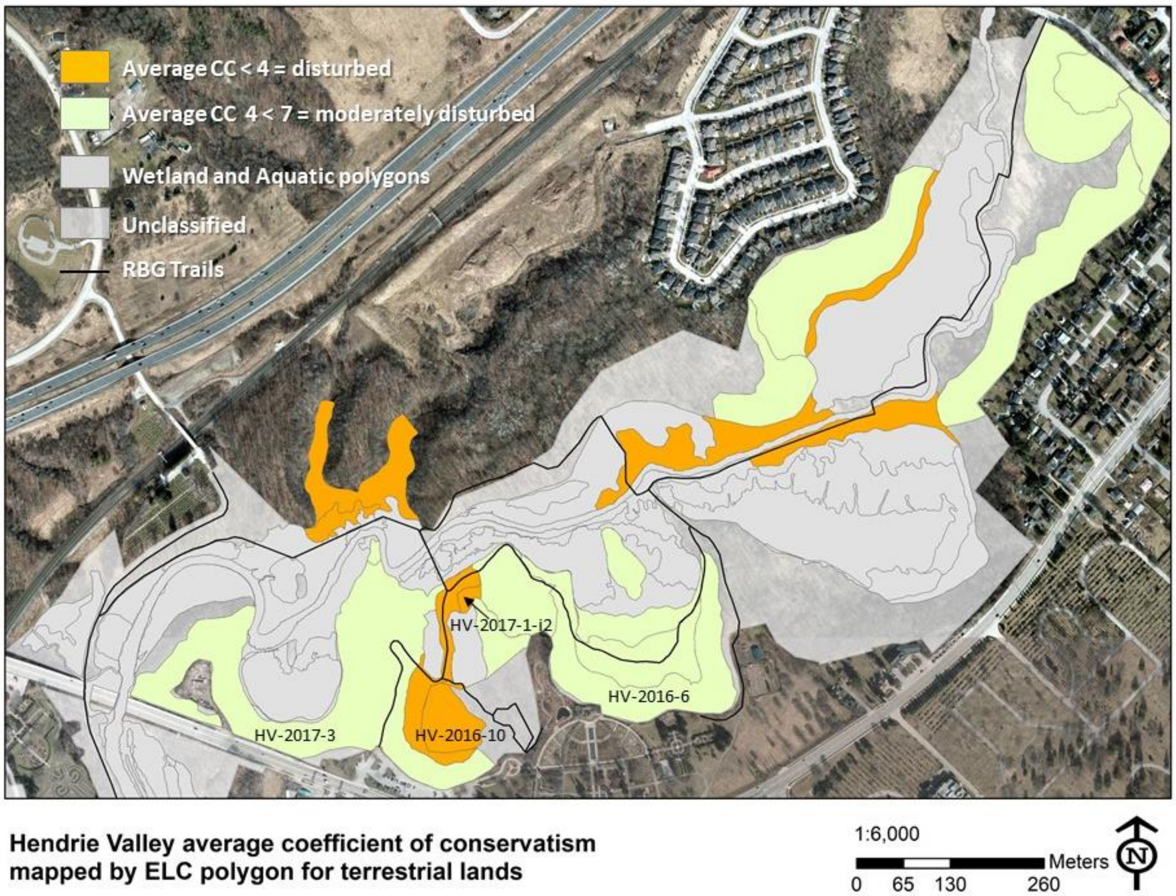


Figure 10. Map of Hendrie Valley terrestrial ELC polygons showing the distribution of the average Coefficient of Conservatism disturbance categories.

Most polygons associated with the disturbed category, identified in orange in Figure 10, fall within the lowland terrestrial areas with fresh-moist soils. Vegetation types of these polygons include Fresh-Moist Green Ash - Hardwood Lowland Deciduous Forest Type and Fresh-Moist Black Walnut Lowland Deciduous Forest Type. Most of the upland polygons with dry-fresh soils fall within the moderately disturbed category. Isolines identifying the topography of the valley were left out of Figure 10 as they would have crowded the features on the map. Polygons with the highest CC values were HV-2016-6 and HV-2017-3 (4.9 and 4.8) while HV-2017-1-i2 and HV-2016-10 had the lowest (2.7 and 2.5).

Breeding Bird Surveys

During the month of June, RBG staff conduct breeding bird surveys across the properties. In Hendrie Valley Nature Sanctuary, there are seven plots that were surveyed in 2018 with six coinciding with forest monitoring plots. Below is a summary of the results collected from these surveys. Trends presented from Hendrie Valley over time are from the original monitoring plots – HV-1 and HV-2.

For a list of all bird species based on known detections in Hendrie Valley Nature Sanctuary, refer to Appendix B. Detections would be either from RBG staff, researchers or from volunteers participating in the Long Watch Project or Marsh Monitoring Program. For more information on the Long Watch Project and how to get involved, please refer to their website at: https://longwatch.ca.

Species Richness

In 2018, across all seven Hendrie Valley breeding bird survey plots, there was a total of 42 bird species detected with an average of 12 bird species per visit. Across the seven plots, an average of 24 individual birds were seen and/or heard per visit. The most abundant bird detected was Red-winged Blackbird (*Agelaius phoeniceus*) with a relative abundance of 32% (Figure 11 below). Second most abundant bird in Hendrie Valley from 2018 breeding bird surveys was Black-capped Chickadee with a relative abundance of 6%, tied with Northern Cardinal at 6%. Fourth in abundance is American Robin followed by Yellow Warbler at 5% and 4% relative abundance, respectively. For a comparison of common birds based on relative abundance between the Escarpment Properties (Rock Chapel and Berry Tract), Hendrie Valley, and Cootes Paradise north and south shore, refer to the *2018 Bird Monitoring Summary* (Peirce, 2019a).

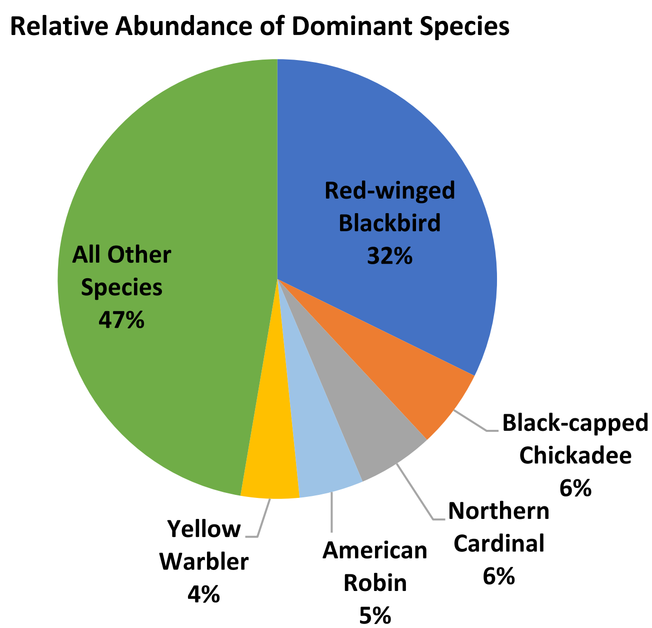


Figure 11. Relative abundance of top 5 bird species from 2018 breeding bird surveys in Hendrie Valley at all seven plots.

When comparing data over time, only HV-1 and HV-2 data is presented, such as in Figure 12 below. The total number of bird species (or species richness) recorded in Hendrie Valley has been increasing overall since breeding bird surveys began in 2009. The fewest number of species observed in Hendrie Valley occurred during the second year of monitoring (2010), with 23 species recorded. In contrast, a total of 37 species were recorded in 2017. An extra species was detected last year, thus a total of 38 species were recorded in 2018. That new species was a House Sparrow (*Passer domesticus*), however since 2013 additional species that have been detected multiple years include Eastern Kingbird (*Tyrannus tyrannus*), Eastern Phoebe (*Sayornis phoebe*) and Wood Duck (*Aix sponsa*). Species richness in Cootes Paradise south and north shore also show overall increasing trends between 2009 and 2018. Overall, all three nature sanctuaries have increasing species richness trends during the June breeding seasons.

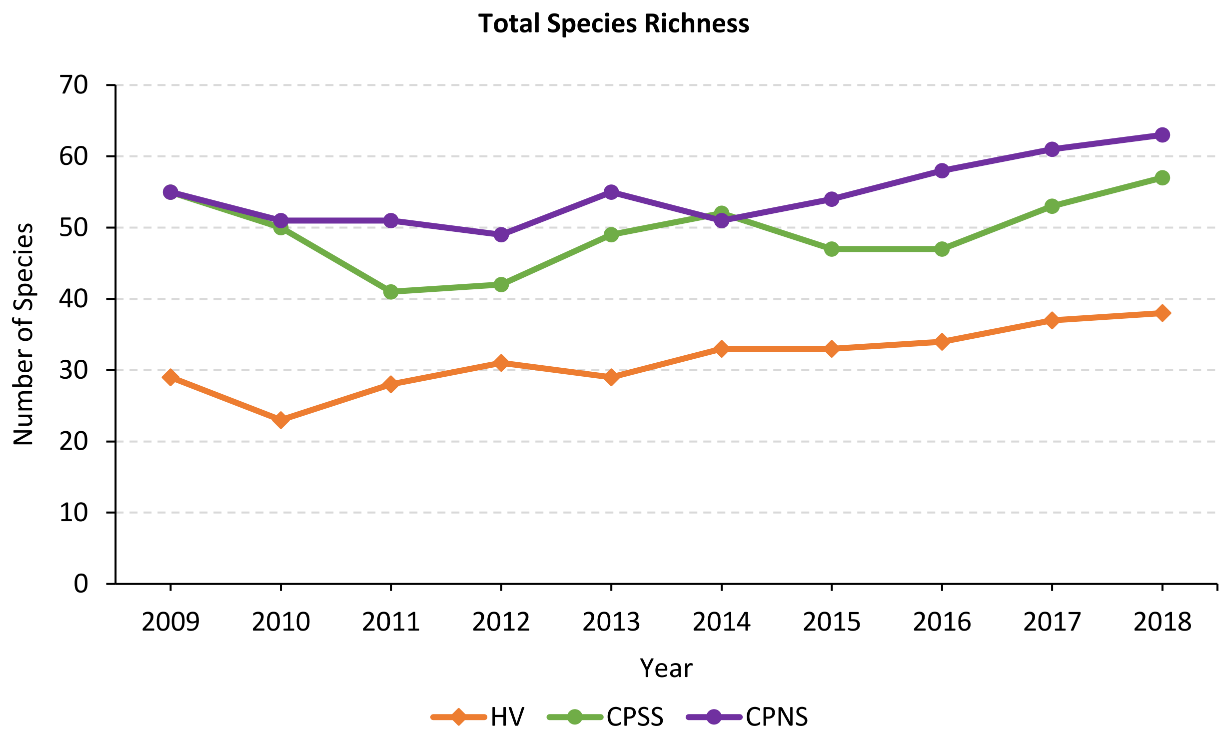


Figure 12. Fluctuations in total number of bird species detected, aurally and visually, during breeding bird surveys in Hendrie Valley (HV-1 and HV-2), Cootes Paradise south and north shore.

When analyzing average individual bird detections per visit per plot, as presented below, Hendrie Valley has had an increase in average detections since 2012 (Figure 13). Again, the data for Hendrie Valley that is presented in Figure 13 is from the original two plots, HV-1 and HV-2. In 2018 there were about 31 average bird detections per visit per plot in Hendrie Valley, while in 2017 there was an average of 36 birds detected per visit per plot. There is more fluctuation and a slightly increasing trend in average bird detections per visit per plot on the south shore of Cootes Paradise over the years than at Hendrie Valley or Cootes Paradise north shore, as presented in Figure 13. In 2017 an average of 32 bird detections per visit per plot occurred on the south shore, whereas in 2018 there were around 27 average detections per visit per plot. The north shore of Cootes Paradise had the least amount of fluctuations in average bird detections per visit per plot over the 10 survey years, with an increase of 7 average bird detections between 2015 to 2018.

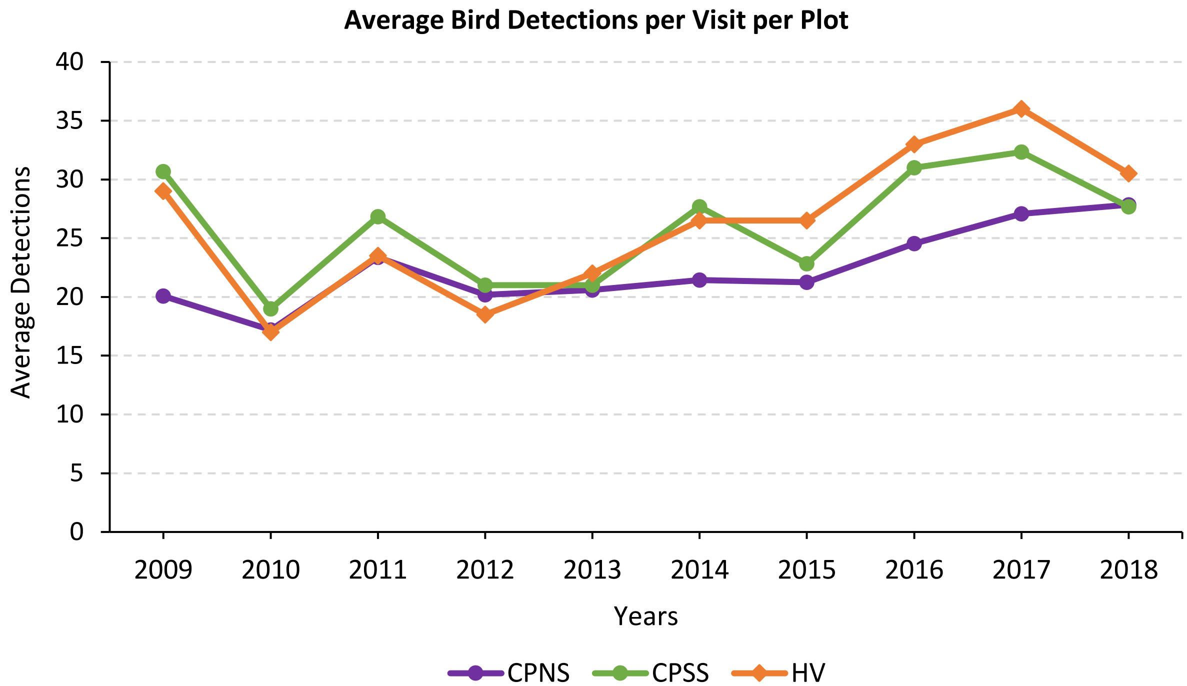


Figure 13. Average bird detections per visit per plot from breeding bird surveys in Hendrie Valley (HV-1 and HV-2), Cootes Paradise south shore and north shore.

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 (University of Idaho, 2009). The Shannon Diversity Index has hovered between 2.24 and 2.82 from 2009 to 2018, with a weak linear relationship. Due to the slight increase in species richness between 2009 and 2018 (Figure 12), it is interesting that the Shannon Diversity Index has remained relatively constant over the 10 years of study (Figure 14). Therefore, the number of detected species in Hendrie Valley may be increasing while their relative abundance remains slightly constant. For example, a new species of one individual may be recorded, producing a low relative abundance, resulting in a minimal affect on the Shannon Diversity Index value.

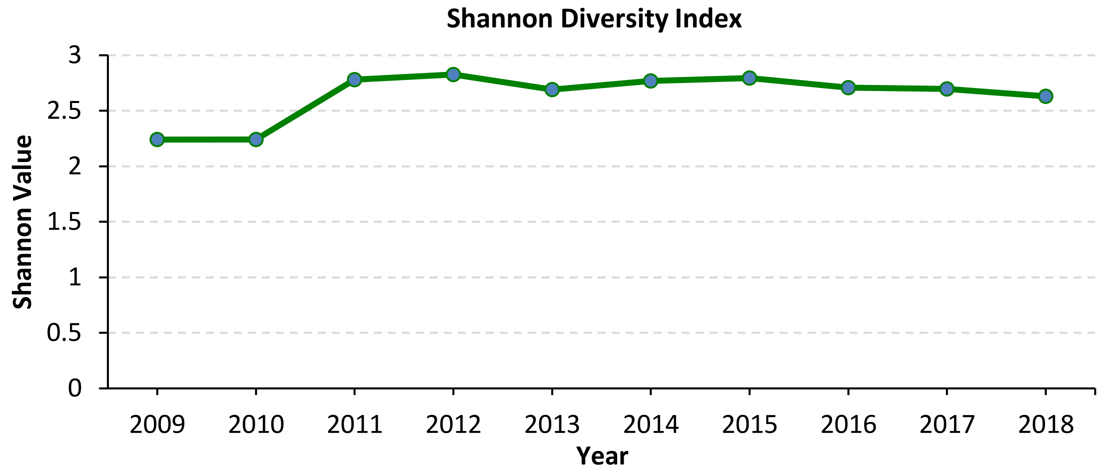


Figure 14. Shannon Diversity Index values per year from 2009 and 2018 based on breeding bird surveys in Hendrie Valley (HV-1 and HV-2).

Changes in Abundance

Overall species richness at HV-1 and HV-2 during survey years appears to be relatively stable with a slight increase. However, there are notable abundance changes in detections for some species, such as the Wood Thrush (*Hylocichla mustelina*), Canada Goose (*Branta canadensis*) and Black-capped Chickadee (*Poecile atricapillus*). In the section below there is more information regarding possible causes for changes in bird species abundances.

Wood Thrush are listed as Special Concern provincially and Threatened federally, thus it is imperative that they continue to be monitored and threats to populations are reduced. Detections of Wood Thrush have declined since breeding bird surveys began in Hendrie Valley, dwindling from 4 detections in 2009 to 0 detections in 2015 and onward (Figure 15). A total of 10 Wood Thrush detections were recorded between 2009 and 2014. Even with the additional five plots in 2018, which gave more coverage across the nature sanctuary, no Wood Thrush were detected. However, since 2013, Wood Thrush detections have increased across the other RBG properties.

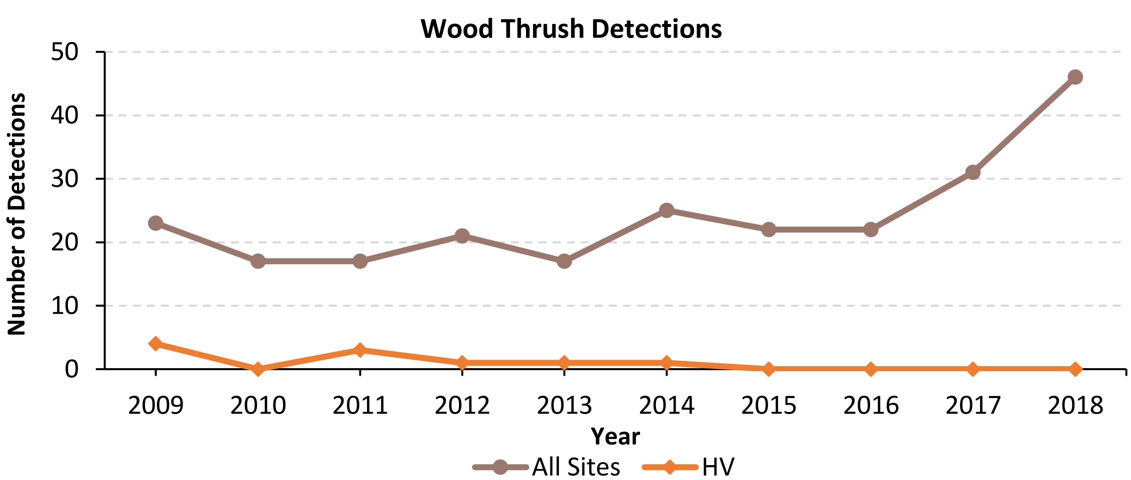


Figure 15. Total number of Wood Thrush detections during breeding bird surveys from 2009 to 2018 in Hendrie Valley (HV-1 and HV-2) and across all other sites.

Detections of Canada Goose (*Branta canadensis*) have substantially increased since monitoring began in 2009 (Figure 16). No Canada Geese were detected in the survey plots from 2009 to 2015. In 2016, only 2 detections were recorded. However, the largest number of detections occurred in 2018 when there were 15 detections of Canada Geese. This is a dramatic increase from only 5 detections in the previous monitoring year. Part of the reason for the increase in detections is likely due to a clearer view of part of a pond within one of the survey plots as the once young tree saplings there have matured. Another possible reason for the increase in detections may be the result of halted goose egg oiling, as egg oiling stopped in 2014 (Court & Theysmeyer, 2015). This may be coincidence – regardless, it will be interesting to see if the number of Canada Goose detections changes in the next 5 plus years.

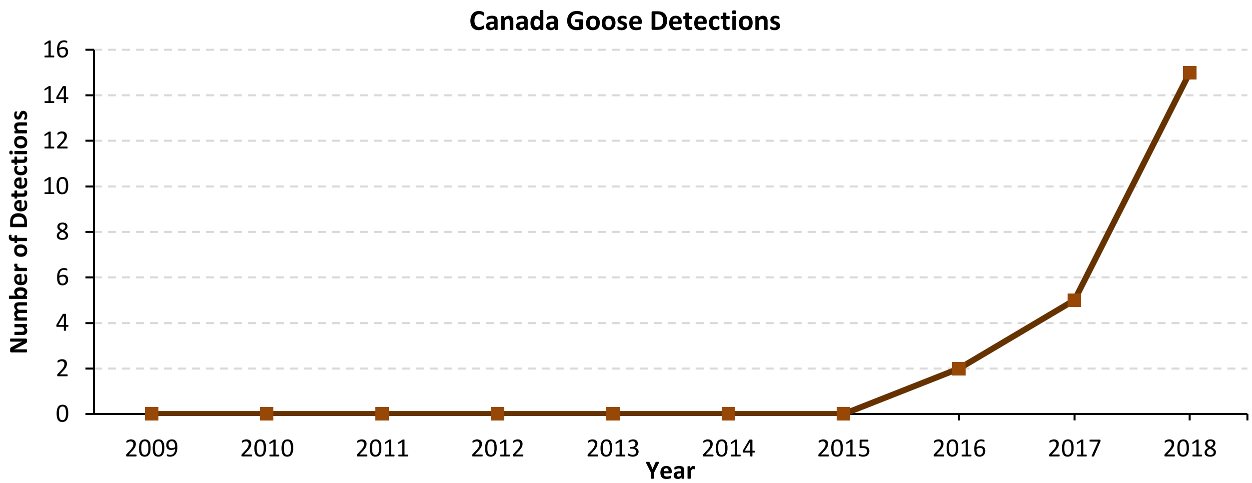


Figure 16. Number of detections of Canada Goose from 2009-2018 during breeding bird surveys in Hendrie Valley at HV-1 and HV-2.

Another change observed from breeding bird survey data is that Black-capped Chickadee (*Poecille atricapillus*) detections are on a gradual decline since 2009 (Figure 17). The average number of Black-capped Chickadee detections per plot in each nature sanctuary can be seen in Figure 17. On a whole, Black-capped Chickadee detections have been declining since monitoring began. The Escarpment Properties are the most variable in the number of detections per plot. However, in 2018 each nature sanctuary fell between 4 and 6 detections. The decrease in the number of detections may be due to several things, including changes in their behaviour, nesting competition pressure from non-native species like House Sparrows, and/or egg and chick predation pressures from rodents.

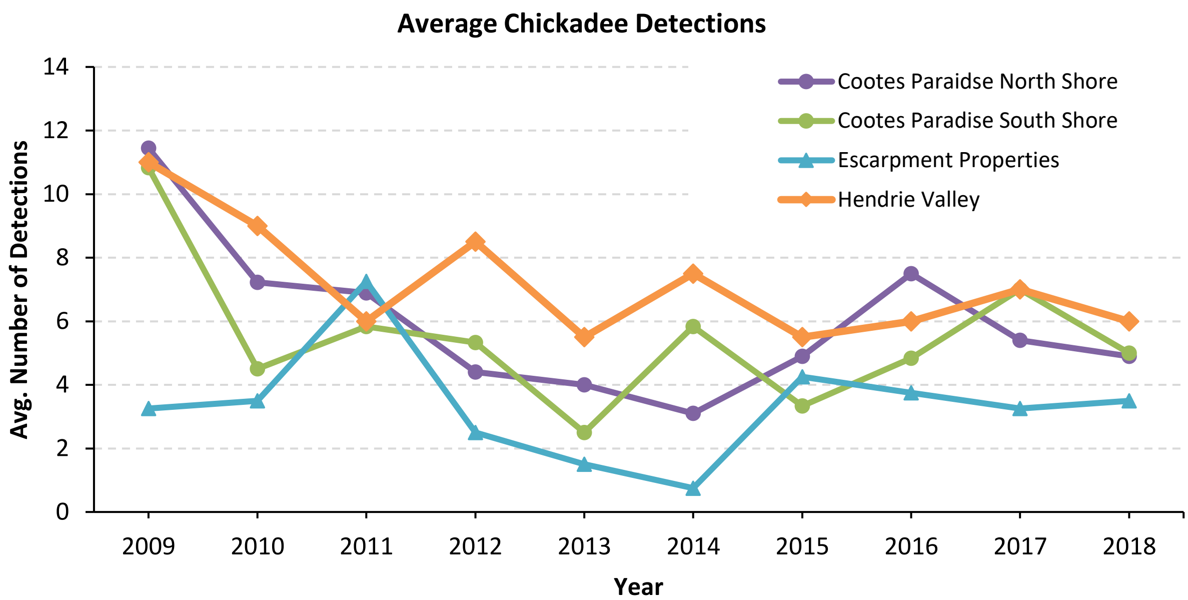


Figure 17. Average number of total Black-capped Chickadees detections per plot in each nature sanctuary during breeding bird surveys from 2009-2018; new sites **excluded**.

Generally, detections of Black-capped Chickadees during breeding bird surveys have declined in Hendrie Valley at the original two plots since 2009 (Figure 17), dropping by an average of 5 detections over the course of 10 survey seasons. The average number of chickadees detected per breeding bird survey visit, along with the maximum and minimum number detected can be observed in Table 10. The distribution of chickadees across Hendrie Valley is not even, as most chickadees on average were detected around HV-3 and HV-1 compared to the other plots.

Table 10. Black-capped Chickadee detections from 2018 breeding bird surveys in all Hendrie Valley plots; most up-stream sites listed first.

Monitoring Plot	Avg # per Visit	Maximum # Detected	Min # Detected	# of Visits
HV-5 (Upper Valley)	2	2	2	2
HV-2	0.5	1	0	2
HV-4	0.5	1	0	4
HV-3	3	3	3	2
HV-7	0.5	1	0	2
HV-1	2.5	4	0	4
HV-6 (Lower Valley)	1.5	2	1	2

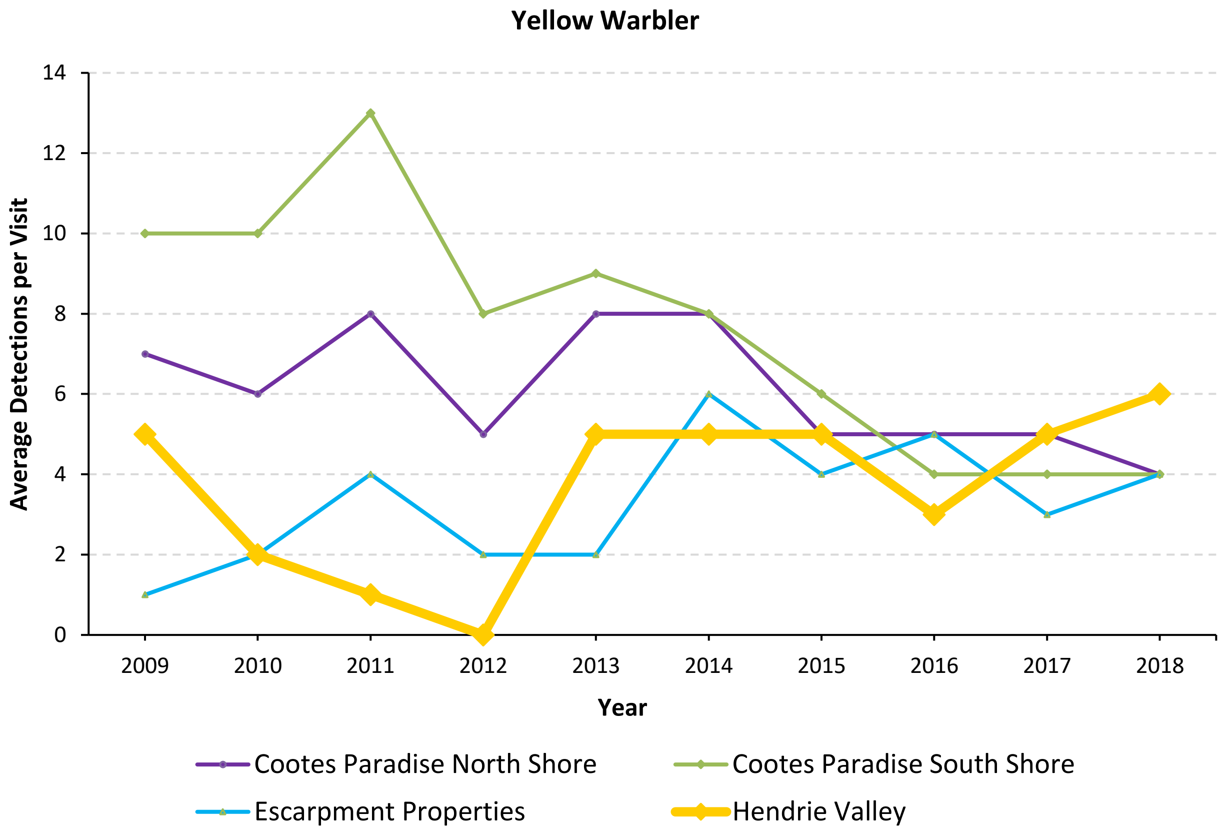


Figure 18. Average detections of Yellow Warbler per visit at HV-1 and HV-2, Escarpment Properties, and Cootes Paradise north and south shore from 2009 to 2018 during breeding bird surveys.

Detections of Yellow Warblers (*Setophaga petechia*) have been declining across the entire property since breeding bird surveys began in 2009 (Figure 18). The nature sanctuary that has experienced the greatest decline in Yellow Warbler detections is Cootes Paradise south shore, where the average number of detections per plot has dropped by more than half during the course of ten years. However, in Hendrie Valley, detections have been rising since 2016. The greatest number of average detections in Hendrie Valley occurred in 2018, with an average of 6 detections per plot.

Breeding: Possible, Probable, Confirmed

RBG conducts yearly monitoring of breeding birds during the height of breeding season (June), with the main goal of identifying species that are using RBG property as their breeding grounds.

Possible and Probable breeding individuals was determined using the following categories:

Possible Breeding	Probable Breeding
• Species observed in its breeding season in suitable nesting habitat (H) • Singing male present/breeding calls heard in its breeding season in suitable nesting habitat (S)	• Pair observed in their breeding season in suitable nesting habitat (P) • Territorial song heard on at least 2 days at the same location, a week or more apart (T) • Courtship or display between a male and a female or 2 males (D) • Visiting probable nest site (V) • Agitated behavior/anxiety calls of an adult (A) • Brood patch on adult female or cloacal protuberance on adult male (B) • Nest-building/excavation of nest hole (N)

A total of 101 possible, 52 probable, and 24 confirmed individual breeders were detected in Hendrie Valley during the 2018 breeding bird surveys (Table 11). HV-1 and HV-2 had the highest number of confirmed breeders at 11 individual birds, while HV-3 and HV-7 had one confirmed breeder. HV-4, HV-5 and HV-6 did not have any confirmed breeding individuals.

Table 11. Number of potential breeding birds at each monitoring plot in Hendrie Valley for 2018.

Site	Possible	Probable	Confirmed	Total Potential Breeders
HV-1	11	9	11	31
HV-2	22	13	11	46
HV-3	19	5	1	25
HV-4	12	4	0	16
HV-5	14	9	0	23
HV-6	13	9	0	22
HV-7	10	3	1	14
All Sites	***101***	***52***	***24***	***177***

Visitor Wildlife Feeding Summary

Peirce, 2018.

Below is a summary from *The Supplemental Wildlife Feeding in Hendrie Valley* report (Peirce, 2019b). Please refer to the full report for more information regarding the study. Most of the study's data was collected during the transect surveys over a period of three months. A total of four trails were visited on 12 to 13 separate occasions which resulted in 1,965 observations of wildlife and 407 number of visitors using the trails, with 156 documented feeding wildlife.

The Mallard (*Anas platyrhynchos*) was the most detected species during trail transects at Cherry Hill Trail with a total of 45% of detections (Figure 19). A distant second most detected species was the Eastern Chipmunk (*Tamias striatus*) which accounted for 13% of all wildlife detections. Non-native House Sparrow (*Passer deomesticus*) was the third highest detected species at 12%. All other species, Black-capped Chickadee (*Poecille atricapillus*), and Blue Jay (*Cyanocitta cristata*) make up the remainder of the detections.

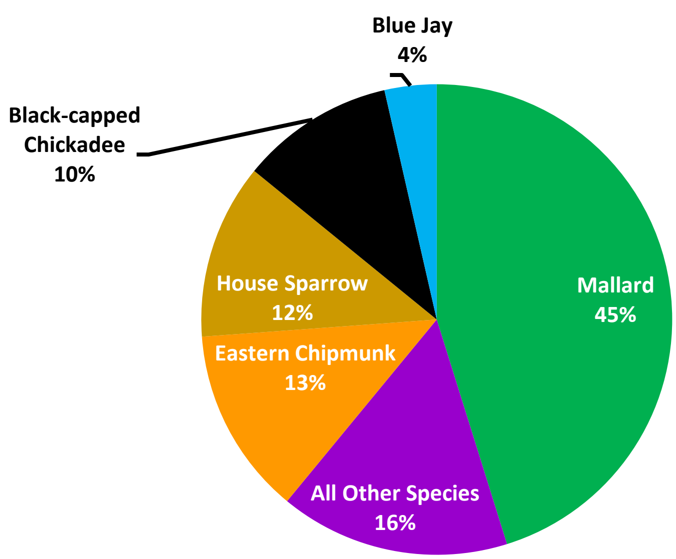


Figure 19. Top five most abundant species observed at Cherry Hill during transects (13 visits) based on number of detections.

The number of wildlife detections per transect appears to be connected to the number of visitors observed along the trail (Figure 20). Cherry Hill had the largest number of wildlife detections at 1,290 along with the highest number of observed visitors at 254. In second place at 338 wildlife and 110 visitor detections was at Grindstone Marshes Trail. Kicking Horse and Creekside Walk trails had the fewest number of wildlife detections and the lowest number of observed visitors.

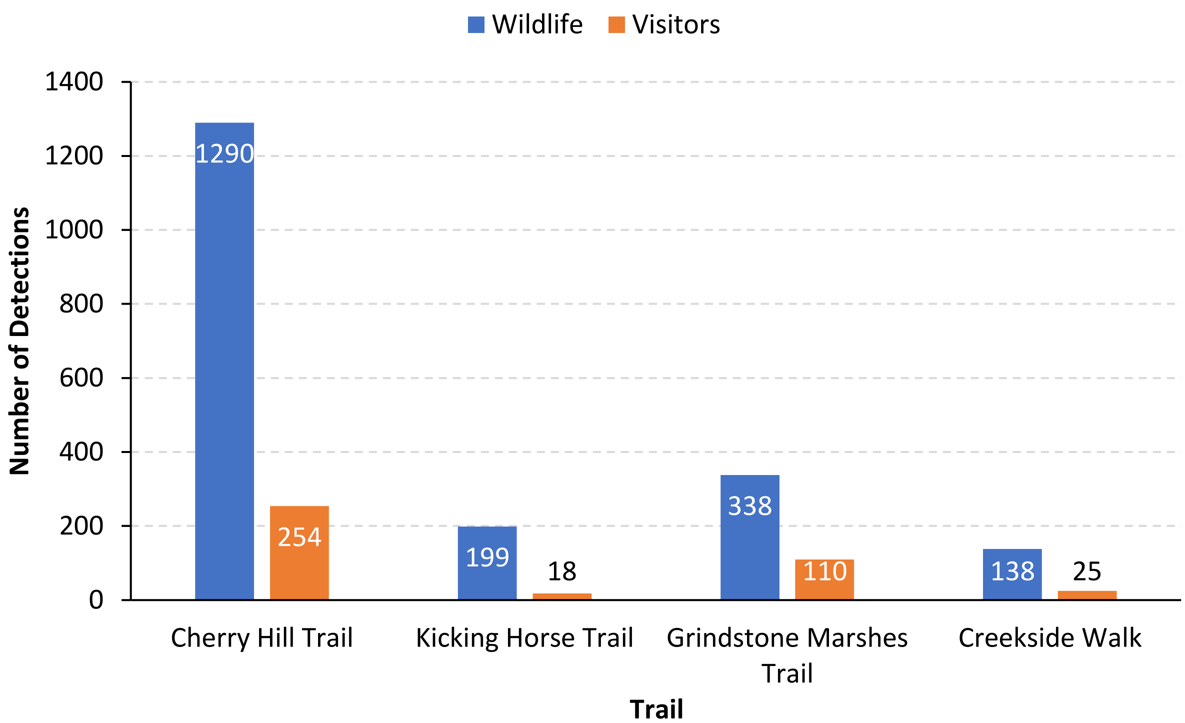


Figure 20. The cumulative number of detections of wildlife and visitors by trail over three months.

The maximum number of detections (in one transect) of Black-capped Chickadees at Cherry Hill was 20 detections (Table 12). This is the highest maximum number detected across the four trails of study. Cherry Hill also had the highest number of average detections per transect with 10 detections. Interestingly, the average number of detections of Black-capped Chickadees per transect at Cherry Hill is higher than the maximum number of detections at the three other trails.

The maximum number of detections of Eastern Chipmunks in one transect was observed at Cherry Hill, with 43 chipmunk detections (Table 12). The average number of chipmunks detected in one transect at Cherry Hill was 12 detections, which is higher than the maximum number detected in one transect at Kicking Horse, Grindstone Marshes Trail, and Creekside Walk.

The maximum number of Mallards detected in one transect at Cherry Hill was 70, with an average of 42 detected per transect (Table 12). These values are incredibly larger than the maximum and average number detected per transect at Kicking Horse, Grindstone Marshes Trail, and Creekside Walk.

Table 12. The average number of detections per transect and the maximum detected in one transect, of popular species being fed by visitors across all study trails in Hendrie Valley over four months of observations.

	Cherry Hill Trail (470 metres; 13 visits)		Kicking Horse Trail (250 metres; 12 visits)		Grindstone Marshes Trail (590 metres; 12 visits)		Creekside Walk Trail (240 metres; 13 visits)	
Species	Avg. # Detected	Max. # Detected	Avg. # Detected	Max. # Detected	Avg. # Detected	Max. # Detected	Avg. # Detected	Max. # Detected
Black-capped Chickadee	10	**20**	3	7	3.1666	5	2.53846	8
Blue Jay	3	**7**	1	3	1.3	4	0.6923	3
Downy Woodpecker	1	**3**	0.083	1	0.5	2	0.23076	1
Eastern Chipmunk	12	**43**	1	4	1.416	8	0.1538	2
Eastern Grey Squirrel	3	**9**	0.833	4	0.833	5	0.7692	4
European Starling	0	0	0	0	0.25	**3**	0	0
House Sparrow	11	**39**	0.25	3	4.5	25	0	0
Mallard	42	**70**	2.25	14	4.166	16	0	0
Northern Cardinal	1	4	1	2	1.3	**5**	0.538	2
Raccoon	0.154	**2**	0	0	0	0	0	0
Red-winged Blackbird	3	**9**	1	6	0.6666	3	0.23076	3
White-breasted Nuthatch	2	**4**	0.5	2	0.5	3	0.23076	1
Wood Duck	3	**13**	0.5	3	0	0	0	0

The number of visitors feeding wildlife and not feeding wildlife at each trail transect can be viewed below in Figure 21. 151 visitors out of a total of 254 visitors observed were feeding wildlife at Cherry Hill during the course of the study. This turns out to be approximately 65% of all visitors seen on the trail. Oppositely, there were only two visitors on Kicking Horse and three visitors at Grindstone Marshes Trail seen feeding wildlife. No visitors were observed feeding wildlife at Creekside Walk, which also had the lowest number of visitor detections across all four trails with 25 visitors observed.

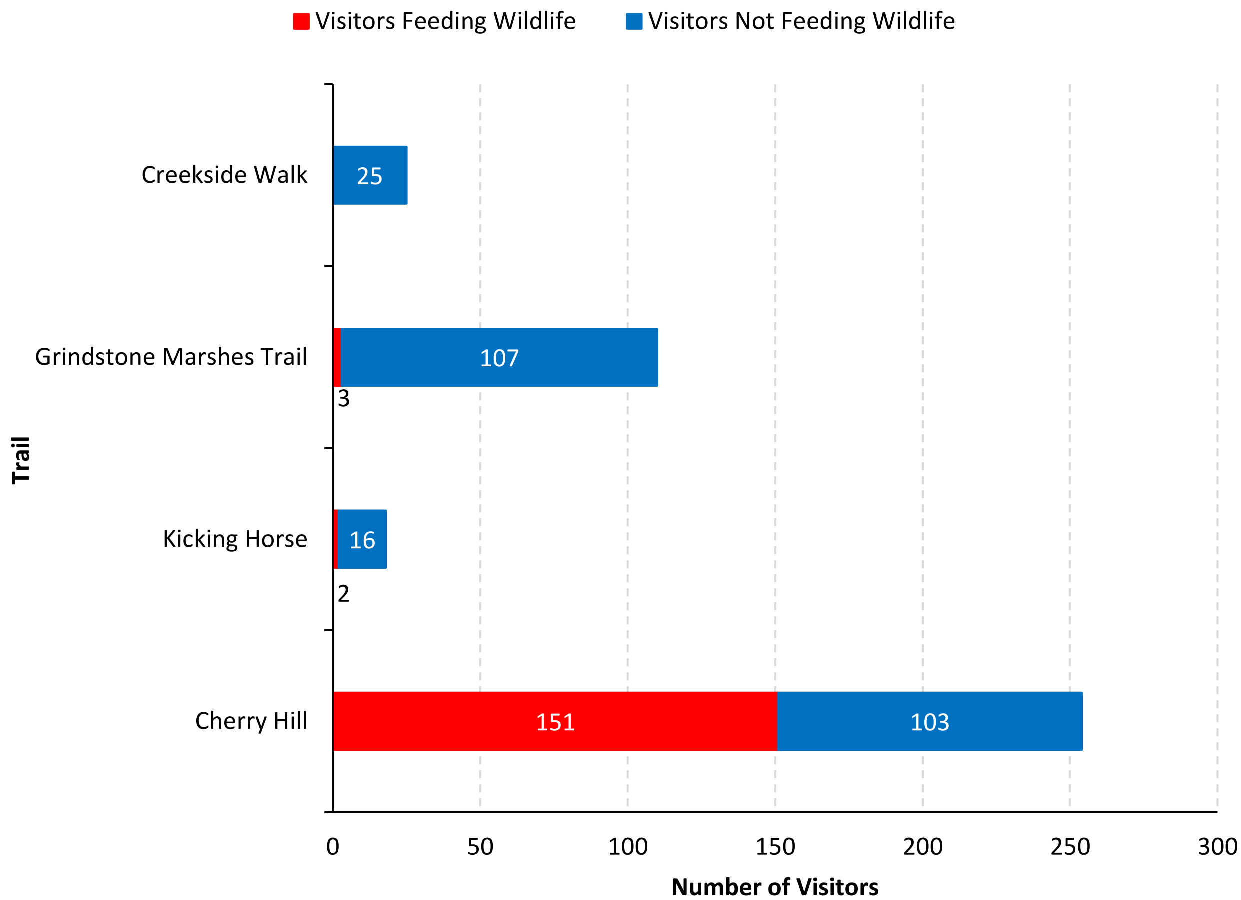


Figure 21. Number of visitors feeding wildlife and not feeding wildlife at each trail.

White proso millet (*Panicum miliaceum*) was the most popular type of supplementary feed used by visitors across all RBG trails (Figure 22). Sunflower seeds were the second most popular supplemental feed, followed by a combination of peanuts, millet, sunflower seeds, peanuts alone, and unknown feed. The unknown category accounts for when the researchers were unable to identify which type of supplemental food a visitor was using to feed the wildlife.

Seed piles along railing in Hendrie Valley – proso millet mix on left, black sunflower seeds on right. Peirce, 2018.

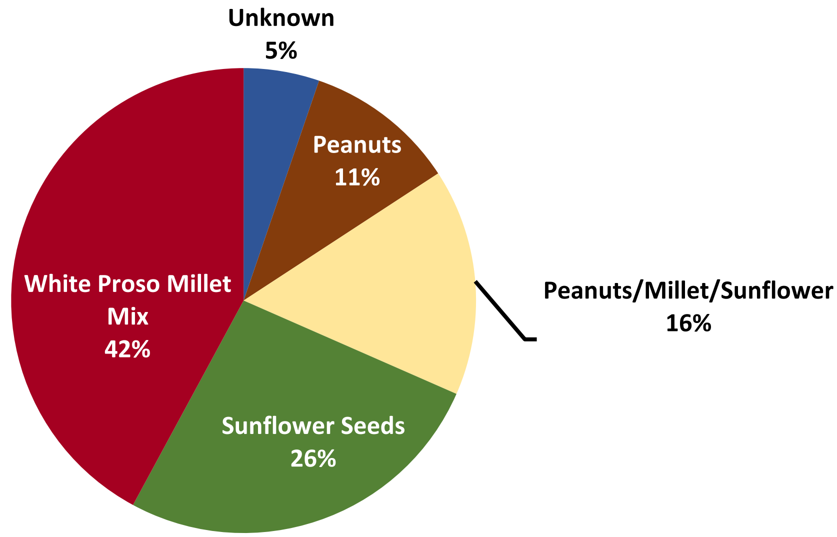


Figure 22. Number of observations of types of supplemental feed brought by visitors on all RBG study trails over four months.

Since 2015, Wood Thrush (*Hylocichla mustelina*) detections at HV-1 (Cherry Hill) during breeding bird surveys have dropped to zero. However, across all other RBG properties, Wood Thrush have continued to be detected at the usual survey plots and at some locations, detections are increasing (Figure 23). Wood Thrush detections across all RBG survey plots have been steadily rising since monitoring began, rising from 23 detections in 2009 to 46 detections in 2018.

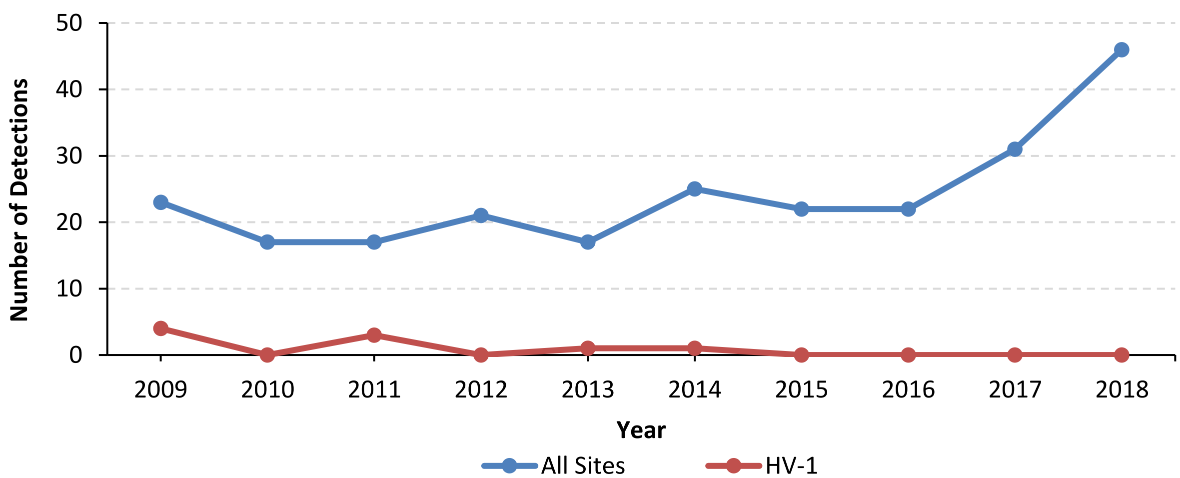


Figure 23. Total number of Wood Thrush detections during breeding bird surveys from 2009-2018 from all other RBG plots and HV-1 (Cherry Hill) from Hendrie Valley.

Amphibian Marsh Monitoring

A total of 4 amphibian species were recorded during the amphibian Marsh Monitoring Program (MMP) surveys in 2018. As displayed below in Table 13, Green Frog (*Lithobates clamitans*) was the most abundant at 21 individuals recorded followed by American Toad (*Anaxyrus americanus*) at only 6, Northern Leopard Frog (*Lithobates pipiens*) at 5, and lastly Spring Peeper (*Pseudacris crucifer*) at 1 individual heard. The total number of amphibians heard in 2018 was low, at 33 individuals heard at nine sites, compared to the last six years of monitoring. The lowest number of amphibians recorded was in 2011 at 17 individuals when five sites were visited.

Table 13. Amphibians recorded during MMP; sites include Sunfish Pond, Blackbird Marsh, and Ponds 1,2,3 & 4.

Species	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2010	2011	2012	2013	2014	2015	2016	2017	2018	Grand Total
American Toad		2	1	4	2	6	1	16	27	10	12	50	3		15	16	13	14	10	6	6	**214**
Gray Treefrog																4		1		9		**14**
Green Frog	24	18	39	18	36	29	49	21	54			1	48	17	67	30	68	41	8	14	21	**603**
Northern Leopard Frog		16	17	10	8	14	15	35	11	13	26		20		25	25	5	21	31	11	5	**308**
Spring Peeper					4				6	2	3	1	50		2	4		1	1	2	1	**77**
Wood frog												2	1									**3**
Grand Total	**24**	**36**	**57**	**32**	**50**	**49**	**65**	**72**	**98**	**25**	**41**	**54**	**122**	**17**	**109**	**79**	**86**	**78**	**50**	**42**	**33**	**1,219**
Total Species	1	3	3	3	4	3	3	3	4	3	3	4	5	1	4	5	3	5	4	5	4	**6**
Sites Visited	5	7	7	7	8	7	7	8	9	9	8	9	9	5	9	9	7	10	9	9	9	**167**

The average number of amphibians heard calling from 1995 to 2018 is presented in Figure 24. There are gaps in data for some years, particularly at the Lower Hendrie Delta sites (Sunfish Pond and Blackbird Marsh). For the Hendrie Valley ponds, Ponds 2 to 4 sites have data records for each year, however, there appears to be no trend. When observing if there is a trend for the total amphibian species recorded over time, there is no significant trend either. Although the average number of individual amphibians is low since 2010, there is a slight increase in the number of species heard which may indicate that marsh restoration efforts (which started in 1994) has had some positive impacts for amphibians in the Hendrie Valley Grindstone Marsh system.

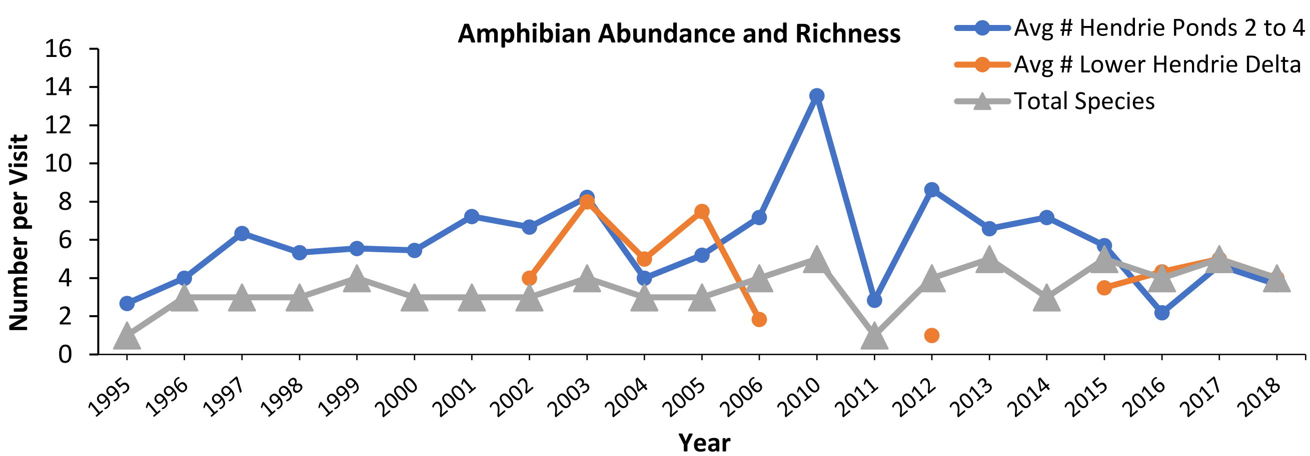


Figure 24. Average number of amphibians and total number of species recorded by volunteers through the Marsh Monitoring Program over time.

Species at Risk

There have been 80 different Species at Risk (SAR) of flora and fauna found on at least one of RBG's properties, with 58 of which recorded in the last 20 years. Of these 80 species, 39 have been observed in Hendrie Valley. Some of the SAR plants have been planted in Hendrie Park's various gardens while others occur naturally in the nature sanctuary. American Chestnut (*Castenea dentata*) has been planted in the gardens but wild growing ones have also been found within RBG's nature sanctuaries. Other planted SAR species like Dense Blazing Star (*Liatris spicata*) and White Wood Aster (*Eurybia divaricata*) are only found in the Horticultural Gardens, whereas Wood Poppy (*Stylophorum diphyllum*) has been planted in the gardens and in Hendrie Valley.

Between 1995 and 2000, Wood Poppy (*Stylophorum diphyllum*) was planted in Hendrie Valley in *ex situ* populations to help with recovery of the provincially and federally Endangered plant (Bowles, 2011; Radassao, 2015). As a result of natural dispersal, some of these planted poppies were recorded in the forest monitoring ground vegetation surveys, with an average of 0.46 stems per vegetation quadrat and 0.96% average cover (Appendix A). In total, there were 11 Wood Poppy stems growing within the vegetation survey quadrats. Through the ground vegetation surveys, changes in stem count and coverage of planted Wood Poppy can be monitored over time.


Male Snapping Turtle with Ranavirus from Cootes Paradise. Piczak, 2018.

In summer 2017, an adult male Snapping Turtle (*Chelydra serpentina*) exhibiting extreme lethargy with lesions on its eyes and body was encountered by a McMaster University student conducting a Master's research project on the area's turtles. The turtle was submitted to a local licensed wildlife rehabilitation centre, where it died soon after. The licensed wildlife custodian submitted the carcass for a necropsy, and test results received early in 2018 confirmed the turtle died of Ranavirus. This case was not only the first laboratory-confirmed case of Ranavirus ever recorded in a Snapping Turtle, but it was also the first laboratory-confirmed case of Ranavirus mortality in a reptile in Canada (McKenzie et al, 2019). Tests for Ranavirus can be conducted on the tissue of freshly deceased individuals. Several other dead reptiles not killed by vehicles have been observed recently in 2018, though they were too decayed to confirm their death was related to Ranavirus. These include a minimum of 2 Snapping Turtles, 2 Red-eared Sliders, 1 Painted Turtle, and 4 dead Northern Watersnakes in Hendrie Valley, as well as a minimum of 3 dead Snapping Turtles in Cootes Paradise marsh. Road mortality of turtles is an ongoing threat, as well as high nest predation from opportunistic mammals. Such mammals include raccoons, skunks, possums, and foxes. For more information on the turtle recovery activities conducted at RBG, refer to the *Turtles of Royal Botanical Gardens Site Specific Recovery Plan* (Harrison & Theysmeyer, 2014).


Close up of the male Snapping Turtle with Ranavirus. Theijn, 2018.

Species at Risk in Canada are protected under the federal Species at Risk Act (SARA) and provincial Endangered Species Act (ESA). For the SARA, plant and animal species are assessed and ranked by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), while for the ESA they are ranked by the Committee on the Status of Species at Risk in Ontario (COSSARO). Species are ranked as either Special Concern, Threatened, Endangered, or Extirpated. Below in Table 14, SAR that have occurred in Hendrie Valley were classified as present if they had been seen or heard in the last 20 years. Species referred to as absent have not been recorded in over 20 years but had been observed or heard on other RBG properties. Those not present on any of RBG's properties in over 20 years were classified as extirpated. It is important to note that not all observations confirm breeding activity, especially when regarding SAR birds as the majority that are detected are migrants. However, 7 of the SAR birds are confirmed breeding within or just outside of Hendrie Valley. All SAR reptiles, insects and mussels found in Hendrie Valley are also confirmed to be breeding individuals.

Table 14. Species at Risk in Hendrie Valley with federal and provincial ranks: Special Concern (SC), Threatened (THR), Endangered (END).

Common Name	COSSARO	SARA	COSEWIC	Last Seen/Heard	Present, Absent or Extirpated
American Columbo	END	END	END	2018	present
American White Pelican	THR	-	-	2018	present
Bald Eagle	SC	-	-	2018	present
Bank Swallow	THR	THR	THR	2015	present
Barn Swallow	THR	THR	THR	2018	present
Black Ash	-	-	THR	2018	present
Black Tern	SC	-	-	1999	present
Blanding's Turtle	THR	THR	END	2018	present
Bobolink	THR	THR	THR	2014	present
Butternut	END	END	END	2017	present
Canada Warbler	SC	THR	THR	2017	present
Chimney Swift	THR	THR	THR	2018	present
Common Nighthawk	SC	THR	SC	2016	present
Eastern Meadowlark	THR	THR	THR	1981	absent
Eastern Musk Turtle	SC	THR	SC	2009/1965	extirpated
Eastern Pondmussel	END	END	SC	2016	present
Eastern Spiny Softshell Turtle	END	THR	END	1984	extirpated
Eastern Wood-Pewee	SC	SC	SC	2018	present
Golden Eagle	END	-	-	2011	present
Golden-winged Warbler	SC	THR	THR	1972	absent
Horned Grebe	SC	SC	SC	2018	present
Least Bittern	THR	THR	THR	2018	present
Lilliput	THR	-	END	2018	present
Loggerhead Shrike	END	END	END	1977	extirpated
Louisiana Waterthrush	THR	SC	THR	1965	absent
Mapleleaf Mussel	THR	THR	SC	2018	present
Midland Painted Turtle	-	-	SC	2018	present
Monarch	SC	SC	END	2018	present
Northern Map Turtle	SC	SC	SC	2018	present
Olive-sided Flycatcher	SC	THR	SC	2014	present
Peregrine Falcon	SC	SC	-	2014	present
Prothonotary Warbler	END	END	END	2016	present
Red Knot	END	END	END	1993	absent
Red-headed Woodpecker	SC	THR	END	1996	absent
Rusty Blackbird	-	SC	SC	2016	present
Short-eared Owl	SC	SC	SC	1998	absent
Snapping Turtle	SC	SC	SC	2018	present
Western Chorus Frog (Great Lakes/St. Lawrence–Canadian Shield Population)	-	THR	THR	1995*, 1997*, 2007*	extirpated
Wood Thrush	SC	THR	THR	2018	present

Note: * refers to unconfirmed observations.

Discussion

Hendrie Valley, the smallest RBG nature sanctuary, holds an incredible amount of native species diversity and consistently exceeds RBG's other nature sanctuaries in native plant cover. Despite these features, Hendrie Valley is not immune to environmental impacts which places it at risk of losing biodiversity and compromising its ecological integrity.

Long term forest monitoring results have shown that as of 2018 the plant community in Hendrie Valley is in a state of transition:

- The forest is shifting from an Oak-Maple dominated forest to potentially an Ash-Cherry-Maple dominated forest. Norway Maple is present and increasing in abundance (9% of the current understory).
- Ash species and Norway Maple have had a recent competitive advantage in the understory layer and native shrub species and cover are declining while non-native invasive shrubs such as ornamental Honeysuckles (*Lonicera maackii and tatarica*), Common Buckthorn (*Rhamnus cathartica*), Multiflora Rose (*Rosa multiflora*) and Common Privet (*Ligustrum vulgare*) are continuing to colonize and spread.
- The apparent decline in leaf litter is favouring the establishment and increased cover of invasive annual and biennial species such as Garlic Mustard (averaging 37 plants/m^2 and found at all monitoring sites), Nipplewort and Japanese Hedge Parsley. Wild Sarsaparilla, Pennsylvania Sedge and Blue-stemmed Goldenrod are among the most common native herbaceous plants, while ash species are the dominant tree seedling.
- Both Ecological Land Classification and forest monitoring surveys have identified numerous ornamental plant escapes that include some potentially invasive species such as Chocolate Vine (Akebia quinata).

Bird surveys have shown relatively positive trends for Hendrie Valley, though other wildlife and amphibian observations have revealed noteworthy concerns:

- Breeding bird surveys have shown a 30-40% increase in species richness over the last decade, however, the Wood Thrush decline and the recent detection of a non-native House Sparrow in index monitoring is concerning. Most common species are Red-winged Blackbird, Black-Capped Chickadee, Northern Cardinal, American Robin and Yellow Warbler.
- Amphibian Marsh Monitoring has shown that amphibian populations remain low and may even be in decline despite ample suitable habitat for reproduction. Species associated with wooded habitats such as the Gray Treefrog and Wood Frog remain low/undetected.
- Recovery efforts for the Blanding's Turtle and other SAR turtles (mostly nest protection and egg incubation) have resulted in an abundance of turtle hatchling releases, yet road mortality, nest predation and having suitable nesting habitat remain a serious concern.
- Visitor activity on the Grindstone Marsh Trail between Cherry Hill Gate and the boardwalk is intense. This section had the highest number of visitors observed and undoubtedly the most wildlife counted during observational trail transects. This is also where the most wildlife feeding occurred, where 90% of transect visits to Cherry Hill had wildlife feeding by visitors observed. Approximately 65% of visitors were seen feeding wildlife at Cherry Hill. High numbers of Mallards, House Sparrows, chickadees, and chipmunks show that these species are congregating to feed on supplemental food.

The above concerns result from historic and current human caused impacts that have disrupted the normal balance of the ecosystem. Ecosystems can recover from periodic disturbances (known as ecosystem resilience), however, numerous disturbances acting simultaneously on an ecosystem can compromise the system's ability to recover. The following impacts are not unique to Hendrie Valley and are common in natural areas in an urban setting in Southern Ontario:

- Non-native **invasive plant** introductions and spread. Invasive plants outcompete and displace native vegetation, effectively changing the plant community over time.
- **Pest outbreaks** and invasions (non-native Gypsy Moth (2007), native Fall Cankerworm (2017), non-native Emerald Ash Borer (2011 – present)). Tree defoliation from caterpillars can cause short term changes to the forest by reducing canopy cover which increases light penetration to the forest floor. It also reduces leaf litter renewal on the forest floor in the fall. Pest outbreaks such as these cause trees to become stressed and can cause canopy dieback (dead branches) and mortality (especially ash) - common long term effects.
- **Drought** and increased frequency of **extreme weather** events due to climate change can also cause tree dieback and mortality, as well as increase erosion with more intense and infrequent rain events. These changing conditions increase disturbance which often favours non-native invasive species.
- Increases in **visitor activity** and **off-trail use** disturbs vegetation and leaf litter which can lead to increased soil erosion and compaction. These activities also disturb wildlife and favour the spread of invasive species.
- **Erosion** within the forested ravines, which is caused by numerous factors including increased water flow from impermeable surfaces in urban areas, causes a reduction in leaf litter, disturbs soil, increases sediment and nutrient loading into water bodies, and favours invasive species introduction.
- Air, water, noise, and light **pollution** from the urban environment have numerous impacts on the ecosystem - from nutrient loading to wildlife behaviour changes.
- **Habitat fragmentation** as a result from historic and current human induced land-use changes such as development, agriculture and natural resource extraction. Natural corridors for species movement are absent or unsafe. Lack of space, along with the amount of people on the trails, may not provide ideal habitat for resident top predators such as coyotes, which leads to imbalanced wildlife populations. The lack of interior forest also leaves the entire forest ecosystem more susceptible to all the impacts listed above.
- More unique to Hendrie Valley are the impacts caused from **visitors feeding wildlife**. These impacts are only just beginning to be understood and will require further study. Higher densities of wildlife formed by species congregating to feed, along with left behind food piles, may lead to increased stress levels, more frequent aggression and increased risk of disease transmission. The quality of seed that visitors bring is generally poor (proso millet) which lacks important nutrients and attracts undesirable non-native bird species. Additionally, seed piles left behind by visitors often attracts concentrations of turtle egg eating mammals, including raccoons and skunks.

The conservation efforts in Hendrie Valley Nature Sanctuary to date have helped maintain its high biodiversity. With continued monitoring, restoration and recovery efforts, many of the impacts can be alleviated to prevent the loss of biodiversity and increase ecosystem resilience. A list of recommendations for future land management, monitoring and restoration activities can be found at the end of this document.

Plant Community

Canopy Tree Layer

The forest canopy is predominantly composed of Red Maple, Red Oak, and Black Cherry. These species represent 62% of the relative abundance of the canopy tree layer for the six plots surveyed in (Table 1). While Red Maple is the most abundance species, Red Oak is the most dominant species by basal area. Evidence that the oaks in Hendrie Valley are quite large and represent the oldest trees in the forest.

Comparing between 2009, 2012 and 2018 canopy tree layer inventories at HV-1 and HV-2, species composition, dominance and density remained stable. Red Maple (*Acer rubrum*) had the highest relative abundance, followed by Red Oak (*Quercus rubra*) and Black Cherry (*Prunus serotina*) between monitoring years (Table 2). White Birch (*Betula papyrifiera*) has declined since 2009 and this is a result of tree mortality. White Birch is a relatively shade intolerant species and was likely suppressed by canopy trees. A difference between 2009 and 2012 was the addition of Bur Oak (*Quercus macrocarpa*) and Black Oak (*Quercus velutina*) in the 2012 inventories, White Oak (*Quercus alba*) then was absent in 2018 along with Sugar Maple. It is possible the Bur and Black Oak trees may have been missed or added in certain years due to proximity to the plot boundary. Since forest monitoring is not conducted annually, one of the challenges when revisiting plots is locating the plot corners and determining where the boundaries are. Over time the blue spray paint that marks trees and shrubs along the boundaries fade away and make it extra difficult to locate when corner markers are hidden or missing entirely. The White Oak died between 2012 and 2018. The absence of Sugar Maple and increased presence of Norway Maple in 2018 could indicate that Norway Maple was miss-identified in 2009 and 2012 as Sugar Maple, or some Norway Maple has been recruited to the canopy layer from the understory as, in 2012 Norway Maple was present in the understory.

Two non-native tree species were recorded in the 2018 canopy tree layer inventories. Norway Maple (*Acer platanoides*) had the higher relative abundance at 8.91%, followed by Horse Chestnut (*Aesculus hippocastanum*) at 1.98% (Table 1). They have also been detected in 8 and 3 ELC polygons, respectively, out of the 22 terrestrial ELC polygons. Neither of these tree species observations come as a surprise as they are common along the forest edge of Hendrie Valley along Plains Road and grow in the Hendrie Park gardens. Both tree species were introduced to North America from Europe as ornamental trees and have been planted in urban areas across Ontario (Kershaw, 2001). Norway Maple is a known non-native invasive tree and is managed in the nature sanctuaries by RBG where area-based invasive species management has occurred as per the Invasive Plant Strategy for Terrestrial Lands. These areas are often associated with critical habitat for Species at Risk and restoration projects. Currently Horse Chestnut is not managed in the nature sanctuaries as their numbers have been low, however, multiage plants have been observed growing outside the horticulture collections in Hendrie Valley.

A troublesome observation in recent years has been an increase in oak mortality in Hendrie Valley. These declines are most likely due to drought and insect herbivory pressures. Non-native Gypsy Moth (*Lymantria dispar*) caterpillars overwhelmed oak trees in 2006 and 2007, leading to some mortality. Substantial oak loss also occurred in 2003 following extreme summer temperatures. In 2016 and 2017 outbreaks of native Fall Cankerworms (*Alsophila pometaria*) occurred property wide, although Hendrie Valley experienced the highest tree defoliation compared to other areas of RBG. Gypsy Moth caterpillars were also present in 2016/2017, but where observed to be in lower numbers in the nature sanctuaries in comparison to the cankerworms. Oak, cherry, maple, and various shrub species at Cherry Hill Gate and HV-1 were significantly impacted by cankerworms in 2017. As can be viewed in Figure 25, these areas are highlighted red indicating high amounts of leaf loss. Trees within HV-1 were almost, if not completely, bare during the month of June in 2017, allowing more sunlight to reach the forest floor that otherwise would have normally be shaded. Pressure from these cankerworm outbreaks, along with other pressures, led to additional oak tree mortality and dieback observed in Hendrie Valley during the 2018 growing season despite the substantial drop in the number of cankerworms observed that same year.

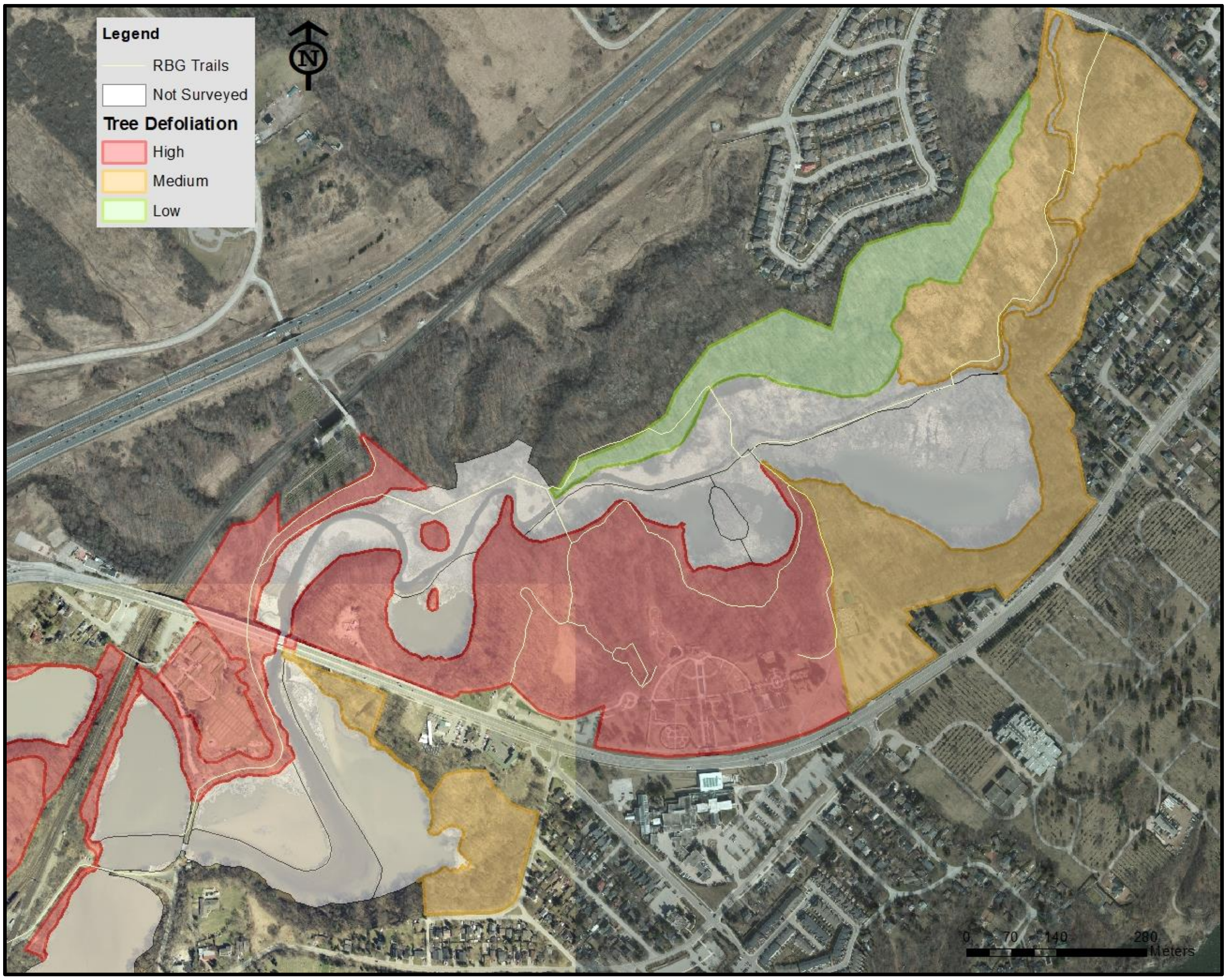


Figure 25. Hendrie Valley tree defoliation in 2017 due to Fall Cankerworms.

The following section will highlight species composition changes that have occurred in the understory between 2012 and 2018. It is possible that the changes detected in the understory are a result from the cankerworm outbreaks which allowed more light to penetrate through the tree canopy. It is likely that outbreaks of cankerworm, Gypsy Moth caterpillars and other tree defoliators will become more frequent in the future with climate change. Long term forest monitoring data will help detect and predict changes that will occur to the forest ecosystem as a result. With this information, RBG staff can prepare and work towards mitigating future effects.

Small Tree and Shrub Layer

2018 understory layer data from all six plots resulted in a total of 32 species documented with 9 being non-native. White Ash was the most numerous understory tree species, followed by Norway Maple, Green Ash, and Black Cherry (Table 3). White Ash (*Fraxinus americana*), Green Ash (*Fraxinus pensylvanica*) and Black Cherry are common Carolinian forest species (Oldham, 2017) and are expected understory trees. Norway Maple is a non-native invasive species, and it is concerning seeing it as the 2nd most dominant understory tree. Considering ash species and Norway Maple represent almost 45% of understory cover relative to all other species (Table 3), including small trees and shrubs that are not designed to reach the canopy, their impact will be even greater in the long term where canopy tree recruitment is considered. This is a significant concern as Green and White Ash will likely not reach maturity (due to Emerald Ash Borer) which leaves Norway Maple as a strong contender for canopy tree replacement. Tree regeneration surveys also confirm the abundance of these three species as the most common saplings, representing over 80% of the saplings recorded (Table 6). This understory data forecasts a much different canopy cover in the future. Hendrie Valley forest may be transitioning from an Oak-Maple dominated forest to and Ash(?)-Maple-Black Cherry dominated forest.

Ash species native to North America are experiencing significant mortality and population declines due to the introduced (*Agrilus planipennis),* or Emerald Ash Borer (Murfitt et al., 2016; Natural Resources Canada, 2018). The International Union for Conservation of Nature (IUCN) has listed all four ash species that occur on RBG property as Critically Endangered (IUCN, 2019). Since 2011, when an adult beetle was confirmed at RBG Main Centre parking lot, there have been large declines of ash species property wide (Radassao & Theysmeyer, 2018). In Hendrie Valley, ash tree mortality has impacted forest canopy cover near some trails, within the forest, and decimated tree cover in tributaries and sections of Grindstone Creek floodplain that had been dominated by Green and Black Ash. From 2012 to 2017 a total of 292 ash trees have been removed along trails and boundaries in Hendrie Valley to maintain safety due to Emerald Ash Borer produced decline (Radassao & Theysmeyer, 2018), with another 46 trees removed in 2018. More seed production, along with possible increases in sun exposure in the understory and ground layers, may be the reason many ash seedlings and saplings have been observed in the forest monitoring plots, as well as across RBG's nature sanctuaries. Unfortunately, it has been documented that White Ash seeds are viable for an average of 2 to 3 years, rarely up to 8 years, with little survivability after longer periods of time. Therefore, if younger Ash trees die from Emerald Ash Borer before being mature enough to produce seed, then there will be little to no regeneration in the future (Barstow et al., 2018).

When comparing understory data between 2012 and 2018 (HV-1 and HV-2 only) it is apparent that ash species and Norway Maple have had a recent competitive advantage and that native shrub species and cover are declining while non-native invasive shrubs such as ornamental Honeysuckles, Common Buckthorn, Multiflora Rose and Common Privet are continuing to colonize and spread.

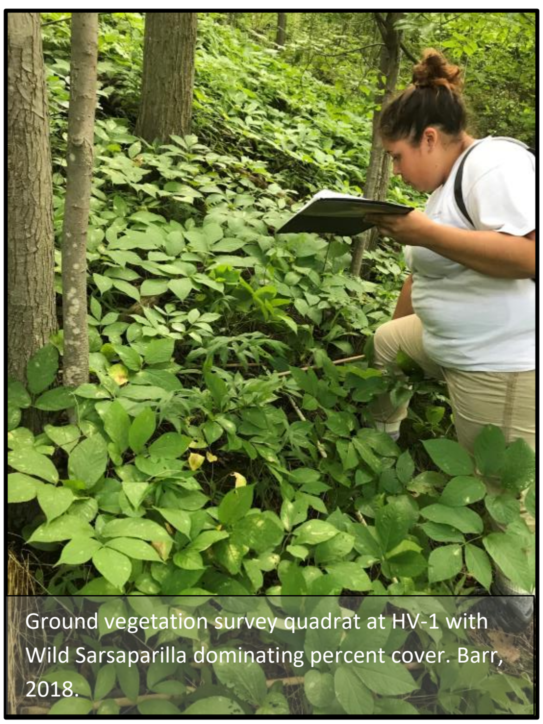
In 2012, a total of 17 species were recorded in the understory layer from HV-1 and HV-2, with 5 being non-native species. The most dominant tree species were Red Maple and Norway Maple, with Choke Cherry (*Prunus virginiana*) as the most dominant shrub species (Table 4). For 2018, there was a total of 16 species recorded in the understory at HV-1 and 2, with 6 species being non-native. Interestingly, a significant change in species assemblage occurred in 2018 at the two plots, with Norway Maple as the most dominant tree, followed by White Ash and Green Ash. Ash species increased from 10% to 31% relative abundance and Norway Maple increased from 15% to 33% relative abundance. Red Maple was fourth dominant in 2018, dropping in coverage from 29% to 14% relative cover since 2012. The increase in native ash species in the understory is likely due to the temporary increase in light exposure caused by cankerworm defoliation in 2016 and 2017. Understory trees that can take advantage of sunlight (particularly ash) would have taken the opportunity to grow bigger; whereas trees that are more shade tolerant (native maples) would not have been as competitive.

Norway Maple was the only non-native invasive species to have a significant increase in relative cover between 2012 and 2018 (Table 4). European Horse-chestnut was no longer present in the understory of the forest monitoring plots in 2018 which means it could have been missed during surveys, removed during invasive species management or died. Common Privet and European Buckthorn were newly recruited to the understory in 2018. Looking at the increase in Norway Maple more closely, it is highly possible that in 2012 it was mis-identified as Sugar Maple or in 2018 some Sugar Maple may have been mis-identified as Norway Maple. If the percent cover of both Maple species is combined in 2012, then they are very close to the cover of Norway Maple in 2018. Sugar Maple was not recorded at all in 2018. These two maples are often mistaken from one another, especially at the sapling stage.

Native understory small tree and shrub species that were recorded in 2012, but not found in 2018 include Smooth Serviceberry (*Amelanchier laevis*), Alternate-leaved Dogwood (*Cornus alternifolia*), and Blue Beech (*Carpinus caroliniana*) (Table 4). Blue Beech decline has been noted across RBG property over the last several years. In 2017 a Forest Health Technician Specialist from the Ontario Ministry of Natural Resources and Forestry visited RBG had noted the Blue Beech decline and took some samples from the trees for analysis. It is suspected that periodic drought conditions that have occurred over the last decade could be the contributing factor to the decline since no new disease or pest was found on the trees upon inspection. In Hendrie Park, gardeners have been noting Golden Canker (also called Cryptodiaporthe canker) on Alternate-leaved Dogwoods (Briggs, 2019). Golden Canker is a common disease of Alternate-leaved Dogwood and can potentially be lethal if infections occur on the main trunk of a tree (Hudelson, 2012). Hendrie Park gardeners have been pruning to prevent the canker from spreading. Upon further inspection of the understory data, all native understory species - Chokecherry (*Prunus virginiana*), Witch Hazel (*Hamamelis virginiana*), Round-leaved Dogwood (*Cornus rugosa*) and Maple-leaved Viburnum (*Viburnum acerifolium*) – have experienced notable declines in cover at HV-1 and HV-2 between 2012 and 2018 (Table 4). Furthermore, there was no single native shrub species that was recorded in over 50% of the terrestrial polygons (Table 1). This could mean that native shrub diversity is high but unevenly distributed throughout the landscape, or it could mean that non-native invasive shrubs, specifically ones highlighted in Table 4 and Table 8 such as Amur Honeysuckle, Common Buckthorn, Multiflora Rose, and Common Privet, are displacing native shrubs in Hendrie Valley. Continued monitoring of the understory will be imperative moving forward and all 6 sites should continue to be monitored in order to have a larger dataset which will help define significant trends. ELC data can also be further studied and analyzed for abundances of invasive species. Decreasing tree cover from disturbances such as invasive pests and drought emanates the potential for non-native invasive plants to spread and establish through the forest. Non-native invasive species are one of the main threats to biodiversity (Murphy, 2005; Clavero et al., 2009; Ontario Biodiversity Council, 2011). Further literature review and/or study on the ecosystem dynamics of the forest understory with emphasis on interactions with invasive species and climate change would be beneficial.

It is important to note that there have been attempts to manage and reduce the abundance of non-native invasive plants in Hendrie Valley. Removals of non-native invasive small trees and shrubs have occurred in the valley most intensively between 2008 to 2011 by staff and volunteers and less intensively afterwards until present, mostly through educational programming where school groups participated in removals along certain trails. Since 2014, Horticultural Garden staff in Hendrie Park, which is adjacent to Hendrie Valley, have been removing non-native invasive shrubs along the garden's boarder, as well as from the Rifle Range and Woodland Garden. Non-native invasive plants removed include European Buckthorn, Euonymus or Burning Bush (*Euonymus alatus*), Manitoba Maple, White Mulberry, Tree of Heaven (*Ailanthus altissima*), Common Privet, European Black Alder (*Alnus glutinosa*) and ornamental Honeysuckle species. All the above removal efforts greatly contribute to reducing further spread and seed banks of the previously mentioned non-native invasive trees and shrubs into Hendrie Valley. However, much more will need to be done in order to eliminate the threat of non-native invasive plants reducing the biodiversity in Hendrie Valley.

Ground Vegetation Layer



Ground vegetation survey quadrat at HV-1 with Wild Sarsaparilla dominating percent cover. Barr, 2018.

For 2018, when data from all six forest monitoring plots is compiled, there was a total of 67 species recorded in the ground layer (Appendix A). Of the 67 species, 15 were non-native. In other words, native ground vegetation accounted for 78% of the species richness verses 22% for non-native species. Hendrie Valley has higher ground vegetation species richness compared to the north shore property of the Cootes Paradise Nature Sanctuary, which only has 45 recorded species from forest monitoring. The ratio of native to non-native plants, however, is the same with 78% native species and 22% non-native species. The south shore property of Cootes Paradise has a much higher species diversity with 78 recorded species, and while it had the greatest number of non-native species recorded (16), 79.5% was native verses 20.5% non-native. While it appears that the south shore is doing slightly better on the non-native species front, when ground vegetation cover is examined (Figure 5), the south shore has the most non-native plant cover compared to the north shore and Hendrie Valley. It is also evident that Hendrie Valley has had consistently higher native vegetation cover than the other nature sanctuaries; 65% for Hendrie Valley compared to 26% and 17% for the south shore and north shore respectively. When the additional 2018 plots are considered for Hendrie Valley, average native plant cover drops to 52%, yet this is still considerably higher than the other sanctuaries.

Hendrie Valley and the south shore of Cootes Paradise are the two most comparable sanctuaries. Both are influenced by the urban landscape; residential properties, roads and manicured landscapes (Hendrie Park, Laking Garden vs. Churchill Park, McMaster University). They both have high visitor activity and neither have a considerable amount of interior forest. Hendrie Valley, because of its smaller size and accessibility, was the first nature sanctuary where RBG took initiatives to focus visitor access and concentrate visitor activity. Examples of this include boardwalks, the South Pasture Swamp platform and various interpretive stops. Unlike the south shore of Cootes Paradise, which has more kilometers of trails (approximately 7.5 km) and seven or more access points, Hendrie Valley has only 4.5 km of trails and three access points for the general public, along with three occasional access points used by staff and supervised groups. These factors may have an influence on some visitor behaviour, particularly off trail use. While there is evidence of off trail use in Hendrie Valley, it seems to be more localized compared to other nature sanctuaries, partially due to it's size but it could also potentially be due to the fact that the valley is located across from RBG's main centre and shares a boarder with Hendrie Park and the Laking Garden. There is more staff and RBG branding around most of the Hendrie Valley entrances compared to the Cootes Paradise south shore which holds no RBG facility (save for the Teaching Garden which is currently operated as the Hamilton Avaiary). A greater RBG presence, focused visitor entrances and focused visitor activities all contribute to improving the health of Hendrie Valley and can perhaps explain why native vegetation cover is greater. Continuing to manage the area with visitor control in mind is imperative to the future health of the Hendrie Valley forest.

In Hendrie Valley, non-native invasive Garlic Mustard (*Alliaria petiolata*) was the most abundant species with an average of 37 individuals per m^2 followed by Pennsylvania Sedge (*Carex pensylvanica*) at 20 clumps per square meter. Garlic Mustard was second highest in average cover at 6.46%, while Wild Sarsaparilla (*Aralia nudicaulis*) was first at 12.30% average cover, and Pennsylvania Sedge third with 6.34%. Plant cover data favoured Wild Sarsaparilla because it is very broadleaved and one individual plant can cover up to 20% of a 1 by 1 meter sampling quadrat. Garlic Mustard covered less area per individual plant and at the timing of data collection, second year plants had already died and first year plants were being counted - which are smaller than second year Garlic Mustard. Also, it should be noted that as per Table 5, Wild Sarsaparilla was only recorded at two forest monitoring plots, while Garlic Mustard was present at every single one. ELC data also confirms that Garlic Mustard is wildly distributed throughout the valley as it was found to be present in 21 out of 22 ELC terrestrial polygons (Table 8). Garlic Mustard is a known invasive plant that has aggressive dispersal, growth rates and use chemical compounds to impede native vegetation growth (Murphy, 2005, Anderson, 2012a). Efforts to remove Garlic Mustard along Grindstone Marshes Trail from Cherry Hill Gate to South Bridle Trail and other portions of Hendrie Valley have occurred by staff and volunteers. In the early summer of 2018, RBG had its first all staff initiative to remove Garlic Mustard from the Woodland Garden in Hendrie Park and near Cherry Hill Gate/Grindstone Marshes Trail in the valley. This all staff event was successful and should continue in the future. Efforts are being taken in 2019 to establish a group of volunteers to assist with removing invasive plants at designated locations within the nature sanctuaries. These volunteers are from the core group of RBG natural lands volunteers who will be trained to work independently and at their leisure. Grindstone Marshes Trail at Cherry Hill Gate will be one of the designated locations.

Ground vegetation data from HV-1 and HV-2 forest monitoring plots can be compared over time, as represented in Figure 5, although five to ten more years worth of data would represent stronger trends. Nevertheless, based on average percent cover, the native vegetation across four monitoring years appears to be stable. In contrast, average cover for non-native vegetation continued being low but shows a slightly increasing trend. In 2009, the average percent cover for non-native plants was 0.69% and in 2018 increased to 4.75%. Similar to impacts in the understory layer from opened tree canopies, increases in sunlight can spur further intensifications in non-native ground vegetation coverage as there is the potential to outcompete native vegetation and not-yet-recorded non-native invasive plants to establish within the plots. Additional forest disturbances that can favour invasive plant germination include but are not limited to off trail use, erosion and wildlife imbalances.

Based on visual observations over the years by staff, non-native Nipplewort (*Lapsana communis*) appears to be increasing in abundance. In 2018 it was observed to be as dominant as Garlic Mustard in areas of disturbance and intense visitor activity - where trail visitors feed wildlife and trample native vegetation off trail. This is also around where Garlic Mustard control has been occurring along Grindstone Marshes Trail (which can also cause disturbance). Interestingly, 2018 is the first documentation of Nipplewort being present in the ground vegetation survey quadrats. Despite an average of 1.96 individuals per m^2 and an average cover of 0.85% in forest monitoring data, Nipplewort was found in 18 of the 22 ELC terrestrial polygons, behind only to Common Buckthorn and Garlic Mustard (Table 8). Nipplewort should be closely monitored and removed in the early growing season simultaneously with Garlic Mustard. Manual removal through hand pulling of Nipplewort has been effective for controlling the species in other areas where it has been spreading (Nawrocki, 2011).

Poa nemoralis, encroachment west end of HV-2017-3 near HV-6. Barr, 2018.

Another notable non-native invasive plant that is present in Hendrie Valley in the ground layer of the forest is Woodland Speargrass/Woodland Bluegrass (*Poa nemoralis*). Woodland Speargrass was recorded in 2018 at only HV-1 through the 1 by 1 meter ground vegetation surveys; however, when analyzing the VSP survey data, which includes plant coverage for the entire 20 by 20 meter plots, Woodland Speargrass was present at HV-1 and HV-6. These two plots fall within the ELC polygon HV-2017-3, which was the only polygon Speargrass was found in. Based on visual observations and data collected from forest monitoring surveys, Woodland Speargrass appears to be spreading further into Hendrie Valley from the west end heading east on the south side of Grindstone Creek. This is concerning as the non-native graminoid poses a major threat to native and Species at Risk ground plants and has already aggressively dominated other areas of RBG's nature sanctuaries, such as the south shore of Cootes Paradise (Vincent, 2018). Staff from the Natural Lands and Science Departments are currently in the field research process of developing Best Management Practices for Woodland Speargrass at RBG, which would highlight effective removal options. Once management options are established for Woodland Speargrass, preventing any further spread into Hendrie Valley should be made a high priority.

Forest floor composition remained relatively similar over the four years, as displayed in Figure 7. With several more years of data, it may be possible for stronger trends to be realized. Leaf litter and bare ground cover were most different in 2012, where bare ground surpassed leaf litter at 54 and 27% average cover, respectively. There is likely a relationship between canopy tree defoliation in 2017 and the amount of leaf litter observed in 2018. Other factors that can influence leaf litter include canopy tree composition (ex. oak leaves degrade slower than maple leaves), slope erosion, non-native earthworms, invasive species, and off-trail use and it is more likely that a number of these factors are working together to reduce the amount of leaf litter. Average moss cover was highest in 2018 at 17%, which could be related to the large amounts of rainfall experienced in 2017, which was also good for terrestrial plants. In the future it would be interesting to compare wet years to moss cover to determine if a relationship between the two is represented in the forest monitoring data. There was an increase in woody debris from 13% average cover to 21% average cover between 2012 and 2018. This could be caused by an increase in canopy dieback and tree mortality.

Ornamental Non-Native Invasive Plants

In addition to the non-native invasive plants detected in forest monitoring, there are even more non-native species that have been detected in Hendrie Valley Nature Sanctuary through ELC or incidental observations. Most of these non-native plants are escapees from gardens, such as from Hendrie Park and surrounding residential areas. These non-native plants include: Winged Euonymus (*Euonymus alatus*), Amur Cork Tree (*Phellodendron amurense*), Porcelain Berry (*Ampelopsis glandulosa*), Black Jetbead (*Rhodotypos scandens*), Lily-of-the-valley (*Convallaria majalis*), Common Barberry (*Berberis vulgaris*), and Five-leaf Akebia aka Chocolate Vine (*Akebia quinata*). Both Porcelain Berry and Chocolate Vine are currently being reviewed by the Canadian Food Inspection Agency and could be regulated under the Plant Protection Act if viewed as a threat to the environment and economy. Through ELC surveys, the locations of these additional ornamental plants are known within designated polygons.

Some non-native invasive plants found in Hendrie Valley are highlighted below.

Ficaria verna leaves and flower, 2018.

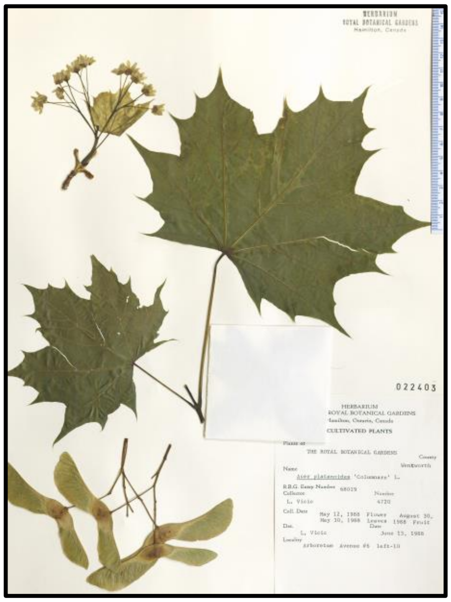
Lesser Celandine (*Ficaria verna*) is a non-native perennial spring ephemeral that has been spreading in Hendrie Valley from Cherry Hill Gate to South Bridle Trail. It has also been found growing behind residential properties where yard waste dumping is rampant. This plant was introduced to North American from Europe as an ornamental garden plant and is a known invasive in areas of the United States and at RBG. The dense mats Lesser Celandine forms as it spreads block native spring ephemerals from growing, creating monocultures that can cover forest floors (Swearingen, 2010; Reinartz, 2014). It is unknown where this species entered Hendrie Valley, or when. There are no records of Lesser Celandine being planted in Hendrie Park, however it has been documented as being sporadically present since 2016 (Peter, 2019). Efforts have been made by staff to remove populations in Hendrie Valley through manual (digging up) and chemical (herbicide) treatments. Management of Lesser Celandine is still in the early stages; thus, effectiveness and best timing of treatment methods are unknown. These treatments will help guide control methods that will be included in a property wide Management Plan for Lesser Celandine at RBG, which will be developed soon.

Petasites hybridus flower and young leaves, 2018.

Common Butterbur (*Petasites hybridus*) is another non-native plant that is present in Hendrie Valley. It was originally thought to be Japanese Butterbur (*Petasites japonicus*) but the flower colour of the ones in Hendrie Valley are red-purple, which is a characteristic of Common Butterbur, instead of greenish-white like the Japanese Butterbur flowers (NatureGate, 2016a). Additionally, herbarium specimens of Butterbur growing in Hendrie Valley that were originally labelled as Japanese Butterbur (*Petasites japonicus*) were verified in 2011 and re-labelled as Common Butterbur (*Petasites hybridus*) by Natalie Iwanycki (at that time RBG's Field Botanist). There are three known patches of Common Butterbur; Large patch along the stream bank within the Rifle Range, another large patch is a few meters downstream in the nature sanctuary, and a third small patch. This third patch was recently found growing adjacent to a residential property, but its proximity to the old Directors House could indicate that it was purposely planted as an ornamental rather than the result of recent yard waste dumping activities. Common Butterbur is a perennial and is native to western Asia and southern Europe, preferring to grow in damp habitats such as ditches and banks, lake shores, woodland margins, and wastelands (NatureGate, 2016b). In 2017 the large patch growing in the nature sanctuary was treated with herbicide. First round of treatments appeared to be successful, however a follow up treatment will be necessary in 2019. This patch with be visually monitored by staff annually to determine treatment effectiveness.

Young *Fallopia japonica* leaves as a result of yard waste dumping in Hendrie Valley, 2018.

Japanese Knotweed (*Fallopia japonica*) looks similar to bamboo, but it is actually a herbaceous perennial plant. It was introduced from eastern Asia to North America in the 1800's and has since spread throughout Canada and Unites States (Anderson, 2012b). It is often planted in gardens as an ornamental plant; however, it is extremely aggressive and often escapes into natural areas. Once established, Japanese Knotweed is very difficult to remove due to its dense root system and ability to withstand flooding. Established stands are dense and the large leaves shade out native ground vegetation, as well as any shrub and/or tree seedlings. As the leaves and stalks fall each season, a thick layer of leaf litter accumulates and makes it even more difficult for native plants to continue growing or establish (Anderson, 2012b). Since native invertebrates evolved with native plants (pollination, consuming and breaking down plant material), as the native vegetation disappears the risk of invertebrate numbers dropping also intensifies, thus threating multiple wildlife species from other insects to arachnids, to birds and amphibians (Tallamy, 2009). RBG has been managing Japanese Knotweed in Hendrie Valley, but it is still present in certain areas. In 2018, as is presented in the photograph, Japanese Knotweed was found spreading into Hendrie Valley behind residential houses where cuttings had been dumped. According to the Ontario Invasive Plant Council's Best Management Plan (Anderson, 2012b), there are several additional non-native ornamental knotweed subspecies and hybrids being recorded in natural areas from other Canadian provinces and it may only be a matter of time before they are found in Ontario.



Norway Maple or *Acer platanoides,* along with its many cultivars, is a common non-native tree planted in urban areas and in city parks. This tree species is native to Europe and was introduced to North America as an ornamental tree (Credit Valley Conservation, 2019). As anyone who has had a mature Norway Maple in their yard has likely experienced, these trees create deep shade that prevents most other vegetation from growing, hence why it’s establishment in natural areas is problematic. Not only are herbaceous plants shaded out, but native trees and shrubs also have been found to have low to zero germination success under a stand of Norway Maples. Not even Sugar Maple (*Acer saccharum*), which is known to be shade tolerant when they are seedlings and saplings (Martin, 1999). The Hendrie Valley Nature Sanctuary is home to a variety of native plants and animals, including Species at Risk and rare species. As can be viewed from tree, understory and ground layer data collected from forest monitoring, Norway Maple is growing in abundance. Thus, management and community outreach efforts by RBG will be essential for long term removal and prevention success.

In response to the spread of ornamental non-native invasive plants, RBG has formed an Invasive Species Committee which contains representatives from all departments across the organization. The goal of the committee is to write an invasive species strategy for RBG. Through the process of writing the strategy, committee members will identify which non-native plants are invasive and whether they occur in the horticultural collections and/or the natural lands. From there, a plan to remove and control such species will be developed for both the gardens and nature sanctuaries. Species on the “watchlist” (species not currently present at RBG) will be flagged to prevent them from being introduced to RBG.

Yard Waste Dumping – Spreading Invasive Ornamental Plants

Yard waste dumping in Hendrie Valley, 2018.

There are multiple sources of stressors on ecosystems situated in Hendrie Valley that degrade habitat quality and threaten plant and wildlife biodiversity. Yard waste dumping documented behind residential houses that surround Hendrie Valley is an example of a human impact that has several negative consequences. Impacts include smothering ground vegetation, increasing soil erosion, increasing non-biodegradable garbage entering the valley (plastic pots, plant tags), and spreading non-native invasive ornamental plants. Young Japanese Knotweed (*Fallopia japonica*) has been found growing adjacent to a house in Hendrie Valley where cut Japanese Knotweed plant material has been dumped. It is also possible that tree blow downs along the edge of the ravines may be attributed to increased soil erosion around roots where dumping has occurred. Further investigations should be done to document the amount of erosion and frequency of tree blow downs along ravine edges where yard waste dumping is rampant.

Wildlife Community

Breeding Bird Surveys

It is important to note that due to the slim forest portions in the valley, the marsh and forest edge habitats heavily influence the species of birds detected. When looking at Figure 11, the marsh associated Red-winged Blackbird had the highest relative abundance when considering all seven plots. Overall species richness at HV-1 and HV-2 during survey years appears to be stable with an increasing trend (Figure 12). However, there are notable abundance changes in detections for some species like the Wood Thrush and Black-capped Chickadee. For Black-capped Chickadee, the decrease in the number of detections may be due to several things, including changes in their behaviour, nesting competition pressure from non-native species like House Sparrows, and/or egg and chick predation pressures from rodents. In the section below there is more information regarding possible causes for changes in bird species abundances.

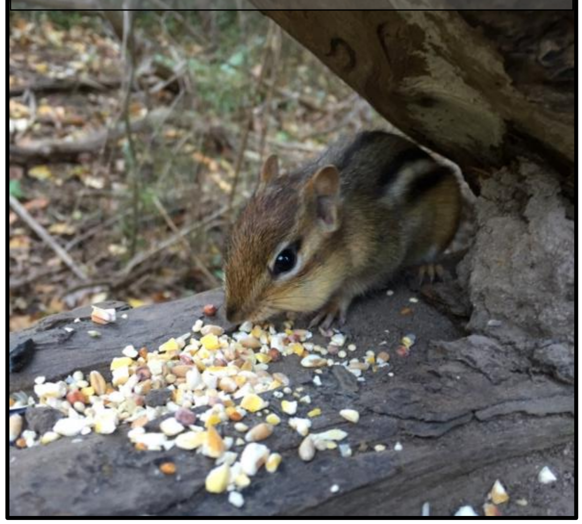
Visitor Wildlife Feeding Summary

Below is a summary from the discussion in *The Supplemental Wildlife Feeding in Hendrie Valley* report (Peirce, 2019b). Please refer to the full report for more information regarding the study.

It is evident, through trail transect data, that the feeding of wildlife in Hendrie Valley is concentrated along two main trails – Cherry Hill (Grindstone Marshes Trail between Cherry Hill Gate parking lot and South Bridle Trail) and Grindstone Marshes Trail at Valley Inn. Visitor numbers at Cherry Hill are incredibly larger in comparison to other trails. As a result, this area is a high priority trail to investigate the impacts of feeding wildlife. The increase in density of wildlife in a small area of Hendrie Valley, along with inflated rodent populations, quality of supplemental food, ecological, and life history impacts are all concerns surrounding the supplemental feeding of wildlife in a nature sanctuary.

As presented in Figure 20, far more wildlife detections were observed along Cherry Hill than on any other study trail. With a high concentration of wildlife in one area of the valley, territorial behaviour could increase amongst individuals resulting in individuals partaking in energetically costly resource-defense behaviour, along with increasing stress levels leading to a greater susceptibility to infectious disease (Robb et al., 2008; Mclaren et al., 1998). A fungal disease, Aspergillosis, occurs when a fungus in the genus Aspergillus produces spores on damp or wet bird seed and birds inhale the spores causing pneumonia and bronchitis in the individual (Terres, 1981). There is the possibility that this fungus occurs on RBG property due to piles of supplemental feed left on the trails being exposed to moisture, providing the ideal breeding ground for such fungus. Therefore, wildlife on RBG property are potentially being exposed to the disease that may otherwise not be a risk if supplementary food was not left behind by visitors.

Eastern Chipmunk at a seed pile (proso millet mix) along Cherry Hill. Peirce, 2018.



Eastern Chipmunks were the second-most detected species along Cherry Hill during trail transects. Since population growth in mammals is typically limited by food (Prevedello et al., 2013), chipmunks may be concentrated in only a few small areas in Hendrie Valley due to the surplus of supplemental food. This causes a shrink in the home range size of chipmunks due to the high concentration of supplemental food, thus increasing density (Sullivan et al., 1983). A high density of chipmunks in one area could influence the reproductive success of their prey (nut-producing trees and ground-nesting birds), as well as the survival of local amphibians and mushroom populations. A threat to human health may also be elevated, as chipmunks have been shown to be hosts for larval Black-legged Ticks (*Ixodes scapularis*) that can carry Lyme Disease (McLean et al., 1993). Another threat to human health with an inflated chipmunk population is the increased risk of rabies in small mammals. In North American, there have been documented cases of rabies present in the Eastern Chipmunk. The first confirmed case occurred in the 1980s, when a young boy in the Unites States was bit by an infected chipmunk (Dowda and DiSalvo, 1984.). Rabies is a fatal viral disease that can be transferred to humans by any infected mammal through a bite or from scratches (Ministry of Natural Resources and Forestry, 2019). With the current rabies outbreak in southern Ontario (confirmed in Hamilton and Burlington), it is not improbable that a chipmunk in Hendrie Valley could be infected with the disease. As chipmunks (and other mammals) are conditioned to seek food from visitors and, as has frequently been observed, from visitors' hands, the risk of being bitten increases. Note that even non-infectious mammals can bite as they are **wild animals**. The concentrations of chipmunks and squirrels, as well as other small mammals attracted to feed piles, can also attract natural predators such as foxes and coyotes.

Wood Thrush (*Hylocichla mustelina*) detections at HV-1 have declined and have been non-existent since the 2009 breeding bird surveys (Figure 23). On the contrary, detections of Wood Thrush have increased over time across all other RBG survey plots. Currently it cannot be determined if one singular aspect of the surrounding ecosystem is causing the disappearance of Wood Thrush at HV-1. Interestingly, Schmidt et al. (2008) showed that rodent abundance over 20 individuals per hectare was responsible for a negative relationship between Wood Thrush population growth and rodent abundance. If the popularity of supplemental feeding has indeed inflated the local chipmunk populations, then the result could be an increase in nest predation of ground-nesting bird species such as the Wood Thrush. This is concerning as Wood Thrush are listed as Special Concern in Ontario; thus, it is essential that impacts to their populations be mitigated in nature sanctuaries. Further investigation into chipmunk abundance in Hendrie Valley is needed.

The Black-capped Chickadee is one of the most sought-after species for visitors to feed at Royal Botanical Gardens. Chickadees are known for their friendly demeanour and their ability to take seeds from a welcoming hand. However, the chickadees residing in Hendrie Valley Nature Sanctuary are smothered with so much love from visitors that it may be altering their diet, foraging behaviour, and social structure. Often when humans feed wild birds it is thought that they are helping the birds. However, there are studies that show no beneficial gain from supplementary feeding of wild birds. Brittingham and Temple (1992) provided supplementary food to Black-capped Chickadees for 25 winters and found that the fed population had identical survivorship to that of a local unfed population. Therefore, it is unnecessary to provide supplemental food to wild birds in an attempt to increase the likelihood of survival over winter. Black-capped Chickadees do not display dependency on supplemental food after the food is suddenly withdrawn (Brittingham and Temple, 1992). Additionally, the sudden removal of supplementary food has been found to not affect a bird's health (Wilcoxen et al., 2015).

Visitors to RBG bring multiple types of supplemental feed for the birds, with white proso millet mix being most commonly used, along with black-oil sunflower seeds and peanuts. Generally, the Black-capped Chickadee diet consists of 70% animal matter and 30% plant matter (seeds, berries), and in the winter this drops to equal parts animal and plant matter (Smith, 1997, p. 33). In the wild, chickadees prefer milkweed, ragweed, goldenrod, sunflower, conifer, and cattail seeds, as well as poison ivy berries (Smith, 1997, p. 40). Naturally, chickadees will consume the seeds of native Woodland Sunflower (*Helianthus divaricatus*) (Audubon, n.d.). Due to the continuous abundance of readily available commercial sunflower seed, it is possible that chickadees at Cherry Hill could be consuming more plant matter than other chickadees that do not have access to supplemental food.

RBG staff have noticed the increase in overly-friendly chickadee behaviour in recent years – with the boldest individuals living in Hendrie Valley. Chickadees regularly follow staff members, and even land on them, in hopes of being offered food. Chickadees are often seen foraging on supplemental food piles that have been left on the trails. Interestingly, it is not common for chickadees to forage on the ground – they typically forage in low-lying vegetation (Smith, 1997, p. 43). Thus, the feeding of chickadees in Hendrie Valley could be altering their foraging behaviour due to visitors leaving seed behind on the trails. Increased foraging behaviour on the ground may leave chickadees more vulnerable to predators.

Black-capped Chickadees create flocks during the winter months, ranging from six to ten individuals, and pair off in spring (Smith, 1997, p. 29). Based on anecdotal evidence from RBG staff, there appears to be more than ten individual chickadees residing in the Cherry Hill area alone during the spring, summer and fall months. In fact, chickadees are rarely known to perch at close distances to each other while taking food or eating (Cornell Lab of Ornithology, 2017). Therefore, the rise in popularity of wildlife feeding could be altering or diminishing Black-capped Chickadees' social structure and behaviour. Typical chickadee behaviour is absent at Cherry Hill where chickadees come in close contact with one another with the intention of obtaining food from visitors.

As displayed in Figure 22, nearly half of all visitors engaging in feeding wildlife used low-quality white proso millet, a bird seed that is known to attract non-native invasive House Sparrows (*Passer domesticus*) and native Brown-headed Cowbirds (*Molothrus ater*) – two birds with detrimental ecological consequences (Horn et al., 2014). Non-native House Sparrows regularly outcompete native bird species for nesting habitat, with some even killing nestlings or adult birds for nesting locations (All About Birdhouses, 2018). Therefore, the type of supplemental feed that the majority of RBG visitors are using has the potential to attract non-native and undesirable species to the Hendrie Valley Nature Sanctuary.

Visitors to RBG must be educated on the scientific facts regarding the impacts of feeding wildlife. Wildlife management requires public education, which could result in increased support for conservation initiatives (Orams, 1996; Newsome et al., 2005). A study conducted in the Bunya Mountains National Park surrounding visitors and the feeding of wildlife had found that the most common reason for people feeding wildlife is to have an interaction with nature (Parkin, 2001). Additionally, an alarming 92% of respondents claimed that they were not aware of the local wildlife service's policy on not feeding wildlife (Parkin, 2001). Both the City of Burlington and City of Hamilton have bylaws that prohibit the feeding of wildlife. Additionally, RBG has a no wildlife feeding by-law across all properties and nature sanctuaries. Even with notices posted at all RBG trailheads, coupled with more recent signs posted along some trails, the potential for RBG visitors not having awareness of the feeding bylaw is a possibility. A positive result of the surveyed guests in the Bunya Mountains National Park is that 91% of respondents said they would refrain from feeding wildlife if they were aware it was harmful to their health (Parkin, 2001). Therefore, with proper education, it is hoped that visitors and guests will comply with RBG policies and municipal bylaws.

Amphibian Marsh Monitoring

Three amphibian species that are most likely to be encountered in Grindstone Marsh include the American Toad, Green Frog and Northern Leopard Frog. Amphibian Marsh Monitoring has been conducted since 1995 and reveals that the number of individual and species of amphibians are relatively uncommon in Hendrie Valley. Monitoring sites initially included Blackbird Marsh (located below the Laking Garden) and the three Ponds associated with the Bridle Trail Loop (Ponds 2, 3, and 4). Additional monitoring sites were included at Sunfish Pond as well, although monitoring at both Sunfish Pond and Blackbird Marsh have been inconsistent over the years. Carroll's Bay, located at the mouth of Grindstone Creek, has never had a monitoring site due to the absence of wetland vegetation, and no amphibians have been reported incidentally calling or breeding in this area for the past 20 years.

Restoration of Grindstone Marsh is an element of the Hamilton Harbour Remedial Action Plan (initiated in 1994). Once the initial 1994 restoration in the Hendrie Ponds occurred, the quality of marsh habitat began to dramatically improve in Blackbird Marsh and Sunfish Pond (lower delta). Since then these ponds have remained relatively consistent in wetland vegetation diversity and coverage, and experienced improved water quality (Johnston et al., 2001). Ongoing major habitat threats are still a challenge for the Grindstone Marsh system, and include non-native invasive flora and fauna, particularly Common Carp (*Cyprinus carpio*), and impairment of water quality.

A concerning observation is the lack of amphibian abundance in Hendrie Valley's Grindstone Mash system, despite the available habitat. Several amphibian species are currently extirpated from Hendrie Valley including the American Bullfrog (*Lithobates catesbeianus*), Pickerel Frog (*Lithobates palustris*) and Western Chorus Frog (*Pseudacris triseriata)*. In addition, the Wood Frog, Spring Peeper and Gray Treefrog continue to remain extremely rare. Of the extirpated frog species, the Western Chorus Frog is classified as Threatened under the federal Species at Risk Act (COSEWIC, 2008).

In neighbouring wetland habitats, the chorus of various frog species with hundreds of individuals calling is often heard throughout the breeding season. Based on historical habitat degradation in Hendrie Valley and marsh system, it is plausible that there may be a compound in the sediment that could be negatively impacting amphibians. Common Carp predation of tadpoles and smaller frogs could be a stressor impeding amphibian numbers (Kloskowski, 2009); however, carp are only present in small numbers in the Grindstone Marsh Ponds. It is also conceivable that amphibian road kill, which remains unstudied, may also be playing a role in the reduction of individuals and species present in the marsh. Another possibility for low amphibian numbers is the high abundance of Eastern Chipmunks (*Tamias striatus*) in Hendrie Valley, which are known to kill and eat frogs (Hesterberg, 1950; Callahan, 1993). One account of frog predation described a chipmunk observed eating plentiful seed and then dash under leaf litter and emerged with a live frog in its mouth, which it ate (Hesterberg, 1950). Chipmunks have been observed as being particularly abundant between Valley Inn (where Blackbird Marsh and Sunfish Pond are located) and Kicking Horse Trail near Pond 4, where the majority of visitor supplemental feeding takes place. It is plausible that, despite the abundance of supplemented seeds, chipmunks may still hunt frogs. All amphibian species currently in Hendrie Valley are susceptible to chipmunk predation when they are on land, however, Spring Peeper, Wood Frog and American Toad would be most susceptible due to their terrestrial nature. Further inquiry into research on chipmunk and frog relationships would be beneficial.

There is also evidence that malathion, an insecticide used to control mosquito larva, may negatively impact tadpoles in freshwater systems (Relyea, 2004). This insecticide is labeled as a Class 7 Pesticide in Ontario and thus can be used by the general public, municipalities and in agricultural operations. There are two products containing malathion that can be purchased: Malathion liquid insecticide-miticide concentrate and Wilson 50% malathion liquid insecticide-miticide (MECP, 2019). Malathion has a half life of 17 days in soil and a half life of 2 to 18 days in water and is known to move quickly through the environment (Gervais et al., 2009). It would be worth further investigating whether more research has been done on tadpole, or even adult amphibian, mortality rates when exposed to malathion, and if it is present in water samples taken from Grindstone Creek and Marsh Ponds.

Recommendations

Recommendations to improve the health and sustainability of Hendrie Valley Nature Sanctuary are presented below, and encompass multiple themes including:

- Visitor Use and Wildlife Feeding
- Non-native Invasive Plant Management
- Amphibians
- Species at Risk protection
- Reforestation
- Land Defragmentation
- Priority Research Questions

Communication of the information in this report to the Cootes to Escarpment EcoPark System partners is also recommended through presentations at the management and stewardship committees.

Visitor Use and Wildlife Feeding

Due to the known and potential impacts of supplemental feeding on wildlife and ecosystems, as well as potential risks to visitor's health, it would appear necessary to proactively cease the feeding of wildlife on RBG property. The long term success of phasing out wildlife feeding at RBG must start with RBG's organizational operations. The responsibility rests with RBG, as well as all visitors and neighbouring residents to Hendrie Valley Nature Sanctuary, to protect the beauty and ecologically diverse community within it for everyone to enjoy now and into the future. Regardless if the complete phasing out of feeding wildlife at RBG is adopted across all RBG programs, it is recommended that:

- ➢ Cease the advertising of feeding wildlife at RBG, including chickadees. This includes RBG's social media accounts and if possible, tourism websites.
- ➢ Create a summary factsheet of reasons why RBG has a bylaw regarding not feeding the wildlife and effects observed in Hendrie Valley for communications and staff training.
- ➢ 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. This will ideally reduce the amount of supplemental feed being left behind on the trails, type of supplemental feed used, reduce the amount of vegetation being trampled (thus reducing introduction and spread of non-native invasive plants), and create an open line of communication between visitors and staff regarding the potential impacts of feeding wildlife.
- ➢ RBG Education Programs adjust bird feeding to cultural land areas only (gardens), such as Kippax Garden and Woodland Garden in Hendrie Park, and stop any feeding activities once entering the nature sanctuaries. Additionally, no other wildlife should be fed other than birds due to ecological and human health risks. Reasons why wildlife (including birds) do not need to be fed in natural areas, as well as potential risks to feeding wildlife, should be the main emphasis of the educational programs.
- ➢ Similar to the above recommendation, any group or club programs that take place on RBG property that including any bird feeding opportunities follow the same practises – 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.

- Public access to Hendrie Valley be adjusted to deter visitors coming only to feed the animals. As an example, the parking fee at Cherry Hill Gate be increased to deter visitors who come solely to feed wildlife and not respect RBG bylaws and the ecological integrity of Hendrie Valley.
- RBG should explore by-law enforcement (municipal, RBG security, conservation officer) if visitors still do not follow RBG and municipal no feeding wildlife by-laws and continue to leave piles of feed along the trails.
- Through staff interactions with visitors, along with the potential distribution of a survey by RBG staff and/or volunteers or in partnership with a university, staff will be able to pinpoint visitor intentions for why they feed wildlife. With this information, RBG staff can proceed with developing effective educational signs and programming explaining why supplemental feeding of wildlife is not necessary in a nature sanctuary.

Non-native Invasive Plant Management

As canopy tree cover is expected to continue to decline and forest disturbances are expected to continue in the shorter term, a surge of non-native invasive plant abundance is anticipated in the understory of Hendrie Valley, especially along the forest edges. Therefore, it is recommended that non-native invasive plant management continue to focus in Hendrie Valley and around Hendrie Park.

Specifically, it is recommended that:

- 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.
- 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.
- 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.
- Coordinate removals and/or treatments of ornamental escapes from adjacent RBG gardens with the Horticulture Department for species including Common Butterbur, Common Barberry, Chocolate Vine, Porcelain Berry, Black Jetbead, Winged Euonymus and Amur Cork Tree.
- New introductions or satellite populations of ornamental invasive plants should be targeted and removed before their populations expand. Areas where this has been observed include behind residential properties along Patricia Drive and Sandcherry Drive as a result of yard waste dumping and where the RBG Director's house once occurred. To help accomplish this and spread awareness among local homeowners, it is recommended that RBG continue to work with Cootes to Escarpment EcoPark System partners and expand collaboration to include targeted educational outreach, as well as exploring opportunities for interested homeowners to act on removing ornamental invasive plants on their properties. Communications to residents adjacent to Hendrie Valley should include the impacts of yard waste dumping (introduction of non-native invasive species, etc.) and offer available options for proper

yard waste disposal. If dumping continues, the only other option to preserve what is left of Hendrie Valley and the biodiversity it contains may be working with Burlington by-law enforcement.

- RBG continues the All Staff Garlic Mustard pulls to encourage staff awareness and interaction between departments, opportunities for office staff to connect with the property, and to encourage educational opportunities regarding invasive plants in gardens and natural areas. This event can be annual or bi-annual and can even be made into a friendly competition between teams or departments with a reward, such as a pizza lunch the following week.
- Horticulture staff continue to remove known non-native invasive plants from Hendrie Park gardens and Laking Garden, particularly from the boundaries of the gardens.
- 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.
- Implement best management practices once completed (currently in development) for Woodland Speargrass control to prevent it from further spreading into the valley.

Amphibians

Although amphibian species and numbers have increased since ecological restoration began in Hendrie Valley, the number of individual amphibians heard and documented calling during breeding season are concerningly low and totally lacking in early spring species. The populations are not reflective of the habitat given the wetland habitat improvements made over the years. It appears there is something other than wetland habitat health causing these low numbers. There are likely multiple historical and/or current factors simultaneously influencing amphibian abundance which may include contamination in marsh sediment, periods of poor water quality, possible contamination of insecticides (i.e. malathion) potentially used by homeowners and municipalities to control mosquito larva, non-native invasive flora and fauna, roadkill on adjacent Plains Road, and possible predation of adult amphibians by out of balance mammal populations. Therefore, it is recommended:

- Implement a roadside small animal barrier to restrict access to the surrounding roads and direct wildlife to safer migration corridors (if any exist). Road kill surveys can help determine priority areas for barriers.
- Review nearby adjacent locations such as Unsworth Avenue and/or upstream at Hidden Valley for calling amphibians during the breeding season. The purpose would be to determine if there are no, less, the same, or more amphibians at these locations compared to the MMP sites in Hendrie Valley. This could provide clues to potential negative impacts to amphibian abundance. If there are less or the same number of amphibians, then the negative impacts are potentially on a broader scale.
- Work with partners to improve quality and quantity of urban runoff entering the Hendrie Valley.

Research Opportunities

- A partnership with a college, university or government agency be developed to facilitate amphibian studies in Hendrie Valley and surrounding areas to investigate potential toxicological effects. Topics to investigate should include but not be limited to sediment sampling for contamination (lead, etc.), water quality (for malathion or other harmful elements such as Chlorine), blood sampling from adult frogs (non-lethal) to test for contaminants, tissue analysis from dead amphibians (for Ranavirus, etc.)

- Research animal populations including insect/prey numbers and availability, and amphibian predation (from invertebrates, fish, birds, mammals) during all life stages.
- Research should be conducted to determine what amphibian predators are present (species and abundance) across the nature sanctuaries (especially Hendrie Valley and Cootes Paradise). This includes investigating chipmunk predation of adult frogs.
- During amphibian migration periods RBG staff and/or volunteers survey adjacent roads for amphibian road kill. 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 iNaturlaist app may be very useful for this type of citizen science. Community involvement would not only increase awareness of the threat's amphibians encounter but could also give RBG the opportunity to build a stronger partnership with residents.

Species at Risk

In order to assist SAR recovery in Hendrie Valley Nature Sanctuary, it is recommended that:

- A focus to improve turtle nesting in the vicinity of the Hendrie Park barn be undertaken.
- Awareness signage on Ranavirus be placed at Valley Inn detailing the seriousness of the virus, how the virus transfers between water bodies via equipment (canoes, kayaks, paddles) and which organization to contact if sick reptiles and amphibians are found.
- Propagate SAR plants in decline in Hendrie Valley including American Chestnut (*Castanea dentata*) and Butternut (*Juglans cinerea*).
- Continue and further develop partnerships with adjacent businesses and landowners to improve awareness and stewardship support.
- In addition to the recommendations within the *Royal Botanical Gardens' American Columbo Frasera caroliniensis Site Specific Recovery Plan* (Richer, 2019), consider land acquisition opportunities around Hendrie Valley, especially areas with/adjacent to Endangered American Columbo (*Frasera caroliniensis*) that are just off RBG property.
- An annual educational pamphlet be distributed to residents adjacent to Hendrie Valley regarding yard waste dumping, emptying pool water, and planting native plants in gardens rather than non-native invasive plants.
- Continue breeding 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.

Reforestation

As sections of forest and treed floodplains once dominated by ash species become bare, along with other tree mortalities experienced in the valley, changes to ecosystem community dynamics and functions are likely to occur. Thus, it is recommended that replacement tree and shrub plantings be completed in Hendrie Valley at specific locations:

- 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. Plants could include: Bitternut Hickory (*Carya cordiformis*), Yellow Birch (*Betula alleghaniensis*), Swamp White Oak (*Quercus bicolor*), Bur Oak (*Quercus macrocarpa*), White Oak (*Quercus alba*)*,* Black Willow (*Salix nigra*), Missouri/Heart-leaved Willow (*Salix eriocephala*), Silky Dogwood (*Cornus amomum*), Round-leaved Dogwood (*Cornus rugosa*), American Elderberry *(Sambucus canadensis).*
- Creekside Walk Trail – Grindstone Creek floodplain from South Pasture Swamp (Pond 4) to Unsworth Avenue has had significant loss of ash trees. Over multiple years, trees should be added to replace the ones lost. Non-native trees and shrubs should be removed prior to planting. Plants could include*:* Silver Maple *(Acer saccharinum),* Black Maple *(Acer nigrum),* Balsam Poplar *(Populus balsamifera),* Eastern Cottonwood *(Populus deltoides),* Black Willow (*Salix nigra*), Swamp White Oak (*Quercus bicolor*), Bitternut Hickory (*Carya cordiformis*), Swamp Rose (*Rosa palustris*), Silky Dogwood (*Cornus amomum*), American Elderberry *(Sambucus canadensis).*

Ecological Land Classification

- Complete ELC throughout Hendrie Valley Nature Sanctuary.
- Undertake a detailed review of the abundance of each non-native invasive plant and ornamental escapes. Specifically note the locations of the ornamental species found while conducting surveys.
- Complete ELC on the lands to the north of RBG's Hendrie Valley property currently under the ownership of the City of Burlington through the Cootes to Escarpment EcoPark System.
- Review ELC rare plants list, in addition to known rare plants in Hendrie Valley, for potential propagation opportunities to assist with plant dispersal in Hendrie Valley.

Land Defragmentation

- Undertake land acquisition associated with the forested north side of the valley to increase forest area and reduce forest edge.
- Relocate the RBG storage facility known as "The Lodge" and undertake habitat restoration at that site.
- Review trail locations to determine if larger protected spaces can be created, particularly between Creekside Walk Trail and Unsworth Avenue Trailhead.
- Determine best locations and approaches to establishing wildlife corridors to adjacent Cootes to Escarpment EcoPark System natural areas.

Further Research Topics and Testing

Through partnerships with researchers, it would be extremely beneficial to have studies completed on the topics below:

Chipmunks

What is the Eastern Chipmunk population in Hendrie Valley? What is their diet (can any analysis be done on scat samples of their diet) and predatory behaviour? To what extent are chipmunks impacting wildlife and tree regeneration?

Soil Quality and Analysis

What microbial communities are present in the soils of Hendrie Valley? What is the extent of earthworm impacts on leaf litter and forest health in the valley? What is the estimated population of earthworms and how many species are present?

As soil conditions and microorganisms determine which plant species grow, it is recommended that forest soil samples be taken to analyze for nutrient overloads, heavy metals and the state of the microbial communities. Some of these samples can be compared to the 2009 sample results from Hendrie Valley (Burtenshaw, 2010). Soil samples to test for microbial communities have never been taken and can provide baseline data on what is present (seasonal samples may be necessary) and can potentially determine if allelopathic effects from non-native plants such as Garlic Mustard are occurring. An option to detect microbial activity in the soil, and thus get an idea of soil conditions, is to test soil respiration by measuring CO_2 output – as microbes break down elements in the soil, CO_2 is released. It was highlighted by Hall and Preston (2008) that Woods End Laboratory, Solvita Soil Life Test (https://solvita.com/soil/) has such a test kit, as well as other soil test kits.

Heavy Metal Analysis

Due to low abundance of amphibians and recent issues with lead levels found in some wildlife species, particularly waterfowl, it is recommended that RBG with Hamilton Harbour Remedial Action Plan partners and/or universities, test for heavy metals to determine what is present in the sediment, water (including groundwater) and aquatic invertebrates in Hendrie Valley. Samples should be taken along multiple points starting from Unsworth Avenue downstream to Plains Road bridge. Samples currently exist downstream of the Plains Road bridge crossing of Grindstone Creek.

Conclusion

Hendrie Valley Nature Sanctuary offers visitors a chance to reconnect with the landscape, escape the bustle of city life and experience the natural beauty of the valley. The valley provides a refuge for a variety of Ontario's native plants and wildlife, including species that are at risk of extinction. With continued long term ecological monitoring, natural and human produced changes within the marsh and forests will be documented and help guide restoration efforts into the future. As monitoring data continues to be collected, the dataset becomes more robust and trends can be identified with a higher level of accuracy. With emerging impacts such as climate change and increased frequency of severe weather events, compounded by historic and current pressures to the valley's ecosystems, our actions matter now more than ever. Through partnerships and collaboration with the local community and partners, not only will a piece of natural heritage be preserved, but also the beauty and diverse ecology that currently remains in Hendrie Valley.

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Appendix A

Summary of ground vegetation surveys (1x1m quadrats) from 2018 for all six Hendrie Valley sites organized by average number of individuals and average percent cover a given species occupied; non-native species are bolded.

Species	Avg # of Individuals (per m²)	Species	Avg % Cover (per m²)
Garlic Mustard ***Alliaria petiolata***	**37.71**	Wild Sarsaparilla *Aralia nudicaulis*	12.2958
Pennsylvania Sedge *Carex pensylvanica*	20	**Garlic Mustard** ***Alliaria petiolata***	**6.4625**
Blue-stemmed Goldenrod *Solidago caesia*	9.08	Pennsylvania Sedge *Carex pensylvanica*	6.3375
Canada Mayflower *Maianthemum canadense*	3.71	White Ash *Fraxinus americana*	5.0417
Japanese Hedge Parsley ***Torilis japonica***	**2.96**	Blue-stemmed Goldenrod *Solidago caesia*	3.6667
Wild Sarsaparilla *Aralia nudicaulis*	2.79	Green Ash *Fraxinus pennsylvanica*	3.3333
Avens sp. *Geum species*	2.42	Maple sp. *Acer species*	3.0417
Dwarf Enchanter's Nightshade *Circaea alpina*	2.38	Choke Cherry *Prunus virginiana*	2.7542
Nipplewort ***Lapsana communis***	**1.96**	**Amur Honeysuckle** ***Lonicera maackii***	**2.7125**
Maple sp. *Acer species*	1.75	Dwarf Enchanter's Nightshade *Circaea alpina*	1.9167
Sedge sp. *Carex species*	1.42	**European Buckthorn** ***Rhamnus cathartica***	**1.3750**
Green Ash *Fraxinus pennsylvanica*	1.42	Sedge sp. *Carex species*	1.1708
Red Maple *Acer rubrum*	1.33	Canada Mayapple *Maianthemum canadense*	1.0833
White Ash *Fraxinus americana*	1.13	Currant/Gooseberry sp. *Ribes species*	1.0458
Amur Honeysuckle ***Lonicera maackii***	**1**	**Burdock** ***Arctium minus***	**1.0417**
Aster sp. *Aster species*	0.92	Wood Poppy *Stylophorum diphyllum*	0.9583
Jack-in-the-pulpit *Arisaema triphyllum*	0.79	Avens sp. *Geum species*	0.9500
Choke Cherry *Prunus virginiana*	0.75	Aster sp. *Aster species*	0.8750
Herb Robert ***Geranium robertianum***	**0.67**	**Nipplewort** ***Lapsana communis***	**0.8458**
European Buckthorn ***Rhamnus cathartica***	**0.63**	Black Maple *Acer nigrum*	0.8333

Species	Avg # of Individuals (per m²)	Species	Avg % Cover (per m²)
Black Maple *Acer nigrum*	0.58	Virginia Creeper *Parthenocissus quinquefolia*	0.7500
Wild Geranium *Geranium maculatum*	0.54	**Japanese Hedge Parsley** ***Torilis japonica***	**0.7167**
Norway Maple ***Acer platanoides***	**0.46**	Jack-in-the-pulpit *Arisaema triphyllum*	0.6708
Honeysuckle sp. *Lonicera species*	0.46	Black Raspberry *Rubus occidentalis*	0.6250
Wood Poppy *Stylophorum diphyllum*	0.46	Summer Grape *Vitis aestivalis*	0.5625
Grass sp. *Poa species*	0.33	**Norway Maple** ***Acer platanoides***	**0.5417**
Northern Wood-sorrel *Oxalis montana*	0.29	Bloodroot *Sanguinaria canadensis*	0.3750
Virginia Creeper *Parthenocissus quinquefolia*	0.29	Honeysuckle sp. *Lonicera species*	0.3417
Summer Grape *Vitis aestivalis*	0.29	Purple-flowering Raspberry *Rubus odoratus*	0.2917
Yellow Wood-sorrel ***Oxalis stricta***	**0.25**	Goldenrod sp. *Solidago species*	0.2917
Jumpseed *Persicaria virginiana*	0.25	Blackberry *Rubus allegheniensis*	0.2917
Currant/Gooseberry sp. *Ribes species*	0.25	Wild Geranium *Geranium maculatum*	0.2500
Bloodroot *Sanguinaria canadensis*	0.25	Red Maple *Acer rubrum*	0.2167
Canada Goldenrod *Solidago canadensis*	0.25	Grass sp. *Poa species*	0.2083
Rue-anemone *Thalictrum thalictroides*	0.25	Ironwood *Ostrya virginiana*	0.2083
Sugar Maple *Acer saccharum*	0.21	Nightshade sp. *Solanum species*	0.2083
Circaea sp. *Circaea species*	0.21	**Multiflora Rose** ***Rosa multiflora***	**0.2083**
Woodland Spear Grass ***Poa nemoralis***	**0.21**	**Herb Robert** ***Geranium robertianum***	**0.1667**
Purple-flowering Raspberry *Rubus odoratus*	0.21	Roundleaf Dogwood *Cornus rugosa*	0.1667
White Birch *Betula papyrifera*	0.17	**Yellow Wood-sorrel** ***Oxalis stricta***	**0.1250**
Early Meadow-rue *Thalictrum dioicum*	0.17	Jumpseed *Persicaria virginiana*	0.1250
Whorled Loosestrife *Lysimachia quadrifolia*	0.13	Whorled Loosestrife *Lysimachia quadrifolia*	0.1250

Species	Avg # of Individuals (per m²)	Species	Avg % Cover (per m²)
Largetooth Aspen *Populus grandidentata*	0.13	**Woodland Spear Grass** ***Poa nemoralis***	**0.0875**
Goldenrod sp. *Solidago species*	0.13	White Birch *Betula papyrifera*	0.0875
Roundleaf Dogwood *Cornus rugosa*	0.08	Canada Goldenrod *Solidago canadensis*	0.0833
Ironwood *Ostrya virginiana*	0.08	Sugar Maple *Acer saccharum*	0.0833
Small Burnet ***Poterium sanguisorba***	**0.08**	**Small Burnet** ***Poterium sanguisorba***	**0.0833**
Dandelion ***Taraxacum officinale***	**0.08**	Sand Sedge *Carex muehlenbergii*	0.0833
Baneberry sp. *Actaea species*	0.04	Festuca Grass sp. *Festuca species*	**0.0833**
White Snakeroot *Ageratina altissima*	0.04	Hairy Solomon's Seal *Polygonatum pubescens*	0.0833
Burdock ***Arctium minus***	**0.04**	Northern Wood-sorrel *Oxalis montana*	0.0625
Sand Sedge *Carex muehlenbergii*	0.04	Rue-anemone *Thalictrum thalictroides*	0.0458
Bitternut Hickory *Carya cordiformis*	0.04	Circaea sp. *Circaea species*	0.0458
Dogwood sp. *Cornus species*	0.04	Early Meadow-rue *Thalictrum dioicum*	0.0417
Dog-strangling Vine ***Vincetoxicum rossicum***	**0.04**	Baneberry sp. *Actaea species*	0.0417
Festuca Grass sp. *Festuca species*	0.04	White Avens *Geum canadense*	0.0417
White Avens *Geum canadense*	0.04	Bitternut Hickory *Carya cordiformis*	0.0208
Virginia Stickseed *Hackelia virginiana*	0.04	Large-tooth Aspen *Populus grandidentata*	0.0083
Witch Hazel *Hamamelis virginiana*	0.04	**Dandelion** ***Taraxacum officinale***	**0.0083**
Common Privet ***Ligustrum vulgare***	**0.04**	White Snakeroot *Ageratina altissima*	0.0042
Hairy Solomon's Seal *Polygonatum pubescens*	0.04	Dogwood sp. *Cornus species*	0.0042
Blackberry *Rubus allegheniensis*	0.04	**Dog-strangling Vine** ***Vincetoxicum rossicum***	**0.0042**
Black Raspberry *Rubus occidentalis*	0.04	Virginia Stickseed *Hackelia virginiana*	0.0042
Nightshade sp. *Solanum species*	0.04	Witch Hazel *Hamamelis virginiana*	0.0042

Species	Avg # of Individuals (per m²)	Species	Avg % Cover (per m²)
Poison Ivy *Toxicodendron radicans var. radicans*	0.04	**Common Privet** ***Ligustrum vulgare***	**0.0042**
Riverbank Grape *Vitis riparia*	0.04	Poison Ivy *Toxicodendron radicans var. radicans*	0.0042
Multiflora Rose ***Rosa multiflora***	-	Riverbank Grape *Vitis riparia*	0.0042
Total Species Richness	**67**		
Non-native Richness	**15**		

**Note: Rosa multiflora does not have average abundance due to it growing outside survey plot; however, leaning portion over survey plot was included in percent cover.*
*** Note: majority of Garlic Mustard plants small first year basal florets.*

Appendix B

List of all bird species detected in Hendrie Valley, including last known observations, through Long Watch Project, MMP and RBG breeding bird surveys.

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
American Black Duck	*Anas rubripes*	2018		✓		
American Coot	*Fulica americana*	2018		✓		
American Crow	*Corvus brachyrhynchos*	2018		✓		
American Goldfinch	*Carduelis tristis*	2018	✓	✓		
American Kestrel	*Falco sparverius*	2018		✓		
American Redstart	*Setophaga ruticilla*	2018		✓		
American Robin	*Turdus migratorius*	2018	✓	✓		
American Tree Sparrow	*Spizella arborea*	2018		✓		
American White Pelican	*Pelecanus erythrorhynchos*	2013				✓
American Wigeon	*Anas americana*	2018		✓		
Bald Eagle	*Haliaeetus leucocephalus*	2018		✓		
Baltimore Oriole	*Icterus galbula*	2018	✓	✓		
Bank Swallow	*Riparia riparia*	2015		✓		
Barn Swallow	*Hirundo rustica*	2018		✓		✓
Bay-breasted Warbler	*Dendroica castanea*	2018		✓		
Belted Kingfisher	*Megaceryle alcyon*	2018	✓	✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Black Tern	*Chlidonias niger*	1999				✓
Black-and-white Warbler	*Mniotilta varia*	2018		✓		
Black-Billed Cuckoo	*Coccyzus erythropthalmus*	2015		✓		
Blackburnian Warbler	*Dendroica fusca*	2018		✓		
Black-capped Chickadee	*Poecile atricapillus*	2018	✓	✓		
Black-crowned Night-Heron	*Nycticorax nycticorax*	2018		✓		
Blackpoll Warbler	*Dendroica striata*	2018		✓		
Black-throated Blue Warbler	*Dendroica caerulescens*	2018		✓		
Black-throated Green Warbler	*Dendroica virens*	2018		✓		
Blue Jay	*Cyanocitta cristata*	2018	✓	✓		
Blue-gray Gnatcatcher	*Polioptila caerulea*	2018		✓		
Blue-headed Vireo	*Vireo solitarius*	2018		✓		
Blue-winged Teal	*Anas discors*	2016			✓	
Bobolink	*Dolichonyx oryzivorus*	2014				✓
Broad-winged Hawk	*Buteo platypterus*	2018		✓		
Brown Creeper	*Certhia americana*	2018		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Brown Thrasher	*Toxostoma rufum*	2018		✓		
Brown-headed Cowbird	*Molothrus ater*	2018	✓	✓		
Bufflehead	*Bucephala albeola*	2018		✓	✓	
Canada Goose	*Branta canadensis*	2018	✓	✓	✓	
Canada Warbler	*Wilsonia canadensis*	2012				✓
Canvasback	*Aythya valisineria*	2018		✓		
Cape May Warbler	*Dendroica tigrina*	2018		✓		
Carolina Wren	*Thryothorus ludovicianus*	2018	✓	✓		
Caspian Tern	*Hydroprogne caspia*	2018		✓		
Cedar Waxwing	*Bombycilla cedrorum*	2018	✓	✓		
Chestnut-sided Warbler	*Dendroica pensylvanica*	2018		✓		
Chimney Swift	*Chaetura pelagica*	2018		✓		
Chipping Sparrow	*Spizella passerina*	2018	✓	✓		
Cliff Swallow	*Petrochelidon pyrrhonota*	2016				✓
Common Goldeneye	*Bucephala clangula*	2017			✓	
Common Grackle	*Quiscalus quiscula*	2018		✓		
Common Loon	*Gavia immer*	2018		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Common Merganser	*Mergus merganser*	2018		✓	✓	
Common Nighthawk	*Chordeiles minor*	2017		✓		
Common Tern	*Sterna hirundo*	2015		✓		
Common Yellowthroat	*Geothlypis trichas*	2018	✓	✓		
Cooper's Hawk	*Accipiter cooperii*	2018		✓		
Dark-eyed Junco	*Junco hyemalis*	2018		✓		
Double-crested Cormorant	*Phalacrocorax auritus*	2018		✓		
Downy Woodpecker	*Picoides pubescens*	2018	✓	✓		
Eastern Bluebird	*Sialia sialis*	2018		✓		
Eastern Kingbird	*Tyrannus tyrannus*	2018	✓	✓		
Eastern Meadowlark	*Sturnella magna*	1981				✓
Eastern Phoebe	*Sayornis phoebe*	2018	✓	✓		
Eastern Screech Owl	*Megascops asio*	2018		✓		
Eastern Towhee	*Pipilo erythrophthalmus*	2018		✓		
Eastern Wood-Pewee	*Contopus virens*	2018	✓	✓		
European Starling	*Sturnus vulgaris*	2018	✓	✓		
Fox Sparrow	*Passerella iliaca*	2018		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Gadwall	*Anas strepera*	2018		✓		
Golden Eagle	*Aquila chrysaetos*	2011				✓
Golden-crowned Kinglet	*Regulus satrapa*	2018		✓		
Gray Catbird	*Dumetella carolinensis*	2018	✓	✓		
Gray-cheeked Thrush	*Catharus minimus*	2018		✓		
Great Blue Heron	*Ardea herodias*	2018	✓	✓	✓	
Great Crested Flycatcher	*Myiarchus crinitus*	2018	✓	✓		
Great Egret	*Ardea alba*	2018	✓	✓	✓	
Great Horned Owl	*Bubo virginianus*	2018	✓	✓		
Greater Yellowlegs	*Tringa melanoleuca*	2018		✓		
Green Heron	*Butorides virescens*	2018		✓		
Green-winged Teal	*Anas crecca*	2018		✓	✓	
Hairy Woodpecker	*Picoides villosus*	2018	✓	✓		
Hermit Thrush	*Catharus guttatus*	2018		✓		
Herring Gull	*Larus argentatus*	2018		✓	✓	
Hoary Redpoll	*Carduelis hornemanni*	2015		✓		
Hooded Merganser	*Lophodytes cucullatus*	2018		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Hooded Warbler	*Wilsonia citrina*	2015		✓		
Horned Grebe	*Podiceps auritus*	2012				✓
House Finch	*Carpodacus mexicanus*	2018		✓		
House Sparrow	*Passer domesticus*	2018	✓	✓		
House Wren	*Troglodytes aedon*	2018	✓	✓		
Indigo Bunting	*Passerina cyanea*	2018	✓	✓		
Killdeer	*Charadrius vociferus*	2018		✓	✓	
Least Bittern	*Ixobrychus exilis*	2017				Least Bittern Call Broadcast Survey
Least Flycatcher	*Empidonax minimus*	2018		✓		
Lesser Black-Backed Gull	*Larus fuscus*	2002			✓	
Lesser Scaup	*Aythya affinis*	2011			✓	
Lincoln's Sparrow	*Melospiza lincolnii*	2018		✓		
Louisiana Waterthrush	*Seiurus motacilla*	1965				✓
Magnolia Warbler	*Dendroica magnolia*	2018		✓		
Mallard	*Anas platyrhynchos*	2018	✓	✓	✓	
Marsh Wren	*Cistothorus palustris*	2018		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Merlin	*Falco columbarius*	2018		✓		
Mourning Dove	*Zenaida macroura*	2018		✓		
Mourning Warbler	*Oporornis philadelphia*	2018		✓		
Mute Swan	*Cygnus olor*	2018	✓	✓	✓	
Nashville Warbler	*Vermivora ruficapilla*	2018		✓		
Northern Cardinal	*Cardinalis cardinalis*	2018	✓	✓		
Northern Flicker	*Colaptes auratus*	2018	✓	✓		
Northern Goshawk	*Accipiter gentilis*	2016		✓		
Northern Harrier	*Circus cyaneus*	2018		✓		
Northern Mockingbird	*Mimus polyglottos*	2017		✓		
Northern Parula	*Parula americana*	2018		✓		
Northern Pintail	*Anas acuta*	2003			✓	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	2018		✓		
Northern Waterthrush	*Seiurus noveboracensis*	2018		✓		
Northern Shoveler	*Anas clypeata*	2018		✓		
Olive-sided Flycatcher	*Contopus cooperi*	2018		✓		
Orange-crowned Warbler	*Vermivora celata*	2018		✓		

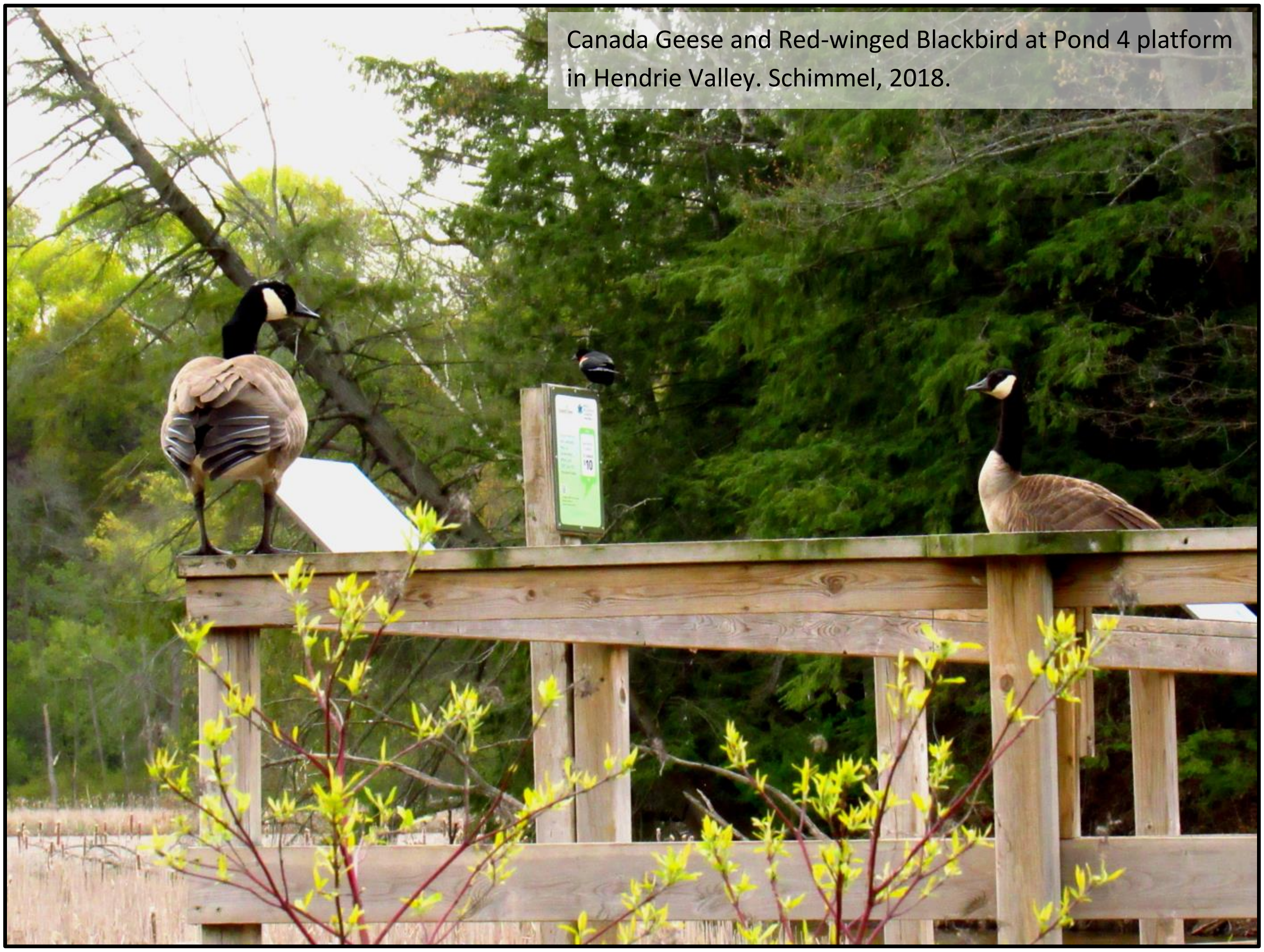
Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Orchard Oriole	*Icterus spurius*	2017				Forest SAR Bird Wandering Transects
Osprey	*Pandion haliaetus*	2018		✓		
Ovenbird	*Seiurus aurocapilla*	2018		✓		
Palm Warbler	*Dendroica palmarum*	2018		✓		
Palm Warbler (Western)	*Dendroica palmarum*	2015		✓		
Pectoral Sandpiper		2018			✓	
Peregrine Falcon	*Falco peregrinus*	2018		✓		
Philadelphia Vireo	*Vireo philadelphicus*	2018		✓		
Pie-billed Grebe	*Podilymbus podiceps*	2018		✓		
Pileated Woodpecker	*Dryocopus pileatus*	2018		✓		
Pine Siskin	*Carduelis pinus*	2018		✓		
Pine Warbler	*Dendroica pinus*	2018		✓		
Purple Finch	*Carpodacus purpureus*	2018		✓		
Purple Martin	*Progne subis*	2015		✓		
Red Knot	*Calidris canutus*	1993				✓
Red-bellied Woodpecker	*Melanerpes carolinus*	2018	✓	✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Red-breasted Merganser	*Mergus serrator*	2018		✓		
Red-breasted Nuthatch	*Sitta canadensis*	2018		✓		
Red-eyed Vireo	*Vireo olivaceus*	2018	✓	✓		
Redhead	*Aythya americana*	2001			✓	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	1996				✓
Red-tailed Hawk	*Buteo jamaicensis*	2018		✓		
Red-winged Blackbird	*Agelaius phoeniceus*	2018	✓	✓		
Ring-billed Gull	*Larus delawarensis*	2018		✓	✓	
Ring-necked Duck	*Aythya collaris*	2018		✓		
Rock Pigeon	*Columba livia*	2018		✓		
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	2018	✓	✓		
Rough-legged Hawk	*Buteo lagopus*	2015		✓		
Ruby-crowned Kinglet	*Regulus calendula*	2018		✓		
Ruby-throated Hummingbird	*Archilochus colubris*	2018		✓		
Ruddy Duck	*Oxyura jamaicensis*	2014			✓	
Rusty Blackbird	*Euphagus carolinus*	2017		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Scarlet Tanager	*Piranga olivacea*	2018	✓	✓		
Sharp-shinned Hawk	*Accipiter striatus*	2018		✓		
Short-eared Owl	*Asio flammeus*	1998				✓
Solitary Sandpiper	*Tringa solitaria*	2018		✓		
Song Sparrow	*Melospiza melodia*	2018	✓	✓		
Sora	*Porzana carolina*	2002				Call Counts
Spotted Sandpiper	*Actitis macularius*	2018		✓		
Swainson's Thrush	*Catharus ustulatus*	2018		✓		
Swamp Sparrow	*Melospiza georgiana*	2018	✓	✓		
Tennessee Warbler	*Vermivora peregrina*	2018		✓		
Tree Swallow	*Tachycineta bicolor*	2018		✓		
Trumpeter Swan	*Cygnus buccinator*	2018		✓		✓
Tufted Titmouse	*Baeolophus bicolor*	2017		✓		
Tundra Swan	*Cygnus columbianus*	2016		✓		
Turkey Vulture	*Cathartes aura*	2018	✓	✓		
Veery	*Catharus fuscescens*	2016				Forest SAR bird Wandering Transects
Virginia Rail	*Rallus limicola*	2018		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Warbling Vireo	*Vireo gilvus*	2018	✓	✓		
White-breasted Nuthatch	*Sitta carolinensis*	2018	✓	✓		
White-crowned Sparrow	*Zonotrichia leucophrys*	2018		✓		
White-throated Sparrow	*Zonotrichia albicollis*	2018		✓		
Willow Flycatcher	*Empidonax traillii*	2018	✓	✓		
Wilson's Warbler	*Wilsonia pusilla*	2018		✓		
Winter Wren	*Troglodytes troglodytes*	2018		✓		
Wood Duck	*Aix sponsa*	2018		✓	✓	
Wood Thrush	*Hylocichla mustelina*	2018		✓		
Yellow Warbler	*Dendroica petechia*	2018	✓	✓		
Yellow-bellied Flycatcher	*Empidonax flaviventris*	2017		✓		
Yellow-bellied Sapsucker	*Sphyrapicus varius*	2018		✓		
Yellow-billed Cuckoo	*Coccyzus americanus*	2018		✓		
Yellow-rumped Warbler	*Dendroica coronata*	2018		✓		
Yellow-throated Vireo	*Vireo flavifrons*	2018		✓		

Common Name	Scientific Name	Last Known Sighting	Breeding Bird Surveys	Long Watch	Marsh Monitoring Program	Incidental and/or Other
Yellow-throated Warbler	*Dendroica dominica*	2015		✓		



Canada Geese and Red-winged Blackbird at Pond 4 platform in Hendrie Valley. Schimmel, 2018.