Upland Area Bird Monitoring

2010 -2022 RBG Data Review

Red-winged Blackbird male
Photo Credit: Brittany Killingbeck

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Document Description

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Executive Summary

Terrestrial Bird Monitoring Surveys at Royal Botanical Gardens (RBG) were initiated in 2008, in part tied to assessment of the impacts of the Spongy Moth pesticide *Bacillus thuringiensis var. kurstaki* (Btk), on upland (terrestrial) birds. Since then, the purpose has been refocused to provide index bird population status monitoring, accumulating ongoing data concerning bird community composition and abundance during peak breeding season in June. Information gathered is reflective of habitat quality and contributes to knowledge on local population trends and species.

This report focuses on terrestrial bird trends between 2010-2022 property wide and for each nature sanctuary. Red-winged Blackbird a meadow species of marshes as well as uplands is the most abundant, with Cedar Waxwing, Song Sparrow, and Black-capped Chickadee common, and with 118 species overall recorded. Sparrow species are notably increasing while warbler species are declining. The full species list is found in Appendix E. Results of the Shannon-Wiener Diversity Index show that the avian community property wide is both highly diverse and resilient to catastrophic forest impacts such as the recent Emerald Ash Borer (EAB). Each nature sanctuary while diverse, struggles with different forest health issues which impact the avian community.

Cootes Paradise North Shore (CP-NS) is the largest nature sanctuary with the highest avian diversity. Despite stressors such as the Emerald Ash Borer (EAB) and White-tailed deer, the avian community shows resilience in species. Common species are persisting through major forest impacts while rare species are in transition. Interior forest birds are stable, but fragile, and warblers show a reduction in diversity. There is ongoing restoration work and invasive species removal in the interior forest which should help alleviate some of the stressors these fragile communities face. More about CP-NS can be found on page 66.

The avian community at Cootes Paradise South Shore (CP-SS) is under intense pressure from off-trail usage, urban development, and restricted space. Despite this, there is surprising resiliency from the avian community, with species richness remaining even. The most notable concern of CP-SS is the steep decline of warblers, even common ones such as the Yellow Warbler. Changes in forest structure are also causing minor shifts in guilds and species assemblage. Reforestation efforts at Captain Cootes South Shore (CP-SS) are promising with evidence of nesting adjacent to newly forested areas where people have been redirected away. Page 73 has more details about CP-SS.

Grassland restoration efforts at Escarpment Properties (EP) have been successful in establishing grassland Species at Risk and uncommon grassland species. Other guilds are remaining stable at Escarpment Properties indicating that avian community at EP is stable overall. A detailed account begins on page 79.

In Hendrie Valley (HV) forest health impacts, such as intense visitation, decline in native shrub and tree regeneration and proliferation of non-native ground cover, are likely reducing available forage and nesting habitat for many species. Diversity is also decreasing despite increases to species richness, as many species are becoming uncommon to rare in surveys. Wildlife feeding continues to be an ongoing problem at HV, with impacts likely more widespread than previously estimated and noted as increasing again 2022 by volunteer monitoring. More details on wildlife feeding at HV can be found on page 83.

Across RBG invasive plant species remain the dominant threat to the avian community as they alter forest structure and reduce available forage. Eurasian Honeysuckle shrub species are particularly troublesome due to its known negative impact on Species-at-Risk birds. Ongoing work across all four sanctuaries has been initiated to alleviate this pressure and are ongoing. Information about how invasive species impact birds can be found on page 102.

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Introduction

Royal Botanical Gardens (RBG) nature sanctuaries are located in the Lower Great Lakes/St. Lawrence Plain Bird Conservation Region 13 (BCR 13), the Ontario portion of which is referred to as BCR 13 ON. The species in this region face the destruction and loss of habitat due to factors such as urban development, pollution, and other human disturbances as a result of the ongoing growth of the human population in the area. Despite the threats associated with the alteration to much of the southern Ontario landscape, BCR 13 ON maintains unique and important habitats for bird species. This region supports the greatest diversity of breeding land birds of any other area in Canada and has an unusually high proportion of species-at-risk, due in part to the region's location at the northern range limit of some species (Environment and Climate Change Canada, 2014).

Situated at the head of Lake Ontario, RBG's nature sanctuaries have long been recognized for their importance to a wide variety of plants and wildlife. In 1927 a block of property akin to the current Cootes Paradise property was formally established as a Provincial Wildlife Sanctuary, specifically tied to protection of migratory birds, known as the Dundas Crown Game Preserve. The land protection was not effective and was reinvented with the formation of RBG in 1941. Today RBG's 971 hectares of natural lands extending from Lake Ontario to the escarpment top host 38% of Ontario's and 23% of Canada's native flora and encompasses significant wetlands, forest blocks as well as a portion of the Niagara Escarpment. The nature sanctuaries, named Cootes Paradise, Hendrie Valley and Escarpment Properties, have also been designated as an Important Area for Reptiles and Amphibians (IMPARA), an Environmentally Sensitive Area, a Provincial Area of Natural and Scientific Interest (ANSI), and an Important Bird Area (IBA) (Royal Botanical Gardens, 2011).

A long history of bird observations and tagging has occurred in and around RBG, with records indicating sightings of at least 277 species in the local area (Curry, 2006; RBG Bird Checklist, 1995), including several rare species such as the provincially and federally endangered Prothonotary Warbler (*Protonotaria citrea*) (Prothonotary Warbler Recovery Team, 2009). Many of the observed species are migratory, as RBG is part of two important North American bird migration flyways (Ward, 2010). However, a significant portion of the species observed inhabit RBG's nature sanctuaries year-round or only during the breeding season. Prior to the year 2008, quantifiable surveys of RBG's upland (terrestrial areas) bird populations had not been

completed since the “Annotated Checklist of the Birds of Royal Botanical Gardens” report by Lamond and Austen (1985).

In 2008, a survey of bird species present during the breeding season at sites surrounding Cootes Paradise was undertaken as part of the Cootes Paradise Forest Decline Study (CP FDS). This study was designed to monitor the effects of spraying the insecticide *Bacillus thuringiensis var. kurstaki* (Btk) (McCormack, 2008). Since then, RBG has made a committed effort to quantify the populations of terrestrial area birds throughout its properties to accumulate baseline data on bird community composition and abundance during peak breeding season. During this time, many birds are nesting and living in the area and are dependent upon local ecosystem resources. In the long term, data trends can help identify changes and stresses on RBG’s terrestrial ecosystems by highlighting areas of terrestrial bird preference and avoidance. This information is used to compliment the Long-Term Forest Monitoring Reports which stem from the original CP FDS. Separately birds of the large coastal marsh areas are captured in Marsh Monitoring Program and periodically described by Bird Studies Canada.

The point count is the most widely used method for quantitatively monitoring bird populations (Ralph et al., 1995), and is the method of choice for the Ontario Breeding Bird Atlas to monitor bird populations (OBBA, 2001). Since 2008, point counts have been conducted on mornings during the month of June in forest monitoring plots and old field plots scattered throughout RBG’s nature sanctuaries. The number of individual detections, species richness, estimated species abundance, dominant species, diversity, presence of invasive species, and occurrence of species-at-risk are examined and compared amongst nature sanctuaries to highlight any differences in bird communities. Long-term monitoring results will be used to track trends in bird community composition and abundance over time, which will help guide habitat management decisions.

While many yearly reports have been done, a formal synthesis of the collected data property wide has not, nor have these reports been made more widely available. The purpose of this report is to synthesize this collection of quantitative index data to highlight trends occurring across the property and in each nature sanctuary. Trends identified can help focus restoration and monitoring efforts to better restore and maintain the current natural landscape at RBG.

Methods

Monitoring Sites

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

Initially 21 sites were monitored, 18 of which corresponded with forest monitoring plots. A plot was added to CP-NS in 2012, and three plots were added to EP between 2017 and 2018. In 2018, five temporary plots in HV were surveyed for one season for an in-depth assessment of that nature sanctuary.

These 30 sites focus on terrestrial habitats, including interior forest, forests with edge effects, secondary forest, successional meadows, grasslands, garden, and plantation. Some plots have wetland influence, but this habitat type is not the focus.

Together, the monitoring plots are scattered amongst RBG's nature sanctuaries. During winter 2012, names of the forest monitoring plots and bird monitoring plots were standardized to unify them; each was given a new name and ID number. New plot names include nature sanctuary codes (CP for Cootes Paradise, EP for Escarpment Properties, HV for Hendrie Valley), sanctuary section codes (NS for north shore of Cootes Paradise, SS for south shore if Cootes Paradise, BT for Berry Tract Escarpment Property, RC for Rock Chapel Escarpment Property), and an individual plot number (Table 1).

Table 1 Previous and new monitoring plot names with corresponding identification codes, and number of site visits

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

Data Collection

Equipment List

- Binoculars
- Identification aids
    - Peterson Field Guide to Birds of Eastern and Central North America (Peterson, 2010)
    - The Cornell Lab Merlin Bird ID App v8
- Clipboard with data sheets and pencil
- Smartphone with time, digital stopwatch, compass, and recording functions
- GPS unit
- Digital camera

Point Count Surveys

The sampling window ranged from May 31st- July 1st and all plots were visited four times, with at least three days in-between samples. Point count surveys were conducted between 5:10 am and 10:45 am. Generally, between six and eight plots were visited per day, with fewer or no plots surveyed on days with inclement weather. To increase efficiency of travel and time usage, plots that were near to each other and within the same nature sanctuary were surveyed on the same day or grouped with plots of the closest nearby nature sanctuary (CP-NS with EP, CP-SS with HV). Point count methodology was based on protocols set by the Ontario Breeding Bird Atlas (OBBA, 2001).

The time of day during which a given plot was visited was intentionally varied during repeat visits to eliminate biases associated with time-of-day bird activity levels. A five-minute period of silence upon arrival at the site allowed for nearby birds to adjust to the disturbance caused by surveyors. This time was also used to record the appropriate site information on the monitoring sheet, including the date, time, study plot code, temperature (°C), percent cloud cover, wind strength (Beaufort scale), surveyors present, noise code (with “1” meaning very low noise level and “5” being extremely loud), and other relevant notes. A compass on a smartphone was used to orient the field data sheet towards magnetic north.

Following this time of silence was a ten-minute period where all species detected by song/call or visual observation within a 100-metre circular radius from the centre of the plot were recorded. Identification aids and other equipment were used at this time. In rare instances a smartphone could be used to make an

audio recording of the call of a rare and/or unknown bird. On the data sheet, species were mapped out on a circle, where the centre represented the data recorder and the edge of the circle represented the plot boundary (Appendix A). Species were placed in the circle based on their direction and approximated distance from the surveyors. If several individuals could be heard, surveyors assumed that multiple birds of the same species were calling only if they were consistently heard calling from distinctly different points (or at the same time). Any species which were visually confirmed were marked with a "v" on the data sheet. Notes were made on breeding behaviour of observed birds and if any nests were present (Appendix B).

Methodology Limitations and Bias

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

The terrestrial bird monitoring surveys at RBG are focused solely on terrestrial species, and point count locations are in terrestrial habitats. While wetlands may have some influence, they are not the target, and thus wetland specific species are severely underrepresented in our point counts. High flying aerial insectivores, such as swifts and swallows, may also be underrepresented as they are above the canopy and can be hard to see and hear. Marsh bird monitoring occurs separately linked with Marsh Monitoring Program administered by Birds Studies Canada.

The surveys are focused to the month of June (and last week of May), when most species have arrived and started breeding. Prescence of early and late breeders may be observed, but definitive proof of breeding will be missed. Only through extensive surveys, territory mapping, or nest searching could a definitive list of breeding birds be made and is not the intent of the survey.

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

Sampling effort per nature sanctuary is not equivalent, which causes bias in species richness and detections. CP-SS and EP are the best represented at 17% an 19% coverage respectively, followed by HV at 13% and CP-NS at 12%.

Data and Statistics

Data used for this report consists of bird surveys between 2010 and 2022. Data was collected in 2008 and 2009, but due to inconsistencies and incompatibilities in methodology these years have been excluded from analysis. As part of continual bird monitoring efforts at RBG, there are volunteer and other monitoring programs that take place alongside and outside of the breeding season. Other programs facilitated at RBG include the Long Watch Project (Migratory Bird Transects), Marsh Monitoring Program (MMP) Marsh Bird Surveys, and Fall Migratory Counts. Migratory data is summarized in an additional report. MMP Bird Surveys are not included in this report, as the focus is on terrestrial species.

For the purposes of analysis, data has been broken down into two categories: unlimited and in-plot. Unlimited data is all birds detected during point counts, including flyovers, birds just outside the plot, birds detected just before and just after the count (less than 5 seconds), and all birds detected during the count. In-plot data solely looks at the birds identified within the 100-metre radial plot and ignores all flyovers, etc.

Unlimited data is used when looking at trends across the property and for each nature sanctuary. This is because the goal is to assess the entire community of birds present across all the terrestrial habitats represented, therefore every bird detected is used to analyse these trends. Wetland species that were detected during surveys are included in this analysis as many species detected rely on and use terrestrial habitats to some extent during the breeding season, whether for forage or resting purposes. Their presence is often minimal but does influence diversity and some guild representations.

In-plot data is used when looking at a particular bird monitoring plot. This is because each survey location looks at a specific type of habitat and any birds using that habitat to breed. As with unlimited data, wetland species are included in analysis as well, albeit they have a much lower impact.

Very few birds were excluded from analysis. Unknown species, excluding gulls, were removed from analysis. Gulls pose a unique problem, as they are typically high and fast flyovers and are ubiquitous across the landscape. Identification to the species level of gulls is uncommon and there are many instances of whole years where gulls are only identified as Gull sp. Due to this all gull species, even ones accurately recorded to the species level, were amalgamated into Gull sp. to use in data analysis. Amalgamating all gulls ensures there is no duplication of species and ensures the number of gulls is still accurately recorded. While gulls

may often flyover, they are highly opportunistic predators and will use terrestrial habitats to forage and rest.

To analyse community trends each bird was assigned four guilds; taxon, nest location, habitat, and foraging (Appendix C). The purpose of placing species into guilds is to assess if there are any trends affecting whole communities which may require further in-depth analysis. There is no universal agreement on what species belong to what guild, and studies often have conflicting or different guild assignments per species. For the sake of uniformity, every species was researched using Birds of the World, and All About Birds to assess nest location, habitat, and foraging guilds.

Birds were assigned a guild based on their breeding habitat and behaviour. Many birds are highly flexible in their diet and habitat usage depending on the time of year. In order to assess effects during the breeding season, only diet, habitat, and nesting requirements during that time were used. For example, the American Robin is a known frugivore during late summer, fall, and winter. However, during its breeding season, the predominant food captured and eaten is insects, caught by probing the ground. The American Robin then, is listed as a ground prober rather than a frugivore.

Habitat and nest location are based on what the species uses most often during its breeding season. In the rare instances that a species is very generalist in its habitat or nest location the generalist tag was applied.

Trends are analysed using linear regression. Often the R^2 value is less than 0.65 and is statistically insignificant. Populations trends still stand out in more severe instances and can lead to further analysis and study. Changes over time are assessed using linear regression rather than percentage change between 2010 and 2022, as linear regression captures more of the fluctuations year over year. It should be noted that for species with very low numbers, the change will be more inaccurate and inflated. Regardless, the severity of a trend will be evident and indicative of further study.

Species Richness, Species Relative Abundance, and Diversity

Species Richness

Species richness is the count of how many species are present, typically within a sample, such as a survey. Species richness can be subject to bias via observer skill and sampling effort. Observer bias can cause species richness to increase or decrease depending on the skill of the observers. Sampling effort, such as the number of times a survey is done, length of time at the location, and if more locations are surveyed will also influence the number of species detected. As more effort is put into surveys more species are found until an asymptote is reached where the likelihood of finding another species reduces to near zero.

RBG has controlled these biases by ensuring counts are done by skilled observers, at the same time of year, the same locations, and with equal amount of effort per location when possible.

Relative Abundance

Relative abundance is a measure of each species in relation to all others detected. The method used for deriving relative abundance for bird point counts is one suggested by Nur et al. (1999). Relative abundance for a given area was obtained by taking the total number of detections of a species for a site, and dividing it by the total number of detections for all species at that site:

$$\text{Relative abundance of species x} = \frac{Sum\ of\ detections\ of\ species\ x}{Sum\ of\ all\ detections\ of\ all\ species}$$

Relative abundance is affected by the same biases as species richness. Any decrease or increase in a species relative abundance will be matched with some sort of increase or decrease in other species.

Relative abundance typically follows a pattern with several common to dominant species followed by a long ‘tail’ of uncommon to rare species. Issues arise when common species begin to become uncommon, the tail begins to shorten, or certain species become ‘super dominant’ and push out all other species, as with invasives. Relative abundance struggles to identify trends in rare or uncommon species as the changes in percentage over time can be lost compared to a more common species.

Diversity

Diversity is a measure of the number of the number of species present and their evenness. A more diverse area has not only more species, but each species is more evenly distributed. To measure diversity, the Shannon-Wiener Diversity Index is used, represented by the formula:

$$H' = -\sum_{i=1}^{n} p_i \ln(p_i)$$

Where H' is the diversity index, and p_i is relative abundance. The higher the value of H' the greater the diversity of a site.

The Shannon-Wiener Index relies on the assumption that all species are identified, which is often untrue. As such it typically under-estimates diversity and rare species have a greater effect on the index than dominant species. The index is most beneficial to use when comparing between surveys that have received equal effort in time, area surveyed, and observers, which is met by RBG's methodology.

The Shannon-Wiener Index works well when there are multiple data points to compare to. As there is thirteen years of data, comparisons and trends can be readily identified.

Results and Discussion

Property Wide

Species Richness and Detections

Since 2010 species richness has increased by approximately 21%. Species richness now averages 73 species detected each year (Figure 1). Detections of birds are also increasing, averaging 2481 detections per year. Average number of detections has increased by 49% since 2010.

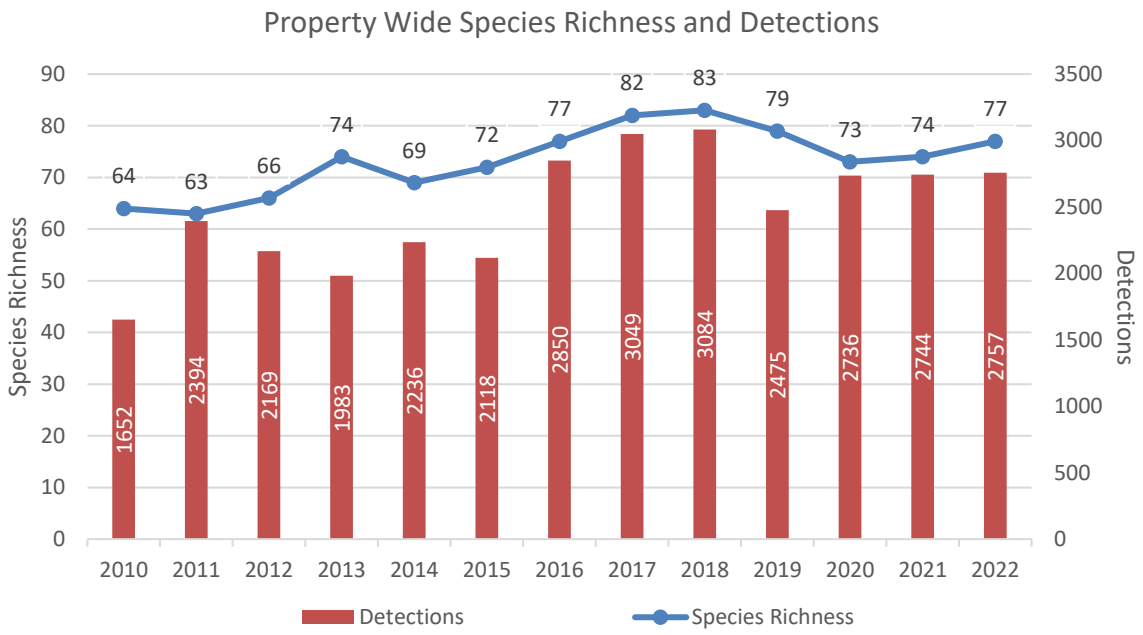

Figure 1 Species Richness and Detections property wide from 2010 to 2022

The increase of species richness and detections is consistent even when excluding survey locations added in 2012, 2017, and 2018. The difference between the average species richness property wide is 3% greater than the average species richness of the original survey locations. Detections show a greater difference, with property wide detections being 10% than the original survey locations.

Diversity

Diversity was measured twice across the property. Once where every new survey location was incorporated, and once where only the original plots were analysed. This was to assess what the impact of new survey locations on diversity.

Results indicate that diversity is increasing property wide and that impacts to diversity seem to affect the property as whole (Figure 2). Overall increase is minor at a 2% increase for original plots, and 5% when including added locations. The difference between the lowest recorded diversity index value and the highest is 9%. The dip between 2019 and 2021 was a decrease of 4% which mostly recovered in 2022.

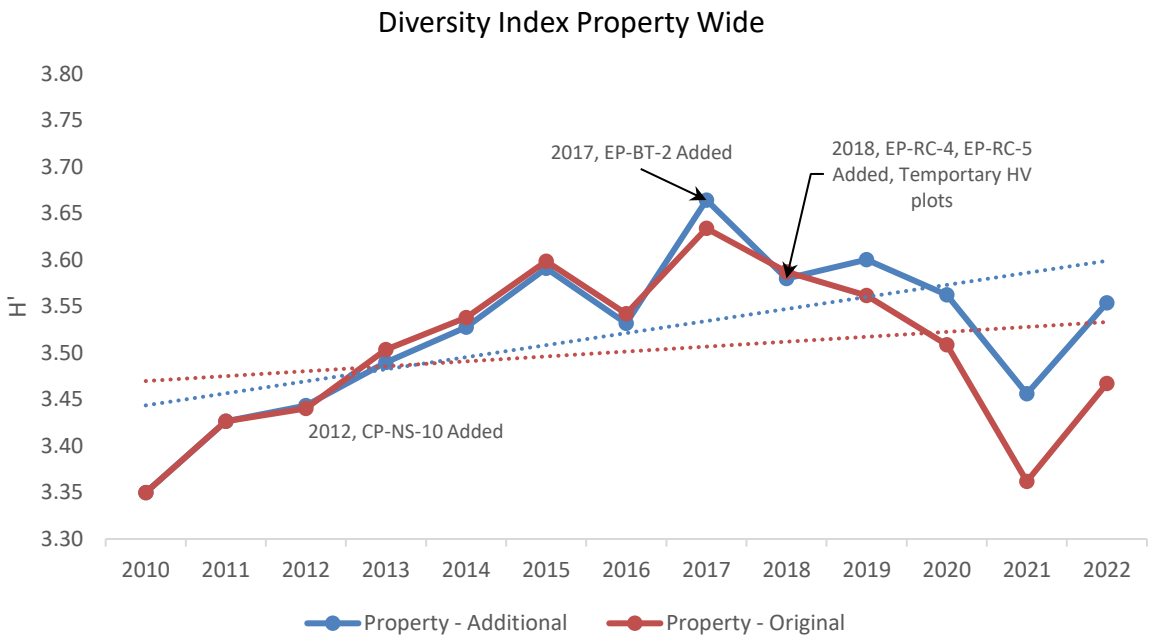

Figure 2 Comparison of Diversity Index values (H') of the original survey plots and property wide (inclusive of all survey plots) from 2010-2022

With the addition of CP-NS-10 in 2012, diversity was slightly lower (>1%) than the original plots. A potential reason for this is that while species richness increased with the addition of CP-NS-10, evenness decreased, thus reducing overall diversity very slightly.

2017 to 2018 saw three new plots added EP-BT-2, EP-RC-4, and EP-RC-5. These survey locations are all in grassland and meadow habitats undergoing restoration and represent a habitat that

had previously been under-represented in surveys. With the addition of these plots more grassland species were detected and in greater numbers, contributing to an increase in diversity.

In 2018, five temporary monitoring plots were added in HV to assess birds across the nature sanctuary for forest health monitoring. Despite the addition of these temporary plots there was minimal impact to property wide diversity, likely due to their minimal impact on species richness and evenness.

Based on the current total number of species found during bird surveys, that being 118, the maximum the diversity index could be property wide is 6.34. This of course is unattainable as all 118 species would not be evenly distributed throughout the property. Values between 3.3 and 3.7 reflect that RBG remains a diverse area and provides significant habitat to terrestrial birds.

Diversity per Plot

Diversity per plot was calculated using in-plot data from 2010-2022 to determine which plots were the most diverse (Figure 3). As each plot surveys a specific habitat it is possible to see which habitats are supporting more diversity than others, and if there are outliers.

Typically, habitats with multiple vegetation layers and plant diversity, such as mature forests, support higher avian diversity than habitats with fewer vegetation layers, such as grasslands (James and Rathun, 1981). However even if an area has lower diversity, it can still support specialist species not found elsewhere.

Interior forest and secondary forest plots are intermixed in the top half of diversity rankings, while grassland specific habitats are lumped into the lower third. This is unsurprising given that grasslands were recently added and are undergoing restoration where native vegetation is still establishing.

Despite the plots in HV (Hendrie Valley) surveying areas suitable for high diversity and having wetland influence HV plots have relatively low diversity. More details about what could causing this lack of diversity in HV is detailed on page 84.

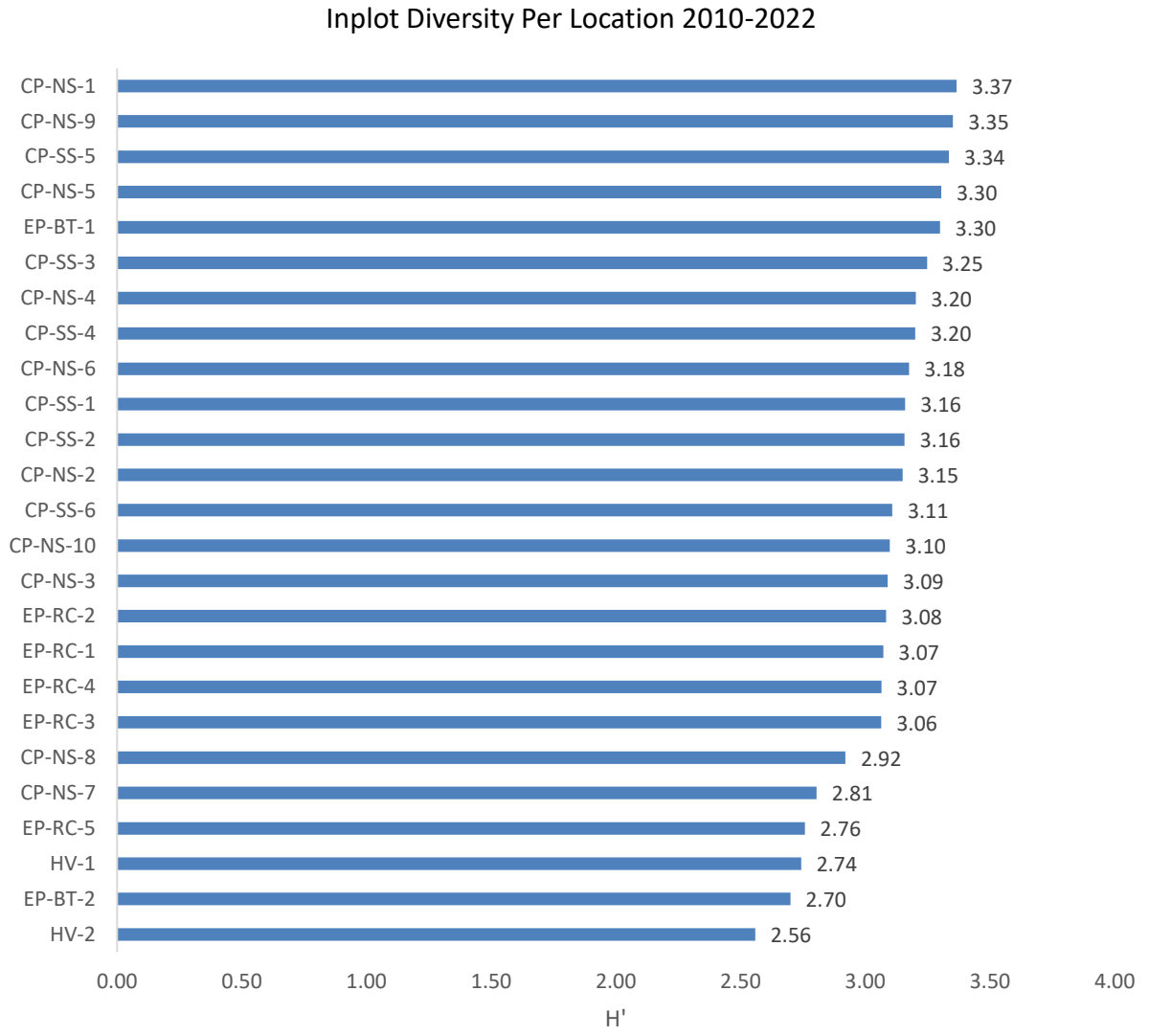

Figure 3 Average diversity (2010-2022) of each terrestrial bird monitoring plot, where H' is the value of the Shannon-Wiener index.

Diversity Minimums and Maximums

Diversity minimums and maximums can indicate outliers on the property and can help indicate if certain locations need more study (Figure 4). These figures are calculated using in-plot data and each point represents a single survey location.

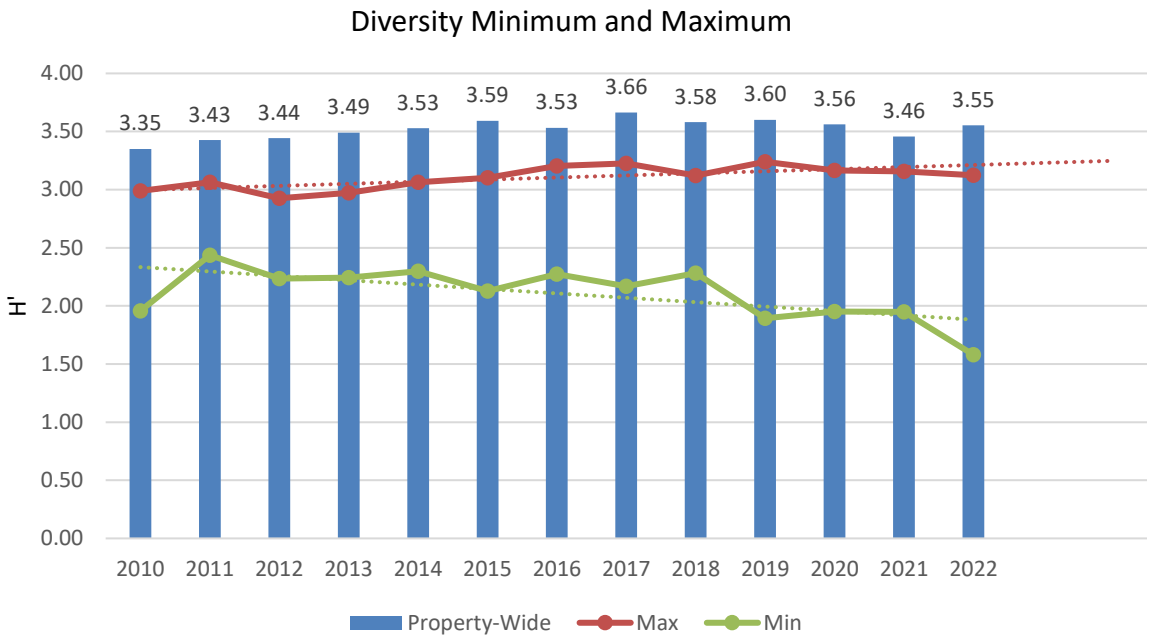

Figure 4 Comparison and maximum inplot diversity and minimum inplot diversity from 2010-2022

Diversity Maximums

Since 2010 the maximum value of recorded diversity has remained stable with a very slight but non-significant increase. Plots that have the most diversity typically are close to multiple habitats where specialist and generalist species can thrive.

For three years, EP (Escarpment Properties) has had the most diverse location either at EP-BT-1, or EP-RC-1. EP-BT-1 is an early successional habitat, providing diverse habitat for generalist and specialist species. EP-RC-1 is an interior forest plot close to edge habitat allowing for detections of interior and forest edge species.

For 3 years the CP-NS (Cootes Paradise North Shore) had the most diverse location, either at CP-NS-9, or CP-NS-5. These locations represent secondary forest and native plantation habitats respectively. Both of these forests are transitional offering a mix of canopy layer and undergrowth for many different species.

For 7 years the South Shore of Cootes Paradise has had the most diverse location, either at CP-SS-5, or CP-SS-2. CP-SS-5 is in secondary forest near parkland and savannah habitats, where

multiple generalists and specialists move through and utilize the habitat. CP-SS-2 is a mature forest with wetland influence and stratified understory.

Diversity Minimums

Hendrie Valley (HV) has the least diverse plots on the property, and this is reflected in diversity minimums. For 8 years the plot with the lowest diversity is in HV. Interestingly in 2018, the temporary plot HV-7 was the least diverse plot property wide.

For 3 years the CP-NS has had the least diverse plot, either at CP-NS-7 or CP-NS-4, which represent regenerating forest and interior forest respectively.

CP-SS-6 was the least diverse plot in 2016, this is surprising due to the diversity of habitat at this location. The typical H' value for this location in 2.7, but in 2016 it was 2.2. This was an outlier year for this location and diversity values returned to normal afterwards.

Surprisingly EP-RC-5 was the least diverse plot ever recorded on the property with an H' value of 1.58 in 2022. This site has recently had restoration work to establish native meadow. Future years will indicate if this a temporary decline as the vegetation and avian community establishes.

Minimum values have been slowly decreasing since 2010. Ideally, there would be an increase in minimum values as habitats were restored. However, there has been habitat degradation on parts of the property due to pervasive invasive plant species, anthropogenic factors, and other effects such as tree diseases. These compounding affects may be impacting certain areas more than others, such as in Hendrie Valley (HV).

Relative Abundance

A total of 118 species have been detected during surveys from 2010-2022. Fifty-five of those species have a relative abundance of less than 1%, often appearing in low numbers and/or not every year of surveys. The relative abundance curve follows the predictable pattern of common species followed by a long tail of rare species (Figure 5).

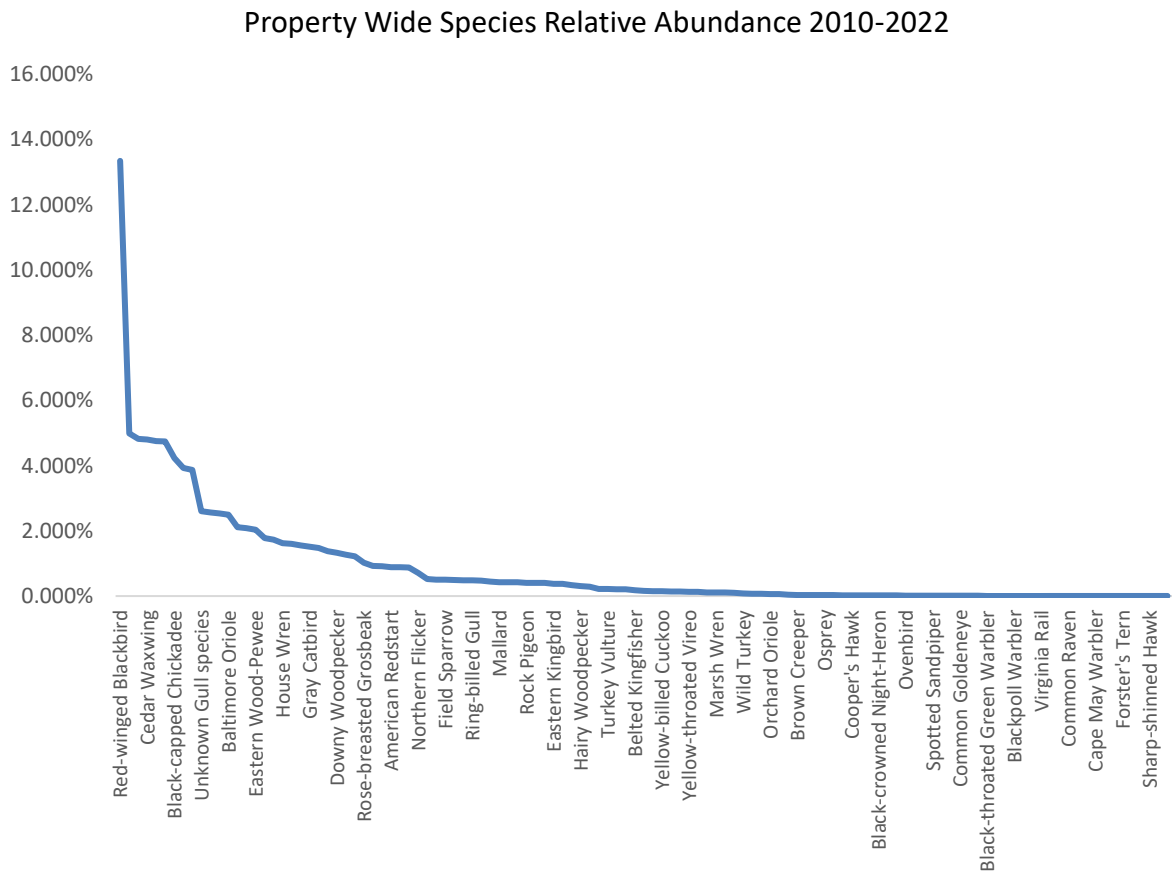

Figure 5 Relative abundance of all detected species during terrestrial bird surveys from 2010-2022, this image does not show all 118 species detected

The top ten most abundant species typically make up 50-60% of all species detected depending on the year. These species are in order of highest relative abundance property wide are; the Red-winged Blackbird, American Goldfinch, American Robin, Cedar Waxwing, Song Sparrow, Yellow Warbler, Black-capped Chickadee, Blue Jay, Northern Cardinal, and the Red-eyed Vireo (Figure 6). Red-winged Blackbird averages 13% of all species detected, while the remaining nine species average between 2-5% each.

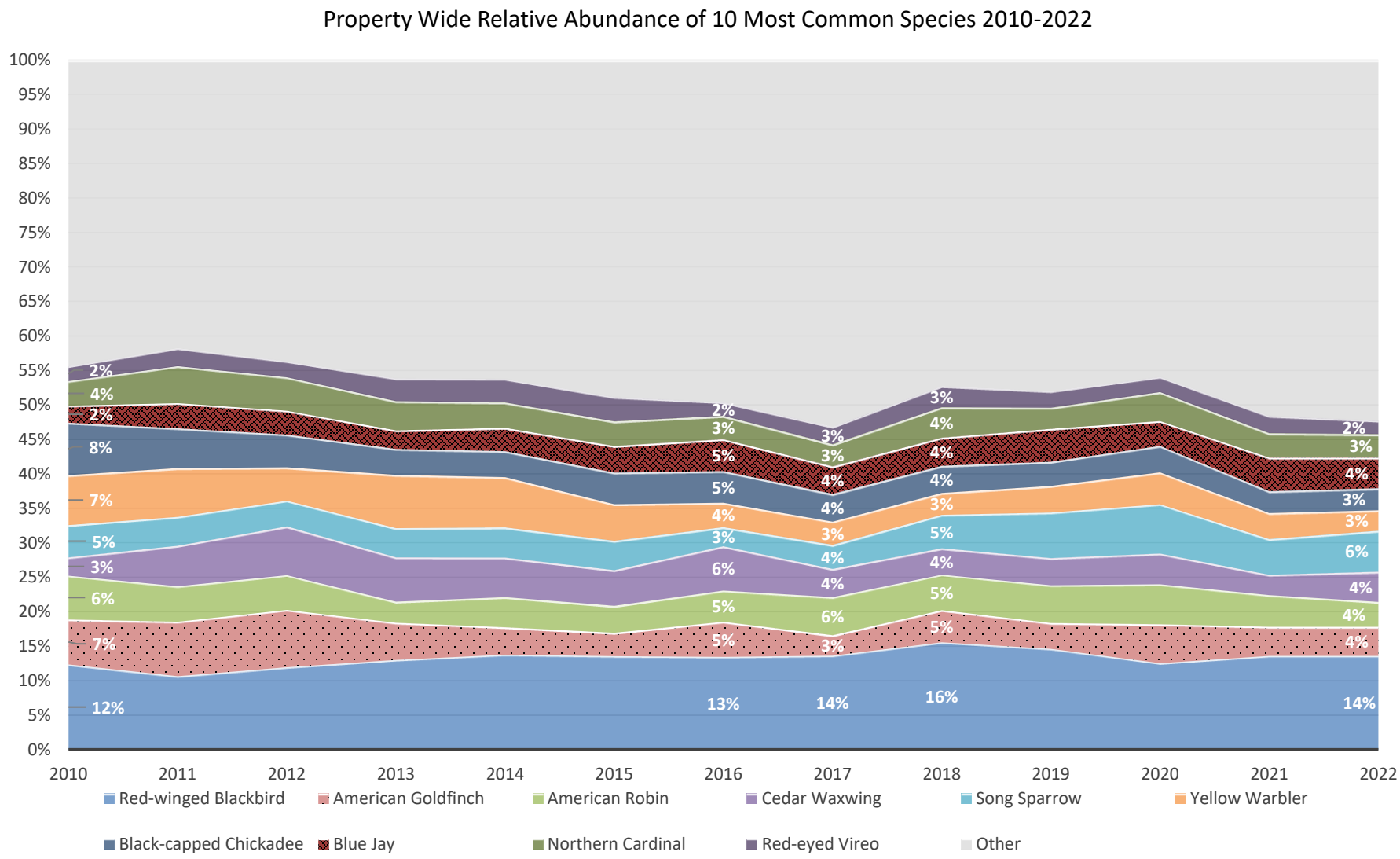

Figure 6 Relative abundance of the ten most common species at RBG from 2010-2022

The change in relative abundance is not always coupled with detections, but detections can provide an overall view of trends (Figure 7). A species relative abundance may decrease even if its detections increase because 1) overall species richness may increase and 2) other species are detected more frequently.

It should be noted that detections are not an adequate representation of the population and change in detections only loosely correlates to changes in population. The number of distinct individuals identified per year is also unknown, and multiple detections are likely the same individual across multiple visits. Detections are also often of singing males, which may be paired or unpaired. Nonetheless, changes in detections can illustrate significant trends which warrant further investigation.

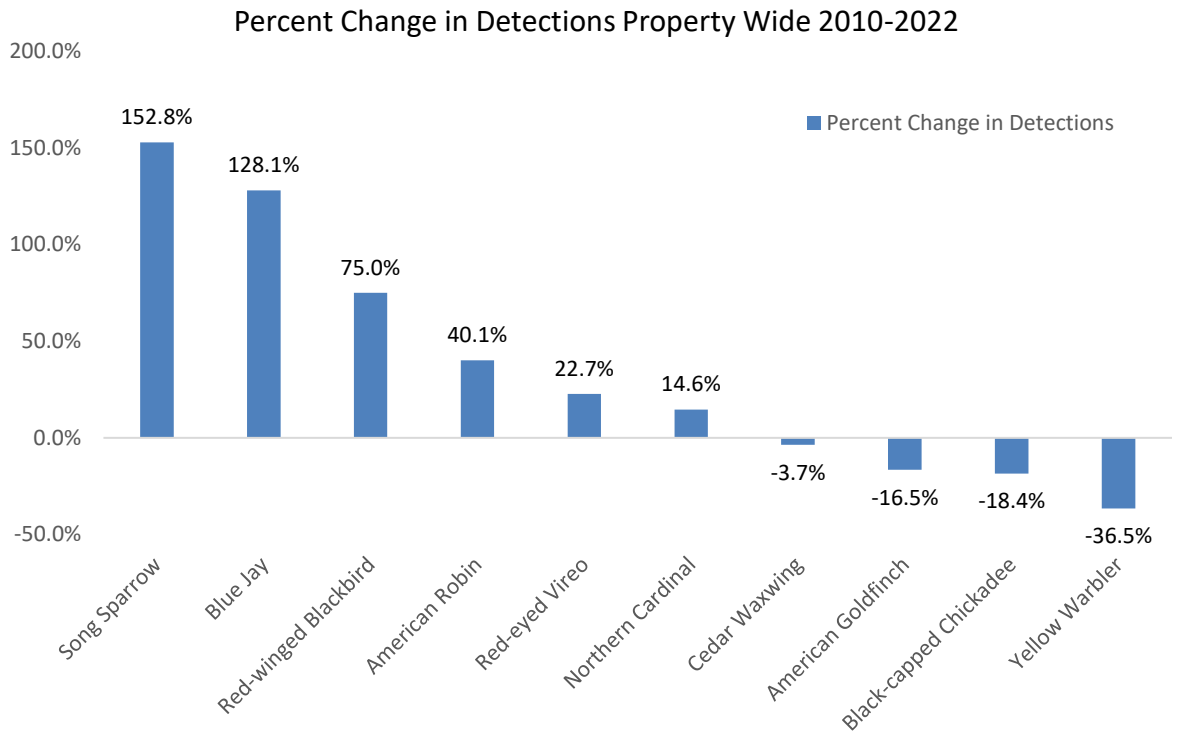

Figure 7 Percent change in detections for the ten most common species at RBG from 2010-2022 ranked in order of greatest percentage increase to greatest percentage decrease

Species Accounts

Red-winged Blackbird

Red-winged Blackbirds are increasing in both relative abundance (2.2%) and detections (75.0%). Red-winged Blackbirds average 300+ birds detected a season, and the near doubling of detections since 2010 is indicative that the population is growing (

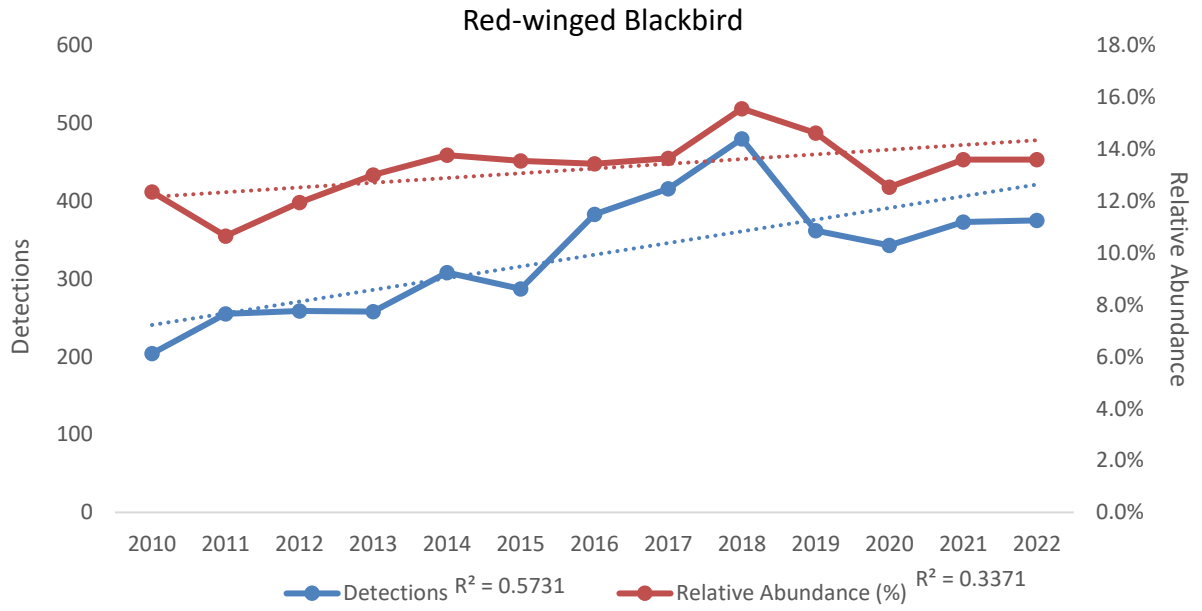

Figure 8). Red-winged Blackbirds continue to be the most abundant species across the property, thriving in wetlands, fields, wet meadows, and gardens. They have been reported in all survey locations, even interior forest, albeit in very low numbers and not every year.

This species readily colonizes new wet meadows and grasslands prior to other specialist species establishing such as Bobolink or Grasshopper Sparrow, as seen in EP-RC-4 and EP-RC-5. Red-winged Blackbirds have small territories ranging from 0.015 to 0.3 hectare, and a single male can have anywhere between two to fifteen females on a given territory (Yasukawa and Searcy, 2020). This increase might be because of consistent restoration efforts both of meadows and wetlands, ensuring there is abundant habitat for this species and, their boisterous nature which makes them easy to detect even in sub-par survey conditions.

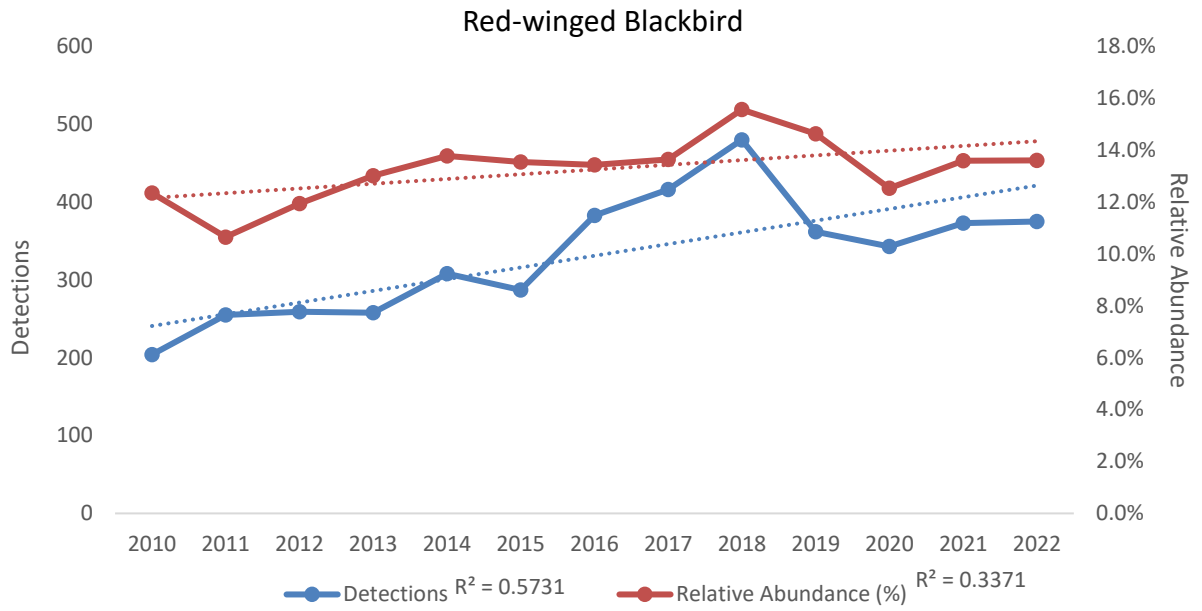

Figure 8 Yearly detections and relative abundance of Red-winged Blackbird across RBG property from 2010-2022

Despite the abundance of Red-winged Blackbirds, species richness and diversity are both increasing property wide. An increase of this species at RBG should be viewed as a positive, as they face persecution on breeding and wintering grounds, are vulnerable to climate change, and declined 36% across North American between 1970 and 2014 (Yasukawa and Searcy, 2020).

American Goldfinch

American Goldfinch are seeing declines in relative abundance (-3.1%) and detections around (-16.5%) (Figure 9). American Goldfinch are very late breeders, typically initiating laying after surveys have been completed. They prefer shrubby and edge habitats and typically avoid deep forest (McGraw and Middleton, 2020). They feed their young almost exclusively seeds from asters, milkweeds, and thistles and their population can fluctuate based on seed crop (McGraw and Middleton, 2020). American Goldfinch are highly gregarious and flock readily throughout the year, with minimal territorial interactions (McGraw and Middleton, 2020).

It is possible that due to the nomadic and gregarious nature of American Goldfinches that all flocks are not recorded each year. Detections show fluctuations year over year, but that overall detections are fairly stable, averaging 247 detections per year. If trends continue downwards both in abundance and detections, even with ongoing restoration efforts, further investigation may be needed.

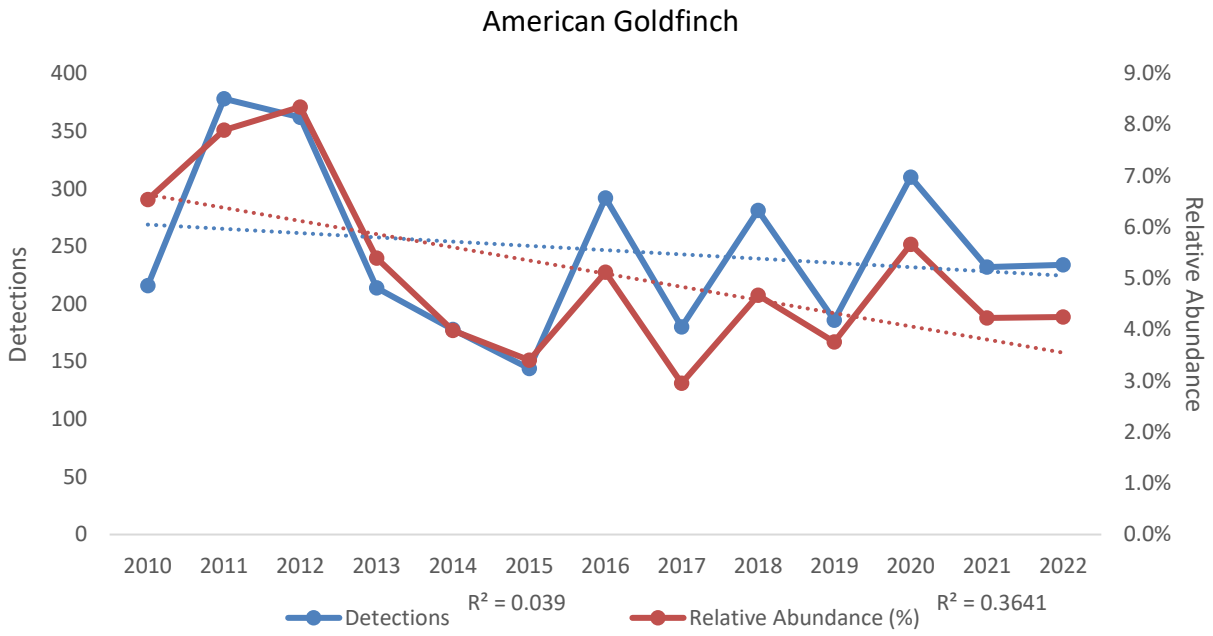

Figure 9 Yearly detections and relative abundance of American Goldfinch across RBG property from 2010-2022

American Robin

The American Robin has seen a minor decrease in relative abundance (-0.4%) but an increase in detections (40.1%) (Figure 10). Robins average around 120 detections a year and have had minor fluctuations since 2010. American Robins are a gregarious common species in urban and open woodland environments but tend to shy away from deep forest and wetlands (Vanderhoff et al. 2020). They also readily nest in invasive shrubs and trees (Vanderhoff et al. 2020). Robins are known to have higher nest predation rates in non-native shrubs, despite preferring them to nest in (Rodewald et al. 2011). If declines in relative abundance continue but detections continue to increase it can be assumed that the changes are due to other species being detected more often, or novel species appearing.

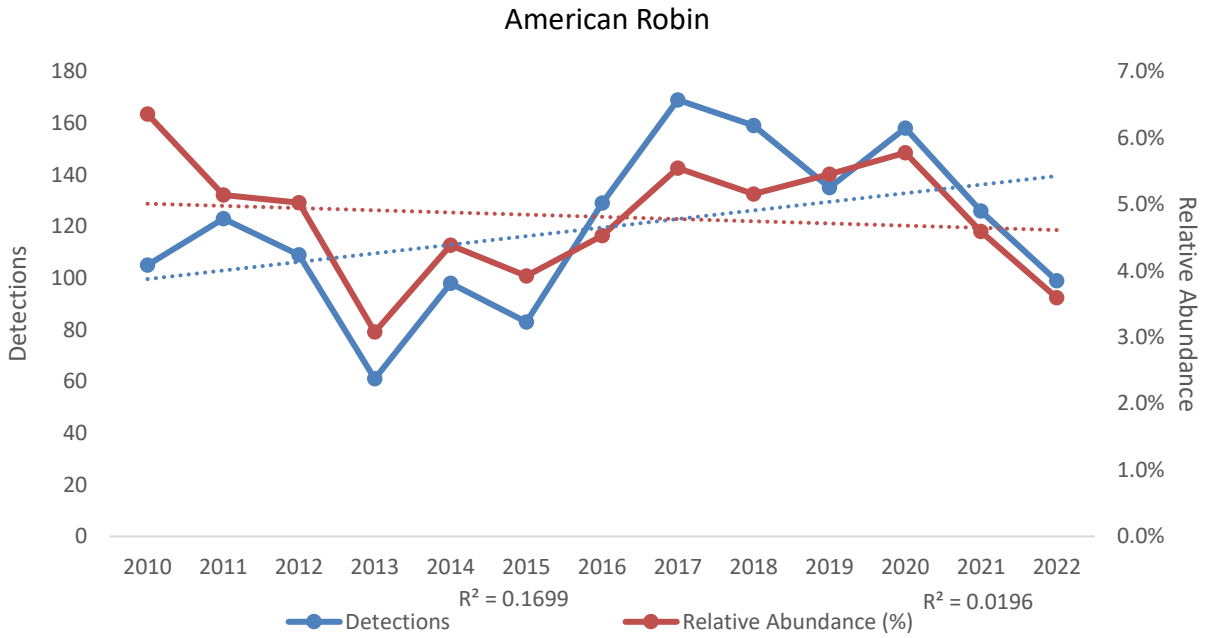

Figure 10 Yearly detections and relative abundance of American Robin across RBG property from 2010-2022

Cedar Waxwing

Relative abundance has declined by 1.8% and detections by 3.7% which is minimal (Figure 11). Cedar Waxwings are the most frugivorous of all birds at RBG and forage over a wide area in search of fruit, sap, and occasionally insects. They are highly gregarious and large groups of them can be seen even during peak breeding season (Witmer et al. 2020). This gregarious nature and wide-distance foraging can skew detections slightly as a nomadic flock may not be

picked up year over year. Currently, Cedar Waxwings can be considered stable on the property.

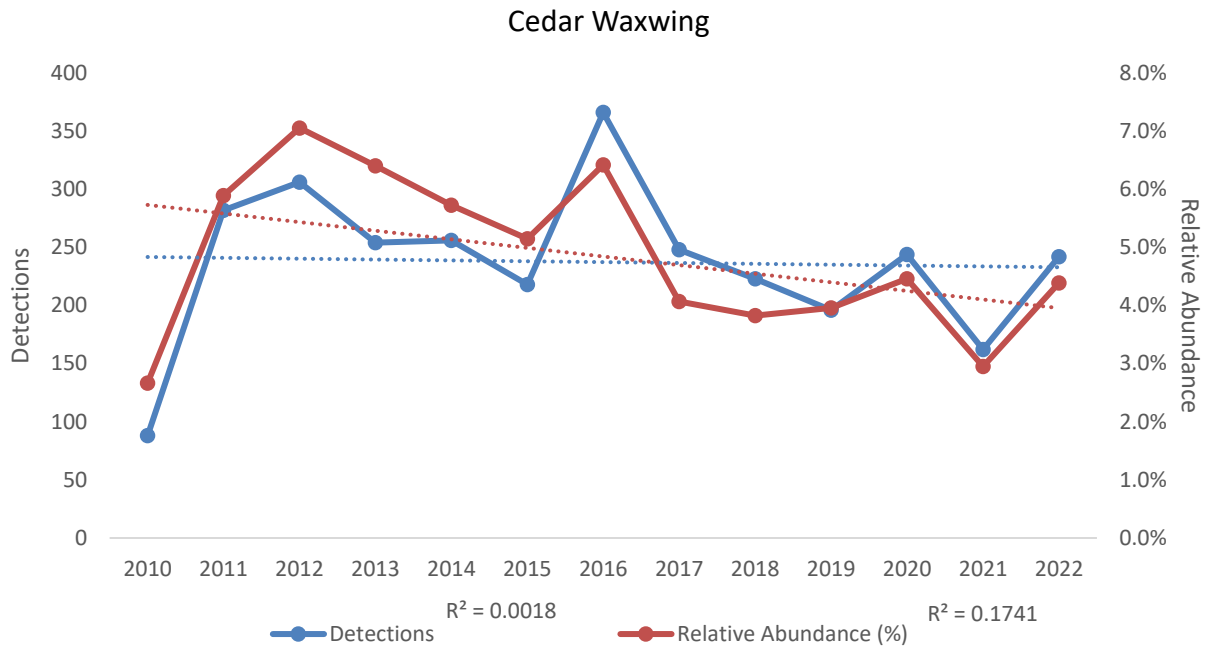

Figure 11 Yearly detections and relative abundance of Cedar Waxwing across RBG property from 2010-2022

Song Sparrow

Song Sparrows have seen a 2.2% increase in relative abundance and 152.8% increase in detections. Song Sparrows are incredibly tolerant of human and natural disturbance and thrive in a variety of grassland, shrub, and urban environments (Arcese et al. 2020). This species is increasing property wide likely due to establishment of grassland habitats and succession of meadow habitats. In good habitats Song Sparrows will have very small territories and may nest anywhere from two pairs per hectare to twenty-five pairs per hectare (Arcese et al. 2020).

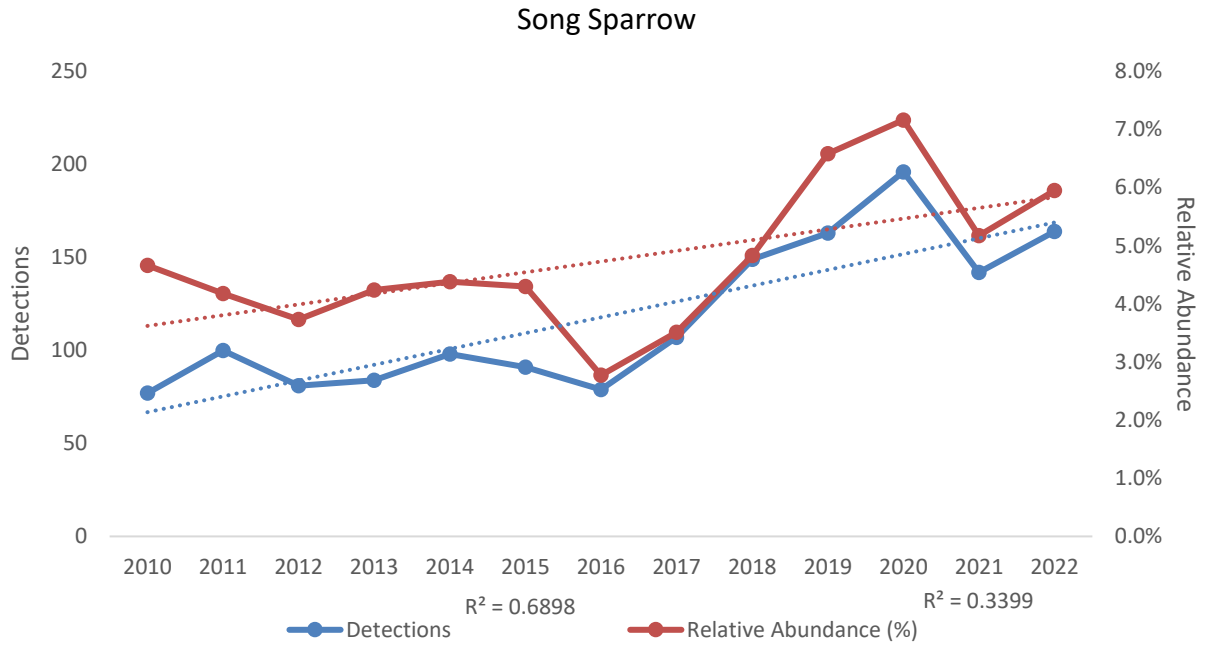

Figure 12 Yearly detections and relative abundance of Song Sparrow across RBG property from 2010-2022

Yellow Warbler

The species with the deepest decline in both relative abundance and detections is the Yellow Warbler. There has been a 4.3% decrease in relative abundance and a 36.5% decrease in detections since 2010 (

Figure 13).

This species relies on riparian habitats and regenerating thickets, mostly of willows and dogwoods in eastern North America (Lowther et al. 2020). While the species is highly territorial, each territory is small averaging 0.2 to 0.45 hectares (Lowther et al. 2020).

Declines in detections are at CP-NS (36.8%) and CP-SS (68.1%). Detections are increasing in EP (44.2%) and HV (99.5%), but overall numbers at these sanctuaries is low (Figure 14). Yellow Warblers are habitat specific, and it may be that habitat is becoming unsuitable for them at CP-NS and CP-SS as understories change. At CP-SS average vegetation cover in the 2-10 metre category declined by 45.8% between 2012 and 2021 (Barr et al. 2021). While this is not the preferred nesting height, Yellow Warblers will still nest as high as 15 metres. This species also readily nests in non-native honeysuckle and other invasive shrubs, which are being removed as

part of the restoration work in CP-SS and CP-NS. It may be that there is a lag between invasive shrub removal and native shrub establishment causing a temporary decline in available nesting habitat.

Yellow Warblers are also negatively affected by the Brown-headed Cowbird and nest predators such as Blue Jays, squirrels, and domestic cats (Lowther et al. 2020). Studies have shown that a reduction in habitat, combined with an intrusion of Brown-headed Cowbirds can reduce a population by up to 50% (Lowther et al. 2020).

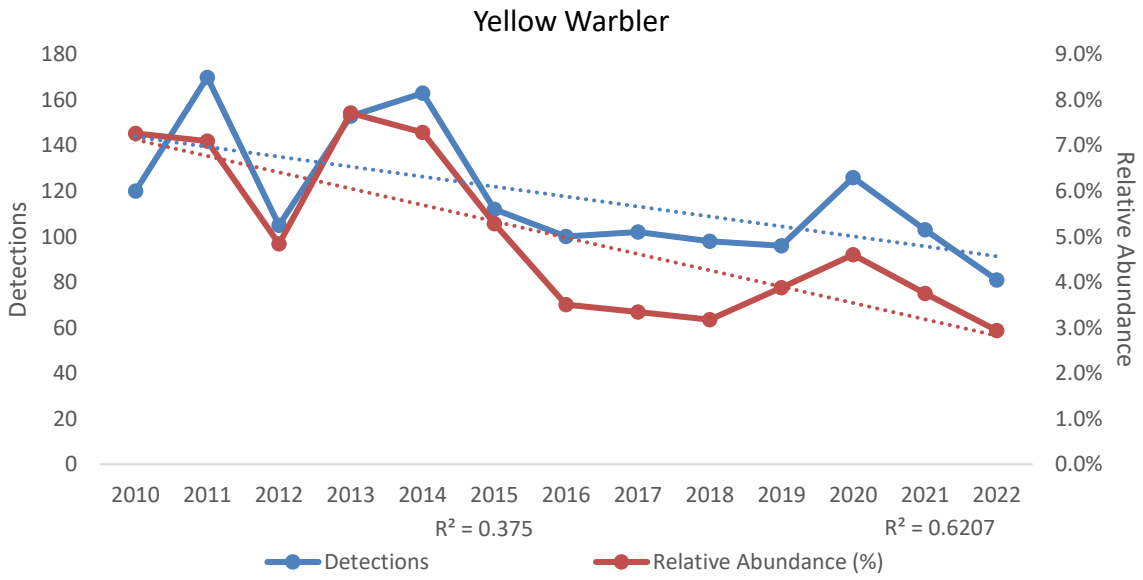

Figure 13 Yearly detections and relative abundance of Yellow Warbler across RBG property from 2010-2022

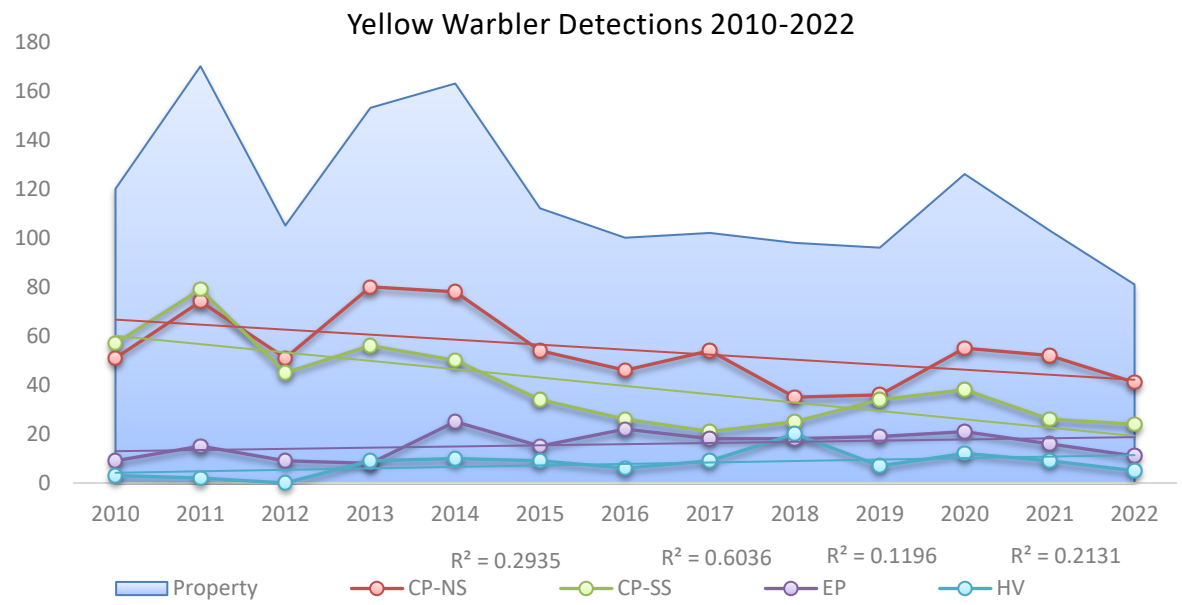

Figure 14 Yellow Warble detections from 2010-2022 across each of the four nature sanctuaries at RBG

Black-capped Chickadee

The Black-capped Chickadee has seen a 2.9% decline in relative abundance and a 16% decline in detections since 2010 (Figure 15). A decline in detections is most severe at CP-NS (-33.7%), CP-SS (15.4%) and HV (14.2%). EP has seen an increase in chickadee detections of roughly 37.1%. CP-NS averages the most detections at around 47 per year, followed by CP-SS at 28, and EP and HV at 15 and 14 respectively (Figure 16). All of these values are based on insignificant R^2 values with detections often less than 100. Overall, despite these changes in detections, Black-capped Chickadees continue to average around 100 detections a year and are likely stable on the property.

The decline in chickadee detections may be due to the presence of supplemental feeding on the property, which can concentrate chickadees in greater than average numbers (Foote et al. 2020). As none of the survey sites are at locations of intense feeding, the impact of this feeding is difficult to quantify. Chickadees are also known to nest in lower densities when there are higher levels of anthropogenic noise, forest habitat is fragmentated, and residential development increases (Foote et al. 2020).

Chickadees prefer forests with large canopy trees and patches of birch and alder to nest and forage in, though they are not restricted to these species (Foote et al. 2020). They also maintain

relatively large territories between 1.3 to 5 hectares, depending on food availability and habitat quality (Foote et al. 2020). It may be that with supplemental feeding and changes in the forest canopy due to pests, chickadees are nesting in lower densities, or concentrating in very specific areas of the property that are under-surveyed.

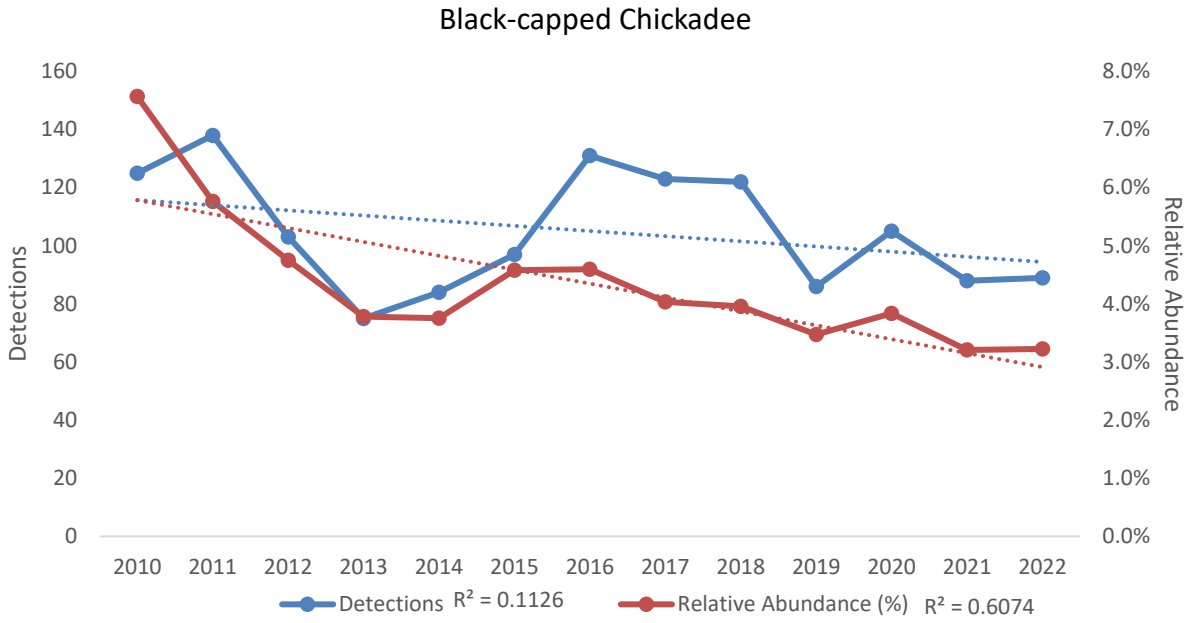

Figure 15 Yearly detections and relative abundance of Black-capped Chickadee across RBG property from 2010-2022

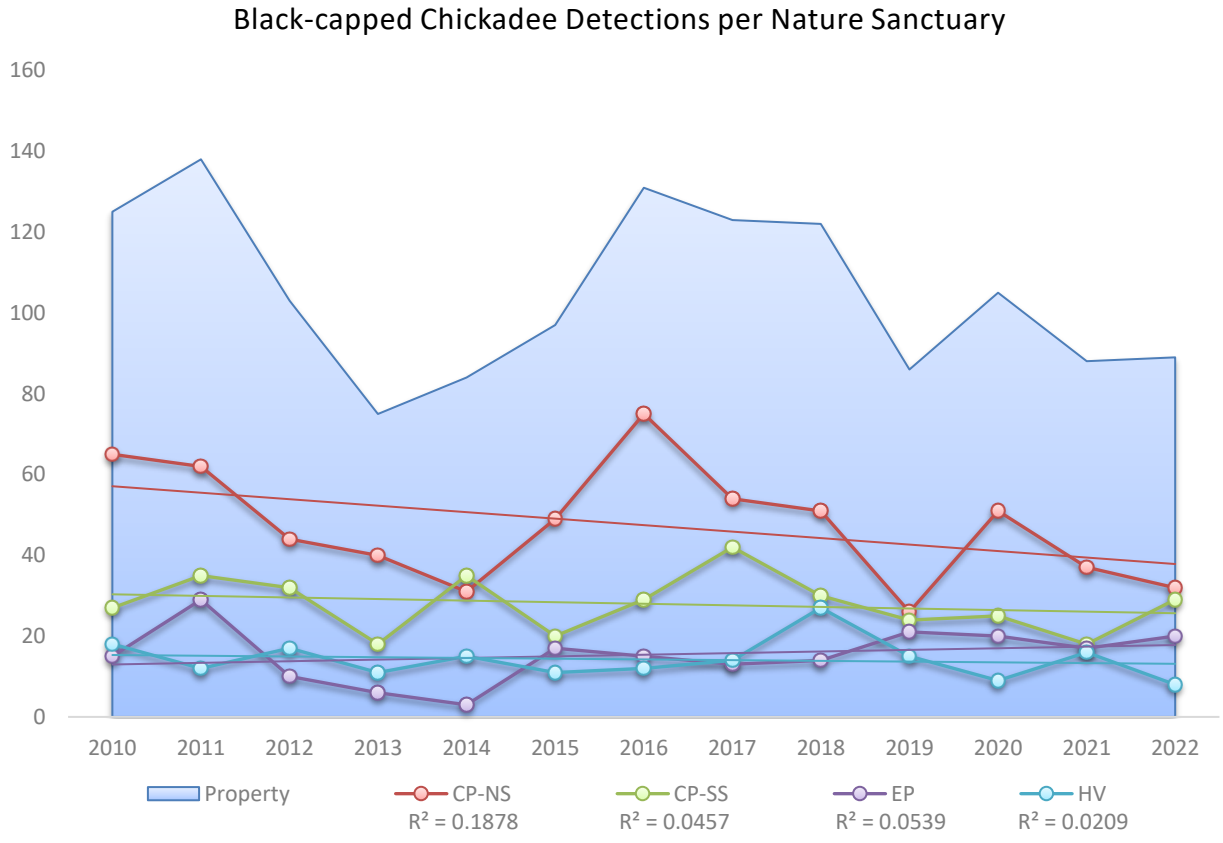

Figure 16 Black-capped Chickadee detections from 2010-2022 across each of the four nature sanctuaries at RBG

Blue Jay

Blue Jays have increased both in relative abundance (1.7%) and detections (128.1%) (Figure 17). Blue Jays prefer more open canopy and edge habitat to interior forest (Smith et al. 2020). A previous study looked at Blue Jay populations after the death of American Elm and found that the population increased and expanded with the thinned canopy (Smith et al. 2020). With many tree deaths due to EAB, Blue Jays may be expanding into newly available habitat.

This species also relies on mast trees such as oaks and beeches (Smith et al. 2020) and populations typically increase with availability of these species. As they often ground cache collected nuts, they are critical to dispersing these species (Smith et al. 2020).

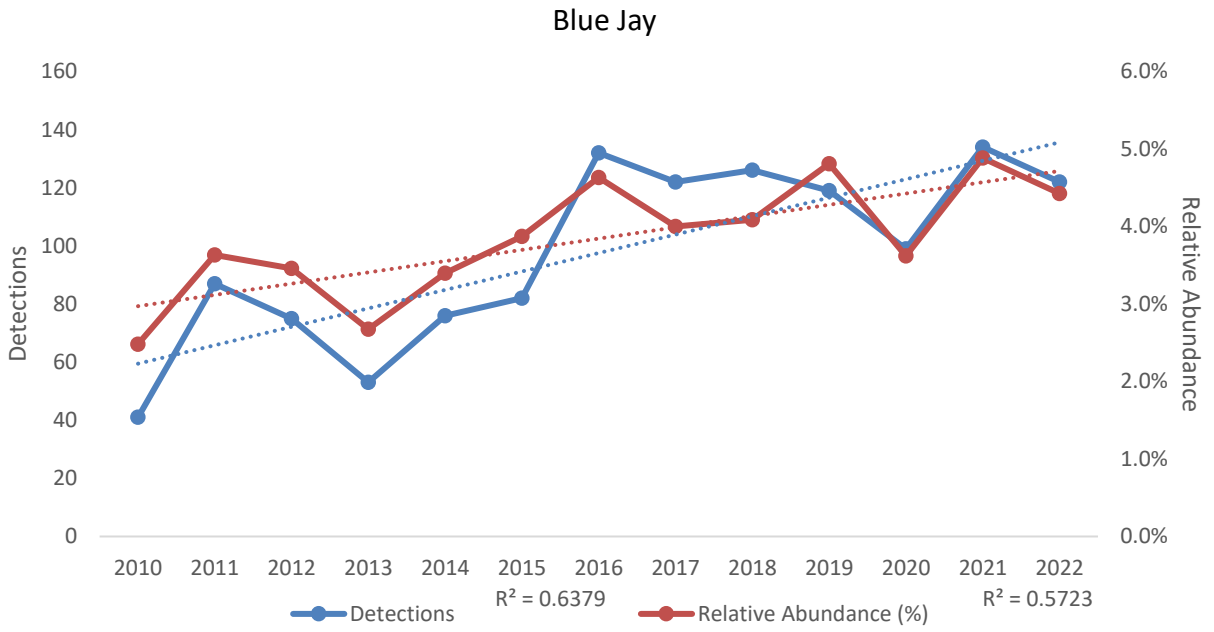

Figure 17 Yearly detections and relative abundance of Blue Jay across RBG property from 2010-2022

Northern Cardinal

Like the American Robin, the Northern Cardinal has seen a minor decrease in relative abundance (1.0%) and an increase in detections (14.6%) (Figure 18). The Northern Cardinal readily occupies a wide variety of forest and shrub habitats, and has been shown to readily nest in non-native honeysuckle (Rodewald et al. 2011). The population appears to be stable, but should be monitored for any major changes in abundance.

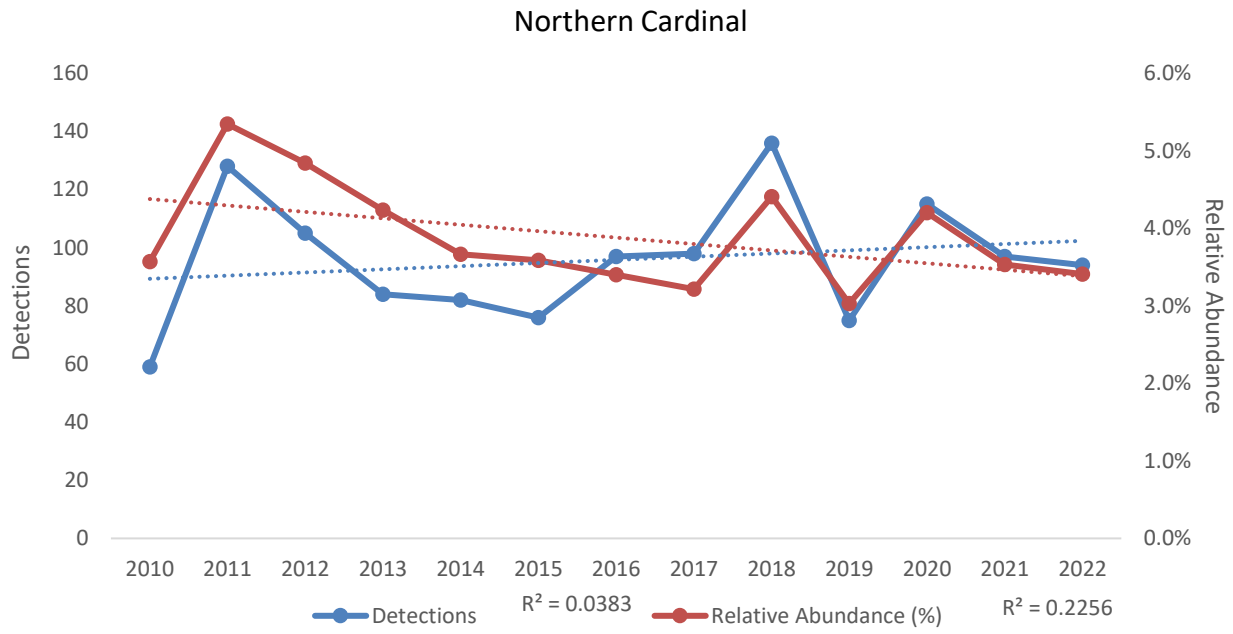

Figure 18 Yearly detections and relative abundance of Northern Cardinal across RBG property 2010-2022

Red-eyed Vireo

Red-eyed Vireos have seen a minor decline in relative abundance (0.44%) but an increase in overall detections (23%) (Figure 19). Red-eyed Vireos are typically detected in low numbers, averaging 64 detections per year. This species relies on interior forests and favours consuming Lepidopteran larvae when it is available (Cimprich et al. 2020). The impact of Btk spray was studied on Red-eyed Vireos and found to have no effects on nesting success, only that adults began nesting about a week later (Marshall et al. 2002). As reflected by (Figure 19) the decline in detections between 2021 and 2022 is within regular range of population fluctuations. The years 2011-2012, 2015-2016, and 2018-2019 all had equivalent or steeper declines than 2021-2022. If the detections of Red-eyed Vireo continue to decline then further study into Btk and other impacts will be needed.

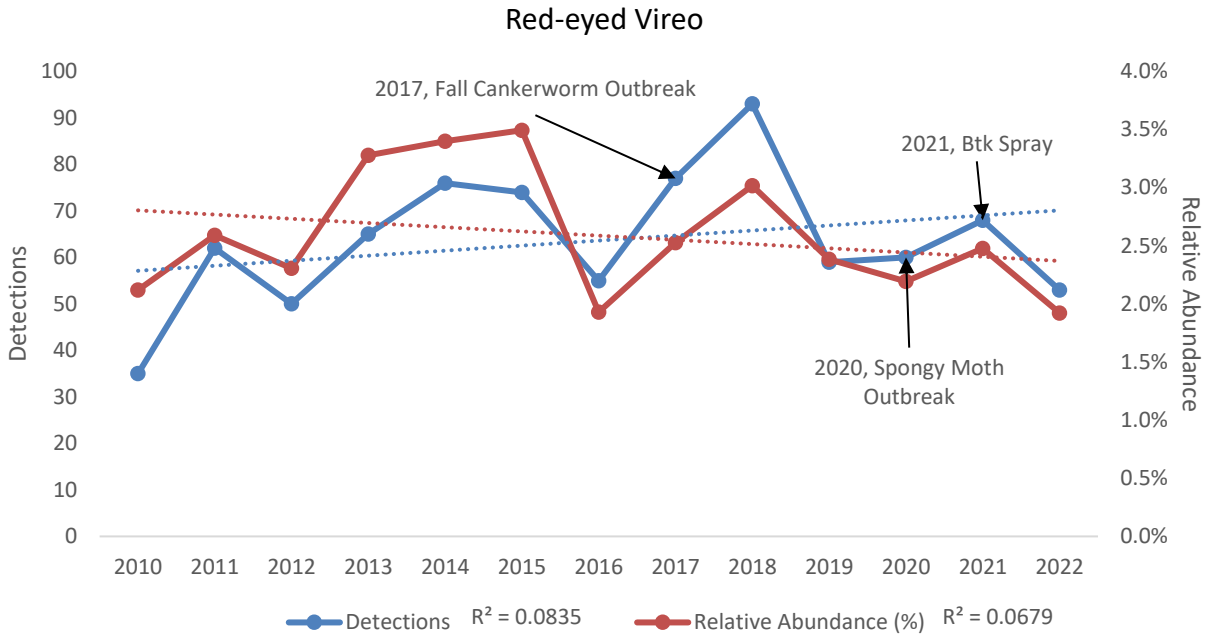

Figure 19 Yearly detections and relative abundance of Red-eyed Vireo across RBG property 2010-2022

Summary

The slight increase in diversity and species richness property wide is indicative of a resilient avian community which is able to sustain itself despite major ecological changes such as EAB impacts 2013 onward, Spongy Moth outbreaks in 2020 and 2021, and Cankerworm outbreaks in 2017, droughts, and other natural impacts.

Restoration efforts in forests, grasslands, and wetlands have likely contributed to an increase in species richness, as more specialist species are able to use the property. As these efforts continue it is likely that diversity and species richness will continue to rise.

Of the most common species, the decline of the Yellow Warbler is the most concerning. Generalist species such as Blue Jays and Song Sparrows are increasing likely due to new habitat and forage availability.

Guilds

Each species was assigned to four distinct guilds, Taxon, Nest Location, Habitat, and Foraging and can be viewed in (Appendix). Guilds are a way of viewing community level changes which are not visible in individual species. Relative abundance was used to assess changes over time. As guilds are an aggregation of many species, the likelihood of detections and relative abundance decoupling is lower, so detections are not used unless the change in trend is severe.

Guilds were analysed using unlimited data, and not all species were analysed. If numbers were very low or incidental, the species was under-represented by survey methods, or if it was a non-terrestrial species it was usually excluded.

Taxon

A total of 40 families have been identified during terrestrial bird surveys at RBG (Appendix). On average most families are between 2-8% relative abundance, with Icterids as the outlier between 15-18% on any given year (Figure 20).

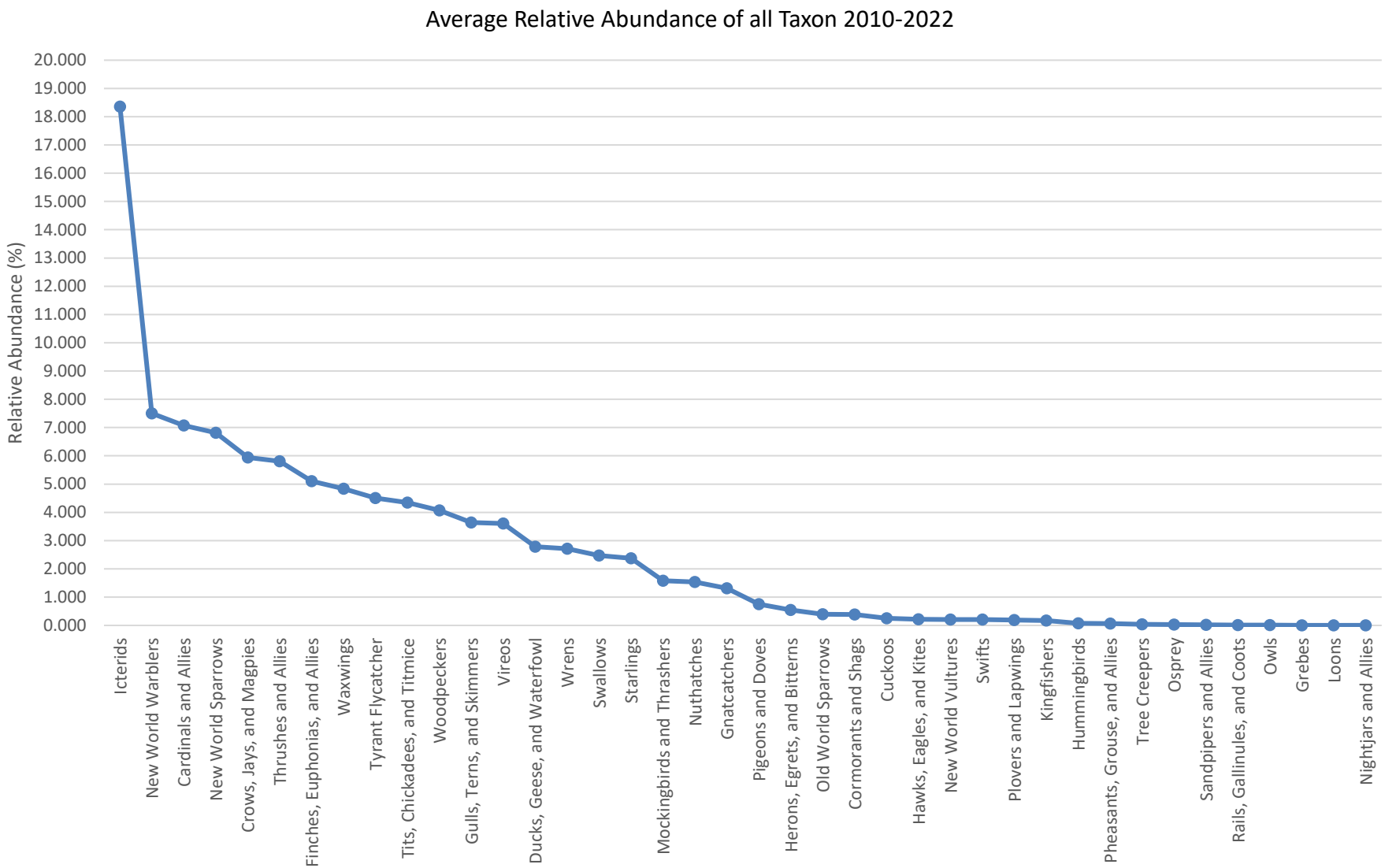

Figure 20 Average relative abundance of all forty Taxon detected at RBG during terrestrial bird surveys from 2010-2022. Taxon not well represented by counts will be severely underrepresented.

Changes to relative abundance over time is limited. Most families (*n* = 27) have had less than a 1% change since 2010. A minor amount (*n*=9), changed between 1-2%, and only a few (*n*=4) showed a change between 2-5% (Table 2). Not all taxa are represented in this table, with 18 families removed from analysis (Appendix).

Table 2 Percent change from 2010-2022 for analysed Taxon at RBG. Taxon that are poorly surveyed or non-targets of terrestrial bird surveys have been removed from analysis.

Taxon	Percent Change 2010-2022
New World Sparrows	5.23
Icterids	1.85
Tyrant Flycatchers	1.68
Woodpeckers	1.63
Starlings	1.39
Cardinals and Allies	1.03
Pigeons and Doves	1.02
Crows, Jays, and Magpies	0.75
Old World Sparrows	0.62
Cuckoos	0.41
Nuthatches	0.36
Swifts	0.34
Wrens	0.15
Thrushes and Allies	-0.53
Swallows	-0.54
Vireos	-0.59
Mockingbirds and Thrashers	-0.80
Gnatcatchers	-1.01
Waxwings	-1.77
Tits, Chickadees, and Titmice	-2.86
Finches, Euphonias, and Allies	-3.12
New World Warblers	-4.31

Icterids – 7 species

This group consists of the blackbirds, orioles, grackles, cowbirds, bobolinks, and meadowlarks. Red-winged Blackbird make up the majority at 72%, followed by Baltimore Oriole at 13% and the Common Grackle at 7%. This group lives in a wide variety of habitats and mostly consume invertebrates during the breeding season. Increases to relative abundance have been slight, at 1.85%, due to increases of Red-winged Blackbirds and Baltimore Orioles property wide.

New World Sparrows – 7 species

New World Sparrows have had the greatest increase in relative abundance at 5.23% since 2010. This group occupies a wide variety of habitat niches at RBG including grasslands, shrublands, and secondary forest. These species mostly forage on insects during the breeding season, but some species are omnivorous and will take seeds, fruits, and animal material when available. Song Sparrows represent 68% of this group, followed by Savannah Sparrow (7.4%), Field Sparrow (7.2%), Chipping Sparrow (7.0%), and Swamp Sparrow (6.9%). As Song Sparrows and grassland sparrows have been increasing likely due to restoration efforts it is unsurprising that the relative abundance has increased.

Tits, Chickadees, and Titmice – 2 species

This group consists almost entirely of Black-capped Chickadees (99.9%) with occasional detections of Tufted Titmouse. The relative abundance of chickadees has declined by 2.86% since 2010. As detailed above there are multiple reasons why this group may have seen a decline in relative abundance and detections across the property.

Finches, Euphonias, and Allies – 2 species

American Goldfinches make up 99.5% of this group as House Finches are unusually absent from surveys. This group has declined in relative abundance by 3.12% with potential reasons for the decline outline in the species account.

New World Warblers – 14 species

On average, only six warbler species are detected each year during terrestrial bird surveys, with the Yellow Warbler, American Redstart, Common Yellowthroat, Pine Warbler, and Blue-winged

Warbler being consistently detected each year. Incidental species such as the Mourning Warbler, Magnolia Warbler, and Black-throated Green Warbler are detected rarely. New World Warblers have seen the largest decline in relative abundance at 4.31%. This is matched with an overall decline in detections of around 20% (Figure 21).

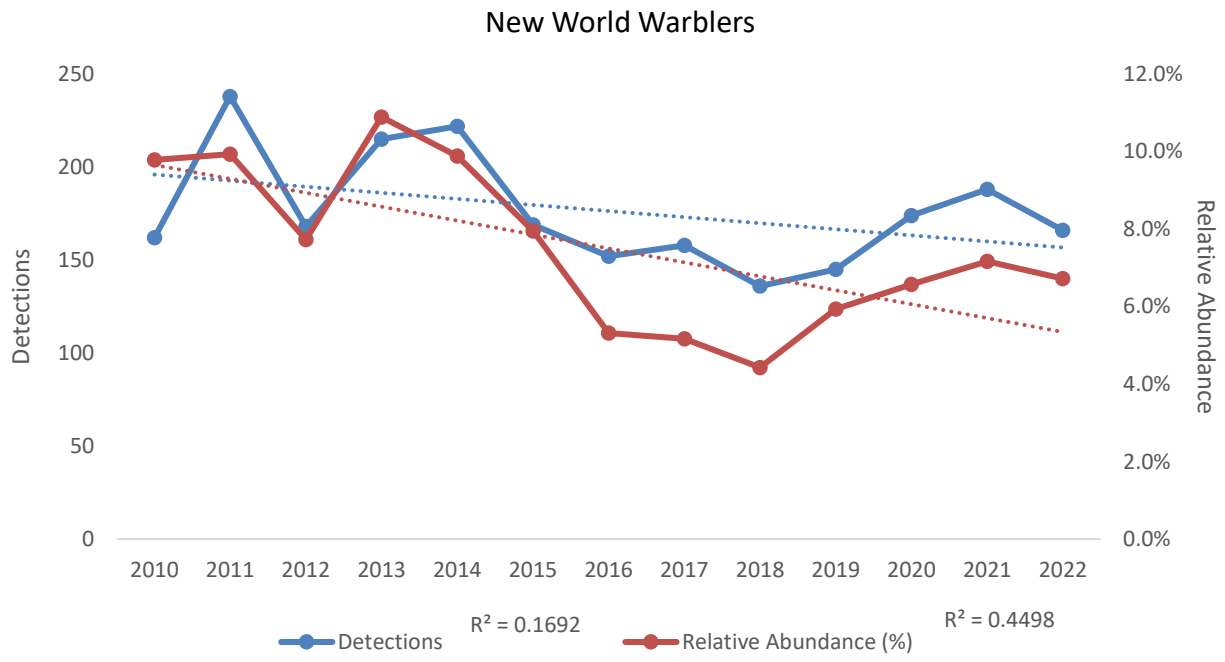

Figure 21 Yearly detections and relative abundance of New World Warblers detected during terrestrial bird surveys from 2010-2022. This graph does not include any migrant-only species such as Blackpoll Warbler that were detected during surveys.

Warbler decline is not even across the property (Figure 22). A decline in detections is most severe at CP-SS at -60.9%. CP-NS has seen a moderate decline in detections at -11.3%. Inversely, detections are up at EP (91.5%) and HV (180.2%). CP-SS and CP-NS have the highest average detections as 63 and 69 respectively. EP and HV average fewer detections at 23 and 12 respectively. For these two sanctuaries a doubling or tripling of detections since 2010 is indicative of very small population changes rather than large shifts.

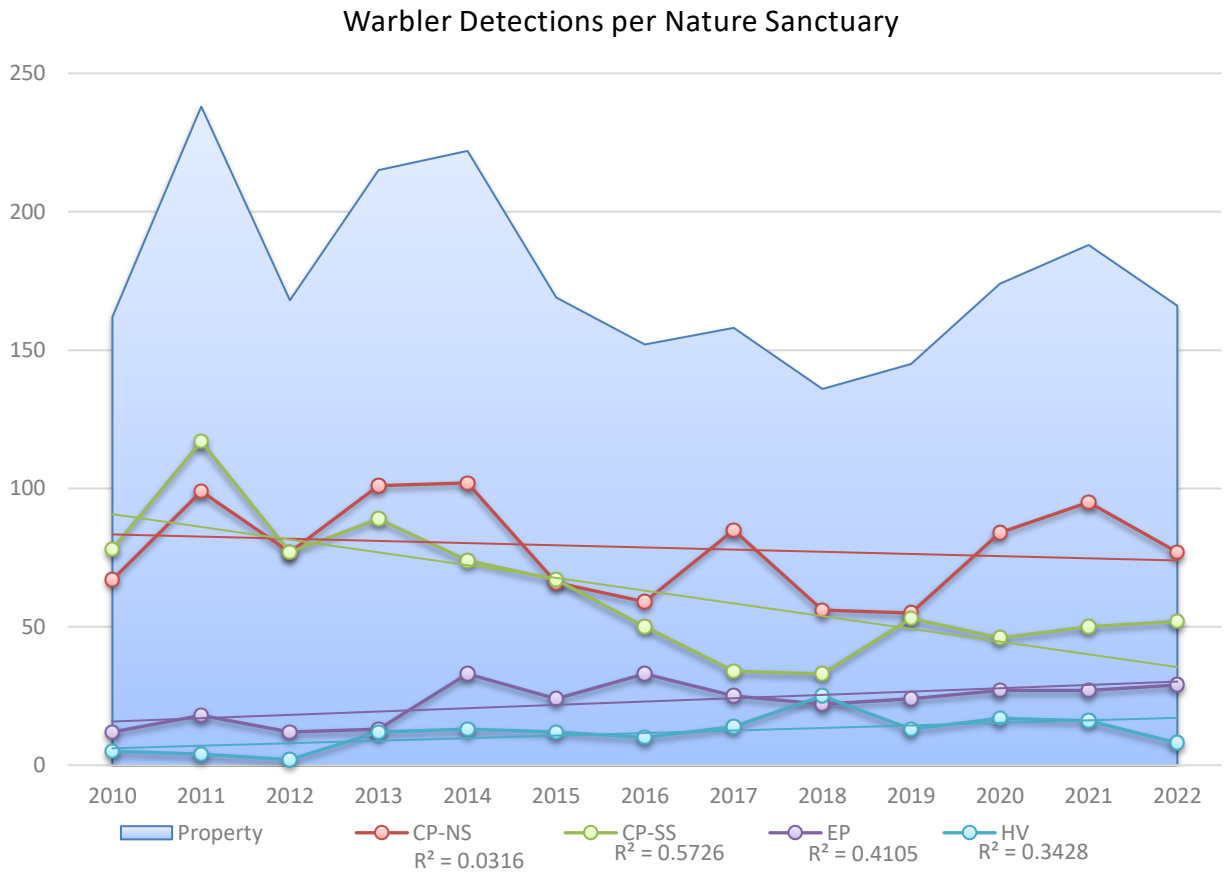

Figure 22 Yearly detections of New World Warblers at RBG nature sanctuaries. This graph does not include any migrant-only species such as Blackpoll Warbler that were detected during surveys.

Causes for warbler decline are not well understood, but studies suggest that even with adequate habitat, warblers may leave an area heavily impacted by human presence (Friesen et al. 1999). The noted decline of warblers observed at CP-SS is consistent with human impact observations noted for CP-SS (Barr et al. 2021). Changes in forest structure, such an increase in invasive plant species, can alter the availability of food during the breeding season which adds pressure to small populations (Friesen et al. 1999).

At RBG, there are three dominant warbler species, the American Redstart (12.3%), Common Yellowthroat (12.8%), and Yellow Warbler (65.6%). The American Redstart and Yellow Warbler, have both seen declines in detections since 2010, at -44.1% and -36.5% respectively. Common Yellowthroats have increased substantially with a 213% increase in detections since 2010.

The reason for this shift may be due to changing forest structure and succession in meadows and thickets. American Redstarts predominantly nest in mature to secondary deciduous forests with abundant shrubs and a well-developed understory (Sherry et al. 2020). Yellow Warblers nest in wet thickets, usually in willow and dogwood. This species dislikes forest edges, grasslands, and mature woodlands (Lowther et al. 2020).

Forest monitoring has shown a decline in shrubs and trees between 2 – 10 metres in height in both CP-NS and CP-SS, likely due to maturation of trees and removal of invasive species (Peirce, personal communication, 22/03/2023). The shift in this vegetation layer has likely reduced available nesting habitat for these species which rely on regenerating trees and shrubs.

Common Yellowthroats, while preferring shrublands, are not as specific as Yellow Warblers or American Redstarts and will nest in nearly any dense deciduous vegetation near wet areas. They will readily nest along the edges of grasslands and in early successional sites (Guzy and Ritchison, 2020). This species may be moving into temporary habitat created by restoration efforts at EP.

As per Robert Curry and his work *Birds of Hamilton*, many species of warblers used to breed in and around the RBG area and particularly on the south side of Cootes Paradise and Hendrie Valley. Since 2010, the Pine Warbler has been the only forest warbler regularly detected. Mourning Warbler, Chestnut-sided, Black-and-White, Blackburnian, Black-throated Green, Cerulean, Nashville, Ovenbird, and Magnolia warblers were once present, and still could all potentially be present at RBG given the proximity to larger natural areas and current forest structure. Despite available habitat, these species are now notably absent from RBG monitoring. More discussion about warblers and potential reasons for the lack of certain species can be found on page 101.

Habitat

Species were assigned to one of ten unique habitat guilds. Of these guilds, one was removed as there were too few observations for sufficient analysis (Open Water). The Wetland habitat was included despite it being a non-terrestrial habitat as that is the habitat for Red-winged Blackbirds which have a significant influence on relative abundance and diversity.

Across all years, birds which use generalist habitats, including forest-generalists, make up about 51% of all birds detected, while the remaining 49% require more specialized niche habitat (Figure 23). Birds which require forest habitats, amount to approximately 33%. The strong influence from wetland birds is also understandable given the location of many survey locations and prevalence of Red-winged Blackbirds.

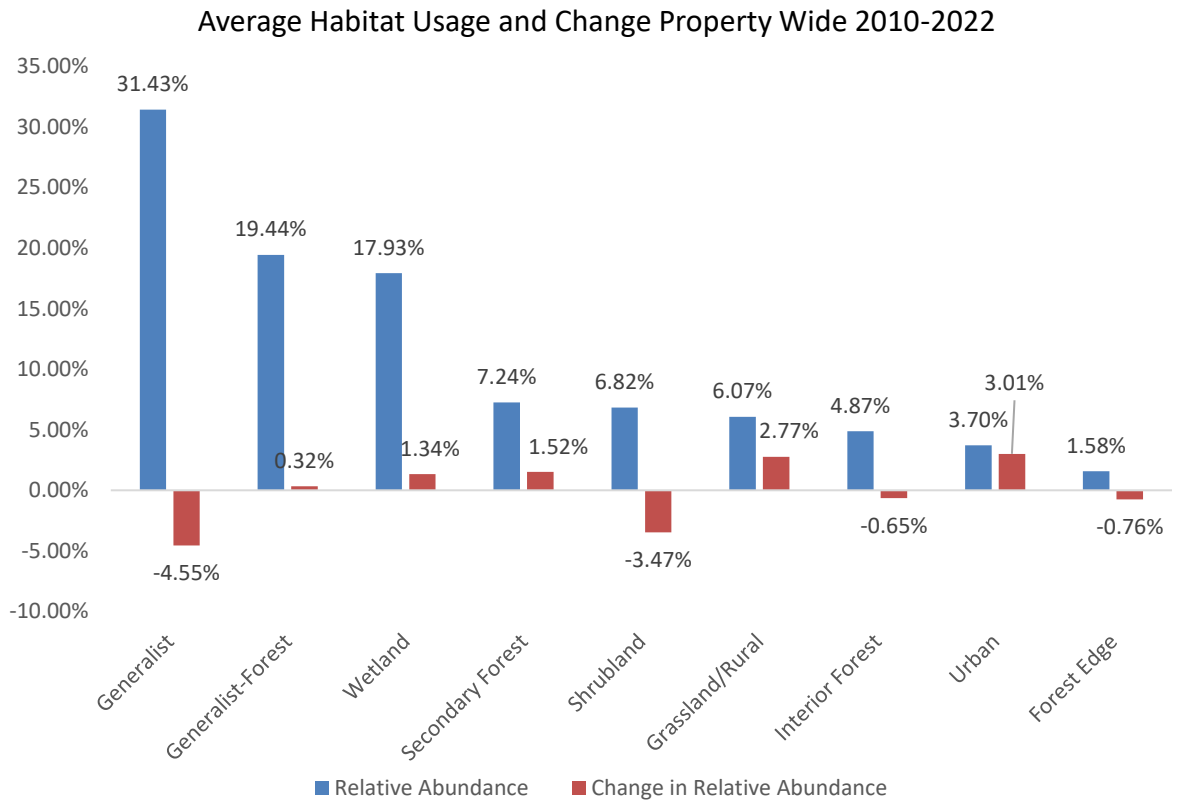

Figure 23 Average relative abundance of nine habitat guilds across RBG property 2010-2022, and change in relative abundance for each guild from 2010-2022. The habitat guild Open Water has been removed from analysis.

Generalists – 16 species

Generalists are species which can nest in a wide variety of habitats and are not restricted to a particular eco-type. While many may require at least a tree or tall structure to be present, they do not rely on woodlands the same way forest generalists do.

Generalists have declined by 4.55% but this is likely due to the weight from American Goldfinches, Northern Cardinals, and Cedar Waxwings, all of which have declined in relative abundance property wide.

Despite this decline, this guild still represents a third of all species detected on the property. Generalists are able to adapt to a wide variety of habitats and food sources and are unlikely to decline significantly property wide.

Forests (All) – 47 species

Relative abundance of forest guilds changed little between 2010 and 2022, with no statistically significant changes in any forest guild property wide. RBG has a diverse forest matrix of forest ecotypes which is able to support many forest species. Changes to the forest are present including EAB impact, invasive plant species, and climate impacts. As each nature sanctuary has different forest types and pressures, more detail about each of the forest guilds will be outlined per nature sanctuary.

Wetland – 19 species

Many of the wetland species detected during surveys utilize terrestrial habitats either to nest or forage. Many of these species are incidental and not recorded every year. The bulk of this guild is attributed to Red-winged Blackbirds, which account for 75% of all detections. There is an increase in both relative abundance and detections, which can be attributed to EP and HV where this species is increasing. Other wetland species are better studied in the Marsh Monitoring Program, which is not detailed in this report.

Shrubland – 9 species

Shrubland birds rely on early to mid-successional growth to nest and forage. They are typically intolerant of mature forests, grasslands, and marshes. This guild is heavily reliant on disturbances to cause breaks in mature systems which allow novel shrub growth.

Shrubland birds have seen a decline of 3.47%, but most of this may be attributed to the Yellow Warbler, which makes up 70% of this guild. As this group relies on disturbance continued maintenance at grassland locations with burns and mowing will provide some necessary habitat. Evidence from forest monitoring shows that the shrub layer within forests in CP-NS and CP-SS is maturing and reaching unsuitable heights for many species. Invasive species removal can also reduce the number of shrubs available for birds to nest in. There is likely a lag between invasive species removal, and native shrub growth which is reducing available habitat for nesting. Ongoing restoration efforts and reforestation should alleviate some of this pressure in the future, and monitoring will be needed to assess restoration impacts on this guild.

Grassland/Rural – 12 species

The species of this guild require large open areas of native grassland, pasture, or savannah to successfully breed. This is one of the more imperiled groups in North America due to habitat loss as grasslands are developed, reforested, and pasturelands are converted to row crops, or mowed more frequently (Johnson and Igl, 2001). Many grassland birds rely on landscape cues and will abandon suitable fields if the surrounding landscape becomes forested or developed (Johnson and Igl, 2001, Renfew at el. 2020).

Restoration efforts and the inclusion of grassland habitat in surveys has increased the representation of this guild. Some species at risk such as the Bobolink have established and are increasing on the property. As more restoration work is done in these habitats it is likely there will be more representation from this guild in the future.

Urban – 5 species

This guild relies almost entirely on man-made structures and is tolerant of intense urban development and human presence. Four of the five species in this guild are either non-native to the region (House Finch), or invasive. Chimney swifts are the only native 'urban' species in this guild. Detections of invasive species have been increasing since 2010, but overall this group is a small percentage of all species present on the property. More information about Chimney Swifts at RBG is found on page 94.

Nest Location

Nest location is not exact, as many species use multiple vegetation layers for nesting. Each species was placed into a category based on its most frequent usage. For example, the Baltimore Oriole can nest in vegetation as low as five metres and as high as twenty-nine metres. Most nest between five metres and twenty metres, so it was given the Lower Canopy tag even though some individuals may nest in shrubs or the upper canopy.

Nesting location is typically more specific than habitat requirements, and while a species may occupy many different habitats it requires specific conditions to nest. Generalist nesting species are therefore rare (5.1%), and specialists are the majority (94.9%) (Figure 24).

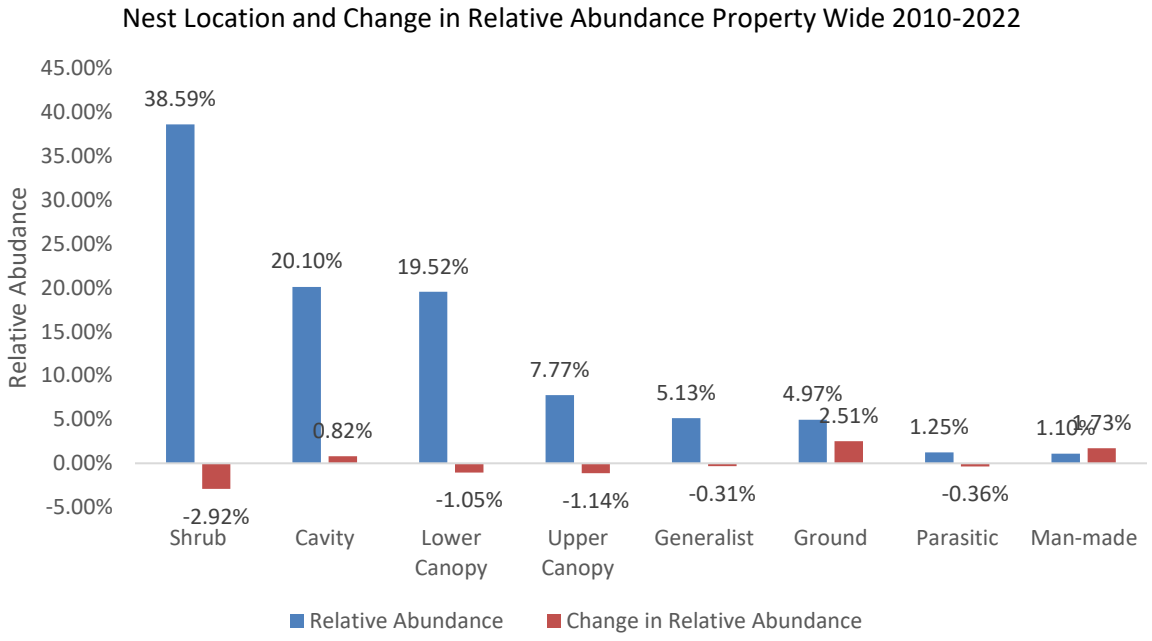

Figure 24 Average relative abundance of eight nesting guilds across RBG property 2010-2022 and the change in relative abundance from 2010-2022

Shrub – 16 species

Most birds detected nest in the shrub layer, which consists of shrubs and very young trees between 0.5 to 5 metres in height. This group includes the abundant Red-winged Blackbirds, American Goldfinches, and Yellow Warbler. Shrub nesters have seen a 2.92% decline since 2010, potentially due to succession of existing shrublands, lag time between invasive species removal

and native species establishment, prevalence of invasive species which can decrease nesting success, and survey locations which focus more on developed forests and grasslands.

Cavity – 19 species

Cavity nesters have seen a minor increase (0.82%) since 2010 and are the second most abundant group. Studies suggest that impacts from EAB positively affect cavity nesters, as there are more suitable snags to nest in (Dosanjh, 2022). Despite an increase in snags, some species of cavity nesting birds are still facing declines due to competition from non-native or aggressive species, and lack of suitable nesting habitat (Environment Canada, 2007). For certain species stewardship actions, such as nest box installation, may need to be taken to provide nesting habitat.

Lower Canopy – 18 species

The lower canopy consists of small trees and very large shrubs 5 to 15 metres in height. If recruitment is poor, much of the existing layer will age into upper canopy trees, without suitable replacement. Pressures from white-tailed deer browse and invasive species supressing recruitment can also inhibit this layer. Lower canopy birds have seen a slight decline in relative abundance (1.05%) but are the third most populous group. Ongoing efforts to reforest areas and remove of invasive species to promote tree recruitment should ensure that this guild remains stable at RBG.

Upper Canopy – 15 species

Upper canopy species nest in trees that exceed 15 metres in height. There has been a slight decline in the relative abundance of this guild since 2010 (1.14%). About 30% of these species are diurnal raptors or waterfowl such as egrets. As these groups are only incidentally recorded it is not surprising to see minor fluctuations in the data. The remaining 70% consists mostly of the Blue-gray Gnatcatcher, Warbling Vireo, Scarlet Tanager, Pine Warbler and Eastern Wood-pewee.

Despite major forest impacts at RBG such as ash die off from EAB and defoliation from Spongy Moth and Cankerworm the relative abundance of this guild did not decline severely. This suggests forest and guild resilience during catastrophic events. With ongoing forest health impacts such as novel tree diseases, this guild should be monitored carefully, especially if additional canopy die-offs occur.

Generalist – 4 species

Generalist species will nest in trees, shrubs, and even man-made structures. At RBG, generalist nesting species are mostly represented by American Robins (96%) which well nest in any structure that can support a nest, from trees to shelving. The other species of note is the Yellow-billed Cuckoo, which has slowly been increasing on the property, likely due to the increase of Spongy Moth which is a preferred prey item for the species (Hughes, 2020).

Ground – 25 species

Ground nesters nest on or close to the ground >0.5 metres, and habitat will range from dense vegetation to bare ground. At RBG grounds nesters have increased in relative abundance by 2.51%, mostly due to the addition of survey plots in grasslands in 2017.

At RBG most ground nesting species are waterfowl (49%), followed by grassland specialists (28%). There are very few records of ground nesting birds in shrublands (6%) or forests (2%). The lack of interior forest and shrubland ground nesters is explained in more on page 100.

Parasitic – 1 species

This pertains to the Brown-headed Cowbird which can be found across much of the property. Brown-headed Cowbirds exclusively lay eggs in other species and rely on the host species to raise their young. This parasitism is known to reduce fecundity in host species as Brown-headed Cowbirds chicks outcompete the hosts young for food and resources, and occasionally kill host chicks.

In 2010 Brown-headed Cowbirds were detected in 9 of 21 survey locations, and in 2022 they were found in 22 of 25 survey locations. Despite their presence property wide, Brown-headed Cowbirds make up very little of the community (1.25%) and have seen minimal change in relative abundance (-0.36%).

Man-made – 4 species

Species that nest in man-made structures can still be found using natural nesting sites, but it is rare. Man-made structures have contributed to the increased distribution of these species as they spread alongside urban and rural development.

At RBG this group consists of two species at risk, the Barn Swallow and Chimney Swift. The other two species are the feral Rock Pigeon, and the Eastern Phoebe, which is detected in very low numbers property wide. This group is rare on the property and has seen minimal increase in relative abundance over time (1.73%). As major infrastructure projects are undertaken in natural areas to create bridges and trails, there may be an increase in detections for this guild.

Foraging

Many species have flexible diets and capture methods depending on the energy needs and time of year. Birds will capture a wide variety of prey items, from seeds, fruits, and insects depending on their energy requirements and availability of food. Breeding requires high amounts of protein and fat, so most birds switch to an insect-based diet even if they mostly consume fruits or seeds outside of the breeding season. To accommodate for changes in diet, species were assigned to a foraging guild based on what is primarily captured and consumed during the breeding season. Several guilds such that lacked data or were non-targets such as Piscivores, Carnivores, and Nectivores were removed.

Other studies have delineated certain broad groups, such as foliage gleaners, into smaller more niche specific groups focusing on specific prey capture items, types of foliage, vegetation layer etc. This is beyond the scope of this report, but groups that are known to be declining may benefit from in-depth studies focusing on these traits.

Foraging guilds are useful in identifying if specialist groups are declining or increasing. Certain groups can be more susceptible to changes in the environment which impact food availability. RBG is dominated by foliage gleaners, omnivores, and ground probers, while ariel insectivores, bark probers, and granivores make up a smaller portion (Figure 25). Specialist predators such as carnivores and piscivores have low representation due to survey methods.

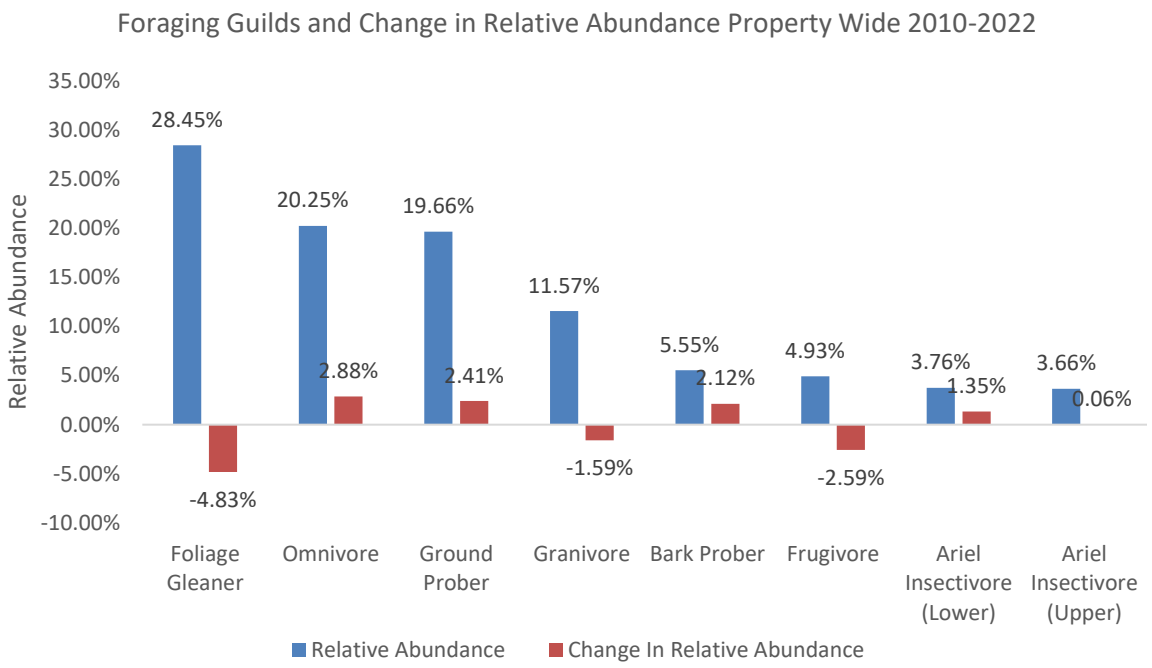

Figure 25 Average relative abundance of eight foraging guilds across RBG property from 2010-2022 and the change in relative abundance from 2010-2022. Four foraging guilds have been removed from analysis (Piscivore, Molluscivore, Nectivore, and Carnivore).

Foliage Gleaners – 34 species

This group contains a diverse range of species, such including warblers, vireos, orioles, and cuckoos. Foliage gleaners mostly take insects off twigs, leaves, fronds etc. Some species may forage in leaf litter by scratching or flipping leaves to expose insects.

The decline of 4.83% in relative abundance is at first concerning, but examining the change over time indicates that foliage gleaners are increasing in detections property wide. This decline then appears to be partly influenced by other foraging guilds increasing in presence across the property.

Even in years with severe defoliation due to fall Cankerworm or Spongy Moth, detections for this group did not decline severely (Figure 26). Post Btk spray, detections remain approximately the same. A more detailed description of Btk impact on page 106.

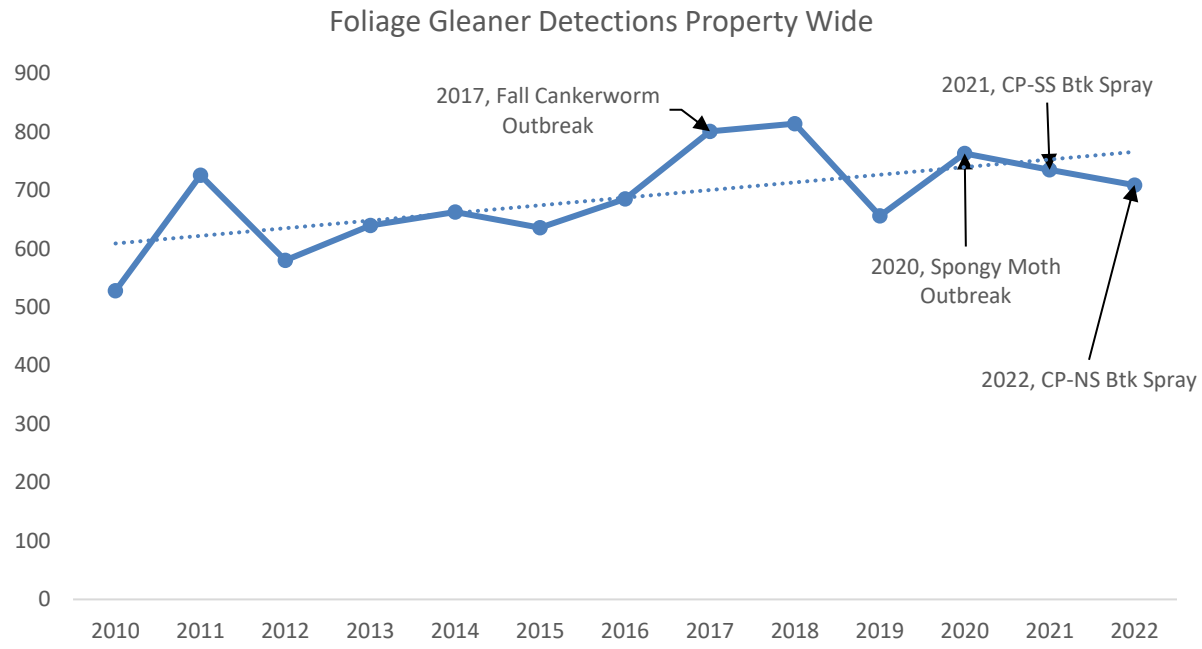

Figure 26 Detections of Foliage Gleaners across RBG from 2010-2022, with years with severe Spongy Moth or Cankerworm outbreaks shown

Omnivore – 22 species

This guild consists of species that eat a wide variety of food types even during their breeding season. Omnivores typically thrive in many environments due to their opportunistic nature and ability to adapt to prey abundance. This guild has seen the largest increase in relative abundance (2.88%) driven by Corvids, and Song Sparrows. As forests continue to change omnivores are able to quickly switch foraging methods and prey items allowing them to expand into new habitat types and take advantage of transitional areas.

Ground Prober – 16 species

This guild also includes species which 'gape' for food. Gaping is done by wedging the bill into soft substrate or clumps of vegetations and opening the bill it to access hidden prey items. Red-winged Blackbirds, Northern Flickers, American Robins, Killdeer, and many other shorebirds are part of this guild. The increase of 2.5%, is likely due to the increase of Red-winged Blackbird detections.

Granivore – 34 species

This guild consists mostly of waterfowl, sparrows, doves, and finches. Granivores predominantly eat seeds or plant material, even during breeding season. Insects will be taken as well, but in lower numbers compared to grains.

Relative abundance is likely declining due to the decline of waterfowl and American Goldfinch observations. The decline is slight at under 2%, but if it continues more study should be done on declining species within the group. Many terrestrial granivores such as finches, breed later in the season to coincide with the seed crop. With continued restoration efforts increasing available forage, granivore representation should increase overtime.

Bark Prober – 18 species

This species consists mostly of woodpeckers, nuthatches, the Pine Warbler, and the Winter Wren. The Winter Wren forages almost exclusively on deadwood but will peel back dead and dying bark to access prey items.

This guild has seen increase in both relative abundance and detections property wide. Woodpeckers have been known to increase with EAB invasion as they predate the abundant emergence larvae (Koenig and Liebhold, 2017). As the invasion progresses woodpecker numbers begin to drop off as the once abundant food supply diminishes (Koenig and Liebhold, 2017). Data from RBG suggests that EAB may have contributed to an increase in woodpeckers (Figure 27), but other factors such as wildlife feeding, increased snags, and other forest pest outbreaks may have also influenced population growth.

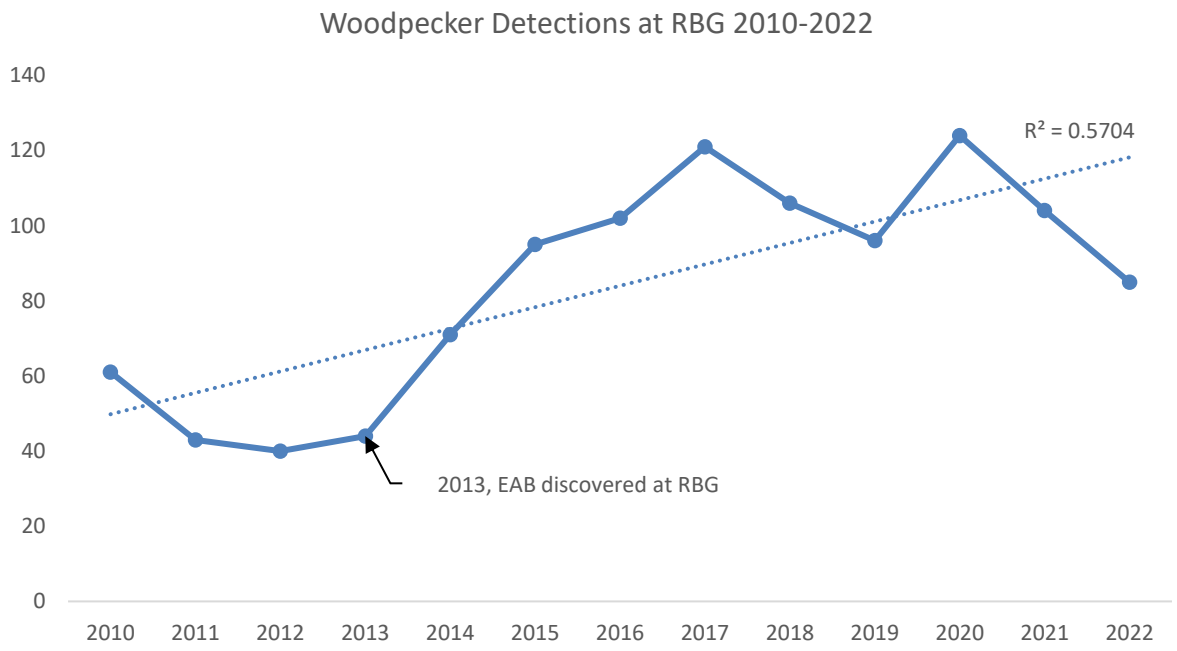

Figure 27 Woodpecker detections at RBG from 2010-2022, excluding Northern Flicker which spend more time ground probing.

Frugivore – 1 species

This group is entirely represented by Cedar Waxwings. Waxwings are unique as they almost exclusively feed on fruit throughout the year and feed their nestlings fruit in addition to insects. Cedar Waxwings will take insects in early spring when the previous years fruit crop is exhausted. Waxwings time their breeding with the emergence of the fruit crop and therefore breed later compared to other species (mid-June to August). As they are intensely gregarious and nomadic in search of fruit crops, a slight decline in relative abundance and detections is not a significant concern. If number continue to decline more study should be done to understand potential vectors impacting fruit crops.

Aerial Insectivores, Lower – 10 species, Upper – 16 species

Aerial Insectivores have been split into two guilds due to the unique microhabitat required for each. Lower aerial insectivores hunt below the canopy, often catching insects on the underside of leaves or twigs. Upper aerial insectivores hunt above the canopy or over open areas often catching insects mid air.

Aerial insectivores have seen some increase in both relative abundance and detections. Current continent-wide trends indicate a decline in aerial insectivores for several reasons, including habitat loss, forage loss due to pesticides, climatic events causing widespread mortality on migration, and impacts on the overwintering grounds.

Aerial insectivores have shown some increase in both detections and relative abundance. As more property is restored and maintained with minimal impacts to the insect community there will hopefully be an increase in this guild over time. Certain aerial insectivores are still very low in numbers, such as the Chimney Swift, Least Flycatcher, Willow Flycatcher, and Eastern Phoebe, and these species should be monitored.

Nature Sanctuaries

Species Richness and Detections

Species richness is dependent on effort, which is not equal between sanctuaries (Table 3). CP-SS and EP have the best representation. CP-NS has the most plots but low representation due to the size of sanctuary. HV while having a similar percentage surveyed to CP-NS, has very few plots and much of the sanctuary is poorly represented.

Table 3 Percentage of area surveyed in each nature sanctuary and across RBG property. At CP-NS and HV some plots were partially off property and thus the total area surveyed area on the property is reduced.

Sanctuary	Terrestrial Area (hectares)	Percentage of Sanctuary Surveyed 100 metre Radial Count	Percentage of Sanctuary Surveyed 150 metre Radial Count
CP-NS*	275	12%	24%
CP-SS	110	17%	42%
HV*	50	13%	28%
EP	115	19%	43%
Property	550	14%	31%

Despite unevenness is representation, species richness is increasing in each nature sanctuary (Figure 28). That species richness is increasing in each nature sanctuary and property wide is indicative that current restoration and maintenance efforts are likely improving and sustaining much needed habitat. Species richness may also be increasing due to observer skill, but there is not enough data to determine if a change in observers at RBG meaningfully contributes to species richness increase.

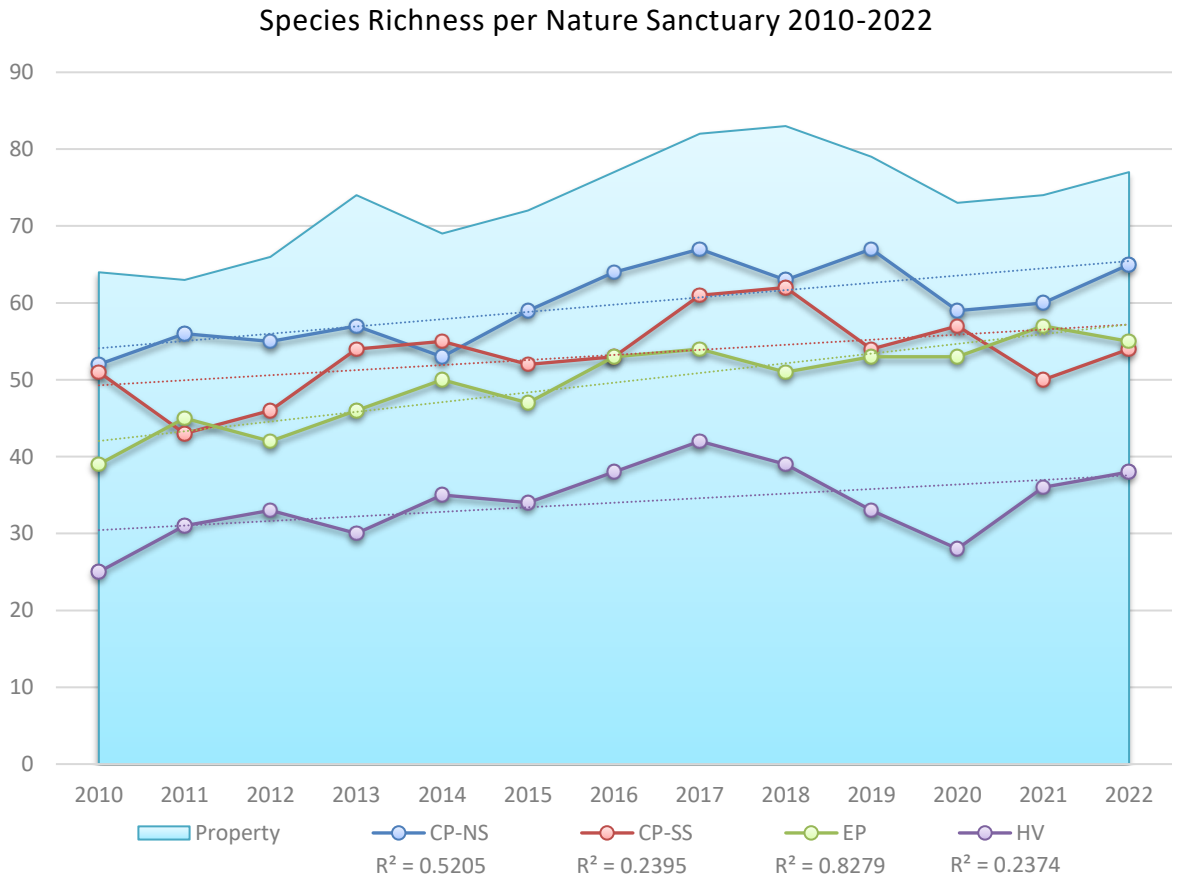

Figure 28 Species richness for each nature sanctuary at RBG from 2010-2022

Increases in species richness is not uniform, with Escarpment Properties (EP) having the largest increase in species richness (Table 4) due to addition of new plots. CP-NS and HV have seen similar increases in species richness over time, despite having different forest composition and forest health impacts. CP-SS has seen the lowest increase in species richness overtime.

Table 4 Percent change in species richness for each nature sanctuary from 2010-2022

Sanctuary	Precent Change from 2010-2022	Average Species Richness per Year
CP-NS	21%	60
CP-SS	16%	53
EP	36%	50
HV	23%	34
Property	21%	73

Detections have increased property wide and in each nature sanctuary (Figure 29). Property wide the average number of detections per plot is 99 birds per year. CP-NS (102), CP-SS (111), and HV (112) all exceed this average. EP is much lower at 80 detections per year and skews the average downwards.

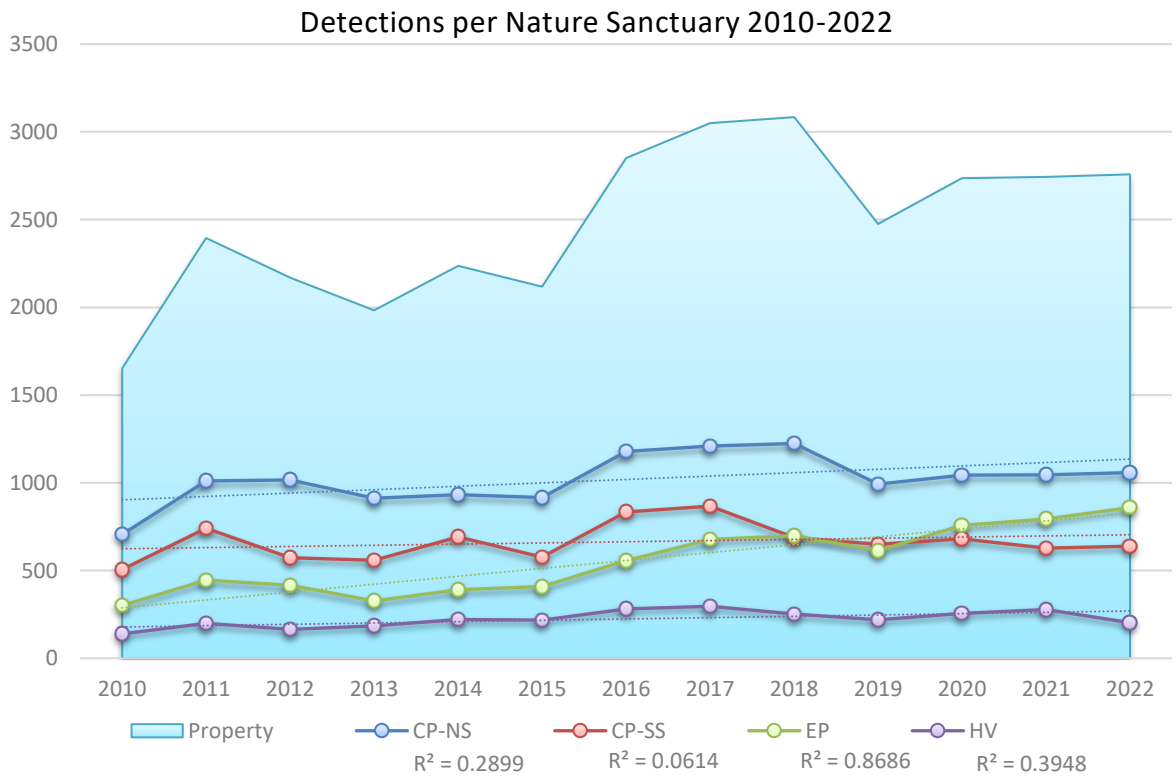

Figure 29 Detections for each nature sanctuary at RBG from 2010-2022

Despite EP being the lowest in average detections per plot, it has seen significant increase in the average number of detections, up 188% since 2010 (Table 5). This increase accelerated with additional plots in 2017, but detections were already increasing prior to these additions.

Table 5 Percent change in detections for each nature sanctuary from 2010-2022

Sanctuary	Percent Change from 2010-2022	Average Detections per Year
CP-NS	26%	1019
CP-SS	13%	664
EP	188%	557
HV	51%	224
Property Overall	49%	2481

The reasons behind the increase in species richness and detections are varied and include increased observer skill, ongoing restoration efforts to provide suitable habitat, and potentially the urban 'island effect' where birds are concentrated in the remaining green spaces at the landscape level. The impact of each of these effects is difficult to determine and further analysis would be required to separate them out.

Diversity

Hendrie Valley (HV) has the lowest diversity of the four nature sanctuaries (Figure 30). Despite the increase in species richness overtime, the abundance of Red-winged Blackbirds skews species evenness making the sanctuary less diverse overall. HV is the only sanctuary which has seen a decline in diversity and is down 11% since 2010.

In 2018 when additional survey plots were added to HV diversity increased by ~10%, indicative of the sanctuary being under-represented in surveys. Despite this increase, HV still remained much lower than the other three sanctuaries, likely due to lower species richness and abundance of Red-winged Blackbirds.

CP-NS, CP-SS, and EP are all very similar in terms of diversity, despite the higher species richness of CP-NS. CP-NS has only seen a slight increase in diversity of 5% since 2010. EP has increased 7%

due to increased species richness from new habitats. CP-SS has remained stable, only increasing about 2% since 2010.

Diversity is strong across each nature sanctuary and indicative of a resilient avian community despite major forest health impacts such as Spongy Moth and EAB. Common birds are remaining common throughout much of the property. As restoration efforts continue species richness and diversity should remain stable or slightly increase.

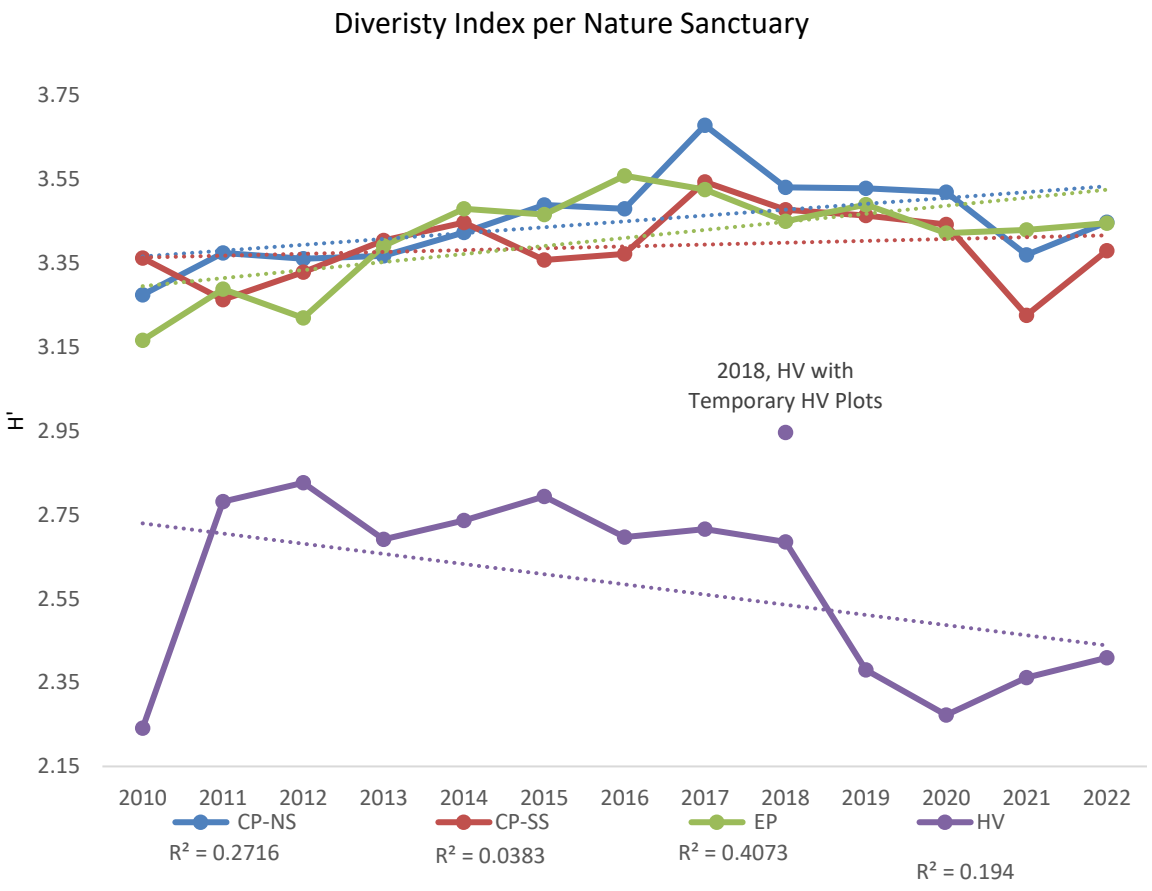

Figure 30 Diversity Index for each nature sanctuary from 2010-2022. At HV, in 2018, diversity is shown with the original plots (line), and with additional surveys (dot)

Cootes Paradise North Shore Details

Cootes Paradise North Shore is the largest nature sanctuary at RBG with around 275 hectares of terrestrial habitat. Much of the sanctuary consists of complex topography of ravines and gullies, with streams and ephemeral wetlands throughout. Forest composition is mixed-wood deciduous consisting mostly of oaks, maples, hickories, pines, and other Carolinian species.

Impacts to the Avian Community

Invasive species

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

After the devastation of EAB, many areas experienced canopy thinning which permitted more light to reach the forest floor. This increase of light causes non-native shrubs to rapidly expand and grow, and many non-native species spread into the interior forest. Non-native shrubs are known to reduce nesting success of several species, provide poor forage for others, and can even exclude native species from nesting altogether (Bakermans and Rodewald, 2006). More details about the impact of invasive shrubs are found on page 102.

White-tailed Deer

White-tailed deer are prevalent throughout CP-NS and indirectly impact birds through intense browsing. White-tailed deer can significantly reduce native tree survival through intense browse, reducing habitat and preventing recruitment into the shrub and lower canopy layer (Loomis et al. 2015, Waller and Alverson, 1997). High densities of deer reduce ground nesting forest birds at the landscape level, and impact interior forest species greater than successional species (Tymkiw et al. 2013). Tymkiw et al. found that neotropical migrants had lower species richness and density in areas with deer greater than twenty individuals per square kilometer and that sensitive species such as Ovenbird were greatly impacted. While official measurements for deer density at RBG

are unavailable, the prevalence of deer and known issues with browse is likely impacting the avian community.

Relative Abundance and Common Species

The relative abundance of the most common species has changed significantly between 2010 and 2022 (Figure 31). There is a noticeable decline in relative abundance for American Goldfinch, Yellow Warbler, and Black-capped Chickadees, which is matched by a decline in detections.

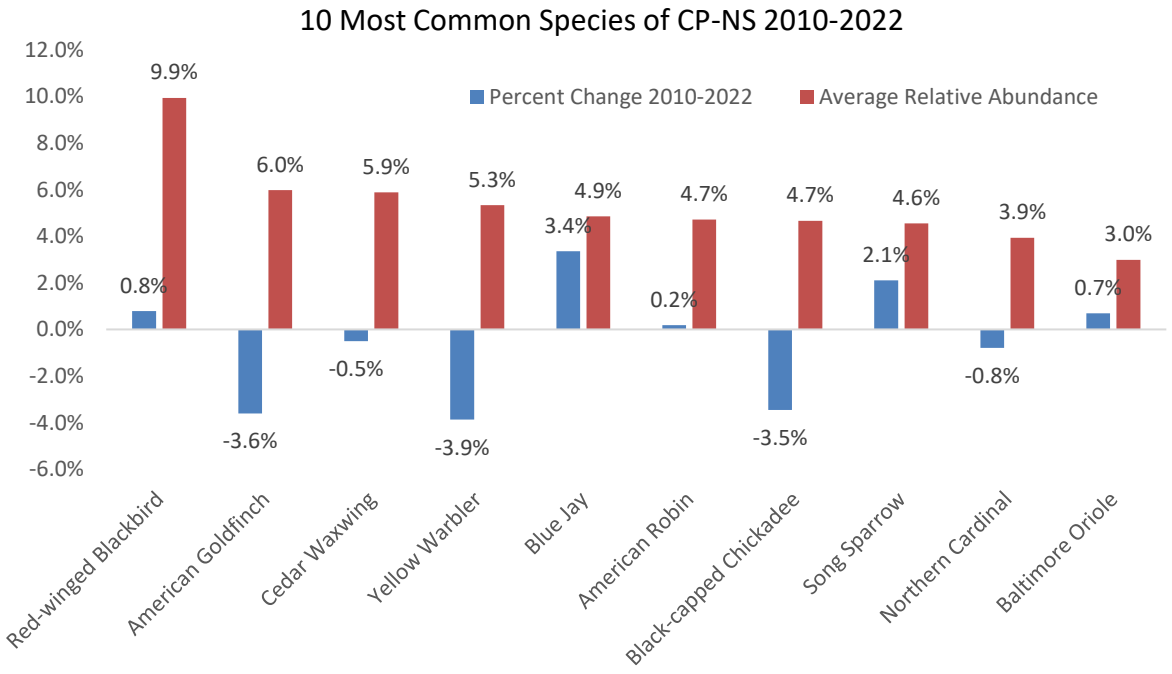

Figure 31 Change in relative abundance of the ten most common species at CP-NS from 2010-2022

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

Yellow Warblers have declined throughout CP-NS, notably at CP-NS-6, CP-NS-7, CP-NS-8, CP-NS-9, and CP-NS-10 where they were previously common (Figure 32). The decline can likely be attributed to loss of nesting habitat through invasive species, deer browse, and forest

maturation, though the impact of each is difficult to tell. Yellow Warbler is also experiencing continent wide decline, with a decrease of 20% between 1966 and 2019 (Lowther et al. 2020).

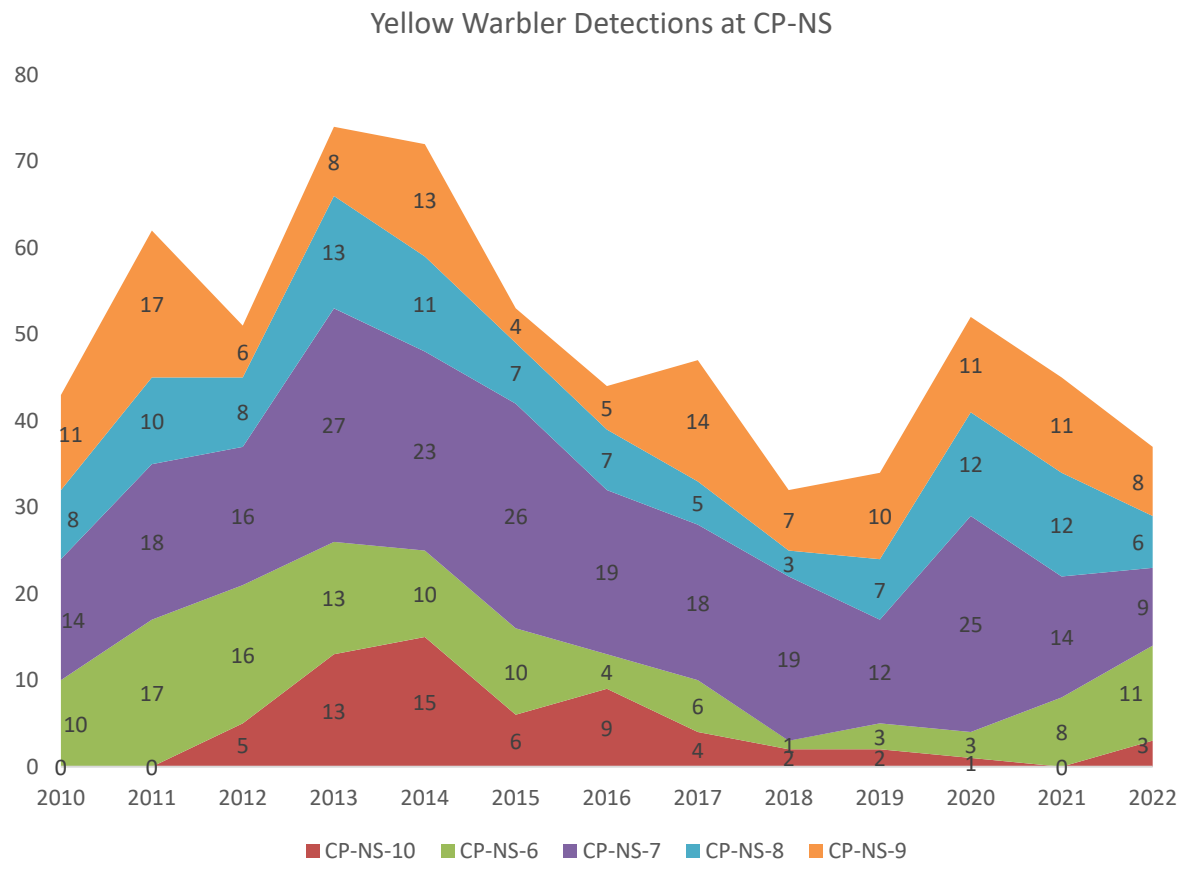

Figure 32 Yellow Warbler detections at terrestrial bird survey plots at CP-NS 2010-2022. Only plots where Yellow Warbler have been detected were included. Note that CP-NS-10 was not surveyed until 2012.

Black-capped Chickadees are noticeably declining throughout CP-NS (Figure 33). Reasons for decline are varied and can include supplemental feeding by RBG visitors which concentrates chickadees in non-surveyed locations, reduction of suitable nesting habitat, as chickadees prefer birch, aspen, and sugar maple, which are uncommon in CP-NS, and other unknown factors.

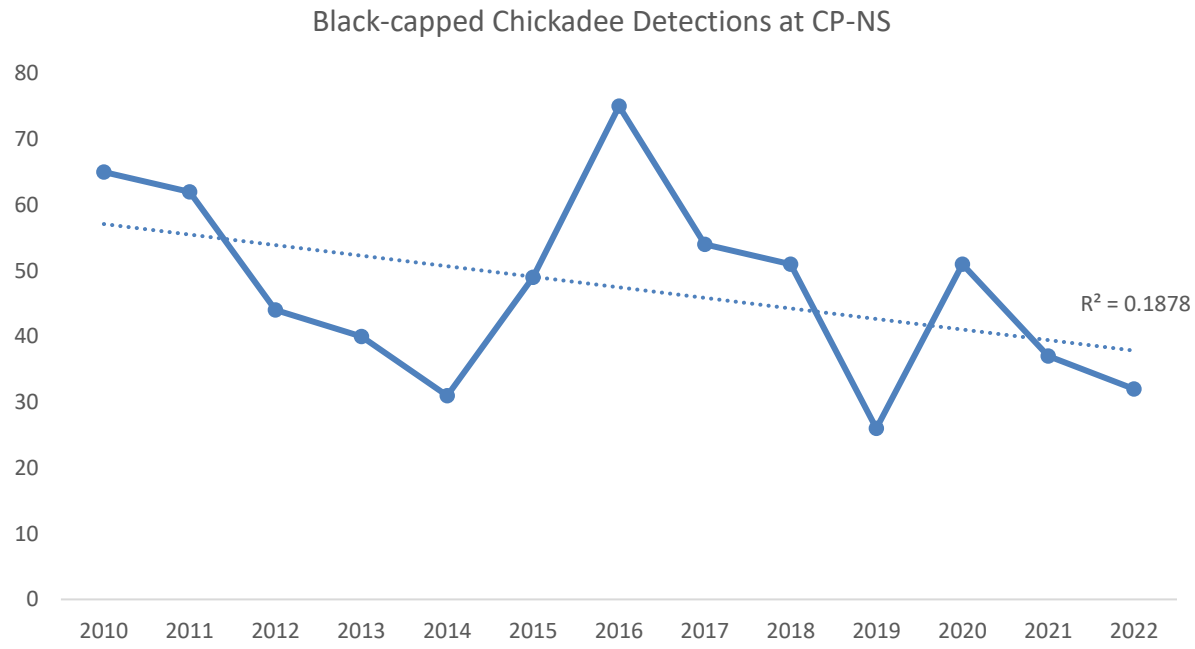

Figure 33 Detections of Black-capped Chickadee at CP-NS from 2010-2022

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

Guilds

Nest Location

The greatest change in nesting location is the decline of shrub nesting birds and the increase of lower-canopy nesters (Figure 34). This may be due to the reduction of the shrub layer at CP-NS due to maturation of trees, reduced recruitment of native species due to invasives and deer, and manual removal of invasive shrubs.

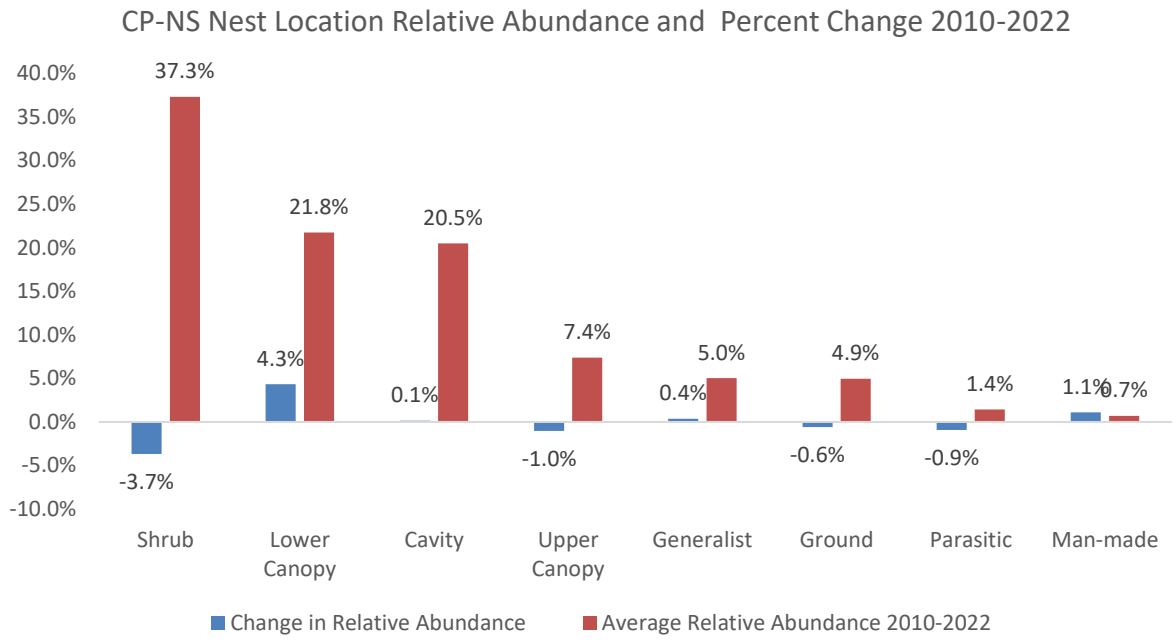

Figure 34 Nest location relative abundance and change in relative abundance at CP-NS from 2010-2022

Habitat

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

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

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

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

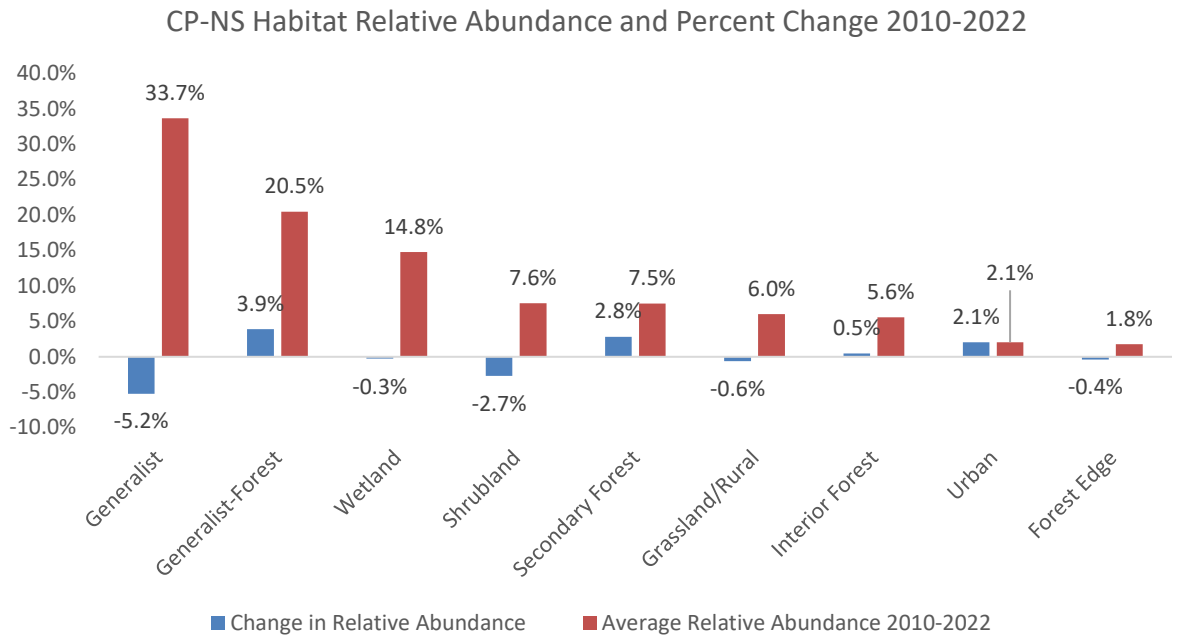

Figure 35 Habitat relative abundance and change in relative abundance at CP-NS from 2010-2022

Foraging

The most notable change is the increase in lower aerial insectivores (Figure 36). This guild relies heavily on the gap between shrubs and upper canopy layer to forage and nest in, and often declines when invasive shrubs dominate the understory. At CP-NS data shows that invasive shrub and ground cover species are falling, and that the shrub layer itself is shrinking. This lack of shrubs is likely facilitating some expansion of this guild into the interior forest.

Granivores are almost entirely American Goldfinch and waterfowl species. As described previously American Goldfinch are declining throughout CP-NS, and waterfowl are only incidentally recorded, so a reduction of this guild is unsurprising.

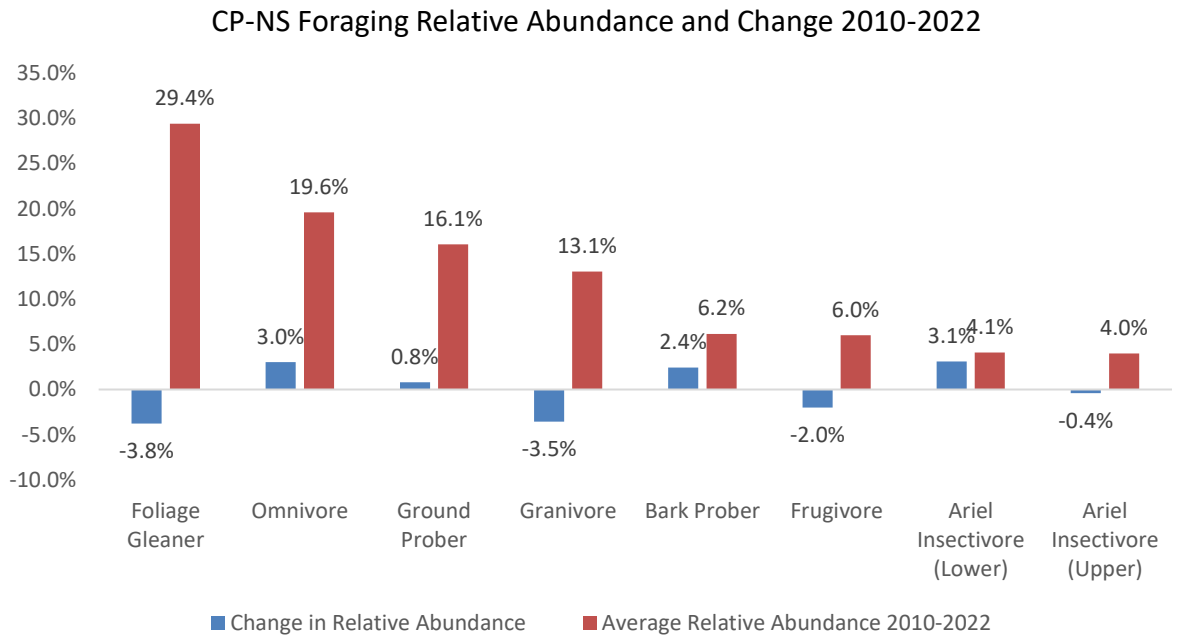

Figure 36 Foraging relative abundance and change in relative abundance at CP-NS from 2010-2022

Foliage gleaners have declined in relative abundance but are stable in detections (Figure 37). The decline in relative abundance then is associated with an increase in detections for other guilds, rather than a decline in foliage gleaners.

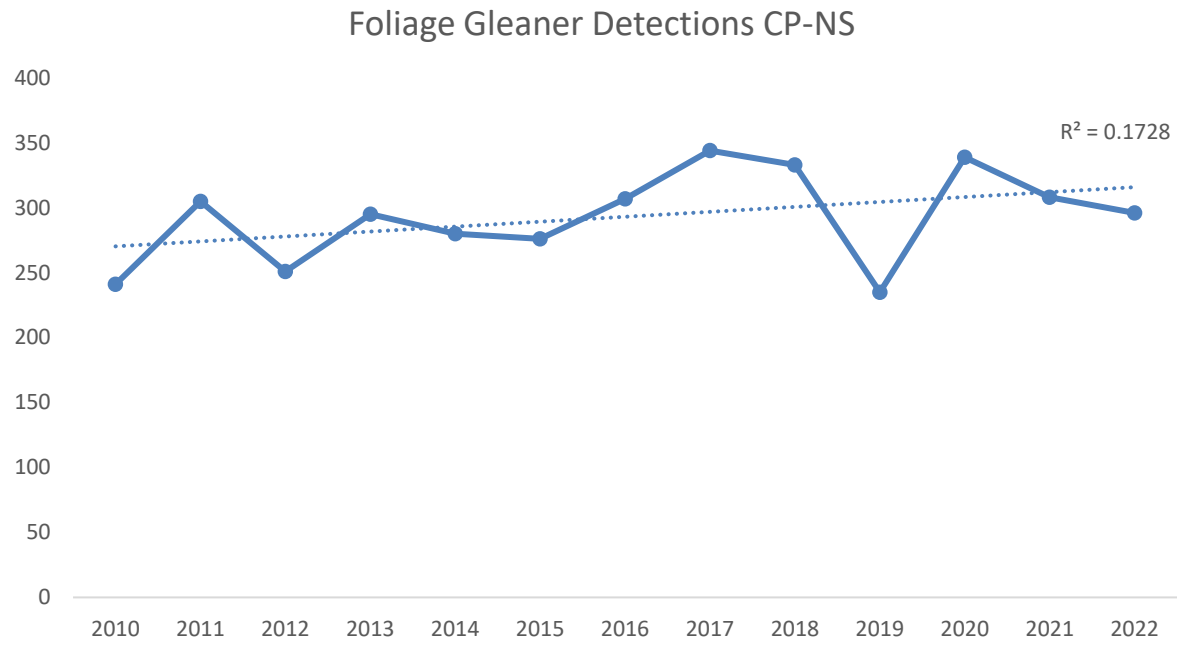

Figure 37 Detections of all Foliage Gleaner species at CP-NS from 2010-2022

Cootes Paradise North Shore Summary

The north side of Cootes Paradise (CP-NS) is the largest and most diverse nature sanctuary. Of all the nature sanctuaries guild representation is the most even indicating a robust avian community and varied habitat types.

Despite numerous stressors such as EAB and White-tailed Deer, the avian community has shown resilience, if fluctuation, in species. Common species are adjusting as forests recover from EAB and shrubland transitions into forest. Interior forest species are best represented at CP-NS but still make up a small percentage overall, highlighting the vulnerability of this guild.

Cootes Paradise South Shore Details

Cootes Paradise South Shore is a narrow strip of forest and wetlands which hugs the south side of Cootes Paradise Marsh. This 110-hectare sanctuary is surrounded by dense urban development on the south and bordered by open water and wetlands to the north, west, and east. Human activity and impacts are very high in this sanctuary due to an inability to control access to the sanctuary and density of people nearby.

Impacts to the Avian Community

Forest Health

Since 1934 about 22 hectares of canopy have been lost (Vincent, 2017). This loss of canopy has created more edge effects and reduced interior forest to the point of non-existence. The canopy is mostly Shagbark Hickory (*Carya ovata*), Red Maple (*Acer rubrum*), and Black Cherry (*Prunus serotina*). Understory shrubs are mostly native species such as Witch Hazel (*Hammamelis virginiana*), White Ash (*Fraxinus americana*), and Black Cherry (*Prunus serotina*). Ground cover is mostly invasive species with Woodland Speargrass (*Poa* nemoralis) and Garlic Mustard (*Alliaria* petiolate) covering much of the south shore, reducing available leaf litter and suppressing native herbaceous growth (Barr et al. 2021).

Data shows that the forest is maturing with a reduction in shrub and tree recruitment. 45% of the 2-15 metre layer has been lost since 2012 indicating that while shrubs and trees are aging out there is a lack of recruitment. This change in vegetation layers is likely driving the decline of several groups such as warblers and foliage gleaners.

Human Impacts

CP-SS struggles with off-trail usage from the surrounding population and the student population at neighbouring McMaster University. Off-trail usage contributes to invasive species spread, disturbs nesting wildlife, and promotes fragmentation of sensitive areas. As outlined in the report by Barr et al. the need to mitigate and control these impacts is urgent and ongoing with restoration efforts and the RBG Master Plan implementation.

Restoration Efforts

Reforestation efforts are underway at Churchill Park (~6.5 hectares) and Bond Street (~7.5 hectares). These efforts have cumulated in over 4,200 native trees and shrubs being planted. Anecdotal evidence suggests that these efforts are successful, with nests being found in planted trees and birds using the restored areas as overwintering habitat. With these ongoing efforts forest obligate species should increase over time.

Relative Abundance and Common Species

At CP-SS nine out of the ten most common species have seen minimal change in relative abundance since 2010 (Figure 38). Species of note are the European Starling, an invasive species, and the Red-eyed Vireo, an interior forest species.

The European Starling is common at CP-SS due to the urban development surrounding the sanctuary. Starlings are prolific breeders near urban development are most prevalent at plots closest to urban development. The Red-eyed Vireo is often considered an interior forest species and while not shy of humans, breeds in lower densities when human presence is high (Cimprich et al. 2020). The population of Red-eyed Vireo is likely very low and likely relies on a 'source' population from CP-NS or other nearby forests.

Yellow Warblers have dropped 7.4% and this decline is reflected in detections, where the species has nearly disappeared from three survey plots and is declining in the remaining three.

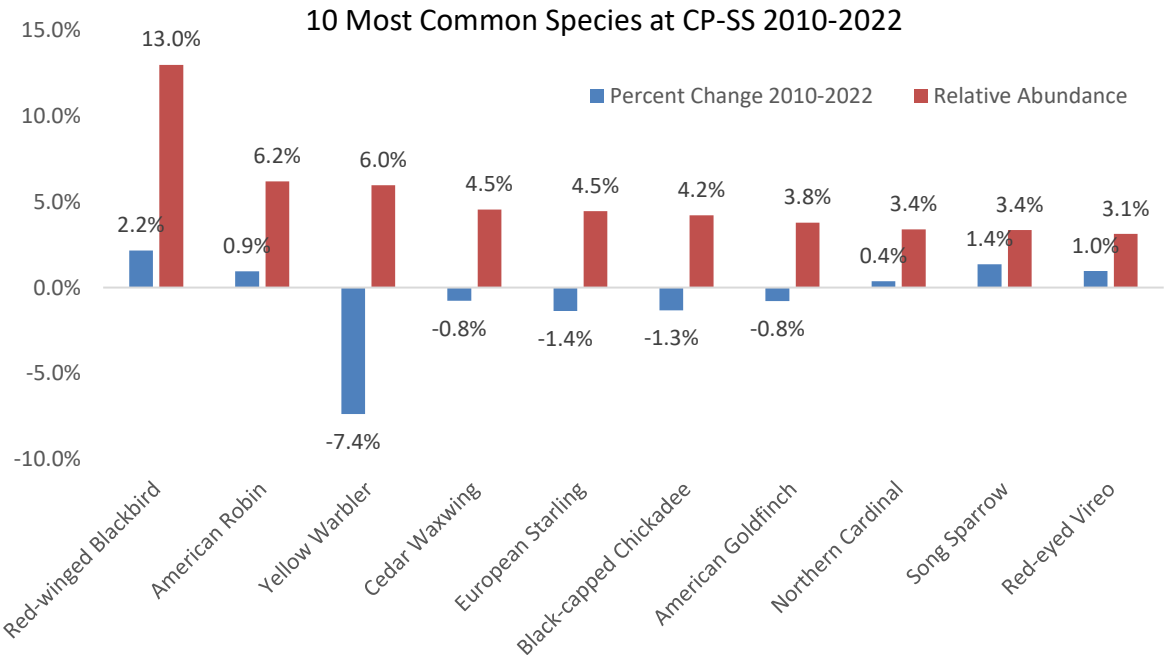

Figure 38. Change in relative abundance of the ten most common species at CP-SS from 2010-2022

The disappearance of Yellow Warbler from CP-SS-2 and CP-SS-3 is notable as both areas are near forested wetlands (Figure 39). The disappearance may be due to the maturation of shrubs and trees at these plots, with a lack of suitable shrub species to make up for the loss of nesting habitat.

CP-SS-4, while not supporting many Yellow Warblers in the past, may have more in the future as restoration efforts nearby provide suitable shrub and tree habitat for the species.

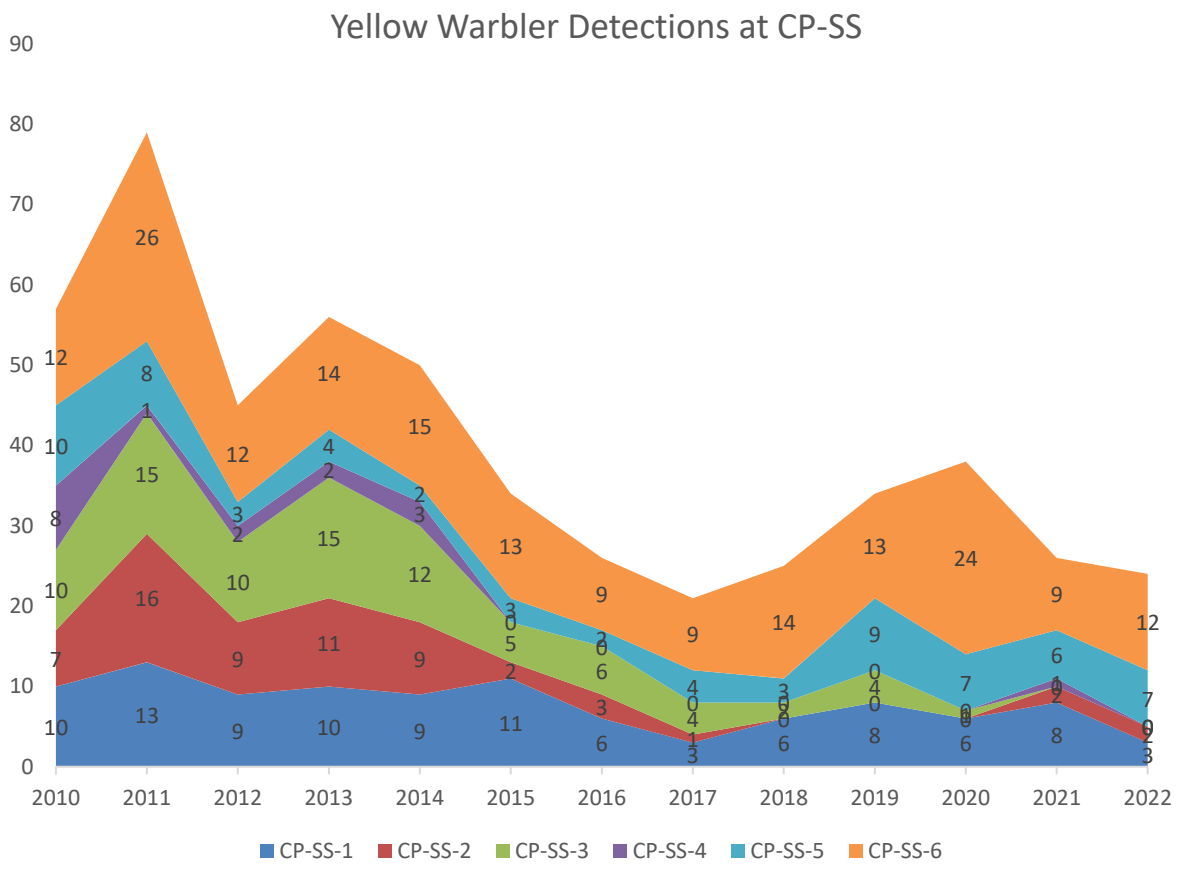

Figure 39. Yellow Warbler detections at terrestrial bird survey plots at CP-SS from 2010-2022

Guilds

Nest Location

There is minimal change in nesting guilds at CP-SS, with no group showing significant changes over time (Figure 40). Shrub nesters are the most common group, alongside guilds that predominantly use forests. As expected, the number of ground nesters, parasitic birds, and birds reliant on man-made structures are low in abundance either due to a lack of suitable nesting habitat or survey locations.

There has been a slight increase in cavity nesters, likely due to ash die back which is providing more suitable snags and presence of European Starlings. The canopy guilds are stable despite

shifts in the understory. Shrub nesters have declined, likely due to the decrease of Yellow Warblers and American Goldfinches.

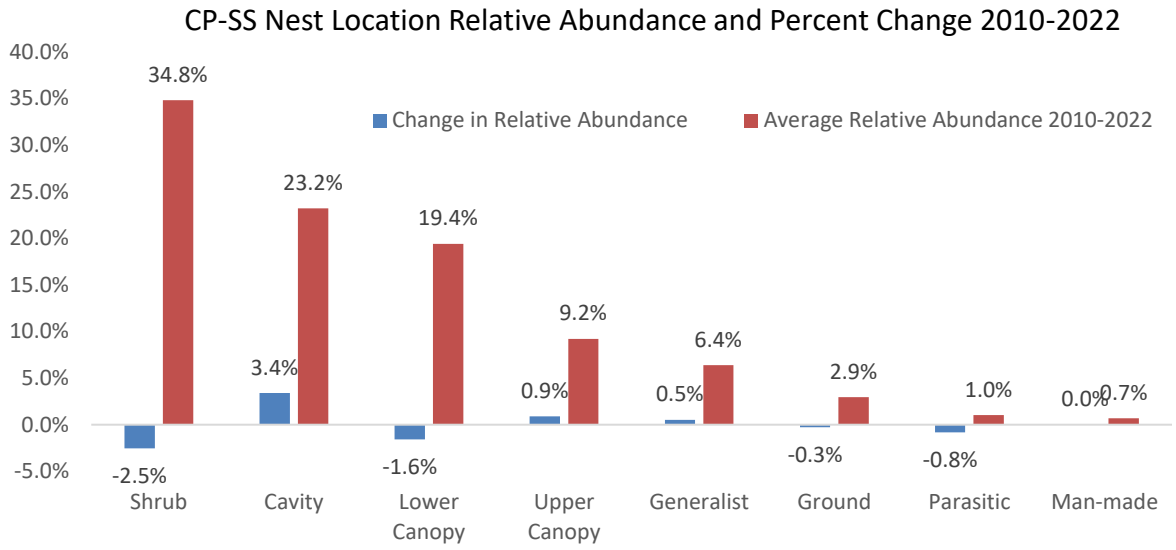

Figure 40. Nest location relative abundance and change in relative abundance at CP-SS from 2010-2022

Habitat

All forest guilds are either stable or increasing (Figure 41). Interior forest species remain a small cohort of detections and are usually absent from CP-SS-4 and CP-SS-6. As expected with the decline of the Yellow Warbler and American Goldfinch, shrubland species are declining.

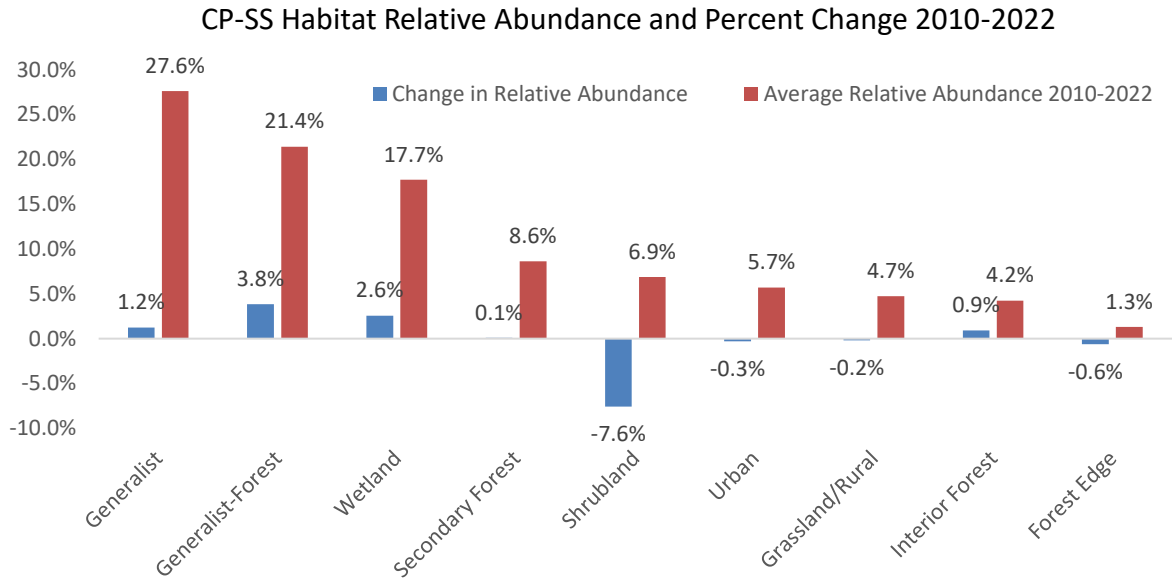

Figure 41. Habitat relative abundance and change in relative abundance at CP-SS from 2010-2022

Foraging

Foliage gleaner species have declined significantly, driven mostly by the decline of Yellow Warblers, American Redstarts, and the Black-capped Chickadee (Figure 42). Some foliage gleaners such as orioles and gnatcatchers are increasing, but detections are low on average. Aerial Insectivores have seen little change at CP-SS. Bark probers have increased likely due to increased foraging habitat from ash die-back.

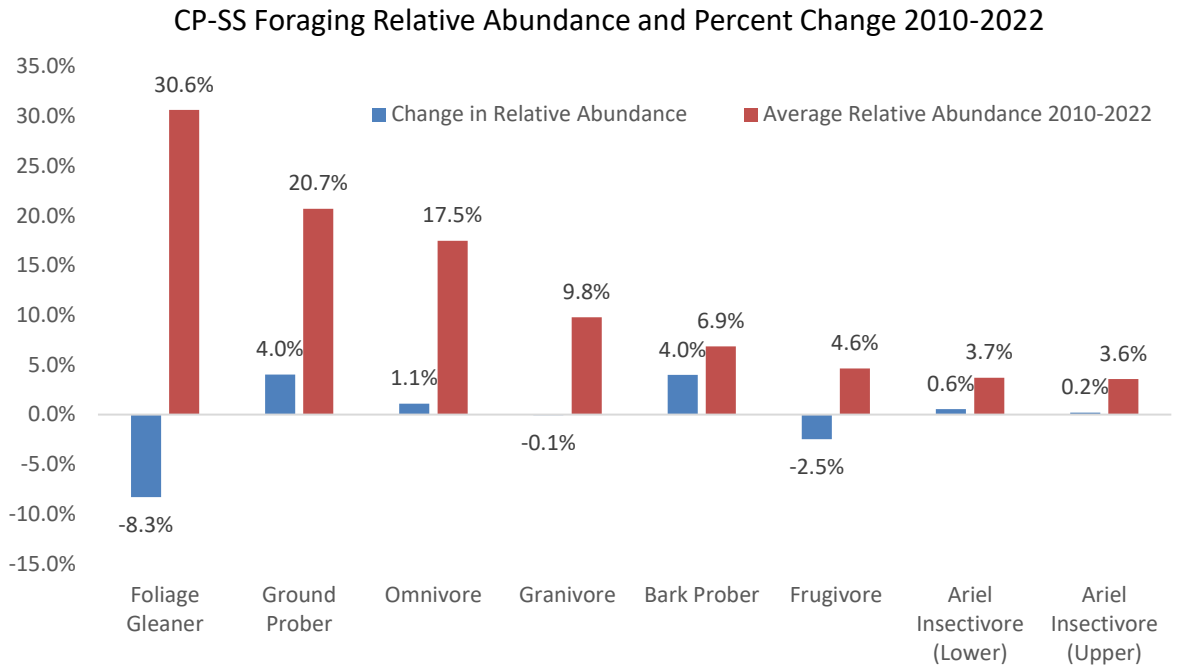

Figure 42. Foraging relative abundance and change in relative abundance at CP-SS from 2010-2022

Cootes Paradise South Shore Summary

As a nature sanctuary under immense human pressures from urban development to off-trail usage CP-SS has shown surprising resiliency. Species richness and diversity have remained the most even of all nature sanctuaries, which is indicative that species turnover is enough to mitigate these effects.

The decline of warbler species is concerning at CP-SS but unsurprising given forest changes. Ongoing restoration efforts should help mitigate some of this decline as shrubs and young trees provide necessary habitat for this guild. Interior forest birds are rare at CP-SS due to the lack of

necessary habitat. Reforestation efforts and human impact mitigation measures should hopefully increase and stabilize this guild.

Escarpment Properties Details

The Escarpment Properties (EP) span approximately 115 hectares of forests, grasslands, and talus slopes along the Niagara Escarpment. These properties connect into other organizations' property such as the Bruce Trail, Hamilton Naturalists' Club, and Hamilton Conservation Authority. Adjacent to much of the sanctuary is agricultural lands which produce row crops as well as a small residential neighbourhood.

Impacts to the Avian Community

Restoration Efforts

Approximately 22 hectares of grasslands are undergoing restoration and maintenance at EP. Efforts include removing invasive species, seeding with native grasses and forbs, and maintaining mowing regimes to prevent woody plant growth.

These efforts are benefiting grassland birds which have seen steep declines across the continent. Species-at-risk, such as the Bobolink, have once again established and are breeding on the property. Common species in steep decline, such as the Field Sparrow, have also established at these properties. With ongoing restoration efforts other species-at-risk, such as the Eastern Meadowlark and Grasshopper Sparrow, may establish at these locations.

Currently, diversity is low in the newly restored sites. This is likely due to the lag time between native vegetation establishment and discovery by breeding birds.

Invasive species removal in forested habitat is also ongoing, with the removal of Dog-strangling vine (*Cynanchum rossicum*), Common Buckthorn (*Rhamnus cathartica*), non-native Honeysuckle (*Lonicera sp.*), and Norway Maple (*Acer platanoides*) when able. These efforts contribute to a healthier understory and suitable habitat for interior forest birds such as Wood Thrush.

Habitat Connectivity

Much of EP is adjacent to other forested nature sanctuaries, which increases the available interior forest for breeding birds. This connectivity is beneficial for many species which are intolerant of

edge effects or human disturbance. Certain species such as the Ovenbird and Red-shouldered Hawk have been absent from the property for some time, but with connectivity and restoration efforts may return to the area, albeit in low numbers.

Relative Abundance and Common Species

Species relative abundance is fluctuating as new grassland plots have been recently added to surveys (Figure 43). These changes are inherently reducing the abundance of certain guilds and species due to the new representation of grasslands and meadows.

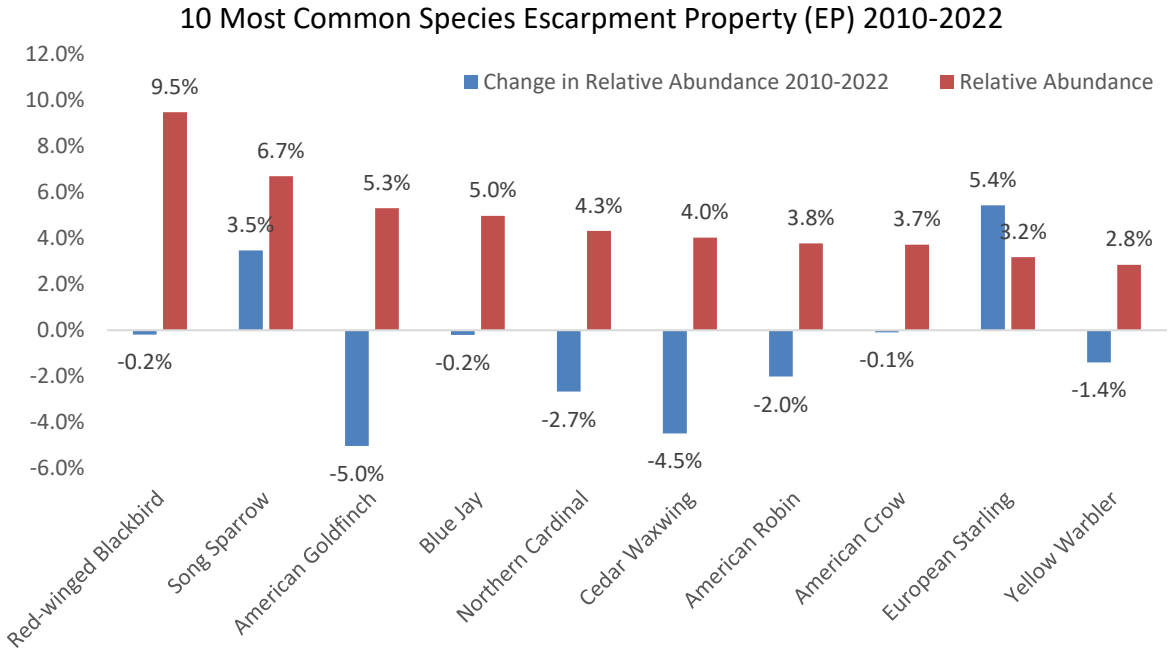

Figure 43. Change in relative abundance of the ten most common species at Escarpment Property from 2010-2022

The decline in American Goldfinch and Northern Cardinal is due to species stability rather than a decline in detections. As these species are stable, the increase in Song Sparrow and European Starling has caused their relative abundance to decline. Cedar Waxwing are declining in overall detections and further monitoring will be needed to assess if the trend is temporary.

European Starlings have increased in both abundance and detections with the addition of new survey plots near agricultural and residential areas. As this species is highly reliant on human activity it is not surprising that they are more prevalent now that areas close to their preferred habitat are being surveyed.

Guilds

Nest Location

Grassland restoration has caused a surged in ground nesters such as Savannah Sparrows and Field Sparrows and representation of this guild will likely increase as restoration is ongoing (Figure 44). Despite the decline in relative abundance in lower canopy and shrub nesting birds, detections for these guilds have increased since 2010.

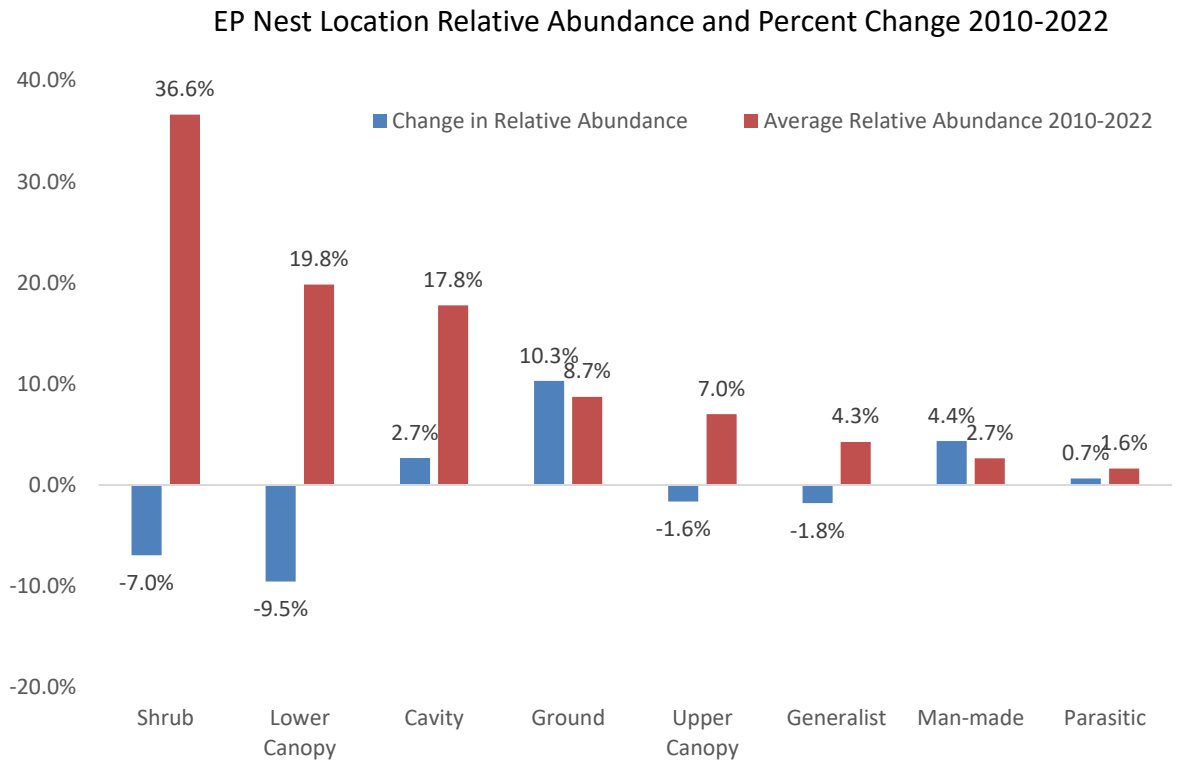

Figure 44. Nest location relative abundance and change in relative abundance at EP from 2010-2022

Habitat

As reflected in nesting location Grassland/Rural birds have dramatically increased (Figure 45). When assessing detections, generalist, forest generalists, and even interior forest birds are all stable or increasing. Instead, the rapid increase of grassland and urban birds is causing the decline in relative abundance of these guilds.

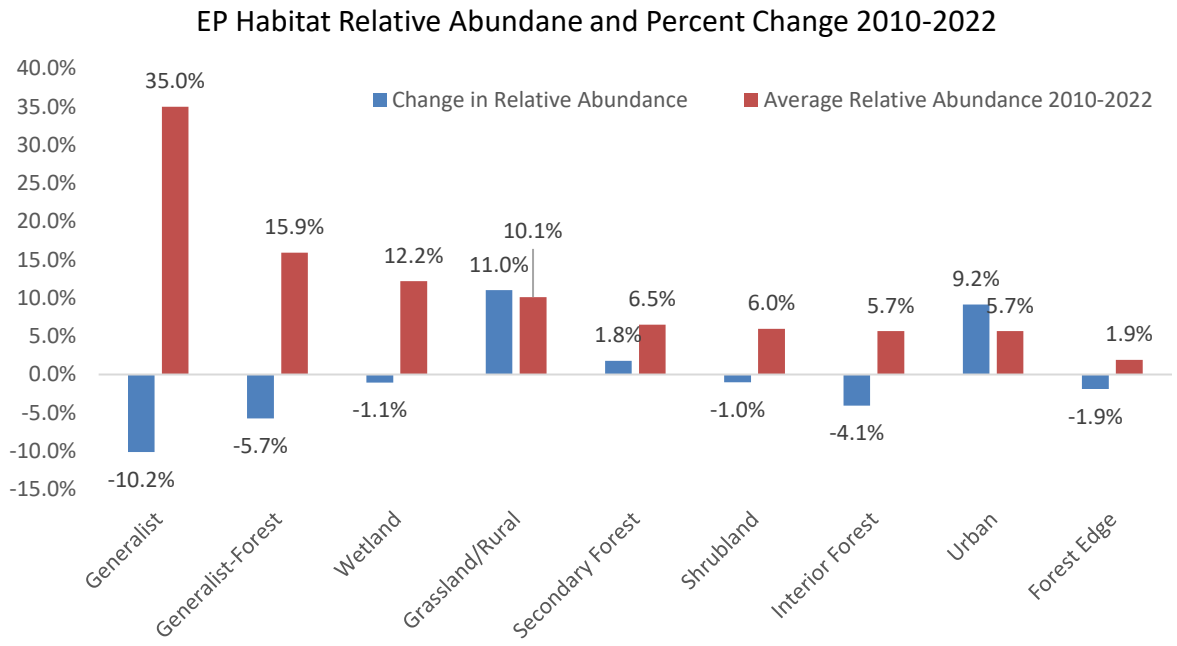

Figure 45. Habitat relative abundance and change in relative abundance at EP from 2010-2022

Foraging

When looking at the foraging guild, it is evident that there is an evenness in guild representation with minor shifts in omnivores and frugivores (Figure 46). The increase in omnivores stems from the increase of Song Sparrows and stability of American Crows. Cedar Waxwings are declining at EP and further monitoring will be needed to assess if the decline is temporary.

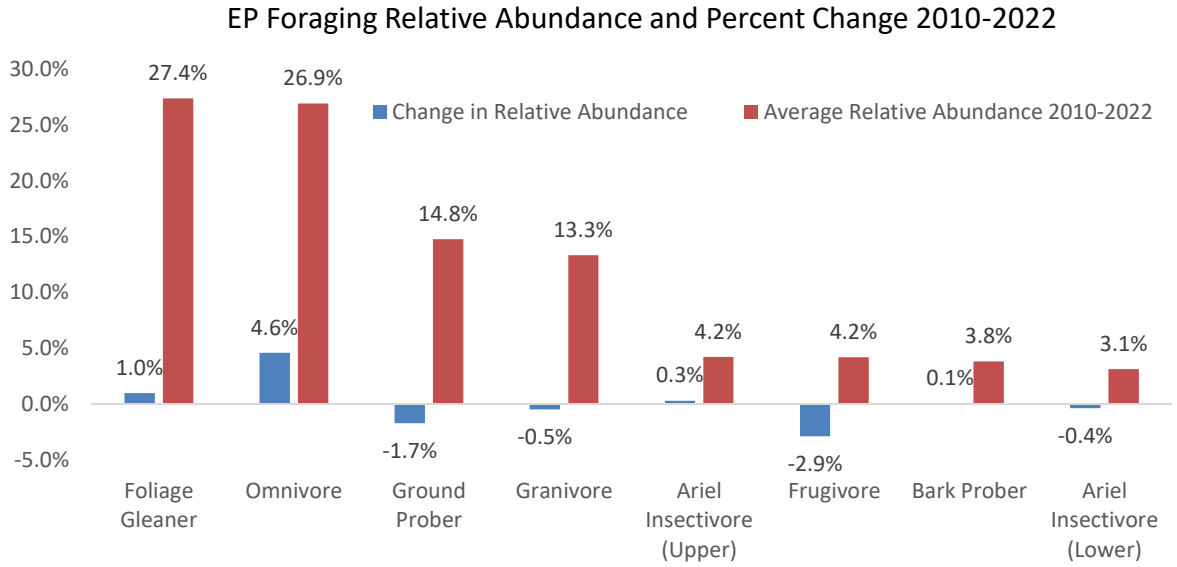

Figure 46. Foraging relative abundance and change in relative abundance at EP from 2010-2022

Escarpment Property Summary

Guilds at the Escarpment Properties (EP) are in transition as more grassland representation has been incorporated into surveys. The rapid increase of grassland specific birds is hopeful and indicative of successful restoration efforts.

Foliage gleaners and forest specific birds are either stable or increasing in detections despite showing a decrease in relative abundance. Their decrease in relative abundance can be attributed to the rapid increase of grassland guilds, rather than a decline in forest bird detections.

Hendrie Valley Details

Hendrie Valley (HV) is approximately 100 hectares of wetlands and forests, bisected by Grindstone Creek and surrounded by urban development. There is roughly 50 hectares of narrow and fragmented terrestrial habitat, restricted to steep slopes and hills. There is no meaningful interior forest within the valley and the abundance of wetland habitat ensures every survey location is influenced by wetlands.

Impacts to the Avian Community

Wildlife Feeding

Supplemental wildlife feeding by RBG visitors is a significant problem in Hendrie Valley, with an overabundance of food impacting all vertebrate taxa present (Peirce, 2019). Visitors often feed poor quality seed such as millet which is lacking in protein and fats required for many avian species, requiring birds to make more frequent foraging trips (Johansen et al. 2014). This increase in foraging can decrease fitness by increasing exposure to predators, reducing time spent at the nest incubating, and increasing nest visits to feed chicks (Peirce, 2019).

Feeding is often indiscriminate, with piles of feed left on walkways and by trails. This indiscriminate feeding increases the presence of mammalian predators such as squirrels and chipmunks which are significant nest predators for birds (Reed and Bonter, 2018). Feed piles can also transfer disease between birds, increase the presence of invasive avian species, and can potentially disrupt established social behaviour in some species (Reed and Bonter, 2018, Wilcoxen et al. 2015).

This increase of food often concentrates birds away from survey areas and to highly travelled public trails. This has likely skewed some survey data, especially with the reduction of Black-capped Chickadees in surveys, and relatively low numbers of invasive avian species being detected.

Forest Health

The canopy of Hendrie Valley is dominated by Red Oak (*Quercus rubra*), Black Cherry (*Prunus serotina*), and Red Maple (*Acer rubrum*). These native trees provide forage and habitat for an abundance of wildlife, with oaks in particular supporting many insect species that birds rely on. The understory is mostly Norway Maple (*Acer platanoides*) and regenerating ash species. This is concerning as stands of Norway Maple have significantly less diversity as they shade out native plant life and support few insect species (Simkovic, 2020). The forest floor is a mix of non-native species, such as Garlic Mustard (*Alliaria petiolate)* and has little to no leaf litter which is detrimental for many terrestrial ground nesting and foraging birds.

The forest structure is indicative that while the canopy is suitable for many species, the understory and ground layers are not. Following the recommendations as outlined in the State of Hendrie Valley Report (Radassao et al. 2019) will help with understory health and regeneration, both of which will contribute to the resiliency of the avian community.

Relative Abundance and Common Species

The relative abundance of the ten most common species in HV have seen significant changes since 2010. Red-winged Blackbirds continue to be the most dominant, averaging 38% of all birds detected and increasing by 14% since 2010. Of the most common, only the Yellow Warbler has seen any increase in relative abundance with a minor increase of 2%. The remaining eight species have all seen declines in relative abundance, between 1-6% depending on the species (Figure 47). This distribution is indicative of a skewed community, as there is only one over-abundant species followed by many uncommon to rare species.

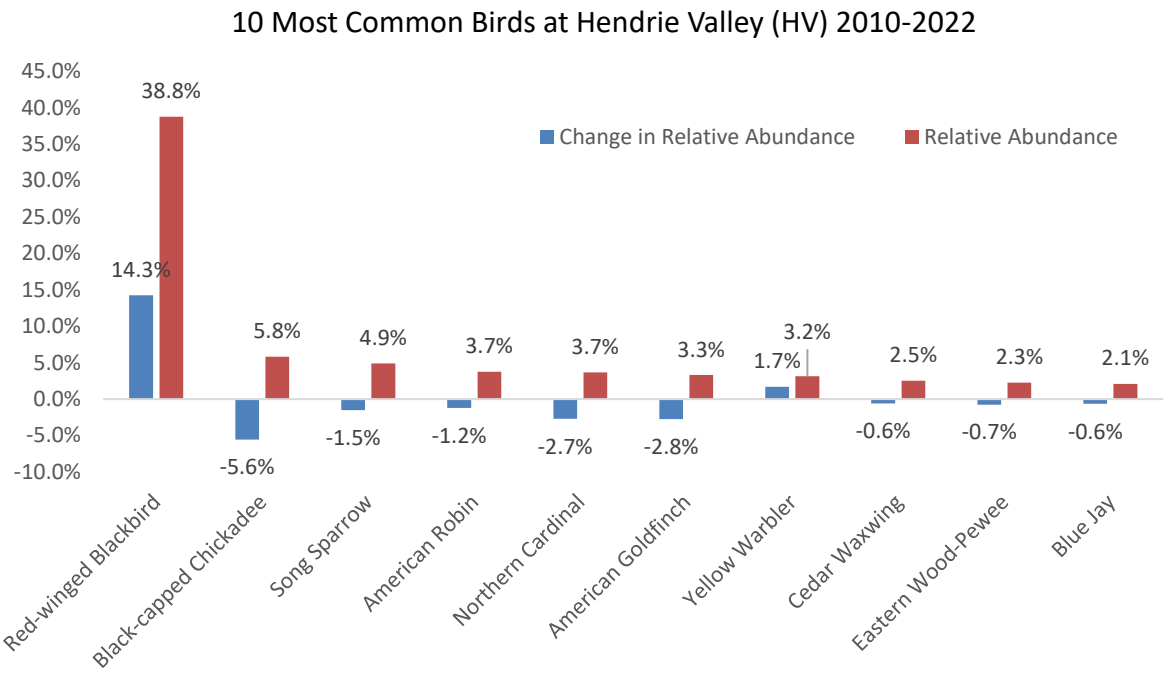

Figure 47. Change in relative abundance of the ten most common species at HV from 2010-2022

Black-capped Chickadees and Wildlife Feeding

Many RBG visitors to Hendrie Valley provide supplemental feed to birds, notably Black-capped Chickadees which are bold and readily land on visitors. The prevalence of supplemental feeding has likely caused changes in social structure and behaviour for this species which are now known to follow visitors and staff in the hopes of food (Peirce, 2019).

Detections and relative abundance of Black-capped Chickadees have been declining in terrestrial bird surveys at Hendrie Valley (Figure 48). This is may be due to the 'lure' effect of visitors, where chickadee flocks congregate along the trail and away from survey locations. 60% of all chickadee detections in Hendrie Valley occur at HV-1, which is close to the trail and a known feeding hotspot.

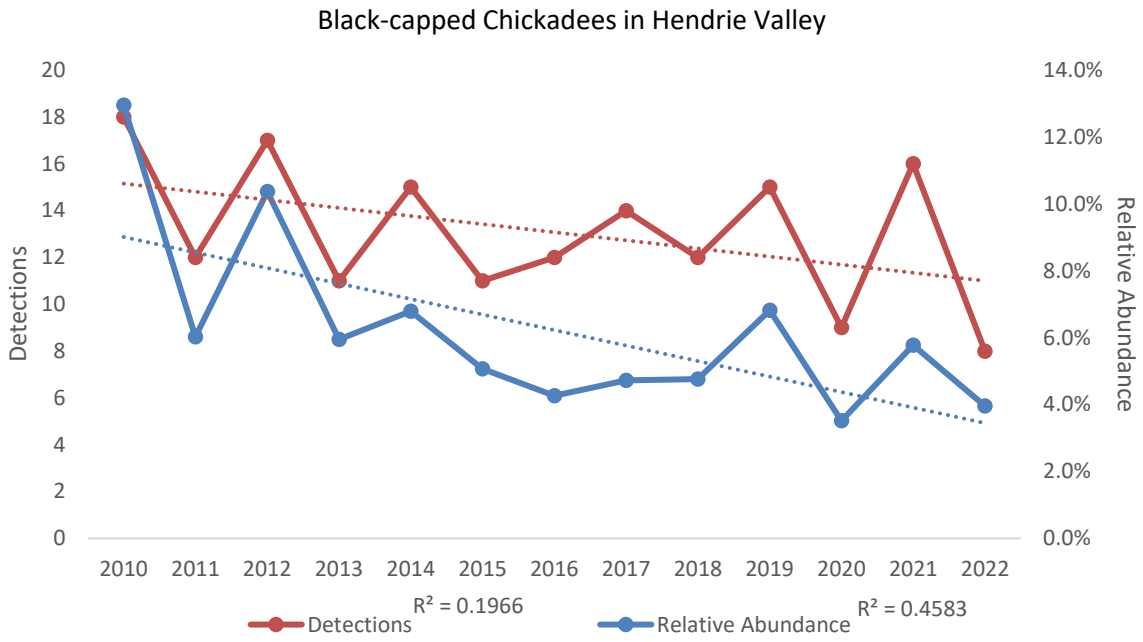

Figure 48 Detections and relative abundance at HV from 2010-2022, includes the additional 2018 monitoring plots

Guilds

Nest Location

Upper canopy nesters have decreased in both relative abundance and overall detections (Figure 49), with one species disappearing from surveys altogether (Blue-gray Gnatcatcher). The only consistent upper canopy nesting species is the Eastern-wood Pewee and Warbling Vireo. Most upper canopy species are sensitive to human disturbance and the increase of feeding and human impact at HV may have been enough to reduce several species.

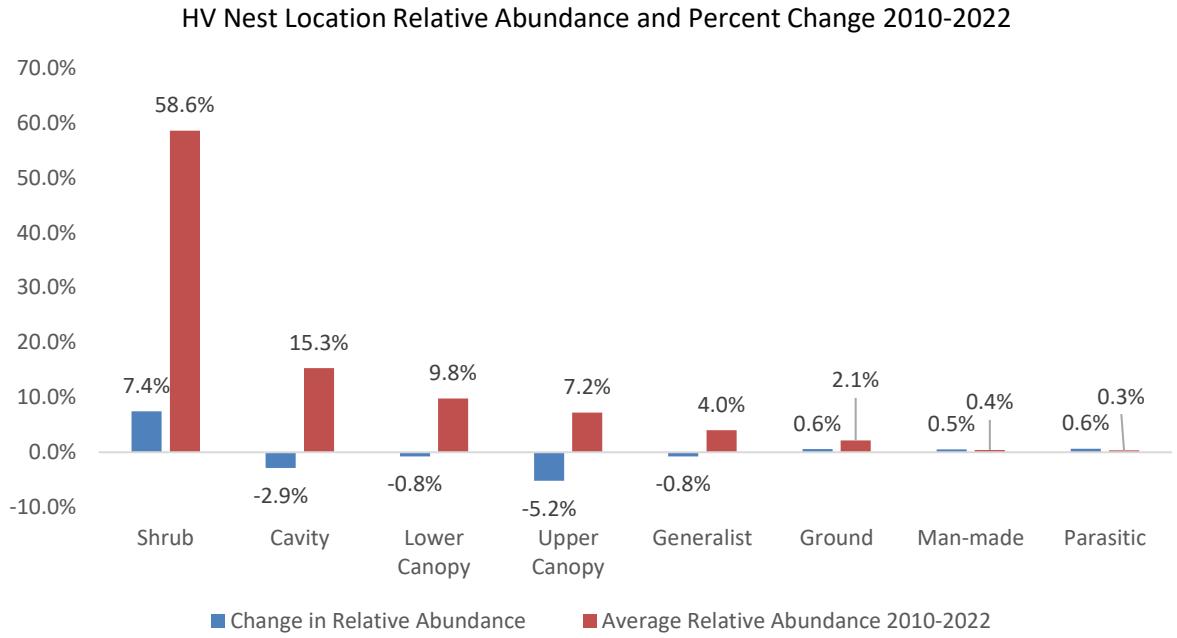

Figure 49. Nest location relative abundance and change in relative abundance at HV from 2010-2022

Habitat

Few guilds have seen significant changes, with wetland, generalists, and forest-generalists seeing the greatest changes over time (Figure 50).

Wetland species, such as the Red-winged Blackbird, continue to increase in HV. Other species such as swans, ducks, and herons are occasionally detected, as survey locations overlook wetlands. Concerningly, the increase of this guild is not only due to an increase in detections for wetland species, but a decrease in detections in other guilds.

Forest-generalist species such as Black-capped Chickadees are declining in detections and abundance in HV. Other generalist-forest species such as the Blue-gray Gnatcatcher, and Hairy Woodpecker have declined to the point of no longer appearing in surveys.

Generalist species are also declining in HV, likely due to changes in food availability and potential increases in nest predation, though further study is needed to confirm the reasons behind the decline.

Interior forest birds are rare in HV, with only 51 detections since 2010. This is unsurprising given the lack of suitable habitat surveyed and available.

The decline in generalist and forest-generalist species in very concerning, given that these guilds are typically the most adaptable to change. As surveys expand to assess more of the sanctuary these trends will need to be revisited to see if the decline is sanctuary wide or localized to these survey locations.

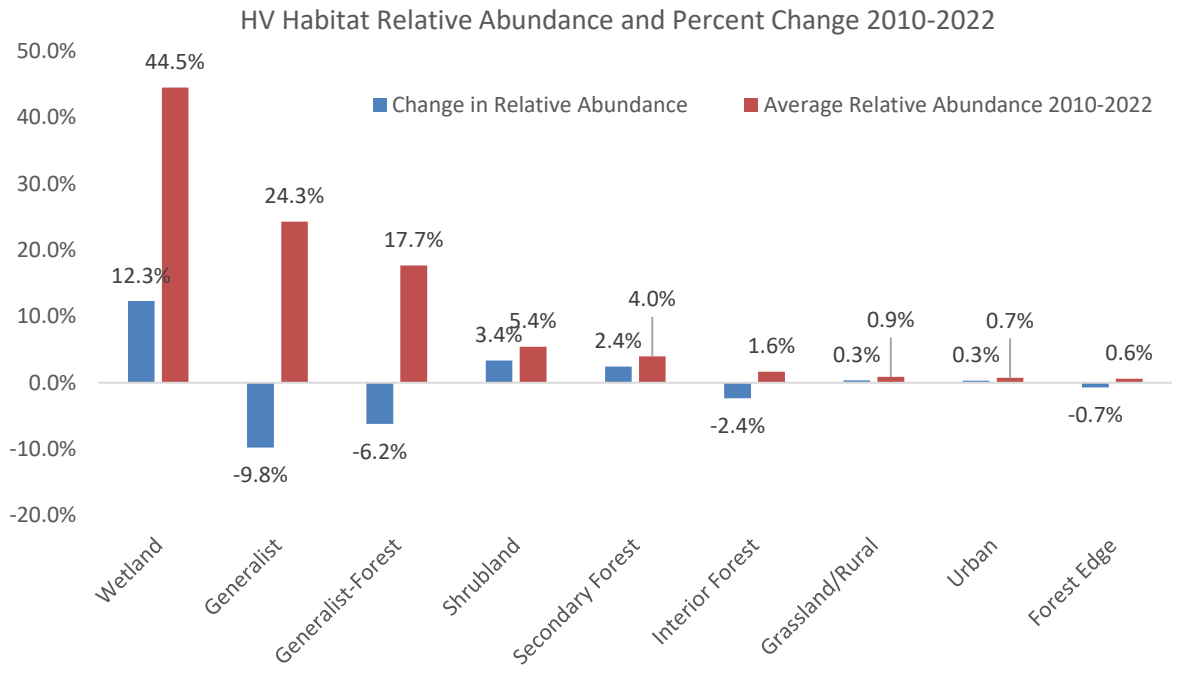

Figure 50. Habitat relative abundance and change in relative abundance at HV from 2010-2022

Foraging

There are three major changes in relative abundance, that being the increase of ground probers, and decrease of foliage gleaners and omnivores (Figure 51). With further examination of foliage gleaners and omnivores the decline in their relative abundance is due to detections remaining stable since 2010. Instead the increase in the number of Red-winged Blackbirds is causing the declines in relative abundance for these guilds.

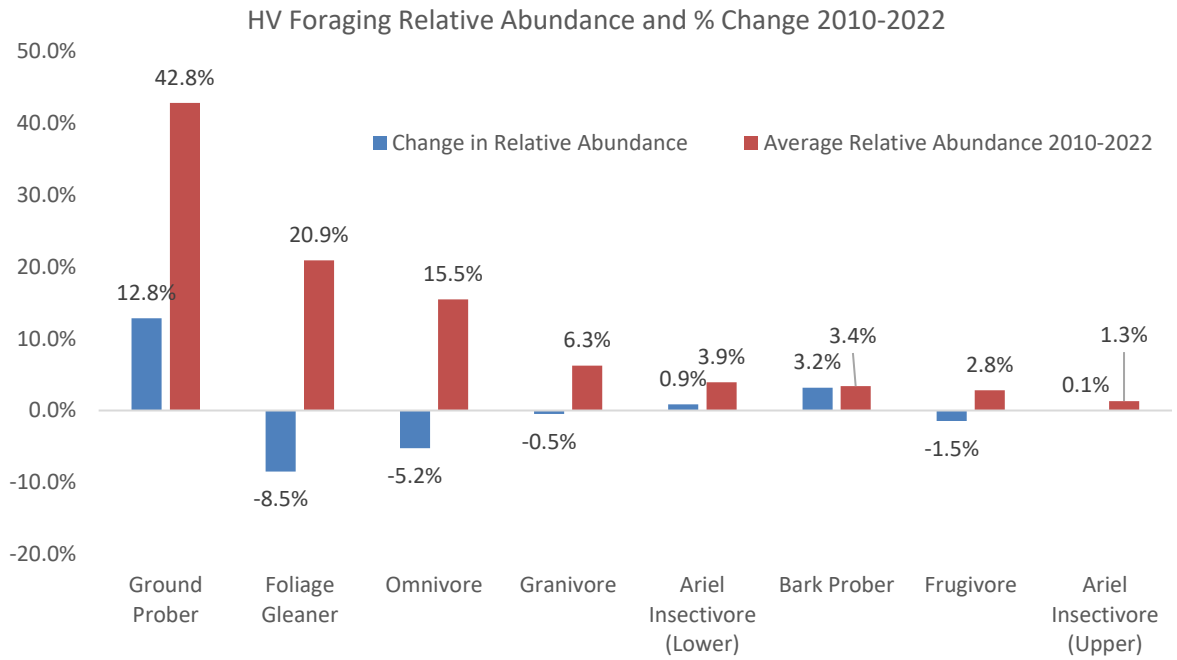

Figure 51. Foraging relative abundance and change in relative abundance at HV from 2010-2022

Hendrie Valley Summary

All changes in guilds are heavily influenced by the increase in Red-winged Blackbirds. While this species has continued to increase other guilds and species have declined not necessarily due to a lack of birds, but because there are that many more Red-winged Blackbirds.

The impact of wildlife feeding has likely skewed the avian community. Bold seed eating species have declined in surveys, likely due to their concentration around feeding hotspots that are under surveyed. Invasive avian species such as the House Sparrow are rarely detected, despite being one of three most abundant species in Peirce's surveys for wildlife feeding.

Forest health impacts, such as a decline in native shrub and tree regeneration and proliferation of non-native ground cover, are likely reducing available forage and nesting habitat for many species. Diversity is also decreasing despite increases to species richness, as many species are becoming uncommon to rare in surveys, while Red-winged Blackbirds increase in abundance.

Despite these numerous issues there is some sign of resiliency from the avian community. Species richness is increasing over time, and when surveys were expanded in 2018 diversity also increased significantly.

Surveys need to be expanded to cover more terrestrial habitat within HV. With only 2 survey plots significant portions of HV are under surveyed. Additionally, a follow-up study on the wildlife feeding report by Peirce would assist in determining how significant the 'lure' of supplemental feeding is to birds.

Species at Risk

Definition

Species-at-risk are species that are facing population declines and potential extinction due to factors, such as habitat loss, climate change, and invasive species. They are identified provincially and federally. Provincially protected species fall under the Endangered Species Act which permits science-based assessments, and once listed "Endangered" or "Threatened" the act provides automatic species and habitat protection. Species are assessed by the Committee on the Status of Species at Risk in Ontario (COSSARO) and are classified in 1 of 4 categories (OMNRF, December 2016):

- Extirpated: Lives somewhere in the world, and at one time lived in the wild in Ontario, but no longer lives in the wild in Ontario.
- Endangered: Lives in the wild in Ontario but is facing imminent extinction or extirpation.
- Threatened: Lives in the wild in Ontario, is not endangered, but is likely to become endangered if steps are not taken to address factors threatening it.
- Special Concern: Lives in the wild in Ontario, is not endangered or threatened, but may become threatened or endangered due to a combination of biological characteristics and identified threats.

Federally protected species fall under the Species at Risk Act. The purpose of this Act is to prevent wildlife species from being extirpated or becoming extinct and provide for the recovery of wildlife species that are extirpated, endangered or threatened resulting from human activity. Additionally, species of special concern are managed to prevent them from becoming endangered or threatened. "The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species," and places them into the following categories:

- Extinct: A wildlife species that no longer exists.
- Extirpated: A wildlife species no longer existing in the wild in Canada but occurring elsewhere.
- Endangered: A wildlife species facing imminent extirpation or extinction.
- Threatened: A wildlife species likely to become endangered if limiting factors are not reversed.
- Special Concern: A wildlife species that may become a threatened or an endangered wildlife species because of a combination of biological characteristics and identified threats.

Species-at-Risk at RBG

Bird surveys have detected a total of nine species-at-risk since 2010, these being the Acadian Flycatcher, Bald Eagle, Barn Swallow, Bobolink, Chimney Swift, Common Nighthawk, Eastern Meadowlark, Eastern Wood-Pewee, and Wood Thrush.

Survey methods used and locations surveyed limit the number of species at risk detections due to the rarity of the birds and specialized habitat they occupy. Several species, such as wetland specialists, nocturnal birds, or secretive birds may be undetected, or under-detected by the point count surveys. Additionally, nest searching is not done during the breeding bird season so breeding evidence is incidental.

Acadian Flycatcher – Endangered

This species was detected in 2011, 2013, and 2015 at CP-NS 2, and has not been detected since. This species is listed as Endangered in Canada and Ontario, and Hamilton is the northern edge of its breeding range (COSEWIC, 2010).

The Acadian Flycatcher nests in mature deciduous forest ravines of oak-hickory and near shaded streams dominated by Eastern Hemlock (*Tsuga canadensis*) (Allen et al. 2020). The species nests in the mid canopy layer in shrubs and small trees between two to nine metres in height (Allen et al. 2020). Nests are typically above or near wet areas such as streams and vernal pools (Allen et al. 2020). Adults exhibit nesting site fidelity year over year, but first-year birds rarely return to

the areas they hatched from. This species prefers large areas of contiguous forest (<100 hectares) but will occasionally appear in tracts as small as 25 hectares (Allen et al. 2020).

Acadian Flycatchers are intolerant of many invasive shrub species. This species is not found in areas where non-native honeysuckle, Multiflora rose, or Garlic Mustard is abundant (Bakermans and Rodewald, 2006). Other impacts are degradation of wintering habitat, forest fragmentation, parasitism by Brown-headed Cowbirds, and loss of preferred tree species such as hemlock and beech to invasive pests (Allen et al. 2020, Chapa-Vargas, Robinson, 2007).

RBG can continue to provide suitable breeding habitat for the Acadian flycatcher by managing invasive plant species to maintain preferred forest ecotypes and ensuring that at least 25 hectares of continuous suitable forest are present. It is important to note that the species may be undergoing range contraction as the population declines continent wide (Allen et al. 2020). As the range contracts the peripheral areas will see losses first as individuals cluster towards the centre of the range. Even with restoration efforts to restore and maintain suitable habitat, a self-sustaining population at RBG may not occur. Nonetheless, many other interior forest species will benefit greatly from these restoration efforts.

Bald Eagle – Special Concern

Bald Eagles resumed breeding at RBG in 2013, a historic moment as it was the first time since the disastrous effects of DDT that Bald Eagles had nested on the Canadian shoreline of Lake Ontario (Royal Botanical Gardens, 2023). Due to current survey methods Bald Eagles are not regularly recorded during surveys despite their continued presence and breeding on the property. The Species-at-Risk team keeps dedicated records of breeding activity on the property. Since 2013, detections of Bald Eagles have slowly been increasing on the property as per the Species-at-Risk records, with an increasing number of immature eagles present, and continuing with a single breeding pair.

Barn Swallow – Threatened

Like many aerial insectivores, Barn Swallow populations are continuing to decrease in North America, due to the combined factors of habitat loss, insect population decline, and climate change (Brown and Brown, 2020).

Barn Swallows are detected yearly and are known to breed on RBG property. A known colony is located near CP-NS-5, but due to the habitat surveyed, individuals are rarely detected in surveys. Detections of Barn Swallows are also increasing at EP as more grassland habitat near developed agricultural areas is surveyed.

The Species-at-Risk team continues to monitor the known colony of Barn Swallows on RBG property. In the future, restoration and maintenance efforts of grassland habitats should also increase detections of Barn Swallows.

Bobolink – Threatened

Bobolink require open grassland and wet meadow habitats with a diversity of grasses and forbs (COSEWIC, 2010). Numbers of Bobolink in Eastern North American have been declining, attributed to habitat loss, fragmentation, and intensification of agriculture (Renfew et a., 2020).

Bobolink are known to have strong settlement cues when choosing nest sites, and will return to suitable nesting areas year over year once found (Johnson and Igl, 2001). It can take some time for Bobolink to 'find' a new location to settle, but if it proves suitable they are likely to return (Johnson and Igl, 2001). Bobolink will abandon grasslands when shrubs and trees begin establishing, but have tolerance to single trees (Renfew et al. 2020). Bobolink are area sensitive, and despite a territory often being 0.5 hectares, they are unlikely to nest in grasslands smaller than 10 hectares Johnson and Igl, 2001, (Renfew et al. 2020).

Historically, Bobolink nested on RBG property at Rock Chapel Field, but due to human disturbance and habitat succession they abandoned the area. In 2017, EP-BT-2 was added to surveys, which is an area of approximately 12 hectares of managed and restored grassland. In 2018, a single Bobolink was detected, and in 2020 nesting was confirmed. Since then, Bobolink detections and breeding pairs have been increasing, with 2022 seeing multiple breeding pairs and confirmed breeding activity. Restoration and management efforts for grassland habitats should continue at RBG. Observers should listen for Bobolink at EP-RC-5 in particular, as restoration efforts continue in this area.

Common Nighthawk – Special Concern

The Common Nighthawk in an aerial insectivore which has seen steep declines, due to habitat loss, climate change, and the reduction of insects due to pesticides (Brigham et al. 2020). This species nests in flat open areas, from grasslands, bogs, and even flat gravel rooftops in cities (COSEWIC, 2010). Common Nighthawks will return to their same nesting ground year over year and have territories ranging from 10 to 30 hectares depending on habitat quality (Brigham et al. 2020).

Common Nighthawk forage at night and are rarely detected in the morning when most breeding bird surveys occur (Knight et al. 2018). Targeted surveys are often needed to get accurate information on Common Nighthawk habitat usage (Knight et al. 2018).

In 2016, a single individual was detected as a flyover. Currently EP-BT-2 is the only location with suitable breeding habitat, as it has dry areas of bare ground mixed with low vegetation. If resources are available, targeted surveys to find Common Nighthawks may be done at this location.

Chimney Swift – Threatened

The Chimney Swift is a small distinct aerial insectivore feeding high above the treeline and often detected by its distinctive chittering calls. Like other aerial insectivores, Chimney Swifts are experiencing declines for multiple reasons, but it is likely due to a decrease in food availability (Steeves et al. 2020). Studies on habitat loss for Chimney Swifts have indicated that it is not the driving factor for their decline (Steeves et al. 2020). Chimney Swifts are not often adequately detected during bird surveys as their nests and roost sites are typically in more urban areas, and they are more easily counted during dusk. Chimney Swifts have a specialized survey method to determine population metrics (Shaffer et al. 2022).

Detections of Chimney Swifts at RBG are infrequent but have been increasing since 2010. Chimney Swifts are most often detected at CP-NS and CP-SS, likely due to proximity of suitable nesting and foraging sites.

Swifts are not colonial, and pairs nest independently in hollow out trees or structures. Occasionally, unpaired birds and helper birds will roost in the same location as a nest. Large

groups of swifts will form communal roosts post breeding and before migration to wintering grounds (Steeves et al. 2020). There is a single known nesting roost and likely nest at the RBG Main Centre which is not surveyed during bird surveys. There is not regular formal monitoring of the roost due to time constraints for both the Terrestrial Ecology Team and Species-at-Risk team.

Eastern Meadowlark – Threatened

Eastern Meadowlark, like Bobolink, are declining with the loss of habitat and changes in agricultural practices (COSEWIC, 2011). This species has a larger territory than Bobolink, at five hectares, but is more tolerant of forest edges and will nest in areas of grassland less than ten hectares (Johnson and Igl 2001, Jaster, 2022). They are also sensitive to human disturbances, and females flushed from their nest due to human activity typically abandon the nest (Jaster, 2022).

Eastern Meadowlarks establish their territories early, typically in April (COSEWIC, 2011). One Eastern Meadowlark was detected once in 2019 at CP-NS-7 in late June, suggesting it was an individual who had either failed the first brood, or was attempting to renest nearby. It was not detected again, suggesting it was not breeding on RBG property.

In the future, Eastern Meadowlark could establish at EP-BT-2, and EP-RC-5, as both areas meet minimum size and habitat parameters. It usually takes birds several years to find and identify suitable nesting sites, but if breeding is successful, they are likely to return. Observers should be aware of the Eastern Meadowlark song, as well as the distinctive rattle.

Eastern Wood-Pewee - Special Concern

The Eastern Wood-Pewee (hereafter pewee) is a small flycatcher which nests in a variety of forest types across the continent. Pewees prefer more open canopy and forests, with large gaps between the shrub layer and canopy layer but will nest in a variety of wooded landscapes from closed canopy forests to more open savannahs (Watt et al. 2020). It is a highly territorial species, remaining territorial on the breeding and wintering grounds. Pewees will hold territory between 2.2 to 7.7 hectares depending on habitat quality and food availability (Watt et al. 2020).

Pewees have been increasing property wide since 2010, with an approximate increase of 30% (Figure 52). All four nature sanctuaries are seeing increases, with CP-NS increasing the most by

20%. The three remaining nature sanctuaries have seen minor increases with CP-SS at 5%, EP at 3%, and HV at 2%.

CP-NS typically has the most detections each year, likely due to the large continuous forest within the sanctuary. In 2022, it was the first time that pewees were detected in every bird monitoring plot at CP-NS at least once during surveys. Pewees have likely increased due to some canopy thinning from ash die-back which provides more open forest to forage in.

In contrast to CP-NS, CP-SS is long and narrow with forested areas hemmed in by Cootes Paradise Marsh and urban development. Pewee detections average half those of CP-NS, but detections are increasing, with pewees being detected at every bird monitoring plot at least once in the past two years. The increase of detections is slight at 5% which is not enough to confirm population increase. The population at CP-SS then, can be considered stable.

Pewee numbers are stable in EP and HV. HV has the lowest number of pewee detections compared to any other sanctuary. HV forests are under-represented, and habitat is limited due to urban pressures surrounding the sanctuary. Overall, pewees appear to be increasing on the property, likely due to a combination of factors such as changes to canopy coverage, forest-stratification, and restoration efforts.

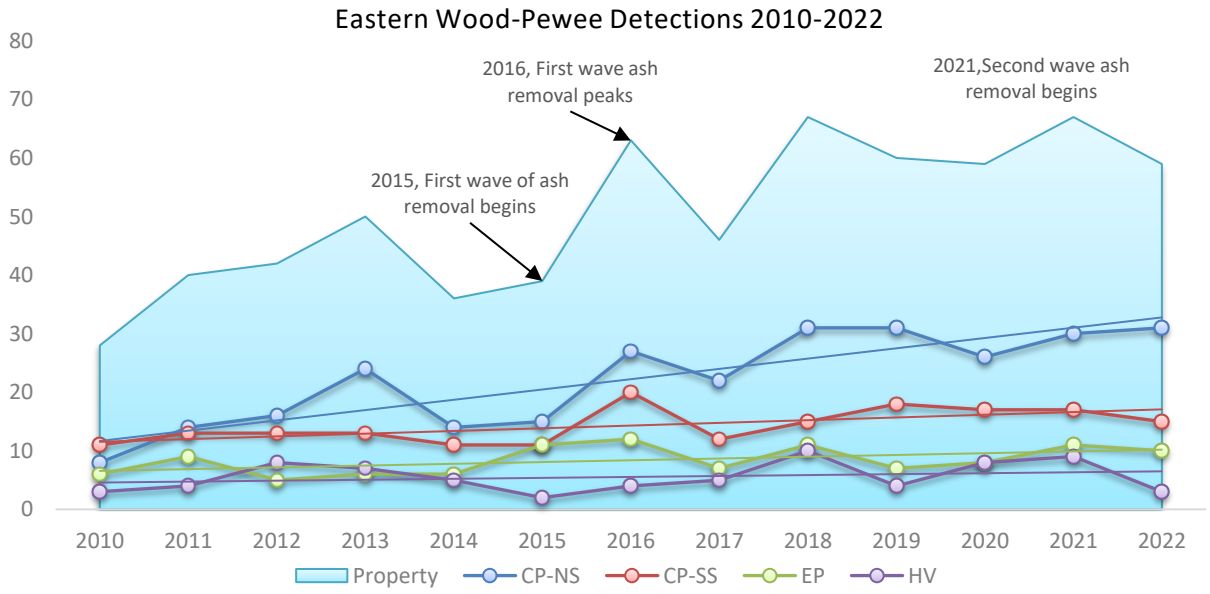

Figure 52. Detections of Eastern Wood-pewee at RBG nature sanctuaries from 2010-2022

Wood thrush – Special Concern

The Wood Thrush is a frequently studied species when examining the impacts of forest fragmentation and habitat loss on interior forest species. An increase in habitat fragmentation, disturbance, and edge effects can negatively impact the species to the point of disappearance from woodlots (Evans et al. 2020).

The breeding habitat of Wood Thrush is generally secondary forests, or patches or forests experiencing regeneration from minor disturbances such as blowdowns, ice storms, or selective logging (Weinberg and Roth, 1998). Wood Thrush prefer a closed canopy with a diverse understory and xeric-mesic soils (Evans et al. 2020). Territories for Wood Thrush are typically small if habitat is high quality, anywhere between 0.08 to 4 hectares. Currently RBG has suitable habitat for Wood Thrush in all four nature sanctuaries, but other factors seem to be causing declines.

Predictions for Wood Thrush population are difficult due to their low numbers across the property and sporadic increases in population. Year-over-year data suggests a minimal increase property wide (2%), but overall detections in the past three years have been worryingly low (Figure 53).

In CP-NS, Wood Thrush have seen some increase (7%), mostly in the interior forest plots where human disturbance, edge effects, and parasitism are lowest. Overall detections at CP-NS are still low, averaging 5.8 detections per year. Risks to Wood Thrush at CP-NS include parasitism from Brown-headed Cowbirds, invasive plants, changes to canopy structure, and human disturbance.

Wood Thrush were never present at CP-SS in great numbers and have nearly disappeared from surveys. While Wood Thrush have been found in small woodlots research suggests that proximity to urban environments negatively impacts them to the point of disappearance from local woodlots (Weinberg and Roth, 1998). It may be that with the human impact at CP-SS, Wood Thrush were not able to sustain their population and breeding adults did not return. It is interesting to note that during the Covid-19 pandemic lockdowns in 2020, Wood Thrush were detected at CP-SS after two years of no detections. With the restoration efforts at Churchill Park

and the endeavor to create interior forest, it is possible that Wood Thrush will return to CP-SS but ongoing efforts to mitigate human impacts will be needed.

At EP, Wood Thrush typically have the highest number of detections and highest number of individuals at any one location. However, detections have been decreasing overtime with a 2% decrease in detections since 2010. Reasons for the decline are uncertain and ongoing monitoring, forest assessment, and human impact studies may be needed to fully understand this decline.

HV had very low instances of Wood Thrush prior to 2015, and between 2015 and 2022 there has only been one detection. This nature sanctuary experiences intense urban pressure and forest health issues such as Cankerworm, Spongy Moth, and EAB. It is unsurprising that Wood Thrush are not able to persist in HV with such high levels of human disturbance. HV is also fairly narrow and surrounded by an urban landscape of subdivisions and roads which increasing edge effects such as predation and parasitism. HV may have always been a 'sink' rather than a self-sustaining population, and intense restoration efforts and human impact mitigation will be needed to create a self-sustaining population.

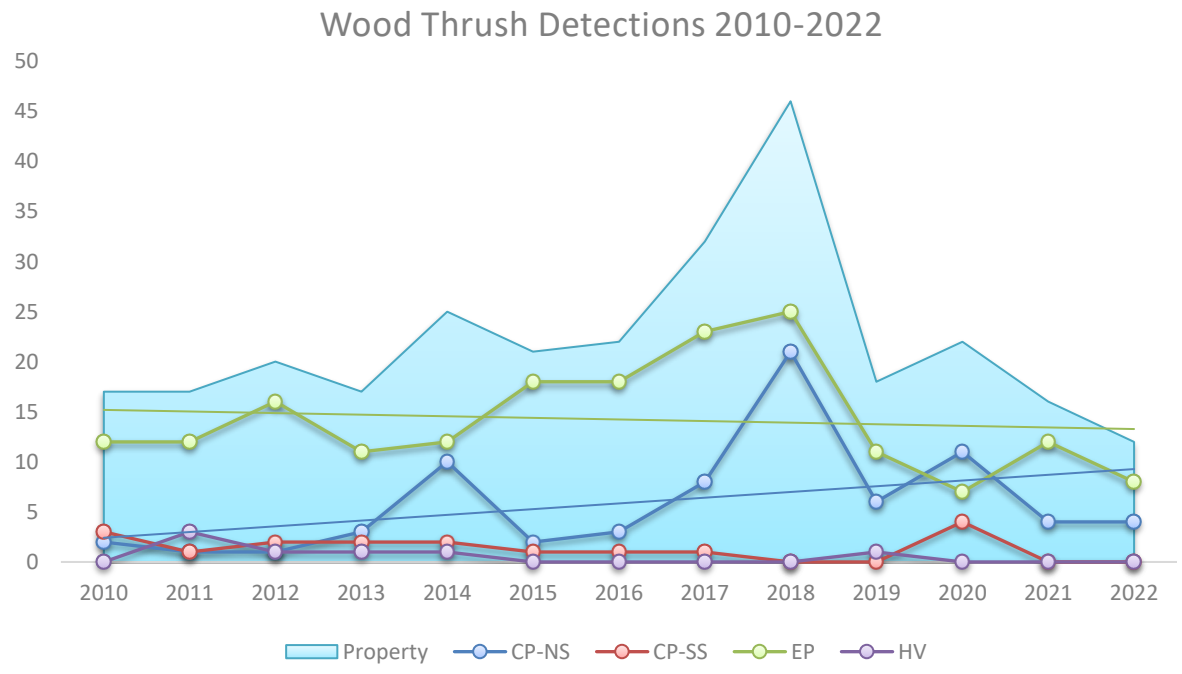

Figure 53. Detections of Wood Thrush at RBG nature sanctuaries from 2010-2022

Wood Thrush are also impacted by Brown-headed Cowbird (hereafter cowbird) parasitism and are considered an 'acceptor species' (Evans et al. 2020). Parasitism by cowbirds reduces Wood Thrush fecundity and can inhibit local population growth. Cowbirds predominantly use edge and open habitats, and fragmentation of woodlots is known to increase presence and impact by cowbirds (Lowther et al. 2020).

Data suggests that this pattern is present on RBG property. Wood Thrush are in highest numbers when there is an absence of cowbirds (Figure 54). They are found in mostly interior forest plots with minimal edge and human impacts. Conversely more open areas dominated by cowbirds see next to no Wood Thrush even if habitat in that area would be considered suitable, such as CP-NS-10, and CP-SS-1.

While it is difficult to say if either species is truly spreading across the property, the number of bird monitoring plots that cowbirds are present at each year is increasing. 2022 saw a record of 17/24 plots with cowbirds. Wood Thrush in comparison were only detected in five plots in 2022 and limited to interior forest locations only.

Continued restoration efforts to create and maintain interior forest is vital for the sustainability of Wood Thrush at RBG. This species is sensitive to edge effects and parasitism, so maintenance of interior forest ensures that this species will persist at RBG.

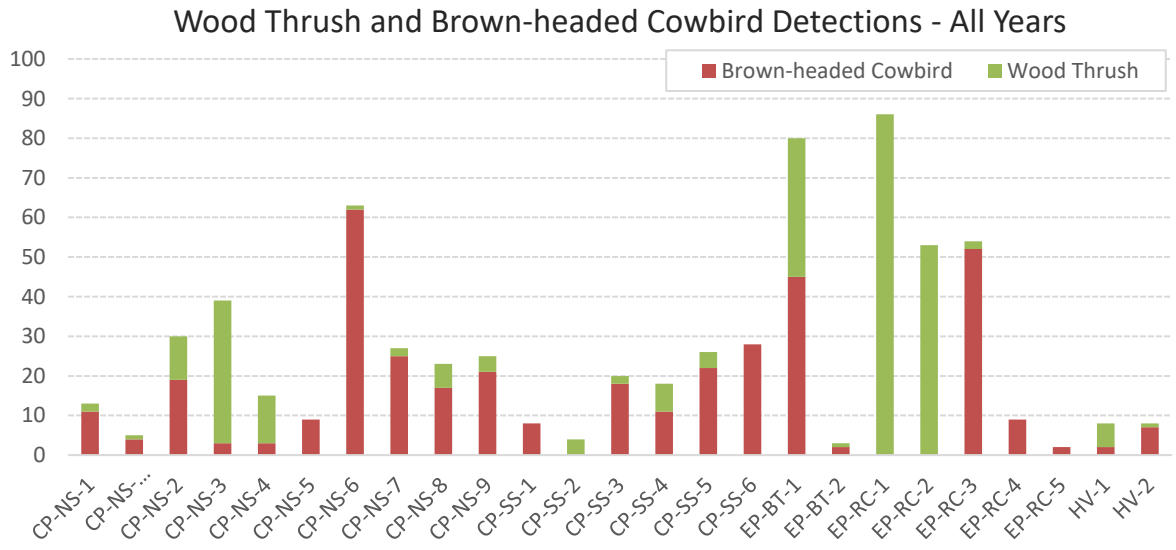

Figure 54. Comparison of Wood Thrush and Brown-headed Cowbird detections at terrestrial bird surveys, from 2010-2022

Ground Nesting Birds

Ground nesting birds are typically sensitive species which usually require large habitat areas and diverse habitat requirements. At RBG, ground nesting birds typically represent 5% of species present. Numbers of ground nesting birds have been increasing with the additional grassland and meadow locations being surveyed.

Grassland

Most grassland ground nesters are intolerant of woody vegetation, human disturbance such as hikers and dogs, and are highly sensitive to forest edge predators such as raccoons (Keyser et a. 1998). Habitat requirements vary from bare ground with sparse grass to dense vegetation at least a metre tall. RBG is currently restoring several grasslands and provides habitat for many different ground nesting grassland birds. Success has been seen with the increase of the Bobolink, a highly sensitive species which requires dense vegetation and large areas of grassland to thrive. In the future, species such as the Eastern Meadowlark, Grasshopper Sparrow, and Vesper Sparrow could all appear at RBG property due to these restoration efforts.

Secondary Forest

Ground nesting birds in secondary forest rely on a diverse and dense understory of plants to forage and nest in. Species such as the Eastern Towhee, Blue-winged Warbler, American Woodcock, and Mourning Warbler all rely on secondary forest. The diversity of an understory is critical for many of these species and a reduction in understory due to maturation, invasion from non-native plants, and heavy browse from white-tailed deer will adversely affect these species.

Interior Forest

Most interior forest nesting birds require very large forest tracts with minimal human disturbance or edge impacts. Currently, the only interior forest ground nesting bird regularly detected during surveys is the Wild Turkey.

Notable ground nesting birds which are missing are the Ovenbird and the Veery. Ovenbirds were rarely detected in surveys and have not been heard since 2011. Ovenbirds require complex understories of varying leaf litter depths, shrub and tree density, and understory diversity (Porneluzi et al. 2020). Forests of a suitable size to produce a self-sustaining population range

from 90 to 500 hectares (Burke and Nol, 2000). Small populations could be found within 14 kilometers of these forests, but they more often 'sink' populations rather than self-sustaining populations (Porneluzi et al. 2020). Despite the large amount of forest required for stable populations, Ovenbirds often have small territories ranging from 0.8 to 1.42 hectares depending on habitat quality and forage availability.

They Veery has not been detected at RBG since 2010. This species requires complex interior forest and understory similar to the Ovenbird. Veeries are known to be impacted by significant White-tailed deer browsing, non-native Honeysuckle, and forest fragmentation, all which reduce suitable habitat and forage (Burke and Nol, 2000). When habitat is suitable for Veeries they can nest in very dense numbers, often only requiring 0.1 to 0.5 hectares per territory (Heckscher et al. 2020).

Warblers

Wood Warblers are neo-tropical migrants that typically rely on foliage gleaning during the breeding bird season. While warblers occupy a wide range of habitats, most in Ontario are forest obligates, relying on interior or secondary forests to breed.

At RBG, both the richness and number of, warblers have been declining. Species such as the Yellow Warbler and American Redstart have both seen steep declines since 2010. Blue-winged Warbler and Pine Warbler remain stable, while the Common Yellowthroat is increasing.

Many species are missing from RBG, such as the Mourning Warbler, Chestnut-sided, Black-and-White, Blackburnian, Black-throated Green, Nashville, and Magnolia Warblers. While each species has very specific habitat types, the diversity of vegetation communities and proximity to 'source' populations such as those in Dundas Valley should permit some of these species to breed at RBG. Yet despite suitable habitat and proximity to source populations, these species are absent.

Many factors are contributing to the decline of warblers, such as climate change and habitat loss on both the breeding and winter grounds. Studies also indicate that urbanization around forests contributes to the loss of neo-tropical migrants, even if the forest itself remains unchanged in

size (Askins, and Philbrick, 1987, Freisen et al. 1999). Freisen et al. found that forests with dense housing near them had half the diversity of neo-tropical migrants as those without houses, and that diversity significantly declined once the number of houses exceeded twenty-five. Reasons why the nearness of houses cause such steep declines is currently under-studied, but the presence of house cats and inherent human shyness of certain species likely contribute to the decline.

Declines may also be attributed to invasive species which can alter or eliminate suitable nesting habitat and reduce insect abundance (Rodewald, 2012). A combination of invasives, proximity of houses, house cats, and climatic events are likely reducing and supressing the current warbler population at RBG (Askins, and Philbrick, 1987).

Restoration efforts to remove invasives, trail closures, and habitat linkage will all support the current warbler population and ideally promote recruitment of new species to RBG. Expanded surveys may also locate areas where certain species may be present but in low numbers.

Invasive Species Impacts

Plants

Invasive species are a global problem, negatively impacting ecosystems throughout the world. Invasive plant species outcompete native plants, change ecosystems and often form monocultures (Kettenring and Adams 2011, Conover, Sisson 2016). Invasive plants are known to change nutrient cycling, soil composition, moisture regimes, and suppress native plant species (Kettenring and Adams 2011). This impact extends into the vertebrate community where invasive plants have demonstrated adverse effects on the avian, herptile, mammalian, and arthropod taxa (Keteenring and Adams 2011,.

At RBG there are some notable invasive terrestrial species which impact avian life, non-native honeysuckle species (*Lonicera spp.*), Common Buckthorn (*Rhamnus cathartica*), Multiflora rose (*Rosa multiflora rosa*), and Garlic Mustard (*Alliaria petiolata*).

Nesting Impacts

Studies in Ohio have shown that non-native honeysuckle can create an ecological trap, where birds such as American Robins, Northern Cardinals, and Wood Thrush chose honeysuckle to nest in despite lowered nesting success (Rodewald et al. 2011). Rodewald et al. suggested the cause of this was that honeysuckle leafs out earlier, appearing more attractive to nest in, but that the open branching pattern is actually conducive to predators finding and accessing nests. Additionally, the monoculture of honeysuckle might provide predators an advantage with forming a source image as there is little variety in plant life to break up the search pattern.

Rodewald et al. found that cardinals and robins nested in lower branches when in honeysuckle monocultures, which increased predation from mammalian meso-predators. In these monocultures, the nesting success of cardinals was reduced by 20%. Certain species, such as Acadian Flycatchers, did not nest in areas heavily invaded by honeysuckle, potentially due to the loss of foraging habitat (Bakermans, and Rodewald, 2006).

Invasive plants also impact forest stratification, suppressing native trees and shrubs and closing the gap between the shrub layer and lower canopy (Tassie and Sherman, 2014). This can be detrimental to lower canopy nesting birds, which nest in young trees within this layer. Additionally, these invasive shrub thickets are not conducive to ground nesting birds, which often have specific requirements around forest floor openness and nesting site availability (Keyser et al. 1998).

Schneider and Miller reported that 'no species or guild benefited from the presence of buckthorn' as it reduced foraging and nesting habitat across species and guilds. This was particularly true in aerial insectivores, as the buckthorn thicket often closed the gap between the shrub layer and canopy, was overly thick, and did not support enough arthropods to forage.

Food and Foraging

The nutritional quality of non-native and native fruits, and their use by breeding and migrating birds, has been the subject of many studies. While it is evident that honeysuckle fruits are consumed in large quantities by frugivores such as Cedar Waxwings during the breeding season and migration, the nutritional quality of these fruits is sub-par (Smith et al. 2013). Non-native

fruits have less fat and less protein than native fruits, forcing migrating and breeding birds to forage more frequently (Smith et al. 2013).

Common Buckthorn and Multiflora Rose are both fruit producing plants which have low nutrient fruits that persist into winter (Smith et al. 2013). Frugivore birds rely on fruits throughout the winter and with an influx of invasive species resort to eating suboptimal fruits (Schneider and Miller 2014). Common Buckthorn is also a known laxative for birds (Schneider and Miller 2014) and can cause detrimental effects such as dehydration.

Both of these species readily outcompete native fruit bearing shrubs and dominate the landscape with many low-quality fruits. It should be noted that just because animals are seen eating these fruits, it is not indicative of these fruits being beneficial to the birds or that they prefer them over native species (Smith et al. 2013). Instead, it has been noted that birds will take fruit opportunistically, and if there is a high percentage of non-native fruits readily available they will consume them first even if the nutritional content is not as high.

Non-native shrub thickets are also known to reduce arthropod and benthic communities through their presence (Narango et al. 2017). Many birds rely heavily on insects during the breeding season to feed their young, and a reduction in arthropods reduces overall food availability and hampers breeding success (Rodewald 2012). The lack of arthropods is also detrimental during early spring migration when the first flush of insects is vital for migrating birds arriving at the breeding grounds (Schneider and Miller 2014).

Impacts to Sexual Selection

Certain bird species rely on 'honest signals' or sexual traits which are indicative of an individual's fitness which cannot be 'tricked or modified' (Lovette and Fitzpatrick, 2016). Many species rely on carotenoids, or red pigments obtained through diet, to indicate their overall fitness. It is assumed that the redder or brighter the individual, the better the territory and foraging prospects.

Invasive honeysuckle berries produce a carotenoid that native species are unable to effectively break down and use. This pigment over-accumulates in feathers and can even give yellow, or orange feathers a red wash (Mulvihill et al. 1992). This increase in brightness can create an

ecological trap, where males that consume more honeysuckle berries appear redder but occupy poor quality habitat (Rodewald and Jones, 2011). This is seen mostly in Northern Cardinals, where in rural areas, the brightest males breed earliest but have the lowest rate of reproduction, likely due to nesting in honeysuckle thickets (Rodewald and Jones, 2011).

Changes in colouration have been observed in Cedar Waxwings, Baltimore Orioles, Yellow-breasted Chat, and the Kentucky Warbler as non-native honeysuckle continues to spread across the eastern seaboard (Hudon et al. 2013, Mulvihill et al. 1992).

Birds

Invasive birds such as House Sparrows, European Starlings, and Rock Pigeons are ubiquitous in the urban landscape. These three species have continued presence at RBG, but do not seem to be increasing or decreasing, remaining at about 1-2% relative abundance property wide. While Starlings and House Sparrows are known nest predators and aggressive to other species, their removal and control is unfeasible.

House Sparrows have been known to impact Barn Swallows by pecking at eggs and removing nesting material (Weisheit, and Creighton, 1989). House Sparrows near the existing Barn Swallow colony should be discouraged from nesting nearby, if time and resources allow. Methods to discourage nesting typically involve spraying the birds with water or destroying their nests. House Sparrows are not currently protected by the *Migratory Bird Treaty Act* and the destruction of their nests is permitted.

Insects

Emerald Ash Borer

The Emerald Ash Borer (EAB) is an invasive species which has and continues to cause catastrophic ash mortality. Up to 99.99% of ash trees succumb to the insect and many forests have experienced changes in species composition and canopy as a result (Dosanjh, 2022).

Change to the canopy layer impacts many aspects of a well-developed forest. Increased regeneration from sunlight hitting the forest floor, a sparser canopy, and vigorous seedling regrowth have changed the composition of many forests in North America (Dosanjh, 2022). Research shows that with significant ash mortality, invasive shrubs readily colonize the area and

establish monocultures (Dosanjh, 2022). At RBG this has been seen with an increase of non-native honeysuckle where ash trees have died or been removed. As previously described, the increase of this shrub species is detrimental to the avian community.

Canopy density is an important and complicated metric for many bird species. Certain species require thinner forest canopies to forage and nest in, while others require contiguous closed canopy. Many birds rely on closed canopies to move through forests safely. With the loss of ash, many of the forests at RBG have experienced some canopy thinning and a loss of very dense canopy, which can impact avian movement throughout the forest.

Dead ash trees also form large amounts of woody debris and standing snags. Woodpeckers and other bark prober species were studied pre and post invasion to see if the increase in dead trees impacted populations (Koenig and Liebhold 2017). It was found that during early infestation woodpecker numbers rose as they ate the pre-emergent larva and declined to post invasion levels when many of the trees had died (Koenig and Liebhold 2017).

Spongy Moth and Btk

Spongy Moth (formerly Gypsy Moth/LDD) is a forest pest present across much of northeastern Canada and United States. Originally brought over from Europe for to cross with silk moths, the population escaped in the 1860's and has been spreading since (Invasive Species Centre, 2023). Despite viruses and predators, Spongy Moth does reach outbreak levels causing complete defoliation of trees, usually broad-leafed hardwoods. For deciduous trees already experiencing stressors, such as drought, or conifers, which are unable to produce new needles after defoliations, the death of the tree is imminent (Invasive Species Centre, 2023).

The direct impact of Spongy Moths and birds has not been widely studied. Some species such as cuckoos prefer to consume Spongy Moth caterpillars during outbreak years but are not able to impact the moth population significantly. As cuckoos are tied closely to caterpillar outbreaks, their population fluctuates with the species (Figure 55).

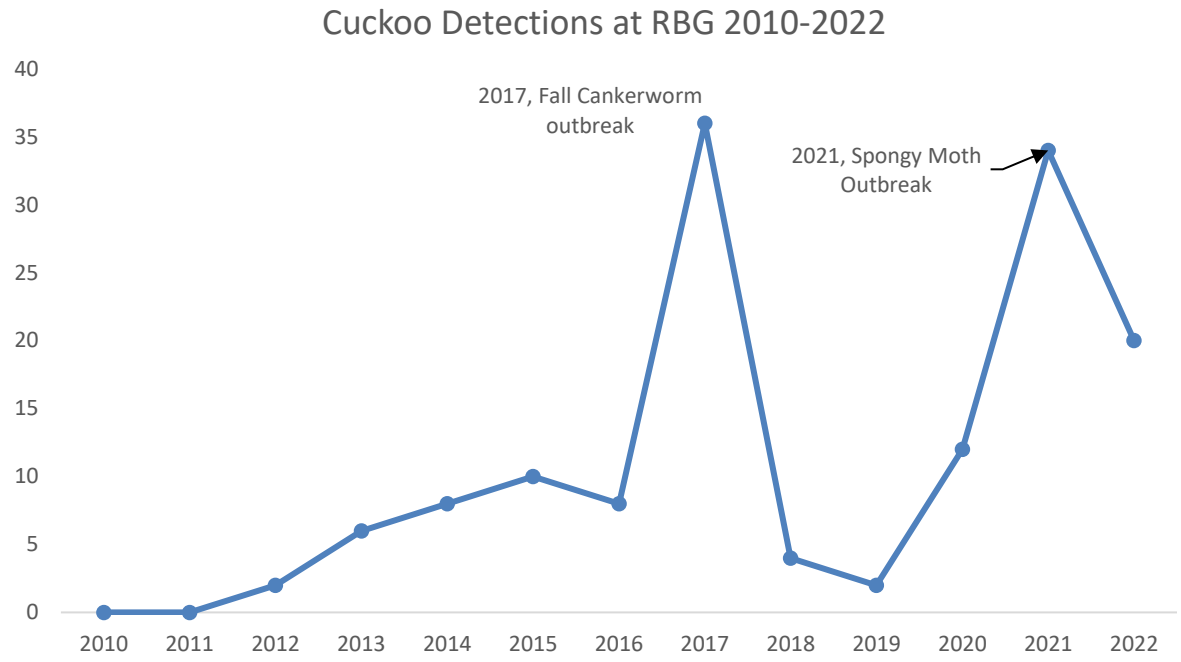

Figure 55 Cuckoo detections at RBG with caterpillar outbreak years marked.

Indirect impacts on the avian community are changes to vegetation structure and foraging strategy caused by severe defoliation (Thurber et al. 1994). In years with severe outbreak, upper canopy foliage gleaners must forage in lower vegetation layers, which may impact fitness (Thurber et al. 1994).

Spongy Moths are typically controlled with insecticides such as Btk (Bacillus thuringiensis car. kurstaki) which impacts all Lepidoptera larvae species at the correct in-star stage (Burgress et al. 1994). Studies have indicated that while foraging habitats and density may temporarily change due to Btk application, there is minimal long-term effect on the avian community (Burgress et al. 1994). Studies focusing on nesting success show that chicks raised the year the spray is applied might have a slower growth rate but that impacts to the overall population are minimal (Burgress et al. 1994, Marshall et al. 2002, Thurber et al. 1994).

Studies have indicated that foliage gleaning species, even those that prefer Lepidoptera seem to be minimally impacted by Btk, as they shift to new foraging strategies and food types. Red-eyed Vireos showed no difference in nesting fitness before and after Btk spray, only that nesting date was initiated later in the year (Marshall et al. 2002).

RBG does not regularly apply Btk, only using it in severe outbreak years. This occasional impact may reduce the fecundity of some species for that year but is not enough to cause a decline in any one species.

Recommendations

Restoration Efforts

The 2018 Environmental Review of Hendrie Valley report, and Cootes Paradise South Shore Forest Ecological Condition Update 2021, both outline critical restoration efforts to manage forest health. As the avian community linked to the health of the vegetative community, following the recommendations in these reports will inevitably assist the avian community. Most importantly is the removal of invasive plant species which negatively impact many avian guilds.

Interior forest species are uncommon and are at risk of disappearing due to changes in forest structure and habitat fragmentation. Continued efforts to remove invasive species from the interior forest are needed to ensure this guild persists at RBG. Additionally, the reduction of human presence in the interior forest is critical as many species are highly sensitive to human, and canine, disturbance.

Grassland restoration is critical for many species, but they also rely on landscape level habitat availability. Ensuring that there are linkages between grasslands is critical, as is ensuring that trees and woody plants do not spread throughout restored areas. Planting trees or shrubs in these areas to increase species richness is not recommended, as it will likely be detrimental to the grassland bird community.

Potential Adjustments to Methodology

Survey Locations

Currently point counts are distributed unevenly across the property, with HV having very poor representation of terrestrial habitats. Additionally, some plots are overlapping, are partially off property, or too far from each other. Current effort dedicated to each plot is four visits within a month. While increasing effort per plot increases species richness at that location, it also reduces the number of plots that can be visited within the time frame.

To address these concerns adjustments have been made to survey locations in order to better represent the property. An updated methodology can be found in **Error! Reference source not found.**.

Distance Sampling

Accurate population metrics are not currently measured as there is no distance sampling during point counts. Adding distance sampling to point counts permits population estimates which can give more detailed information about ongoing trends. This sampling is especially useful as an alternate to property wide intensive surveys for rare species such as Species-at-Risk.

Distance sampling estimating the distance of birds from the observer, and using these observations to extrapolate population and density. A key assumption of distance sampling is that all birds close to the observer are seen/heard, while those farther away are not. By estimating distance bias in distance from the observer can be reduced and estimates on population size can be done.

Distance R packages are free to use and allows users to implement collected data to effectively bin, truncate, and manipulate distance-sampled data. This data can be input into other programs to estimate population and density of species. See Appendix for more details on software programs.

Auditory Training

Occasionally birds are missed because observers are unfamiliar with their call and are unable to get an adequate recording. Some species may establish at RBG following restoration efforts, and observers should be familiar with the calls of the following species prior to surveys: Eastern Meadowlark, Grasshopper Sparrow, Vesper Sparrow, Mourning Warbler, Chestnut-sided Warbler, and Magnolia Warbler.

Fecundity and Survivorship Studies

Without survivorship or fecundity studies knowing what the true rate of recruitment and thus, the rate of population increase or decline, is impossible. For several species, such as the Wood Thrush, survivorship studies may be beneficial, especially at CP-NS and EP. Additionally, survivorship studies on Black-capped Chickadees should help provide information about the true

impact of wildlife feeding for this species, or what other factors may be influencing species decline.

Spot mapping can provide both density and partial survival information without the need to approach nests. While time consuming, it may be beneficial to engage in spot mapping at certain locations in the interior forest, or at restoration sites, to fully understand the before and after impact of restoration work on the avian community.

Inter-department Cooperation

Currently, many avian Species-at-Risk are under surveyed and under monitored due to a lack of organization mandate and resources. There is a potential partnership opportunity, particularly given the strategic location of the RBG property in southern Ontario. The federal government is the lead agency on bird monitoring and programs. Currently the RBG Species-at-risk program is dedicated to special fundraising efforts and the recovery of turtles. Occasion SAR bird specific population surveys occur as funding permits, however currently bird surveys coincide with the intensive turtle nest protection and tracking work. As such only limited bird population detailed surveys have occurred in recent years, with funding for local Species at Risk birds also not a priority of recent federal and provincial programs. As such there are not staff to effectively search for or monitor avian Species-at-Risk. Several species are likely under-represented or missing from collective data given their likely small populations. Connections with other organizations or skilled volunteers may be needed to monitor and survey certain species such as swallows, Chimney Swift, Prothonotary Warbler, Red-headed Woodpecker, and Least Bittern, many of which have had past benchmark population detailed surveys.

Extensive addition bird monitoring data also exists under other activities. Currently avian data from the occasional Fall Waterfowl Count dating back decades, and March Monitoring Program are not centralized in a single RBG bird monitoring database, reducing ease of access to formulate comprehensive datasets. Considerable paper data also exists from historical monitoring and bird banding. When resources allow, effort could be dedicated to ensuring that avian data from these programs continues to be collected and aggregated into this central database for future analysis.

Cooperation with Other Organizations

Roles and responsibilities of lead organizations are changing, and thus opportunities to change process may be needed. To have a better understanding of the avian community within Hamilton, further efforts could be made to network with nearby organizations of the Cootes to Escarpment EcoPark and the Niagara Escarpment overall that partake in avian monitoring. Working with other organizations can facilitate knowledge transfer, identify knowledge gaps, and identify needed corridors or restoration targets. Additionally, there may be opportunities to pool resources, allowing for more areas of RBG and the surrounding area to be surveyed for Species-at-Risk.

Summary

The breeding bird community at RBG is diverse and resilient across most species, with diversity, species richness, and detections increasing from 2010. Substantial changes to user activity and elimination of the many informal trails has no doubt played a significant roll. Grassland species are also increasing with old field restoration efforts, and reforestation efforts are promising at the south side of Cootes Paradise. Also currently, there is no evidence that Btk is negatively impacting the avian community at RBG.

Ongoing forest health impacts, such as invasive insects and plants are threatening several communities, notably interior forest birds, ground nesting birds, and warblers. The human impact at CP-SS and HV is significant and likely negatively impacting the bird communities there.

Recommendations for invasive species management from the RBG terrestrial ecologist in the Cootes Paradise South Shore Ecological Update 2021, and the 2018 Environmental Review of Hendrie Valley (Barr et.al 2022, Radassao et al 2019) should be followed through to ensure that the avian community can continue to thrive at RBG.

As with any taxa that must endure continuous catastrophic impacts, there will eventually be a reduction in resiliency as species are eroded resulting in decline and community reassembly. While the avian community at RBG is currently robust, there are some warning signs, notable with warbler decline and interior forest species. Ongoing forest health impacts from invasive

pests, plants, and human impacts will continue to test the avian community, and monitoring and restoration efforts will be vital to mitigate and track these factors.

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Appendices

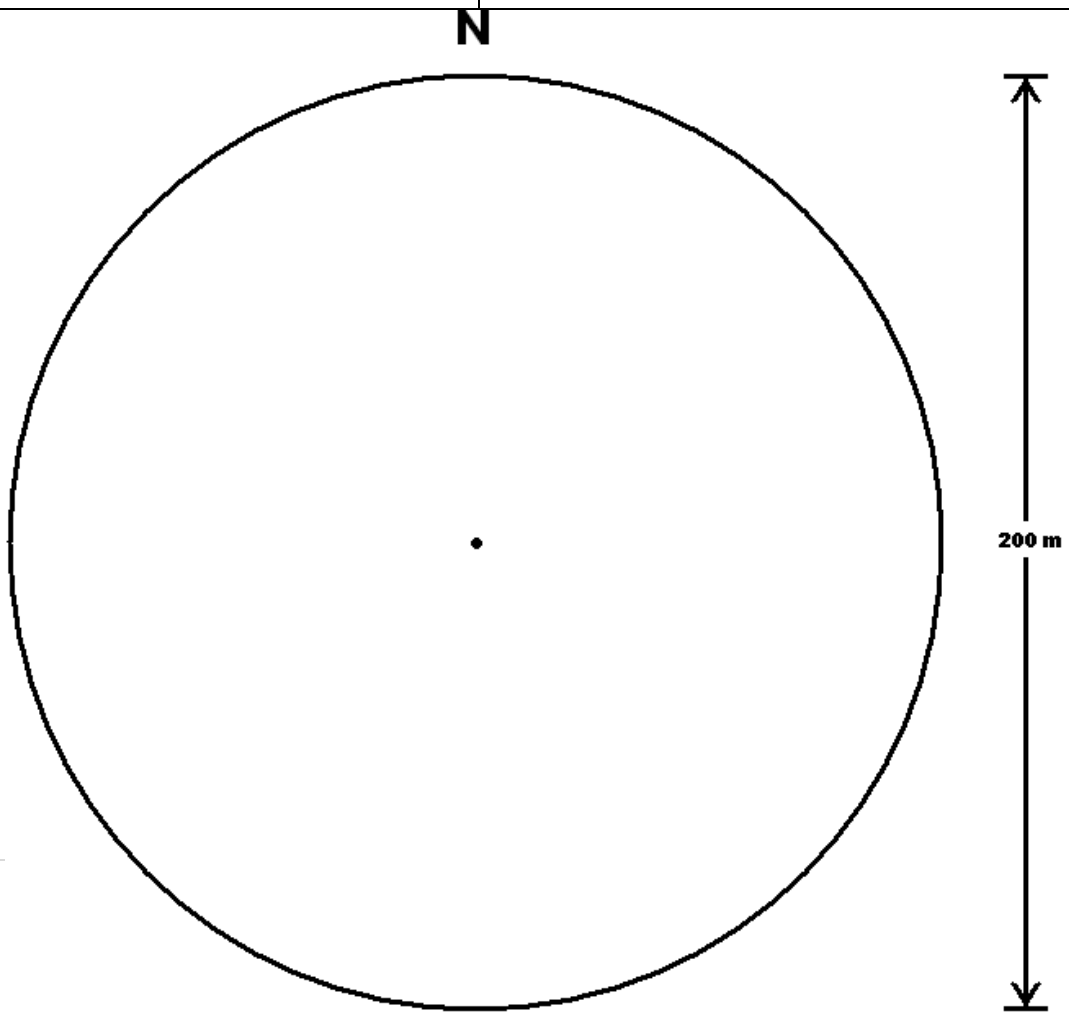
Appendix A

Data Sheet for Terrestrial Bird Monitoring Surveys

RBG Breeding Bird Atlas

Bird Point Count Data Sheet

Date	Time	Noise Code
Study Plot Code		
Temperature (°C)	Percent Cloud Cover (%)	Wind Speed (km/h)
Researchers		
Fly-bys	Notes	



Appendix B

Breeding Bird Codes as per the Ontario Breeding Bird Atlas

Observed	
X	Species observed during its breeding season, but NOT in suitable nesting habitat (no breeding evidence found). Note that this code is rarely used as birds tend to occupy nesting habitat during the breeding season. Do not use for species known to be migrants.
Possible	
H	Species observed in suitable nesting Habitat during its breeding season.
S	Singing male or adult producing other sounds associated with breeding (e.g., calls or drumming) in suitable nesting habitat during the species' breeding season.
Probable	
M	Multiple singing/calling/drumming individuals (7 or more) heard during one visit to a single square and in suitable nesting habitat during the species' breeding season. Use with caution to avoid counting migrants.
P	Pair observed in suitable nesting habitat during the species' breeding season.
T	Presumed Territory based on the presence of an adult bird (usually singing, but not necessarily so), in the same suitable nesting habitat patch on at least two visits, one week or more apart, during the species' breeding season. Use discretion when using this code. "T" is not to be used for colonial birds, or species that might forage or loaf a long distance from their nesting site (e.g. Turkey Vulture, and male waterfowl).
D	Courtship or Displays involving a male and female (e.g., courtship feeding, copulation) or antagonistic behavior between two or more individuals (e.g., territorial disputes or chases), in suitable nesting habitat during the species' breeding season.
V	Bird Visiting a probable nest site in suitable nesting habitat during the species' breeding season.
A	Agitated behavior or alarm calls of an adult in suitable nesting habitat during the species' breeding season.
B	Brood patch or cloacal protuberance on an adult in suitable nesting habitat during the species' breeding season.
N	Nest-building by wrens or nest hole excavation by woodpeckers (both may build dummy or roosting nests so nest-building alone is not enough to confirm breeding).
Confirmed	
NB	Nest building, including the carrying of nesting material, by all species except wrens and woodpeckers.
DD	Distraction Display, injury-feigning, or other displays attempting to draw attention away from a nest or young.
NU	Empty Nest Used or identifiable eggshells from earlier in the same nesting season.
FY	Recently Fledged Young (nidicolous species – whose young are raised in a nest) or downy young (nidifugous species – whose young leave the nest soon after hatching) incapable of sustained flight.
AE	Adult Entering, occupying, or leaving a nest site (visible or not) or whose behavior suggests the presence of an occupied nest.
FS	Adult carrying a Faecal Sac.
CF	Adult Carrying Food for young.
NE	Nest containing eggs
NY	Nest with Young (seen or heard)
J	Recent juvenile. Bird is in pre-basic plumage shortly after expected fledging date. May still be following parents and begging for food. (Code added by RBG staff)

Appendix C

Guild Definitions - Habitat, Foraging, Nest Placement

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

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

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

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

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

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

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

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

Appendix D

List of all Taxon detected at RBG during Terrestrial Bird Surveys from 2010-2022

Taxon	Number of Species
Cardinals and Allies	4
Cormorants and Shags	1
Crows, Jays, and Magpies	3
Cuckoos	2
Ducks, Geese, and Waterfowl	7
Finches, Euphonias, and Allies	2
Gnatcatchers	1
Grebes	1
Gulls, Terns, and Skimmers	5
Hawks, Eagles, and Kites	5
Herons, Egrets, and Bitterns	4
Hummingbirds	1
Icterids	7
Kingfishers	1
Loons	1
Mockingbirds and Thrashers	2
New World Sparrows	7
New World Warblers	14
Nightjars and Allies	1
Nuthatches	2
Old World Sparrows	1
Osprey	1
Owls	2
Pheasants, Grouse, and Allies	1
Pigeons and Doves	2
Plovers and Lapwings	1
Rails, Gallinules, and Coots	2
Sandpipers and Allies	2
Starlings	1
Swallows	3
Swifts	1
Thrushes and Allies	3
Tits, Chickadees, and Titmice	2
Tree Creepers	1
Tyrant Flycatcher	9
Vireos	3
Waxwings	1
Woodpeckers	5

Appendix E

Species detected per year during Terrestrial Bird Surveys at RBG from 2010-2022

Species Name	Scientific Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Acadian Flycatcher	*Empidonax virescens*		✓		✓		✓							
Alder Flycatcher	*Empidonax alnorum*								✓		✓			
American Black Duck	*Anas rubripes*													✓
American Crow	*Corvus brachyrhynchos*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
American Goldfinch	*Spinus tristis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
American Redstart	*Setophaga ruticilla*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
American Robin	*Turdus migratorius*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
American Woodcock	*Scolopax minor*				✓									
Bald Eagle	*Haliaeetus leucicephalus*								✓	✓	✓	✓		✓
Baltimore Oriole	*Icterus galbula*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Barn Swallow	*Hirundo rustica*		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Belted Kingfisher	*Megaceryle alcyon*	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Black-billed Cuckoo	*Coccyzus erythropthalmus*				✓		✓	✓	✓	✓	✓		✓	✓
Black-capped Chickadee	*Poecile atricapillus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Black-crowned Night-Heron	*Nycticorax nycticorax*	✓	✓				✓							
Blackpoll Warbler	*Setophaga striata*										✓			
Black-throated Green Warbler	*Setophaga virens*								✓	✓				
Blue Jay	*Cyanocitta cristata*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Blue-gray Gnatcatcher	*Polioptila caerulea*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Blue-winged Warbler	*Vermivora cyanoptera*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bobolink	*Dolichonyx oryzivorus*									✓		✓	✓	✓
Brown Creeper	*Certhia americana*	✓	✓	✓				✓	✓					
Brown Thrasher	*Toxostoma rufum*		✓	✓	✓	✓		✓	✓	✓		✓	✓	
Brown-headed Cowbird	*Molothrus ater*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Canada Goose	*Branta canadensis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cape May Warbler	*Setophaga tigrina*				✓									

Carolina Wren	*Thryothorus ludovicianus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Caspian Tern	*Hydroprogne caspia*			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cedar Waxwing	*Bombycilla cedrorum*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chestnut-sided Warbler	*Setophaga pensylvanica*	✓												
Chimney Swift	*Chaetura pelagica*			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chipping Sparrow	*Spizella passerina*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Common Goldeneye	*Bucephala clangula*										✓			
Common Grackle	*Quiscalus quiscula*		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Common Loon	*Gavia immer*												✓	
Common Nighthawk	*Chordeiles minor*							✓						
Common Raven	*Corvus corax*												✓	
Common Tern	*Sterna hirundo*				✓		✓	✓	✓	✓	✓	✓		
Common Yellowthroat	*Geothlpis trichas*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cooper's Hawk	*Accipiter cooperii*							✓		✓		✓		✓
Double-crested Cormorant	*Nannopterum auritum*		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Downy Woodpecker	*Dryobates pubescens*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eastern Bluebird	*Sialia sialis*				✓	✓		✓	✓	✓	✓	✓	✓	✓
Eastern Kingbird	*Tyrannus tyrannus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eastern Meadowlark	*Sturnella magna*										✓			
Eastern Phoebe	*Sayornis phoebe*					✓	✓	✓	✓	✓	✓	✓	✓	✓
Eastern Screech-Owl	*Megascops asio*				✓			✓						
Eastern Towhee	*Pipilo erythrophthalmus*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eastern Wood-Pewee	*Contopus virens*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
European Starling	*Sturnus vulgaris*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Field Sparrow	*Spizella pusilla*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Forster's Tern	*Sterna forsteri*			✓										
Gray Catbird	*Dumetella carolinenesis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Great Blue Heron	*Ardea herodias*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Great Crested Flycatcher	*Myiarchus crinitus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Great Egret	*Ardea alba*				✓					✓		✓		

Great Horned Owl	*Bubo virginianus*									✓				
Green Heron	*Butorides virescens*			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Hairy Woodpecker	*Dryobates villosus*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
House Finch	*Haemorhous mexicanus*	✓			✓		✓	✓						
House Sparrow	*Passer domesticus*	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
House Wren	*Troglodytes aedon*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indigo Bunting	*Passerina cyanea*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Killdeer	*Charadrius vociferus*	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Least Flycatcher	*Empidonax minimus*										✓		✓	✓
Magnolia Warbler	*Setophaga magnolia*	✓			✓									✓
Mallard	*Anas platyrhynchos*	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Marsh Wren	*Cistothorus palustris*	✓		✓	✓	✓			✓		✓	✓	✓	
Mourning Dove	*Zenaida macroura*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mourning Warbler	*Geothlypis philadelphia*	✓			✓	✓								
Mute Swan	*Cygnus olor*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Northern Cardinal	*Cardinalus cardinalus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Northern Flicker	*Colaptes auratus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*								✓	✓				
Orchard Oriole	*Icterus spurius*					✓				✓	✓	✓	✓	✓
Osprey	*Pandion haliaetus*					✓	✓	✓	✓	✓			✓	✓
Ovenbird	*Seiurus aurocapilla*	✓	✓											
Pied-billed Grebe	*Dryocopus pileatus*			✓										
Pileated Woodpecker	*Setophaga pinus*	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pine Warbler	*Melanerpes carolinus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Red-bellied Woodpecker	*Sitta canadensis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Red-breasted Nuthatch	*Vireo olivaceus*						✓	✓	✓					
Red-eyed Vireo	*Buteo lineatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Red-shouldered Hawk	*Buteo jamaicensis*	✓				✓								
Red-tailed Hawk	*Agelaius phoeniceus*	✓				✓	✓	✓		✓	✓	✓	✓	✓
Red-winged Blackbird	*Larus delawarensis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Rock Pigeon	*Pheucticus ludovicianus*		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
Rose-breasted Grosbeak	*Archilochus colubris*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ruby-throated Hummingbird	*Passerculus sandwichensis*	✓	✓	✓		✓	✓	✓	✓	✓	✓			
Savannah Sparrow	*Piranga olivacea*								✓	✓	✓	✓	✓	✓
Scarlet Tanager	*Accipiter striatus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sharp-shinned Hawk	*Melospiza melodia*								✓					
Song Sparrow	*Porzana carolina*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sora	*Actitis macularius*									✓	✓			
Spotted Sandpiper	*Melospiza georgiana*								✓	✓		✓		
Swamp Sparrow	*Leiothlypis peregrina*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tennessee Warbler	*Tachycineta bicolor*												✓	
Tree Swallow	*Cygnus buccinator*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trumpeter Swan	*Baeolophus bicolor*				✓				✓	✓	✓			
Tufted Titmouse	*Catharetus aura*									✓				
Virginia Rail	*Rallus limicola*		✓				✓							
Warbling Vireo	*Vireo gilvus*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
White-breasted Nuthatch	*Sitta carolinensis*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
White-throated Sparrow	*Zonotrichia albicollis*			✓										
Wild Turkey	*Meleagris gallopavo*				✓			✓	✓	✓	✓	✓	✓	✓
Willow Flycatcher	*Empidonax traillii*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Winter Wren	*Troglodytes hiemalis*							✓	✓					✓
Wood Duck	*Aix sponsa*		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Wood Thrush	*Hylocichla mustelina*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Yellow Warbler	*Setophaga petechia*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Yellow-bellied Flycatcher	*Empidonax flaviventris*					✓								
Yellow-billed Cuckoo	*Coccyzus americanus*			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Yellow-throated Vireo	*Vireo flavifrons*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

Appendix F

Distance Sampling

Distance Sampling is the 'binning' of detected birds into distances from the observer to later analyze and estimate the density and potential population of birds. This can especially useful when trying to estimate how many birds of a specific species are present in the area.

Distance sampling runs on a few assumptions.

1) All individuals at the observer will be detected
2) Not all individuals far from the observer will be detected

R Studio is an opensource software where statistical packages can be downloaded and used to analyze large data sets. Thankfully a team has developed the Distance project, which focuses on distance sampling analysis: http://distancesampling.org/

This team has assembled a series of R packages to help with analysis, and provide examples on how to use each package, their assumptions, and limitations. Currently a detailed methodology is beyond the scale of this report.

Appendix G

Species Rarity Lists

Species rarity lists were composed using inplot data for Terrestrial Bird Surveys. The lists are limited in so far as that only species present during the month of June, and those that are easily detected by point counts are present. Certain groups, such as raptors, owls, and waterbirds will all be rare and under-represented due to survey methodology.

Inplot data was used as habitat was being assessed. Rather than using the species-specific guild-habitat, each individual survey location was used. This is because species often overlap in habitat usage, so going solely by guild would eliminate many species that may be detected. Habitat at survey locations is detailed in Table X. A total of five distinct habitat types were used; Forest – Wetland Influence, Forest – Interior, Forest, Forest –Successional, and Meadow. A sixth category Forest – All was an amalgamation of all forest habitats surveyed.

To determine rarity all detections from 2010-2022 per habitat were added together and relative abundance within that habitat was calculated. Species were then divided into one of the six rarity categories as defined below:

Abundant - Greater than 10% relative abundance. This species is ubiquitous across the habitat and will almost always be found when birding or conducting surveys.

Common: Between 10% and 1%. This species is found throughout the habitat and in good numbers. The species is almost always detected while birding or conducting surveys.

Uncommon: Between 1% and 0.1%. The bird is present in this habitat but not in large numbers. Typically found in more specific habitat features than common species. Will likely be found during birding or surveys, but in low numbers or pairs.

Rare: Between 0.1% and 0.01%. The species is unlikely to occur in this habitat, either due to low numbers, under-representation during surveys, or an incidental detection as the species moves through unsuitable habitat. It is not likely that the bird will be detected during surveys or birding.

Very Rare: Less than 0.01%. The species is either unsuitable to the habitat and was incidentally detected, is a species poorly represented by surveys, or very rare in the region. It is highly improbably that the species will be detected during surveys or regular birding in this habitat.

Incidental: This species does not breed at RBG's latitude and was detected during surveys before it had completed migration. It is highly improbable that it would be detected during surveys or regular birding.

Below are six lists with all species per specific habitat and their rarity in that area. It should be noted that CP-NS-5, which is listed as Plantation for habitat type was put into the Forest category, CP-NS-6 which is listed as Garden was put into the Successional category, and CP-SS-4 which is listed as Forest (Edge) was put into the Forest category.

Table 6 Forest All - 20 Plots

Species Name	Rarity
Red-winged Blackbird	Abundant
American Robin	Common
Black-capped Chickadee	Common
Blue Jay	Common
Cedar Waxwing	Common
Northern Cardinal	Common
Yellow Warbler	Common
Red-eyed Vireo	Common
Song Sparrow	Common
American Goldfinch	Common
Eastern Wood-Pewee	Common
Baltimore Oriole	Common
White-breasted Nuthatch	Common
Red-bellied Woodpecker	Common
Great Crested Flycatcher	Common
Indigo Bunting	Common
Downy Woodpecker	Common
American Crow	Common
Blue-gray Gnatcatcher	Common
European Starling	Common
Rose-breasted Grosbeak	Common
Carolina Wren	Common
House Wren	Common
American Redstart	Common
Gray Catbird	Common
Wood Thrush	Common
Brown-headed Cowbird	Common
Warbling Vireo	Uncommon
Common Yellowthroat	Uncommon
Northern Flicker	Uncommon
Common Grackle	Uncommon
Swamp Sparrow	Uncommon
Scarlet Tanager	Uncommon
Canada Goose	Uncommon
Chipping Sparrow	Uncommon
Pine Warbler	Uncommon
Wood Duck	Uncommon
Hairy Woodpecker	Uncommon
Mourning Dove	Uncommon
Eastern Kingbird	Uncommon
House Sparrow	Uncommon
Belted Kingfisher	Uncommon
Tree Swallow	Uncommon
Great Blue Heron	Uncommon
Mute Swan	Uncommon
Pileated Woodpecker	Uncommon
Killdeer	Uncommon
Yellow-throated Vireo	Uncommon
Field Sparrow	Uncommon
Marsh Wren	Uncommon
Mallard	Uncommon
Eastern Phoebe	Uncommon
Red-tailed Hawk	Uncommon
Willow Flycatcher	Uncommon
Eastern Bluebird	Uncommon
Yellow-billed Cuckoo	Uncommon
Wild Turkey	Uncommon
Green Heron	Rare
Black-billed Cuckoo	Rare
Caspian Tern	Rare
Brown Creeper	Rare
Barn Swallow	Rare
Common Tern	Rare
Eastern Towhee	Rare
Northern Rough-winged Swallow	Rare
Ruby-throated Hummingbird	Rare
Trumpeter Swan	Rare
Winter Wren	Rare
Bald Eagle	Rare
Black-crowned Night-Heron	Rare
Acadian Flycatcher	Rare
Great Egret	Rare
Blue-winged Warbler	Rare
Ovenbird	Rare
Cooper's Hawk	Rare
Double-crested Cormorant	Rare
Mourning Warbler	Rare
Red-shouldered Hawk	Rare
Spotted Sandpiper	Rare
Least Flycatcher	Rare
Orchard Oriole	Rare
Red-breasted Nuthatch	Rare
Black-throated Green Warbler	Very Rare
Brown Thrasher	Very Rare
Eastern Screech-Owl	Very Rare
House Finch	Very Rare
Osprey	Very Rare
Sora	Very Rare
Tufted Titmouse	Very Rare
Virginia Rail	Very Rare
Alder Flycatcher	Very Rare
American Woodcock	Very Rare
Chestnut-sided Warbler	Very Rare
Great Horned Owl	Very Rare
Magnolia Warbler	Very Rare
Pied-billed Grebe	Very Rare
White-throated Sparrow	Very Rare
Yellow-bellied Flycatcher	Very Rare
Common Loon	Incidental
Tennessee Warbler	Incidental

Table 7 Forest - Wetland Influence, 6 plots

Species Name	Rarity
Red-winged Blackbird	Abundant
Black-capped Chickadee	Common
Song Sparrow	Common
American Robin	Common
Yellow Warbler	Common
Blue Jay	Common
Northern Cardinal	Common
Cedar Waxwing	Common
American Goldfinch	Common
Baltimore Oriole	Common
Eastern Wood-Pewee	Common
Swamp Sparrow	Common
Red-eyed Vireo	Common
Great Crested Flycatcher	Common
Warbling Vireo	Common
White-breasted Nuthatch	Common
Canada Goose	Common
Downy Woodpecker	Common
Common Yellowthroat	Common
Wood Duck	Common
American Crow	Common
Blue-gray Gnatcatcher	Common
Red-bellied Woodpecker	Common
Carolina Wren	Common
House Wren	Common
Common Grackle	Common
Pine Warbler	Common
Northern Flicker	Common
American Redstart	Uncommon
Gray Catbird	Uncommon
Belted Kingfisher	Uncommon
Mute Swan	Uncommon
Eastern Kingbird	Uncommon
Great Blue Heron	Uncommon
Rose-breasted Grosbeak	Uncommon
Marsh Wren	Uncommon
Brown-headed Cowbird	Uncommon
Indigo Bunting	Uncommon
Tree Swallow	Uncommon
Mourning Dove	Uncommon
Mallard	Uncommon
European Starling	Uncommon
Hairy Woodpecker	Uncommon
Willow Flycatcher	Uncommon
Killdeer	Uncommon
Scarlet Tanager	Uncommon
Green Heron	Uncommon
Wood Thrush	Uncommon
Caspian Tern	Uncommon
Pileated Woodpecker	Uncommon
Northern Rough-winged Swallow	Uncommon
Red-tailed Hawk	Uncommon
Trumpeter Swan	Uncommon
Bald Eagle	Uncommon
Black-crowned Night-Heron	Uncommon
Eastern Phoebe	Uncommon
Great Egret	Uncommon
Chipping Sparrow	Rare
Yellow-billed Cuckoo	Rare
Yellow-throated Vireo	Rare
Black-billed Cuckoo	Rare
House Sparrow	Rare
Ruby-throated Hummingbird	Rare
Spotted Sandpiper	Rare
Brown Creeper	Rare
Cooper's Hawk	Rare
Orchard Oriole	Rare
Sora	Rare
Virginia Rail	Rare
Black-throated Green Warbler	Rare
Common Loon	Rare
Eastern Bluebird	Rare
Least Flycatcher	Rare
Osprey	Rare
Pied-billed Grebe	Rare
Yellow-bellied Flycatcher	Very Rare

Table 8 Forest – Interior, 3 plots

Species Name	Rarity
Blue Jay	Abundant
Red-eyed Vireo	Abundant
Black-capped Chickadee	Common
Cedar Waxwing	Common
American Robin	Common
Northern Cardinal	Common
Red-bellied Woodpecker	Common
Eastern Wood-Pewee	Common
White-breasted Nuthatch	Common
Great Crested Flycatcher	Common
Red-winged Blackbird	Common
Baltimore Oriole	Common
American Goldfinch	Common
Scarlet Tanager	Common
American Crow	Common
Wood Thrush	Common
Pine Warbler	Common
Downy Woodpecker	Common
Indigo Bunting	Common
Rose-breasted Grosbeak	Common
Song Sparrow	Common
Carolina Wren	Common
Northern Flicker	Common
Brown-headed Cowbird	Uncommon
Common Yellowthroat	Uncommon
Hairy Woodpecker	Uncommon
Pileated Woodpecker	Uncommon
Yellow Warbler	Uncommon
Blue-gray Gnatcatcher	Uncommon
Canada Goose	Uncommon
Wild Turkey	Uncommon
Gray Catbird	Uncommon
Brown Creeper	Uncommon
Ovenbird	Uncommon
Yellow-billed Cuckoo	Uncommon
American Redstart	Uncommon
Common Tern	Uncommon
Red-tailed Hawk	Uncommon
Ruby-throated Hummingbird	Uncommon
Yellow-throated Vireo	Uncommon
Common Grackle	Uncommon
Tree Swallow	Uncommon
Eastern Kingbird	Rare
Swamp Sparrow	Rare
Winter Wren	Rare
Eastern Bluebird	Rare
Eastern Screech-Owl	Rare
Eastern Towhee	Rare
Field Sparrow	Rare
Green Heron	Rare
Killdeer	Rare
Least Flycatcher	Rare
Mourning Dove	Rare
Red-breasted Nuthatch	Rare
Acadian Flycatcher	Rare

Table 9 Forest, 11 plots

Species Name	Rarity
Blue Jay	Common
Northern Cardinal	Common
American Robin	Common
Black-capped Chickadee	Common
Red-winged Blackbird	Common
Cedar Waxwing	Common
Red-eyed Vireo	Common
Eastern Wood-Pewee	Common
Yellow Warbler	Common
Indigo Bunting	Common
Baltimore Oriole	Common
Red-bellied Woodpecker	Common
White-breasted Nuthatch	Common
Wood Thrush	Common
American Redstart	Common
American Goldfinch	Common
House Wren	Common
Great Crested Flycatcher	Common
Rose-breasted Grosbeak	Common
American Crow	Common
Downy Woodpecker	Common
Song Sparrow	Common
Carolina Wren	Common
European Starling	Common
Scarlet Tanager	Common
Common Grackle	Common
Gray Catbird	Common
Blue-gray Gnatcatcher	Common
Northern Flicker	Common
Brown-headed Cowbird	Uncommon
Warbling Vireo	Uncommon
Chipping Sparrow	Uncommon
Hairy Woodpecker	Uncommon
Mourning Dove	Uncommon
Yellow-throated Vireo	Uncommon
Eastern Phoebe	Uncommon
Eastern Bluebird	Uncommon
Red-tailed Hawk	Uncommon
House Sparrow	Uncommon
Field Sparrow	Uncommon
Yellow-billed Cuckoo	Uncommon
Wild Turkey	Uncommon
Pileated Woodpecker	Uncommon
Common Yellowthroat	Uncommon
Black-billed Cuckoo	Uncommon
Canada Goose	Uncommon
Pine Warbler	Uncommon
Winter Wren	Uncommon
Eastern Kingbird	Rare
Eastern Towhee	Rare
Killdeer	Rare
Mallard	Rare
Red-shouldered Hawk	Rare
Belted Kingfisher	Rare
Brown Creeper	Rare
Cooper's Hawk	Rare
Great Blue Heron	Rare
Green Heron	Rare
Red-breasted Nuthatch	Rare
Tufted Titmouse	Rare
Willow Flycatcher	Rare
Alder Flycatcher	Rare
Barn Swallow	Rare
Black-throated Green Warbler	Rare
Chestnut-sided Warbler	Rare
Eastern Screech-Owl	Rare
Great Horned Owl	Rare
Least Flycatcher	Rare
Tree Swallow	Rare
Tennessee Warbler	Incidental

Table 10 Successional, 3 plots

Species Name	Rarity
Yellow Warbler	Common
Red-winged Blackbird	Common
Cedar Waxwing	Common
Song Sparrow	Common
American Robin	Common
Black-capped Chickadee	Common
American Goldfinch	Common
Gray Catbird	Common
Northern Cardinal	Common
Baltimore Oriole	Common
European Starling	Common
Blue-gray Gnatcatcher	Common
Brown-headed Cowbird	Common
Blue Jay	Common
Indigo Bunting	Common
Tree Swallow	Common
House Wren	Common
American Crow	Common
Warbling Vireo	Common
White-breasted Nuthatch	Common
Eastern Wood-Pewee	Common
Rose-breasted Grosbeak	Common
Downy Woodpecker	Common
Common Yellowthroat	Common
Great Crested Flycatcher	Common
Red-eyed Vireo	Common
Common Grackle	Common
American Redstart	Common
Red-bellied Woodpecker	Common
Chipping Sparrow	Uncommon
Northern Flicker	Uncommon
Wood Thrush	Uncommon
Carolina Wren	Uncommon
Eastern Towhee	Uncommon
Field Sparrow	Uncommon
Blue-winged Warbler	Uncommon
Eastern Kingbird	Uncommon
House Sparrow	Uncommon
Mourning Dove	Uncommon
Mallard	Uncommon
Scarlet Tanager	Uncommon
Black-billed Cuckoo	Uncommon
Canada Goose	Uncommon
Caspian Tern	Uncommon
Ruby-throated Hummingbird	Uncommon
Killdeer	Uncommon
Yellow-billed Cuckoo	Uncommon
Hairy Woodpecker	Rare
Orchard Oriole	Rare
Barn Swallow	Rare
Great Blue Heron	Rare
Mourning Warbler	Rare
Pine Warbler	Rare
Brown Thrasher	Rare
Common Tern	Rare
Eastern Bluebird	Rare
Pileated Woodpecker	Rare
Eastern Phoebe	Rare
House Finch	Rare
Red-tailed Hawk	Rare
Yellow-throated Vireo	Rare
American Woodcock	Rare
Bald Eagle	Rare
Belted Kingfisher	Rare
Cape May Warbler	Rare
Chestnut-sided Warbler	Rare
Magnolia Warbler	Rare
Mute Swan	Rare
Osprey	Rare
White-throated Sparrow	Rare
Willow Flycatcher	Rare
Blackpoll Warbler	Incidental

Table 11 Meadow, 6 plots

Species Name	Rarity
Red-winged Blackbird	Abundant
Song Sparrow	Abundant
Yellow Warbler	Common
American Goldfinch	Common
Tree Swallow	Common
Cedar Waxwing	Common
Northern Cardinal	Common
American Robin	Common
House Wren	Common
Savannah Sparrow	Common
Indigo Bunting	Common
European Starling	Common
Blue Jay	Common
Baltimore Oriole	Common
Willow Flycatcher	Common
Black-capped Chickadee	Common
Gray Catbird	Common
American Crow	Common
Brown-headed Cowbird	Common
Field Sparrow	Common
Common Yellowthroat	Common
House Sparrow	Common
Barn Swallow	Uncommon
Red-eyed Vireo	Uncommon
Eastern Kingbird	Uncommon
Bobolink	Uncommon
Red-bellied Woodpecker	Uncommon
Rose-breasted Grosbeak	Uncommon
Great Crested Flycatcher	Uncommon
Eastern Wood-Pewee	Uncommon
Mourning Dove	Uncommon
Common Grackle	Uncommon
White-breasted Nuthatch	Uncommon
Eastern Towhee	Uncommon
Northern Flicker	Uncommon
American Redstart	Uncommon
Carolina Wren	Uncommon
Chipping Sparrow	Uncommon
Downy Woodpecker	Uncommon
Eastern Bluebird	Uncommon
Blue-gray Gnatcatcher	Uncommon
Orchard Oriole	Uncommon
Wood Thrush	Uncommon
Yellow-billed Cuckoo	Uncommon
Brown Thrasher	Uncommon
Killdeer	Uncommon
Mallard	Uncommon
Rock Pigeon	Uncommon
Ruby-throated Hummingbird	Rare
Scarlet Tanager	Rare
Pileated Woodpecker	Rare
Black-billed Cuckoo	Rare
Great Blue Heron	Rare
House Finch	Rare
Least Flycatcher	Rare
Eastern Phoebe	Rare
Hairy Woodpecker	Rare
Magnolia Warbler	Rare
Red-tailed Hawk	Rare
Warbling Vireo	Rare
Alder Flycatcher	Rare
Blue-winged Warbler	Rare
Chestnut-sided Warbler	Rare
Common Nighthawk	Rare
Eastern Meadowlark	Rare
Sharp-shinned Hawk	Rare
Wild Turkey	Rare
Wood Duck	Rare
Yellow-throated Vireo	Rare

Table 12 Habitat Type of Each Plot as per the 2020 Bird Monitoring Report

Plot Name	Habitat Type
HV-1 Cherry Hill	Forest (wetland influence)
HV-2 South Pasture Swamp	Forest (wetland edge)
HV-3 Bridle South	Forest
HV-4 Quarry Forest	Forest
HV-5 Unsworth	Forest
HV-6 The Lodge	Forest
HV-7 Bridle North	Forest
EP-BT-1 Thornapple Loop	Successional (mid)
EP-BT-2 Berry Tract South	Meadow (early successional)
EP-RC-1 Lower	Forest
EP-RC-2 Upper	Forest
EP-RC-3 Field	Meadow (early successional)
EP-RC-4 Borer's Field	Meadow (early successional)
EP-RC-5 Romar Field	Meadow (early successional)
CP-NS-1 Captain Cootes	Forest (wetland influence)
CP-NS-2 Grey Doe	Forest (interior)
CP-NS-3 Interior North	Forest (interior)
CP-NS-4 Interior South	Forest (interior)
CP-NS-5 Homestead	Plantation (Placed into Forest category)
CP-NS-6 Lilac Dell	Garden (Placed into Successional Category)
CP-NS-7 York Road Parkette	Meadow (early successional)
CP-NS-8 Segato Field	Meadow (early successional)
CP-NS-9 Hopkins Loop	Successional (mid)

Plot Name	Habitat Type
CP-NS-10 Borer’s Creek	Forest (wetland influence)
CP-SS-1 President's Pond	Forest (wetland edge)
CP-SS-2 Mac Landing	Forest (wetland influence)
CP-SS-3 Ravine Road	Forest
CP-SS-4 Churchill South	Forest (edge) (Placed into Forest Category)
CP-SS-5 Churchill North	Forest
CP-SS-6 Princess Point	Successional (mid-late)