From Chickadees to Eagles: The UBC Bird Biodiversity Report

In contribution to the long-term biodiversity monitoring project at the UBC Farm

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ENVR 400

UBC FARM

Team Members

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Abstract

Biodiversity monitoring is vital for understanding how the community composition of local ecosystems is changing during a time of accelerating environmental changes due to climate change and land use changes, amongst others. Volunteer birders from Nature Vancouver have been collecting observational bird data since 2007 at the UBC farm, recording species seen and heard at the nine determined stations that make up the farm. In this study, we explored how bird abundance and diversity at the UBC farm have changed from 2007 to 2022. To achieve this, we looked at three possible explanations as to why bird abundance and diversity may be changing which included habitat type, migration timing, the very recent COVID-19 lockdowns that occurred during 2020 and part of 2021, and a preliminary investigation on El Nino-Southern Oscillations (ENSO) events. Specifically, we tested the hypotheses that bird abundance will vary through time migration timing and changes in human activity, and that bird abundance and diversity will vary through time with habitat type. We found that changes in the abundance of migratory birds have shown a small change in migration timing since 2007 and suggest that migratory birds are experiencing advanced migration away from the farm. We observed that diversity varied drastically between habitat types, with only a few species showing a high consistency throughout the years. This suggests that habitat selection is occurring, with a few species being able to dominate in many habitats. Finally, we observed that during COVID-19 lockdowns (2020-2021), when human activity on the farm decreased, total mean bird abundance displayed general increasing trends compared to before and after lockdowns, however, it is unknown whether this change is statistically significant. This study is preliminary in nature, delving into data not previously explored, and thus to come to any strong conclusions more intensive analysis is required. Our results hope to spur discussions and be of inspiration for those who wish to explore deeper into this subject and data.

1

INTRODUCTION

Biodiversity monitoring around the world is important not only to understand the abundance and diversity of organisms with a changing climate but also to help us better manage these ecosystems (Navarro et al., 2017). As the global environment continues to change and modern agricultural practices and standards continue to bring environmental challenges, there is an increasing interest in using citizen scientists to assist in biodiversity monitoring and provide data needed to assess and analyze how species are changing in abundance and distribution. What is particularly of interest to us and UBC is how biodiversity is changing on the UBC Farm. Studies have shown that current agricultural standards are correlated to decrease biodiversity in and around farmland (Erisman et al., 2016), and this sentiment is also expressed by the UBC Farm (2019) in their long-term biodiversity monitoring plan report.

The Long-Term Biodiversity Monitoring project on the UBC farm seeks to understand the unique agroecosystem that makes up the farm and how the biodiversity that inhabits it is changing (UBC Farm, n.d.). The UBC Farm (2019) focuses on three primary aspects of biodiversity; landscape diversity, crop diversity, and unplanned species, which build the foundation that supports food production and other beneficial ecosystem services. In addition, biodiversity indicators are used to assess how management strategies affect biodiversity. Indicators include bees, vascular plants, earthworms, birds, mammals, and soil microbes. Collaboration of researchers, students, UBC courses, and the public to continuously monitor and analyze the biodiversity on the farm will provide insight into how the ecosystem services that sustain the farm, and the overall sustainability are being affected.

Specifically, the goal of our project is to analyze the bird biodiversity data collected by Nature Vancouver at the UBC Farm. This analysis is vital to the biodiversity monitoring project as this is the first time this large data set is being analyzed since it began in 2007. The implications of this first-time analysis are that we can observe any population trends within the bird community at the farm over a 16-year period and that we can measure this trend against variables such as weather phenomena, seasons, migration, and human activity (i.e. the COVID-19 pandemic). Furthermore, the analysis can help inform the UBC Farm on its biodiversity management practices and possibly help create areas that continue to support increased biodiversity.

UBC Farm, n.d

The UBC Farm is a unique farmland system, designed in 2001 within a 90-year-old hemlock coastal forest to support biodiversity, research, organic food cultivation, student learning, and community involvement (UBC Farm, n.d.). Dr. Kremen, a UBC professor and primary investigator of the WoRCS lab, (pers. comm., October 27, 2022) describes the UBC Farm as an environment that explicitly promotes biodiversity through its complex land structure and diverse crop varieties. The Farm practices agroecology, an uncommon farming approach that understands the interconnectivity of the different elements in an ecosystem. For example, the UBC Farm cultivates annual crops, plants perennial hedgerows, and maintains forest stands to support biodiversity and soil health.

In 2011, the Centre for Sustainable Food Systems (CSFS) was established to deepen the connection between academics and the UBC Farm through innovation and research of sustainable food systems (CSFS at UBC Farm, n.d.-b). The CSFS encompasses the ongoing research, teaching, and cultivation at the UBC Farm, as well as being involved in research and learning opportunities in other national and international communities.

1.2 Biodiversity Effects on the UBC Farm

We sought to understand how bird diversity and abundance on the Farm are changing by looking at four potential drivers; migration, weather, land use change, and human activity. We chose these as potential drivers due to the extensive library of scientific literature that explains the potential effects they have on bird abundance and diversity. Additionally, unexpected major global events and phenomena such as periods of extreme heat, recent atypical ENSO cycles, and the COVID-19 pandemic provide unique opportunities to look into how changing global ecological and social environments are impacting birds at a local level.

Differences in migration timing could explain some of the variances in abundance and diversity of migratory birds on the UBC farm. The timing of their arrival and departure is synchronized with the availability of food, nesting sites, and other environmental factors (Gauthreaux, 2019). If the timing of migration shifts, birds could fall out of synchronization and be met with lower food and nest site availability if they arrive too early. Alternatively, if a species arrives too late they could miss when insects are at their greatest abundance. As a result bird abundance and diversity could be negatively affected.

Weather and climate are very well-known influences on the behaviour and fitness of birds. Extreme temperature fluctuations and shifts within the climate can affect migration timing and cause widespread deaths of individuals and flocks (Lv et al., 2023). Additionally, climate events that occur on larger timescales, particularly ENSO events, have been correlated with changes in bird abundance (Vandenbosch, 2000). Further, fluctuating weather patterns, together with land use changes exacerbate the effects of each other (Brook et al., 2008). While we do not have a dedicated section within this report that details our analysis conducted on the correlation between ENSO events and bird abundance on the UBC Farm, a preliminary analysis can be found in the appendix.

Land use change is a well-documented anthropogenic force of general biodiversity loss, especially for bird diversity and abundance due to their unique sensitivity to environmental changes. The alteration of natural landscapes for the purpose of urbanization or agriculture can lead to the loss, fragmentation, and degradation of habitats crucial for the survival of birds, which can lead to the loss of species richness (Stouffer, 2020).

Anthropogenic activity including visitation, development, and road traffic can partially interrupt critical bird behaviours on the UBC Farm. Behaviours such as mating songs and calls can be drowned out by excessive noise pollution from nearby roads and ongoing construction, and mobility can be limited as birds avoid people and their activity (Derryberry et al., 2020). These effects can result in a decrease in reproductive success and fitness (Schrimpf et al., 2021).

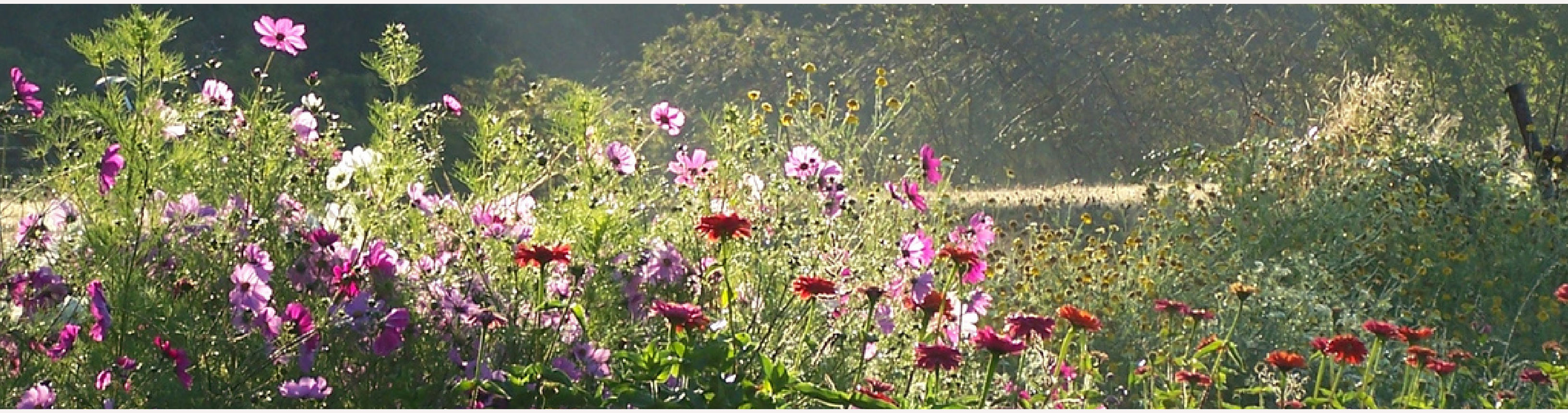
Understanding how these drivers are affecting bird populations is an essential factor in the development of effective conservation strategies and would greatly help the UBC Farm develop its own strategies to achieve its sustainability objectives.

1 The overarching objective that guided our analysis was:

To explore the bird data provided by Nature Vancouver and determine the changes in bird diversity over the course of 16 years on UBC Farm.

2 We will achieve this goal by:

- Determining whether there was a change in abundance of birds from before, during, and after the COVID-19 pandemic due to the changing numbers of visitors and human activity.
- Determining how bird diversity and abundance has varied spatially over time at the farm.
- Determining the temporal changes in bird migration for migratory species at the Farm.



UBC Farm, n.d

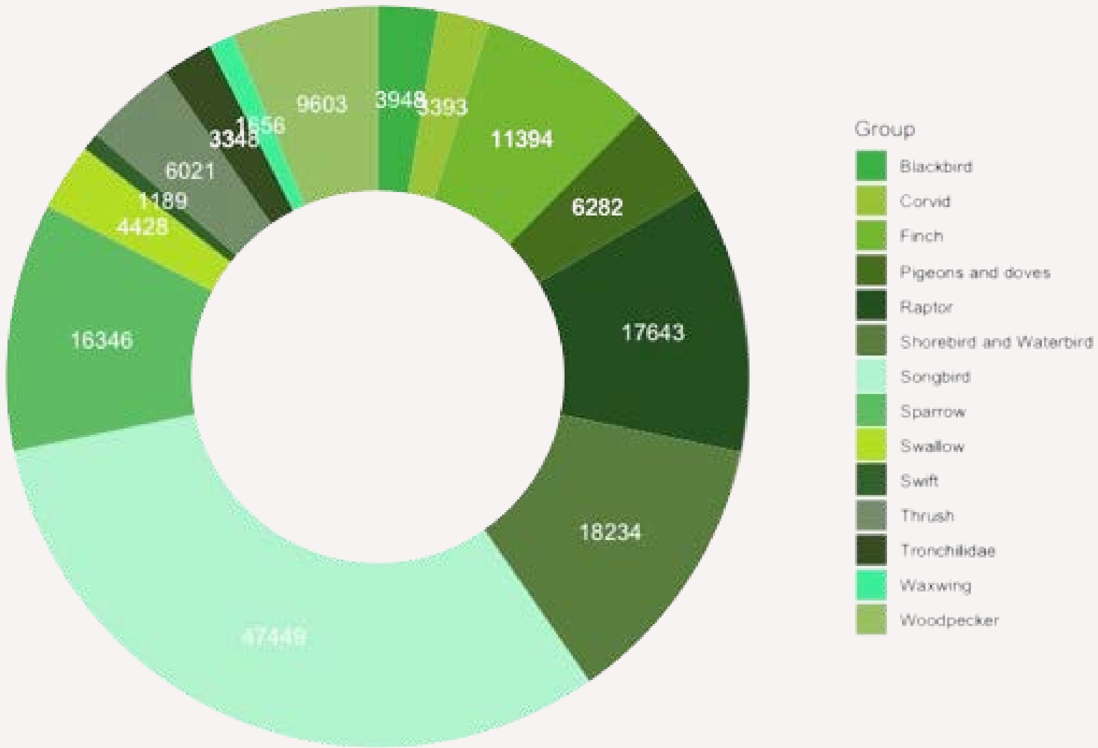
1.4 Nature Vancouver and Other Data Providers

Nature Vancouver is a society founded 105 years ago with the goals of promoting education and ecosystem protection throughout Vancouver (Nature Vancouver, n.d.). The citizen scientists and bird enthusiasts within the organization have been collecting bird biodiversity data from the UBC Farm since 2007, and it is one of Nature Vancouver's most prominent projects.

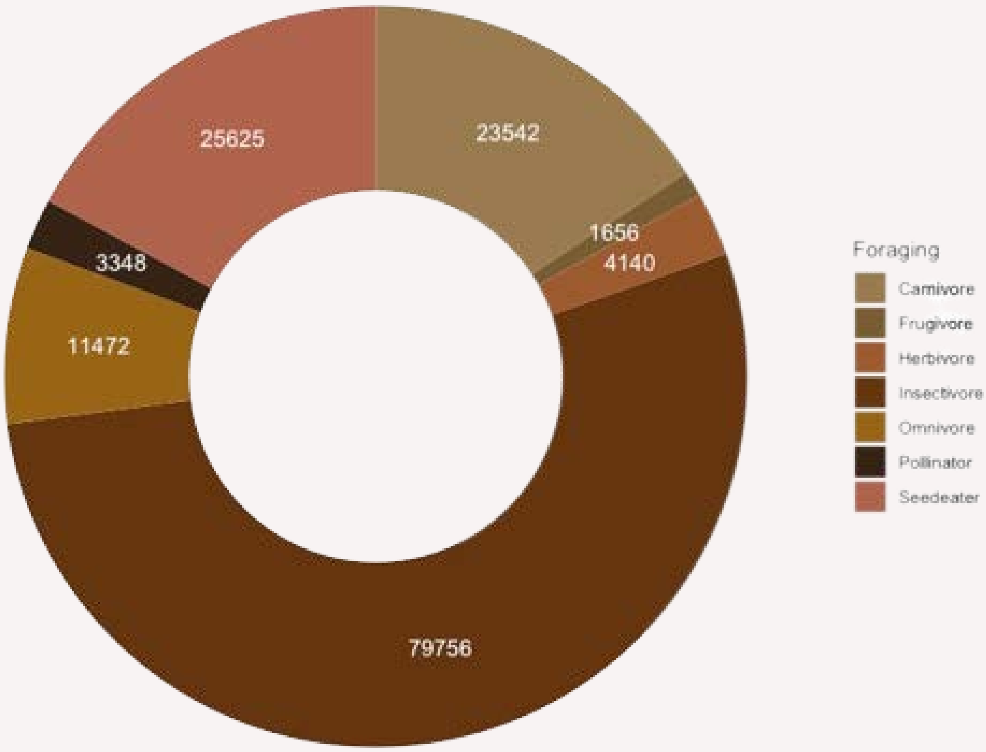
Data provided by Nature Vancouver was collected through visual and auditory observations once a month and recorded in a notepad before being digitalized in a spreadsheet. The data collected included the date, bird species, total observations, and number of observations at each station (9 stations in total). Bird survey was done for all nine stations from early morning to early afternoon, and it is important to note that each station is not a specific point, but a general area. The number of surveyors and the individual surveyors were not consistent each month and given the mobility of birds, it is possible that birds are counted multiple times or not at all. To account for bird occurrences that could be heard but not seen, the Merlin app was used to identify bird calls.

Dataset Name	Description	Relevant Variables
Bird data	Data collected by Nature Vancouver at UBC Farm every third Sunday of the month from 2007-2022.	date - date of survey bird - the genus/species of bird total - total count of a species observed on the date of survey station - location on the Farm count - number of birds observed at the specific station year - year of survey month - month of survey

144 Unique bird species

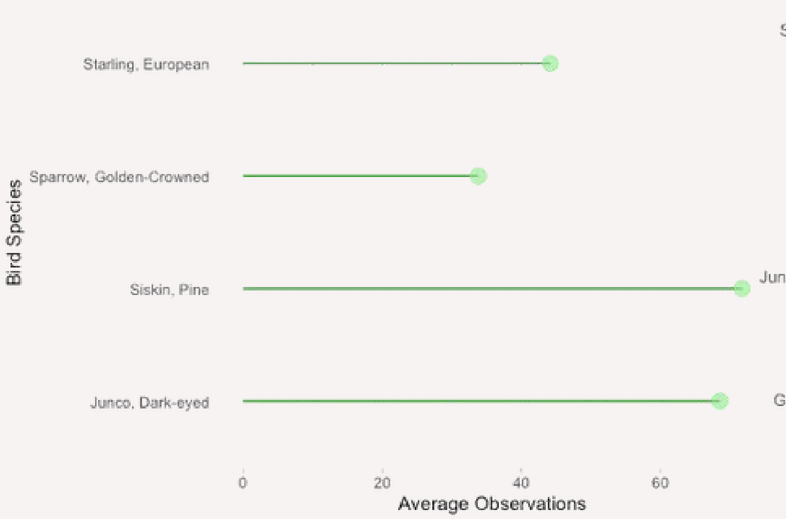


There are 144 unique bird species represented at the farm over the 16 year study period (2007-2022). Based on the abundance of birds present at the farm, songbirds make up the largest proportion of bird types. Shorebirds and waterbirds, raptors, and sparrows also make up a large proportion of the bird abundance at the farm. 10 other groups are represented with at least 1000 observations over the study period.

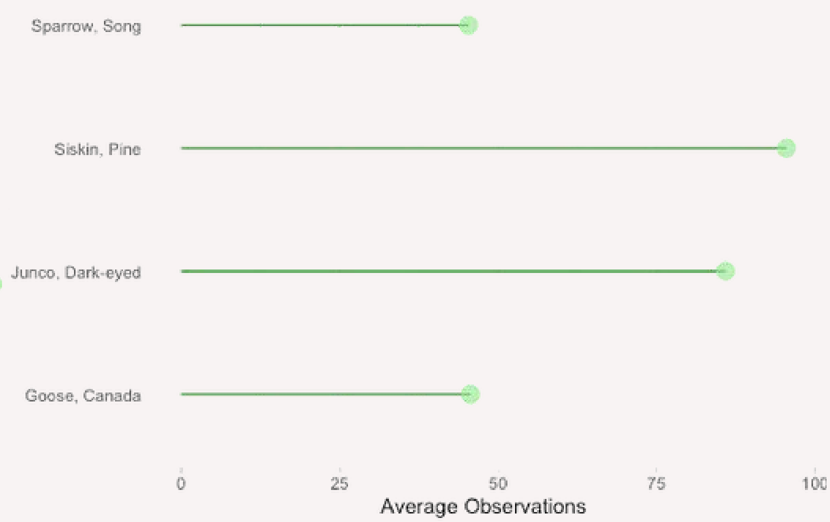


Over half of the bird species at the farm can be categorized as insectivores. This means that a significant portion of their diet comes from insect consumption. Other largely represented foraging birds are carnivores and seedeaters. Carnivores mainly encompasses raptors and seedeaters include various bird groups including some finches and sparrows.

Winter

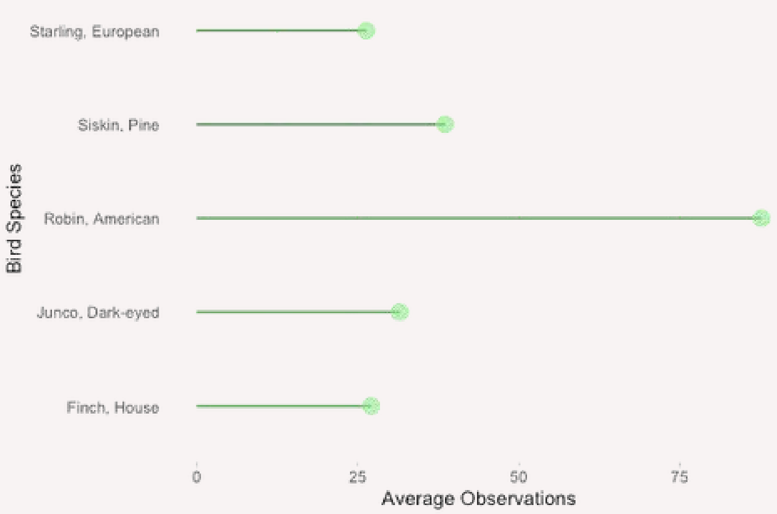


Fall

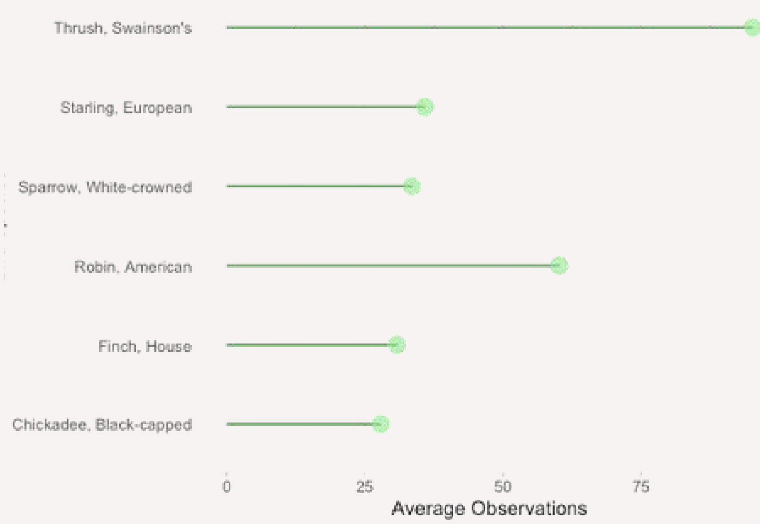


There are 71 unique bird species in the winter and 85 unique species in the fall. During both seasons, the pine siskin and dark-eyed junco are the most abundant species. While the pine siskin can be short and long-distance migrants, some of the species in BC are non-migrant residents. The dark-eyed junco is a migratory bird and winter occurrences should be low due to their southward migration in the late fall period.

Spring



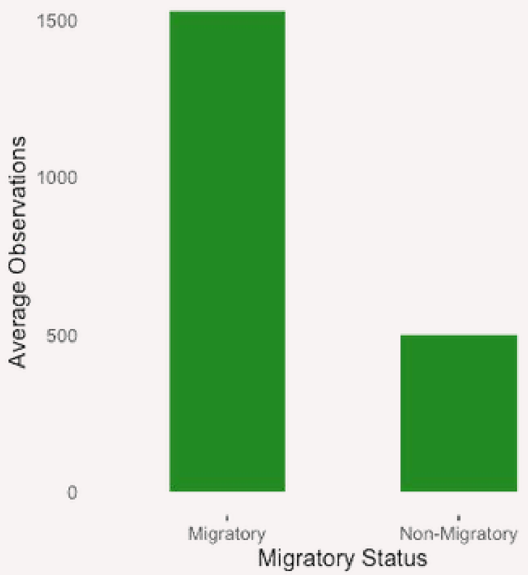
Summer

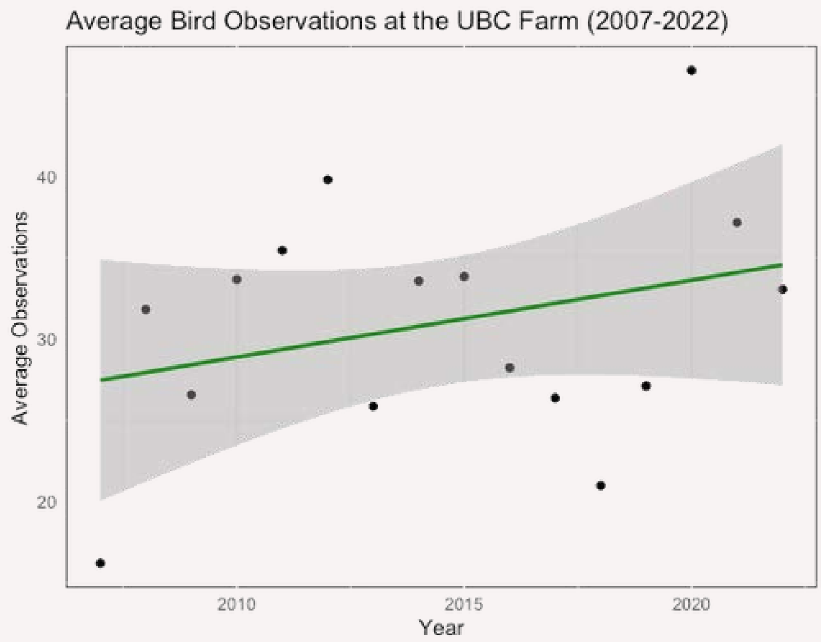


In the spring, there are 106 unique species found at the farm. The American robin and pine siskin are the most abundant species in the spring. While the American robin can reside year-round in BC, they also begin their distant northward migration in February. There is a slight shift in dominant species in the summer. Unique species decrease to 88 and the American robin and Swainson's thrush dominate.[more text]

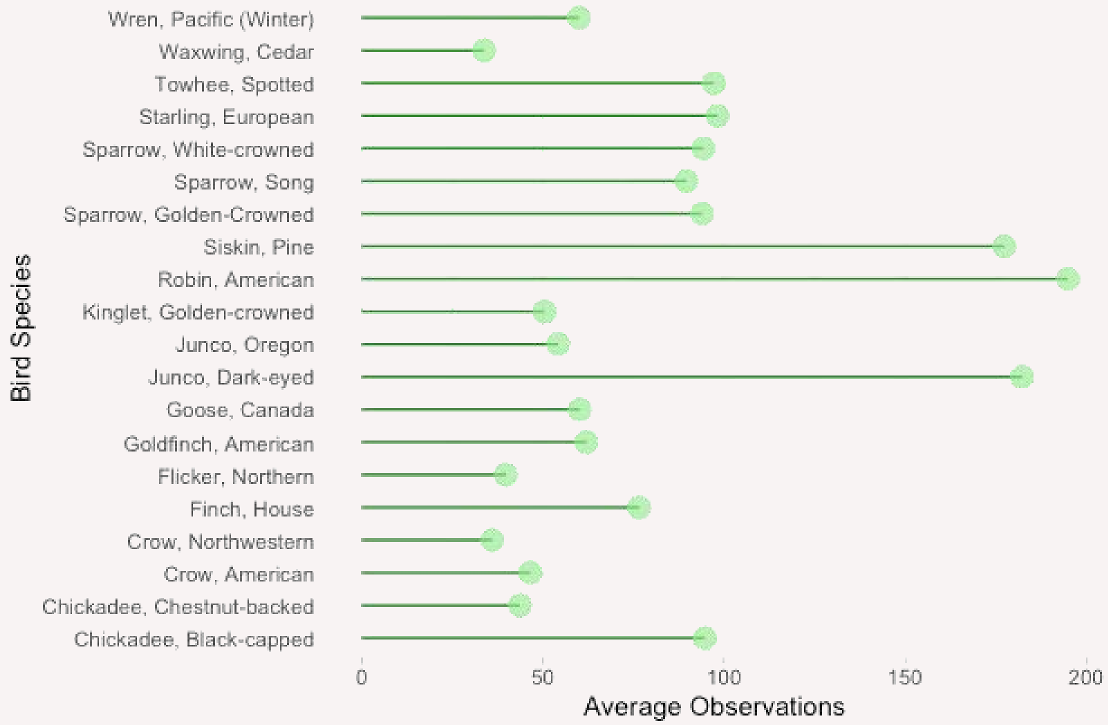
1.5 Summary Demographics

Although there have been inter-annual fluctuations, there has been a general increasing trend of bird observations at the UBC Farm since 2007.





Migratory birds are more represented on the Farm than non-migratory birds. There are 16 unique non-migratory bird species and 92 unique non migratory bird species on the Farm.



The top 20 most abundant species at the Farm make up 71% of total average bird observations from 2007-2022

Abundant Birds at the Farm

based on the average of yearly observations from 2007-2022

Joshua Covill, Macaulaly library. Retrieved from: https://www.allaboutbirds.org/guide/American_Robin/photo-gallery/60412921

American Robin (*Turdus migratorius)*

The American robin is a common thrush throughout North America (The Cornell Lab, n.d.). They are long-distance and short-distance migrants and some populations also reside year-round in British Columbia. Their migratory patterns are also closely related to their foraging patterns as they move towards moist woods in the winter, where they can consume berry producing trees and shrubs. In the spring and summer, they occupy spaces where worms and insects are abundant.

Pine Siskin (*Spinus pinus)*

The Pine siskin is a small finch that primarily nests in open coniferous forests. This is so they can capitalize on the abundance of cone seeds that are typically found in these forests. They are the most widespread of the finches found in British Columbia (BC Breeding Bird Atlas, n.d.). They can also take advantage of wildflower seeds and in BC, their high population can often coincide with healthy wild seed crops.

David M. Bell, Macaulaly library. Retrieved from: https://www.allaboutbirds.org/guide/Pine_Siskin/photo-gallery/67276581

Sam Hough, Macaulaly library. Retrieved from: https://www.allaboutbirds.org/guide/Dark-eyed_Junco/photo-gallery/66115741

Dark-eyed Junco (*Junco hyemalis)*

The Dark-eyed junco (also known as the Oregon junco) are sparrows and the most abundant forest birds in North America. They are able to breed in coniferous and deciduous forests and in the winter, they utilize open woodlands, gardens, and fields. Seeds make up over 75% of the junco's diet.

2

Migration

For many bird species, migration is a crucial aspect of their life history. Many migratory species' populations are in decline (Teitelbaum et al., 2023). Migratory birds are integral as they are a part of varying ecosystems throughout their phases: breeding season, fall migration, wintering, and spring migration (Faaborg et al., 2010). According to Somveille et al., there are roughly 1,855 species of bird that migrate (2013). It has always been challenging to study migratory birds due to their constant movement and occupation of varying locations (Rushing et al., 2014). In Canada, British Columbia (BC) acts as a crucial stopover area for many migratory bird species (Murchison et al., 2016). The UBC Farm with its diverse habitat and crop types can be a shelter for both resident and migratory bird species.

This report aims to explore the changes in migratory bird abundance through time at the UBC Farm and emphasize the importance of conservation efforts for these bird species. Dr. Kremen (pers. comm., October 27, 2022) describes the UBC Farm as an environment that explicitly promotes biodiversity for its complex land structure and diverse crop varieties.

Additionally, different bird species in British Columbia, require different nesting, feeding, and overwintering habitats (Wilson, 2004). Dr. Kremen (pers. comm., October 27, 2022) explains that a diversity of bird species on farmlands require many food sources, such as seeds, berries, fruits, soil organisms, insects, etc., and the UBC Farm is an example of land that provides all of these requirements. Furthermore, the Farm's variety in land-types and components (forest, crop fields with varying species and plants, heterogeneity, hedgerows, buildings, etc.) contribute to the bird diversity by providing nesting, overwintering, and breeding sites.

A flock of swallows migrating (Cosmos Magazine, 2022).

2.1 Methods

Preparing the Data for Analysis

The Atlas of the Breeding Birds of British Columbia and the BC Species Summary from the BC Species & Ecosystems Explorer were used to confirm if a bird species was considered a migratory bird. This list was compiled on Google Sheets and downloaded to use to filter out just the migratory birds from the data provided by Nature Vancouver. This new data frame will be referred to as 'the migratory data frame' and was the main data frame used for the analysis.

Analysis of Data

The program RStudio was used for the entirety of the analysis.

1. Log the migratory data frame.
    a. This was done to remove any skewness in the data frame and the k constant was to avoid logarithms of zero which would be undefined.
    b. Using the formula log(x+k)
        i. x is the species count
        ii. k is constant, 1 was used
2. Average bird counts in the summer months (June-August).
    a. Studies such as by La Sorte et al., state that migratory birds that fly the western flyway follow a fall migration rather than a spring migration (2014). Therefore, we assumed that using the summer bird count as the baseline bird abundance before migration was sufficient.
3. Calculate the proportions of migratory birds in September, October, November, and December compared to the summer mean for every year.
    a. This meant that for some migratory bird species, if for certain years the summer mean count was 0, then their proportions for September-December would be infinity and therefore invalid for plotting and would be excluded from the analysis. Therefore not all the years 2007-2022 are included in every bird analysis
4. Plot the summer mean, September proportion, October proportion, November proportion, and December proportion and perform a linear regression.
    a. The resulting slopes of the linear regression can be found in Table 1 of the Appendix.
5. Specific birds of interest were then plotted to visualize the change in migration over the years.
6. A statistical test called the ANCOVA was conducted for these species.
    a. This was to compare the multiple lines (slopes) of linear regression for each bird species in order to determine if there was any significant change between the years.

2.2 Featured Migratory Birds

Bird Selection

In this section of the report, we aim to provide a detailed analysis of the population trends of six migratory bird species at UBC Farm. These species were chosen based on their ecological significance, species with population decline in BC, and their general interest to our research group. A comprehensive list of migratory bird species with available data for ANCOVA analysis can be found in the appendix. These are species selected based on the availability of valid years for graphing proportions (as if the summer mean count was 0, the proportions of birds present in subsequent months would be infinity and impossible to graph).
This analysis provides a more detailed look at population changes of select migratory bird species at the UBC Farm and contributes to the broader understanding of the impact of environmental factors on bird populations both at the farm and in other locations.

American Goldfinch

A breeding female American goldfinch pictured in the Sapsucker Woods--Wilson Trail North, Tompkins, New York, United States (McGowan, 2016).

Spinus tristis

BC list: Yellow
General Status Canada: 4 - Secure

American goldfinches are granivores that tend to nest in bushes or small trees (B.C. Conservation Data Centre, 2010). They can be found in the southern regions of British Columbia, where the species is observed to be in population decline (Martell, 2015). Southern breeders are residents while northern populations migrate (B.C. Conservation Data Centre, 2010).

2.2.1 American Goldfinch

American Goldfinch Range Map

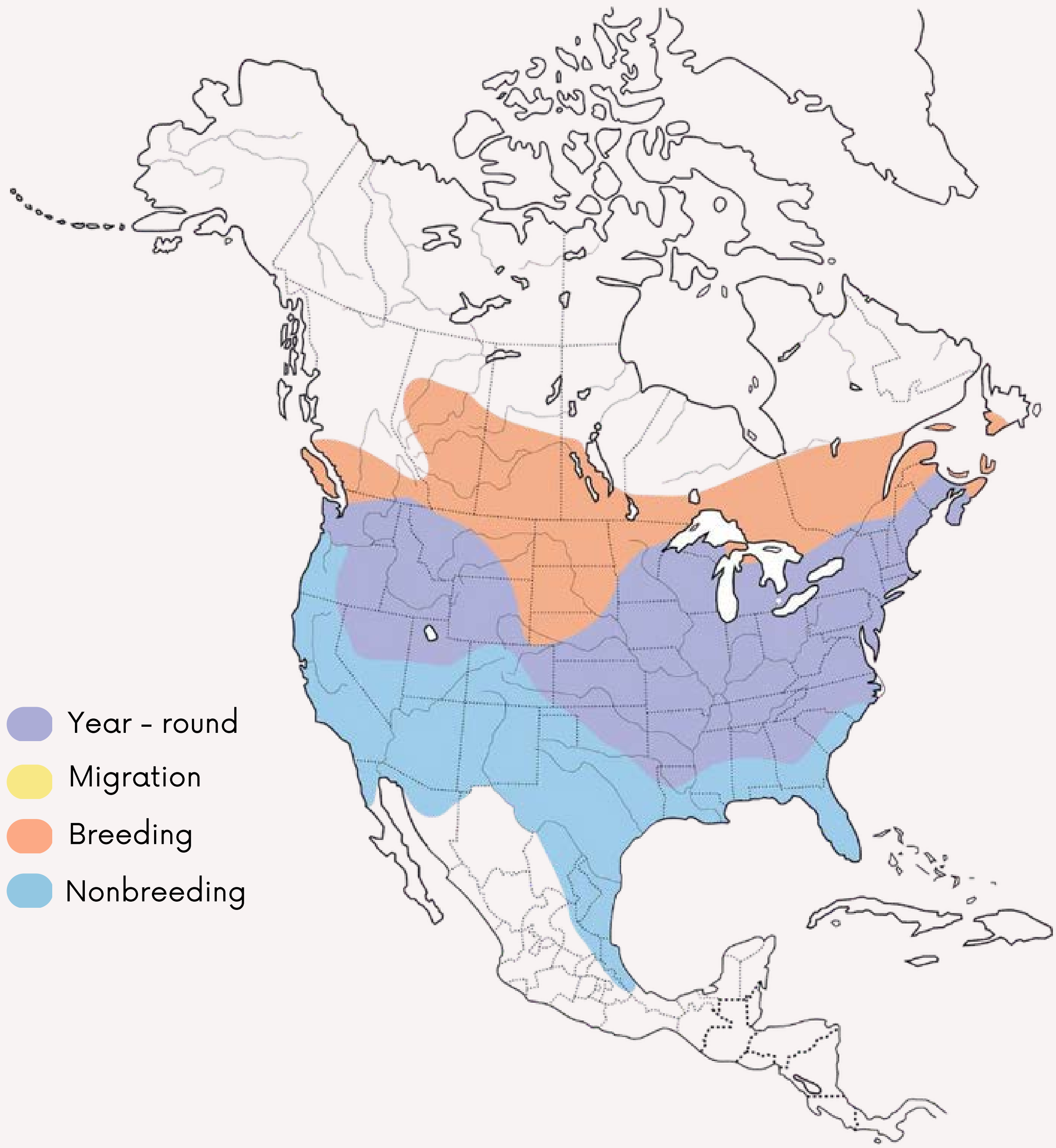


Figure 1. The distribution of the American goldfinch in North America (McGraw & Middleton, 2020)

How does the migration for the American goldfinch change through time?

Table 1. The analysis of variance table produced on RStudio using ANCOVA analysis.

Source	df	Sum Squared	Mean Squared	F value	Pr (>F)
year	1	0.43	0.4268	0.0774	0.781850
variable	**4**	**87.03**	**21.7565**	**3.9442**	**0.006584****[**]
year:variable	4	12.42	3.1059	0.5631	0.690346
Residuals	60	33.96	5.5160		

ANCOVA was used to investigate whether there were any significant changes in the slopes of the linear regression over the years. The ANCOVA table above shows that there was a significant effect of the variable (months) on the response variable (proportion of goldfinch birds) with an F value of 3.9442 and a p-value of 0.006584. However, there was no significant effect of the years, nor was there a significant interaction between years and months.

In conclusion, the analysis suggests that there has been a slight increase in the proportion of migratory goldfinch birds at the UBC Farm during the fall months from 2007 to 2021, but there was no significant change in the slope of the regression line over time.

How does the migration for the American goldfinch change through time?

An ANCOVA analysis was conducted to investigate the change in trends of the migratory goldfinch birds at the UBC Farm over a period of 15 years (2007-2021). The data was first cleaned by removing any years with Inf in the Summer Mean or monthly proportions as this would not be possible to perform a linear regression. Additionally, any rows with NAs were replaced with 0 as there were no bird counts. The data was grouped by year and summarized to calculate the summer mean and proportions of bird counts for each month (September to December).
The data was then plotted using ggplot2 to visualize the trend in the proportion of goldfinch birds over time. Some plots showed a slight increase in the proportion of goldfinch birds during the fall months from 2007 to 2021, with some fluctuations from year to year. This same method was used for the bird species following the American goldfinch.

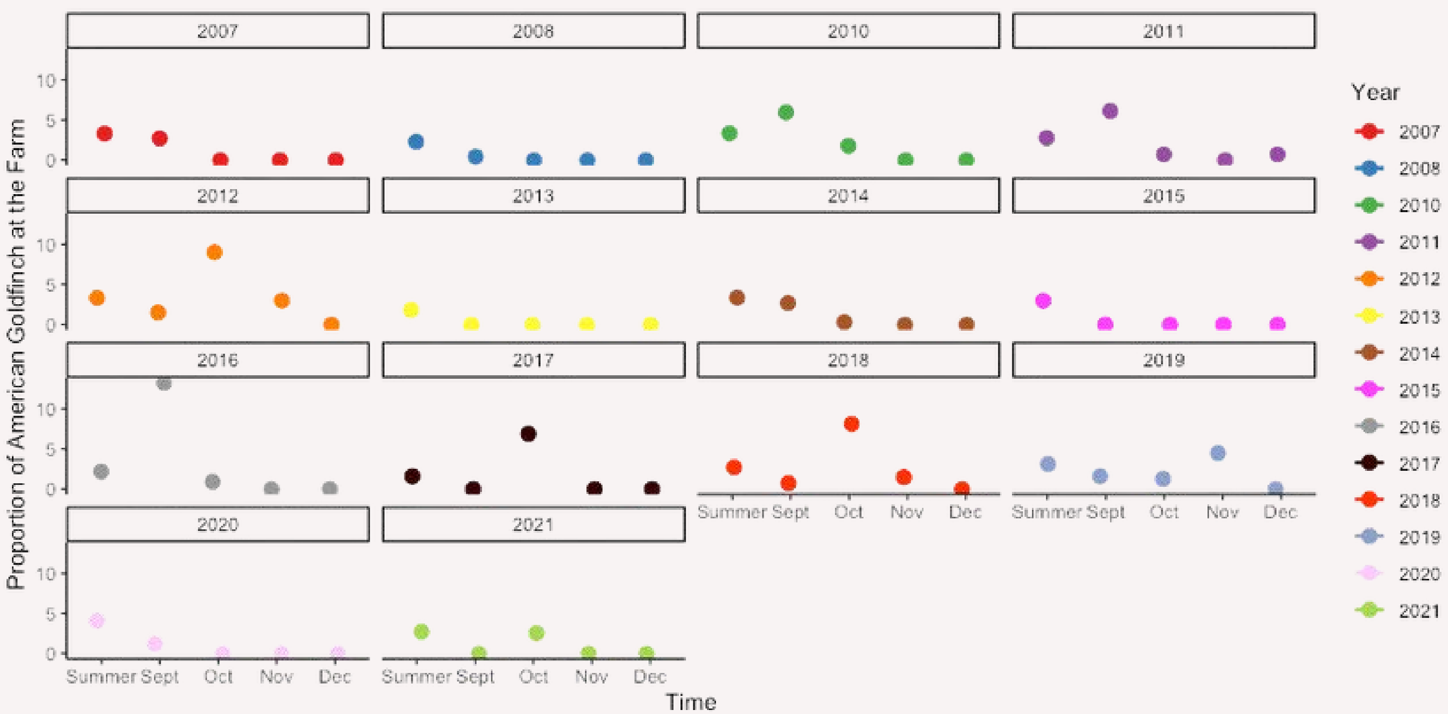


Figure 2. Plots of proportions of American goldfinch at the UBC Farm over the years.

How does the migration for the American goldfinch change through time?

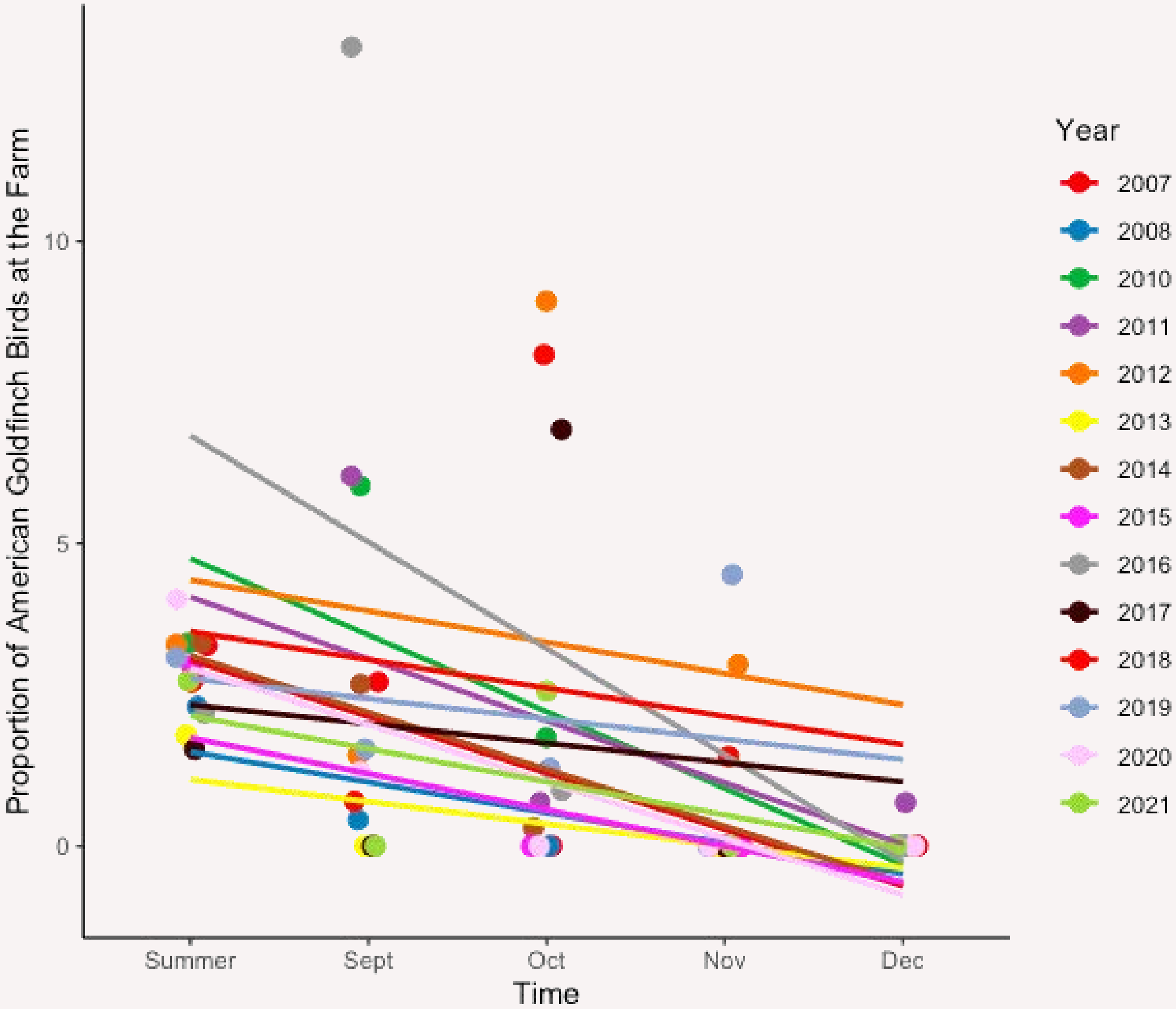


Figure 3. Plots of proportions of American goldfinch at the UBC Farm over the years.

The figure demonstrates changes in migration for the American goldfinch from years 2007-2021. There is an overall decreasing trendline for all years, which can mean that the American goldfinch are migrating away from the UBC Farm each year as the season shifts from summer to fall. Certain years such as 2010, 2011, and 2016 seem to have a much steeper negative slope, which means that the changes in American goldfinch abundance at the farm is a lot more abrupt compared to the other years.

Bald Eagle

A bald eagle found roosting (Allgood & Smith, 2018).

Haliaeetus leucocephalus

BC list: Yellow
General Status Canada: 4 - Secure

The bald eagle species have extensive migration in North America, breeding in Canada and Northern America before migrating south for the winter (B.C. Conservation Data Centre, 2011). In British Columbia, they can be found throughout the province, especially near coastal regions or regions with rivers and lakeshores (Barry, 2015). Despite no population-level threats, individuals may still be vulnerable (Barry, 2015).

2.2.2 Bald Eagle

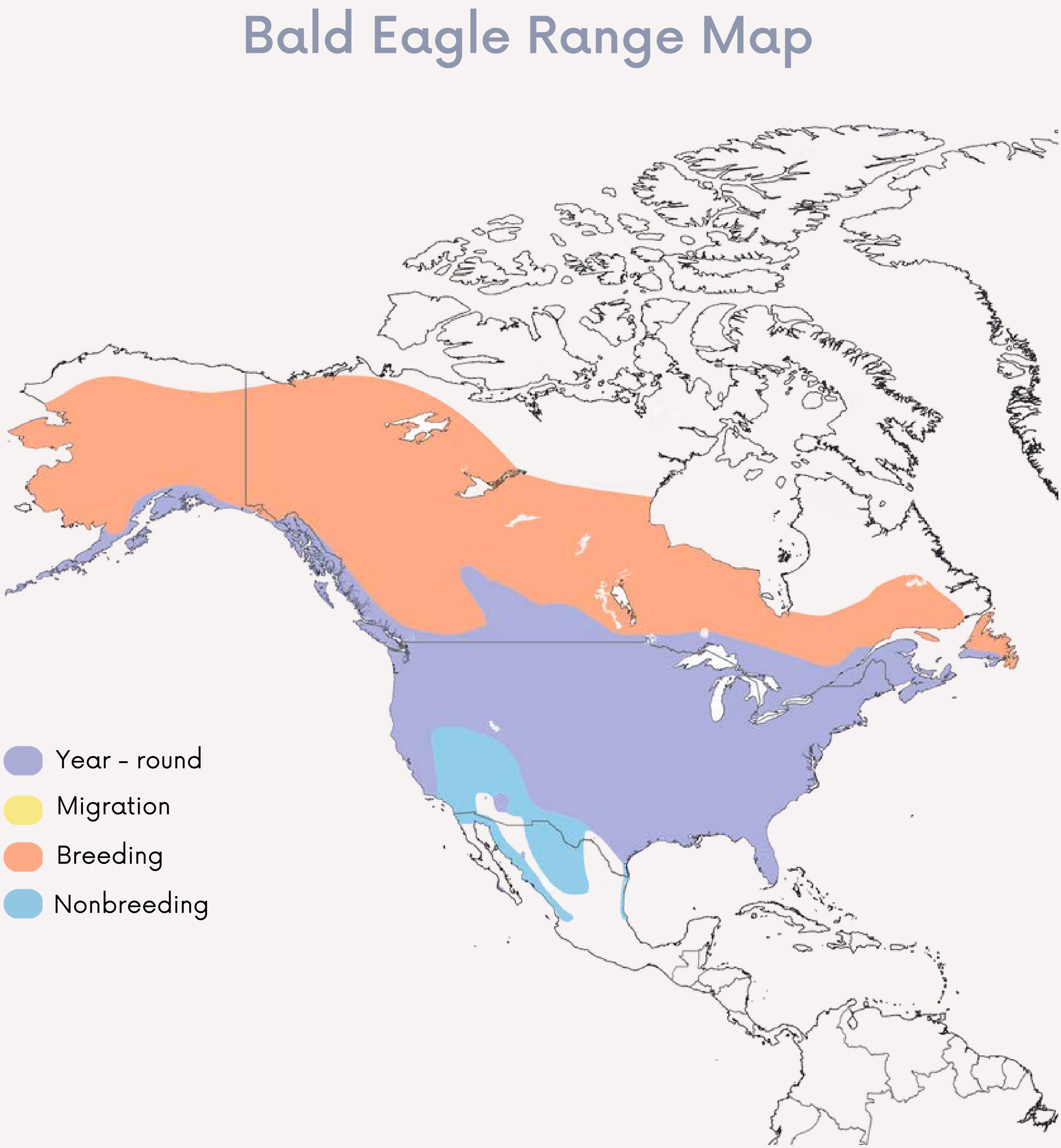


Figure 4. The distribution of the bald eagle in North America (MBuehler, 2022)

How does the migration for the bald eagle change through time?

Table 2. The analysis of variance table produced on RStudio using ANCOVA analysis.

Analysis of Variance Table					
Source	**df**	**Sum Squared**	**Mean Squared**	**F value**	**Pr (>F)**
year	1	0.	0.0051	NaN	NaN
variable	**4**	**19.2194**	**4.8049**	**NaN**	**NaN**
year:variable	4	20.8065	5.2016	NaN	NaN
Residuals	0	0.0000	NaN		

ANCOVA was used to investigate whether there were any significant changes in the slopes of the linear regression between the two years for the proportion of bald eagles at the UBC Farm.
The ANCOVA results show that the overall model is not significant, with all p-values being NaN. The ANCOVA table above shows that there was no significant effect of the variable (months) on the response variable (proportion of bald eagles) with an F value of 1.4102 and a p-value of 0.2387. Furthermore, there was no significant effect of the years, nor was there a significant interaction between years and months. This suggests that there is no evidence of a significant difference in slopes between the two years. However, it's worth noting that the standard errors and t-values for all coefficients are also NaN, which could be an indication of some issue with fitting the model on the data due to there only being two valid years to graph.

In conclusion, the analysis suggests that there was no significant change in the proportion of bald eagles at the UBC farm during the fall months from 2007 to 2021, and there was no significant change in the slope of the regression line over time.

How does the migration for the bald eagle change through time?

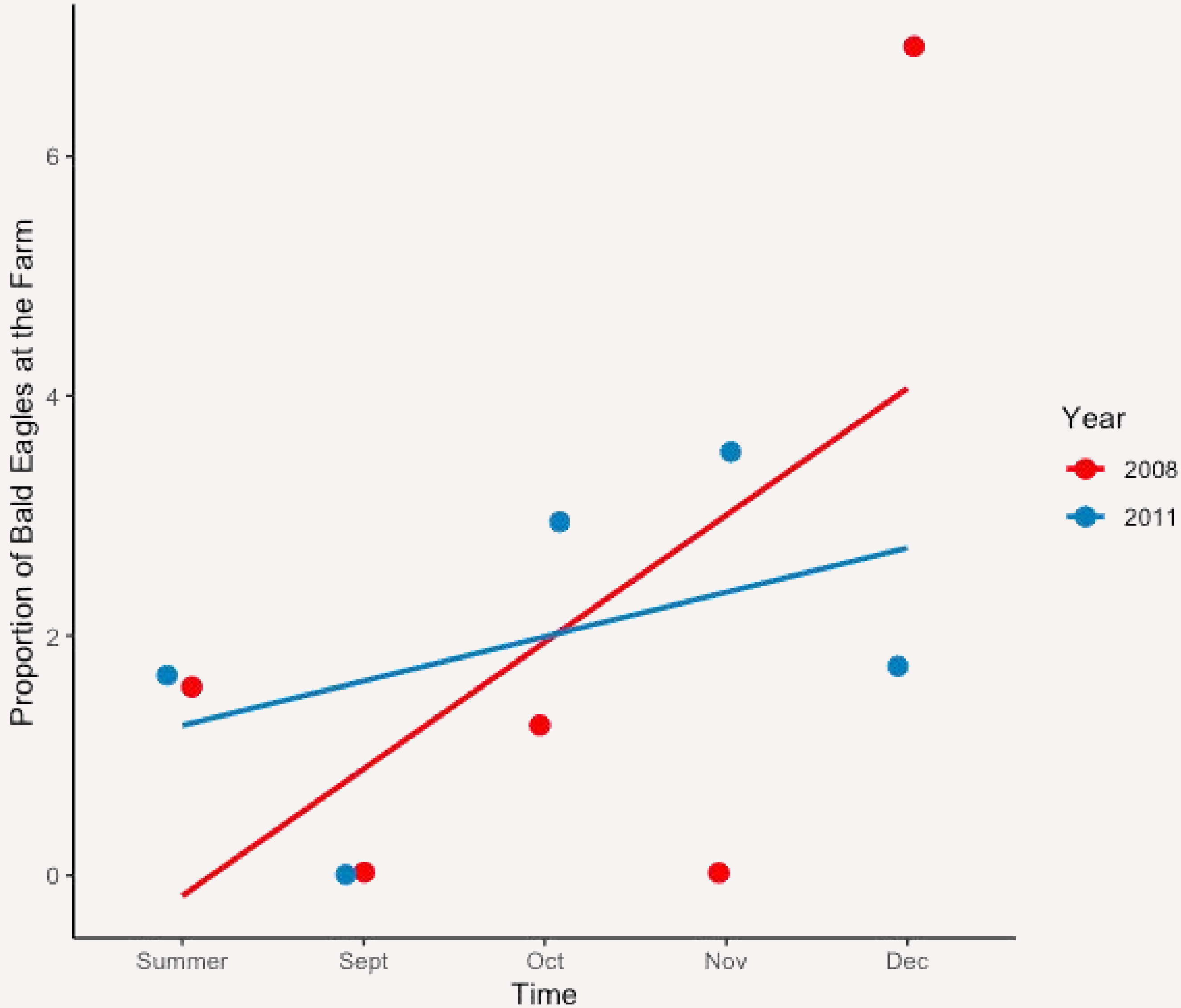


Figure 5. Plots of proportions of bald eagle at the UBC Farm over the years.

This figure only shows the change in proportions of bald eagles at the UBC Farm for 2008 and 2011 due to the method of finding proportions using the summer mean count as mentioned previously. There seems to be an increase in the spotting of bald eagles at the UBC Farm towards the end of the year, with a greater increase in 2008 from the summer to December compared to 2011.

Barn Swallow

A barn swallow perched on wood (BirdFact, 2022).

Hirundo rustica

BC list: Yellow
General Status Canada: 4 - Secure

The Barn Swallow is an invertivore that may form flocks of thousands of birds (B.C. Conservation Data Centre, 1994). They migrate long distances and are distributed throughout the world, mainly in North America for breeding (Hearne, 2015). They nest in areas such as under bridges, in barns, and buildings, and typically reuse old nests (B.C. Conservation Data Centre, 1994).

Barn Swallow Range Map

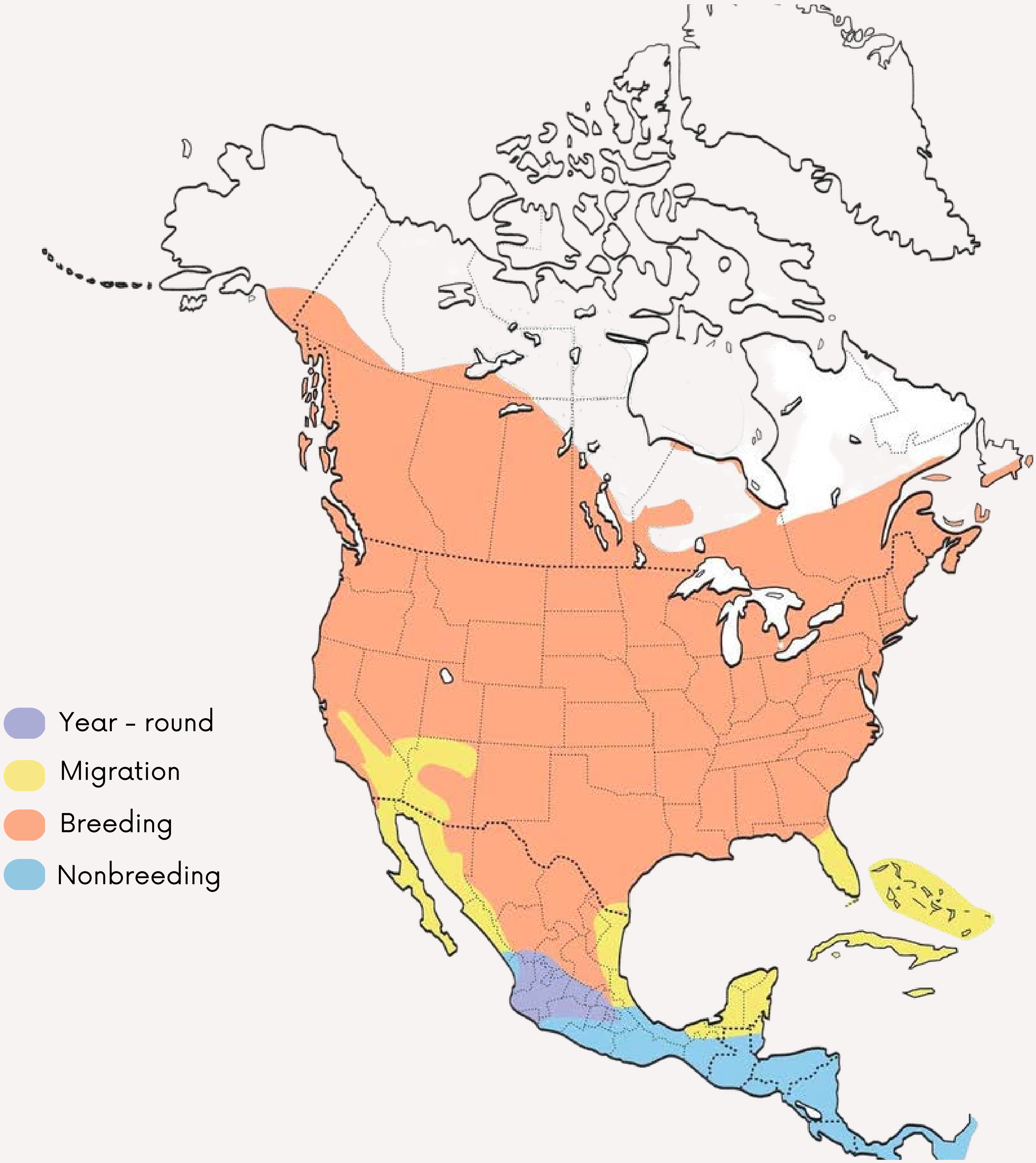


Figure 6. The distribution of the barn swallow in North America (Brown, 2020)

How does the migration for the barn swallow change through time?

Table 3. The analysis of variance table produced on RStudio using ANCOVA analysis.

Analysis of Variance Table					
Source	df	Sum Squared	Mean Squared	F value	Pr (>F)
year	1	0.684	0.6837	6.8994	0.01451*
variable	**4**	**43.578**	**10.8946**	**109.9329**	**1.747e-15*****
year:variable	4	1.440	0.3601	3.6332	0.01820*
Residuals	25	2.478	0.0991		

ANCOVA was used to investigate whether there were any significant changes in the slopes of the linear regression over the years. Based on the ANOVA and regression results, the interaction term between year and variable, the p-value is 1.747e-15; therefore, this interaction is significant ($p < 0.05$), indicating that the slopes for each variable are different from each other over time. In the regression output in RStudio, the interaction coefficients (year:variable2, year:variable3, year:variable4, year:variable5) are all significant ($p < 0.05$), further supporting this conclusion. Therefore, it appears that the slopes are significantly different from each other.

How does the migration for the barn swallow change through time?

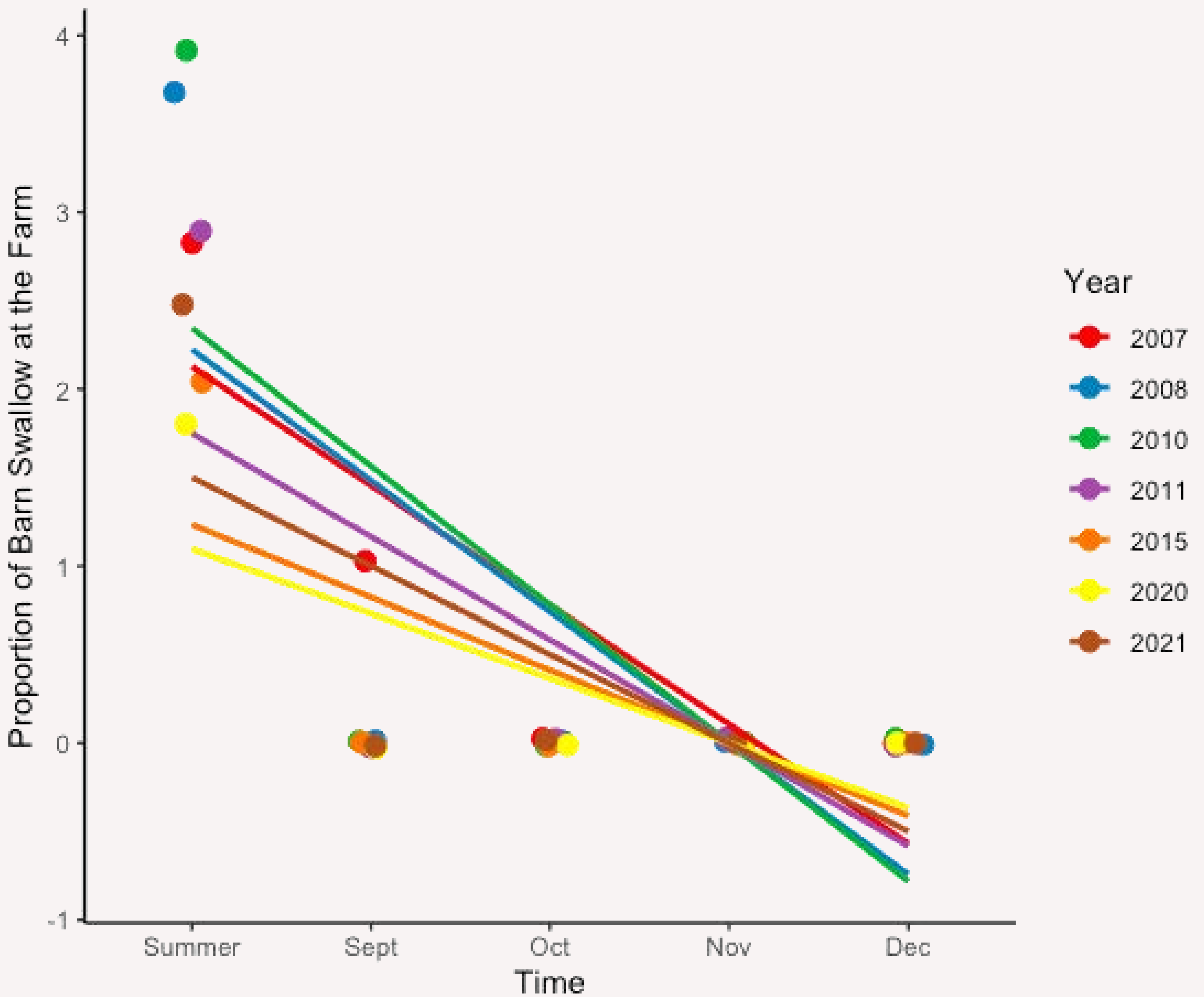


Figure 7. Plots of proportions of barn swallow at the UBC Farm over the years.

The figure demonstrates the decrease in barn swallows proportions over the years at the UBC Farm. The ANCOVA results show that the slopes are significantly different from each other. Therefore, since the proportions of barn swallows present at the UBC Farm are at zero after the summer months (except in September of 2007), this means that the only change between the years that is affecting the slopes is the summer mean counts. Generally, the summer mean seems to be decreasing over time. These trendlines make sense as the barn swallow migrates away from Canada usually starting in September (Langlois, n.d.).

Pacific-slope Flycatcher

A pacific slope flycatcher perched on a branch in Yakima County, Washington, USA (Higbee, 2005).

Empidonax difficilis

BC list: Yellow
General Status Canada: 4 - Secure

The Pacific-slope Flycatcher is primarily an insectivore that also occasionally feeds on berries and seeds (B.C. Conservation Data Centre, 2009). They are abundant along the coast of BC, and breed throughout the province (Weber & Cannings, 2015). They nest mostly in coniferous trees, riparian woodland, and second-growth woodland (B.C. Conservation Data Centre, 2009).

2.2.4 Pacific-slope Flycatcher

Pacific-slope Flycatcher Range Map

Figure 8. The distribution of the Pacific-slope Flycatcher in North America (Lowther & Patten, 2020)

2.2.4 Pacific-slope Flycatcher

How does the migration for the Pacific-slope flycatcher change through time?

Table 4. The analysis of variance table produced on RStudio using ANCOVA analysis.

Analysis of Variance Table					
Source	df	Sum Squared	Mean Squared	F value	Pr (>F)
year	1	0.0222	0.0222	0.8091	0.4096
variable	**4**	**18.1868**	**4.5467**	**165.7913**	**1.686e-05*****
year:variable	4	0.0888	0.0222	0.8091	0.5692
Residuals	5	0.1371	0.0274		

ANCOVA was used to investigate whether there were any significant changes in the slopes of the linear regression over the years. The ANCOVA table above shows that there was a significant effect of the variable (months) on the response variable (proportion of Pacific-slope flycatchers) with an F value of 165.7913 and a p-value of 1.686e-05 which is $p < 0.001$. However, there was no significant effect of the years, nor was there a significant interaction between years and months.

The regression model summary shows that R-Studio outputs show that the variable coefficients, were all highly significant ($p < 0.001$), indicating that the number of Pacific slope flycatchers observed varies significantly across the months. The high R-squared value (0.9926) indicates that the model explains most of the variance in the data. Overall, these results suggest that the number of Pacific-slope flycatchers observed is strongly influenced by the month of observation, but not by the year of observation.

2.2.4 Pacific-slope Flycatcher

How does the migration for the Pacific-slope flycatcher change through time?

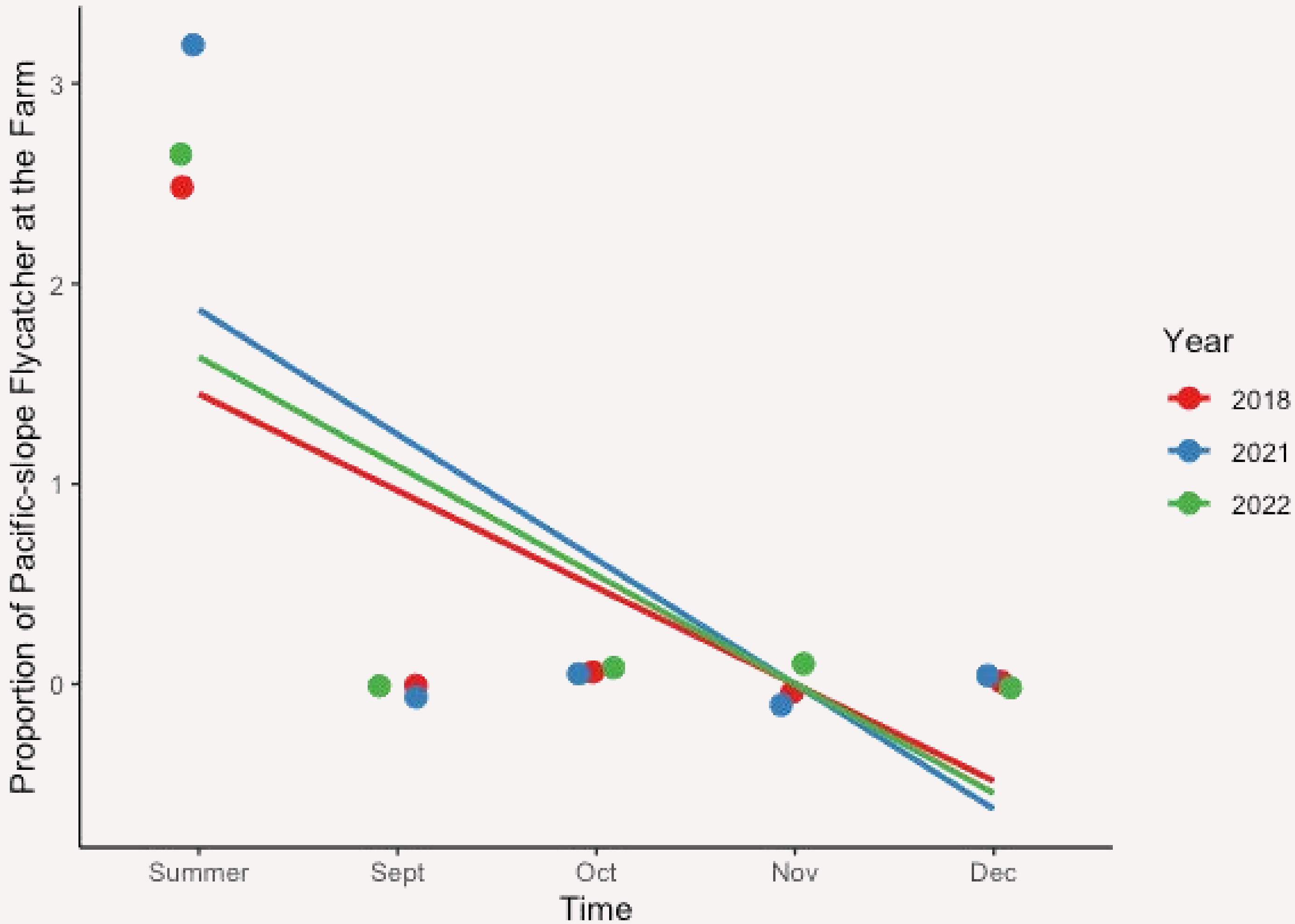


Figure 9. Plots of proportions of Pacific-slope flycatcher at the UBC Farm over the years.

The figure demonstrates the decrease in Pacific-slope flycatchers' proportions over the years at the UBC Farm. The ANCOVA results show that the slopes are significantly different from each other. Therefore, since the proportions of Pacific-slope flycatchers present at the UBC Farm are at zero after the summer months, this means that the only change between the years that is affecting the slopes is the summer mean counts.

Violet-green Swallow

Violet-green Swallow pictured in Iona beach, Richmond, BC (punkbirdr, 2016).

Tachycineta thalassina

BC list: Yellow
General Status Canada: 4 - Secure

The Violet-green swallow is an invertivore that feeds on insects that are caught in flight or foraged for on the forest floor (B.C. Conservation Data Centre, 1994). They have a long breeding range from the Boreal forests of Canada to the Sierra Madre of Mexico (Ryder, 2015). They nest in places such as woodpecker holes, tree cavities, old nests, building crevices, and bird boxes (B.C. Conservation Data Centre, 1994).

2.2.5 Violet-green Swallow

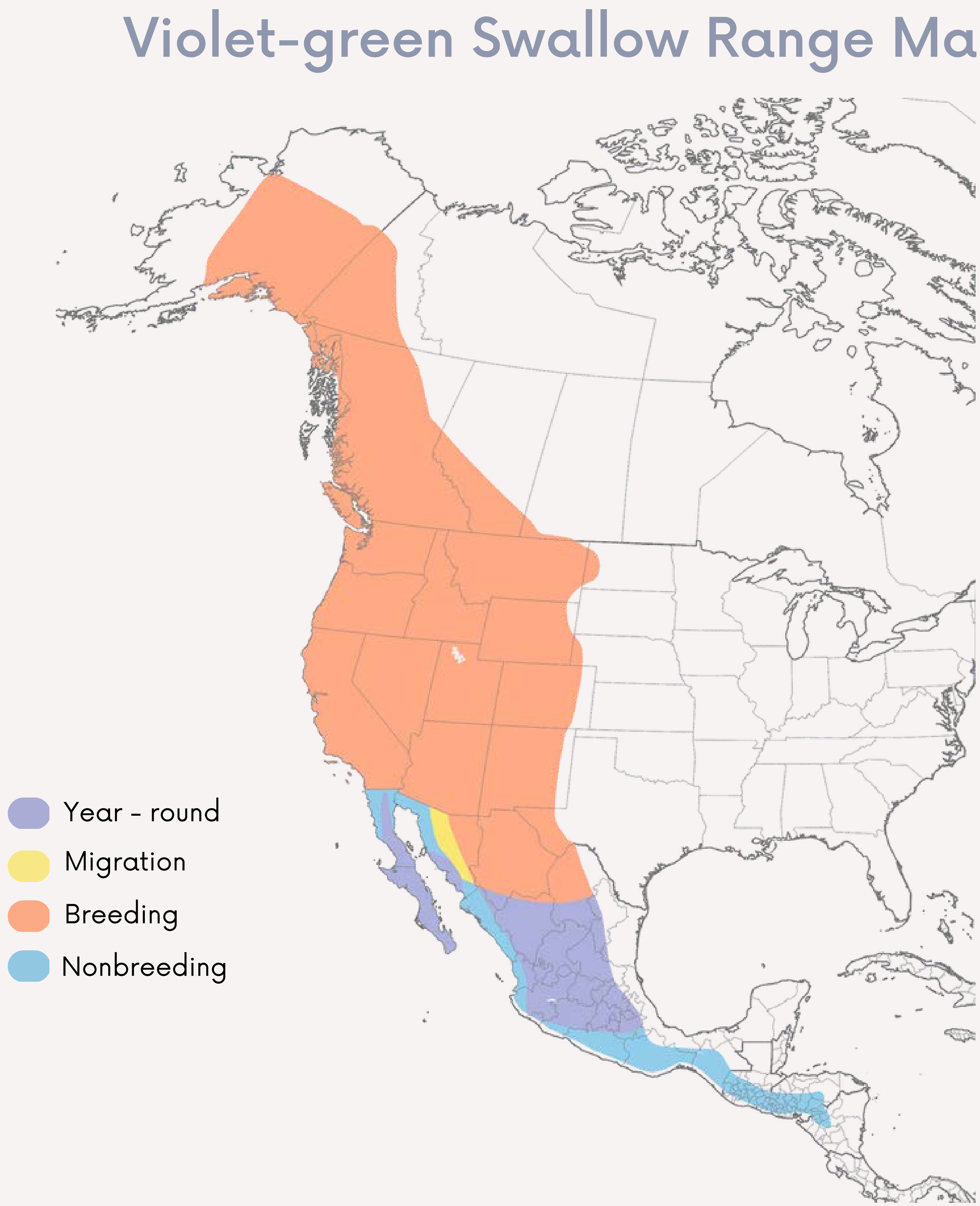


Figure 10. The distribution of the Violet-green Swallow in North America (Brown, 2020)

2.2.5 Violet-green Swallow

How does the migration for the Violet-green Swallow change through time?

Table 5. The analysis of variance table produced on RStudio using ANCOVA analysis.

Source	df	Sum Squared	Mean Squared	F value	Pr (>F)
year	1	0.0362	0.362	0.4435	0.5349229
variable	**4**	**20.8268**	**5.2067**	**63.7141**	**0.001773*****
year:variable	4	0.1450	0.0362	0.4435	0.7745173
Residuals	5	0.4086	0.0817		

ANCOVA was used to investigate whether there were any significant changes in the slopes of the linear regression over the years. The ANCOVA table above shows that there was a significant effect of the variable (months) on the response variable (proportion of Violet-green swallow) with an F value of 63.7141 and a p-value of 0.001773 which is $p < 0.01$. However, there was no significant effect of the years, nor was there a significant interaction between years and months.
The high R-squared value (0.9809) indicates that the model explains most of the variance in the data. Overall, these results suggest that the number of Violet-green swallows observed is strongly influenced by the month of observation, but not by the year of observation.

2.2.5 Violet-green Swallow

How does the migration for the Violet-green Swallow change through time?

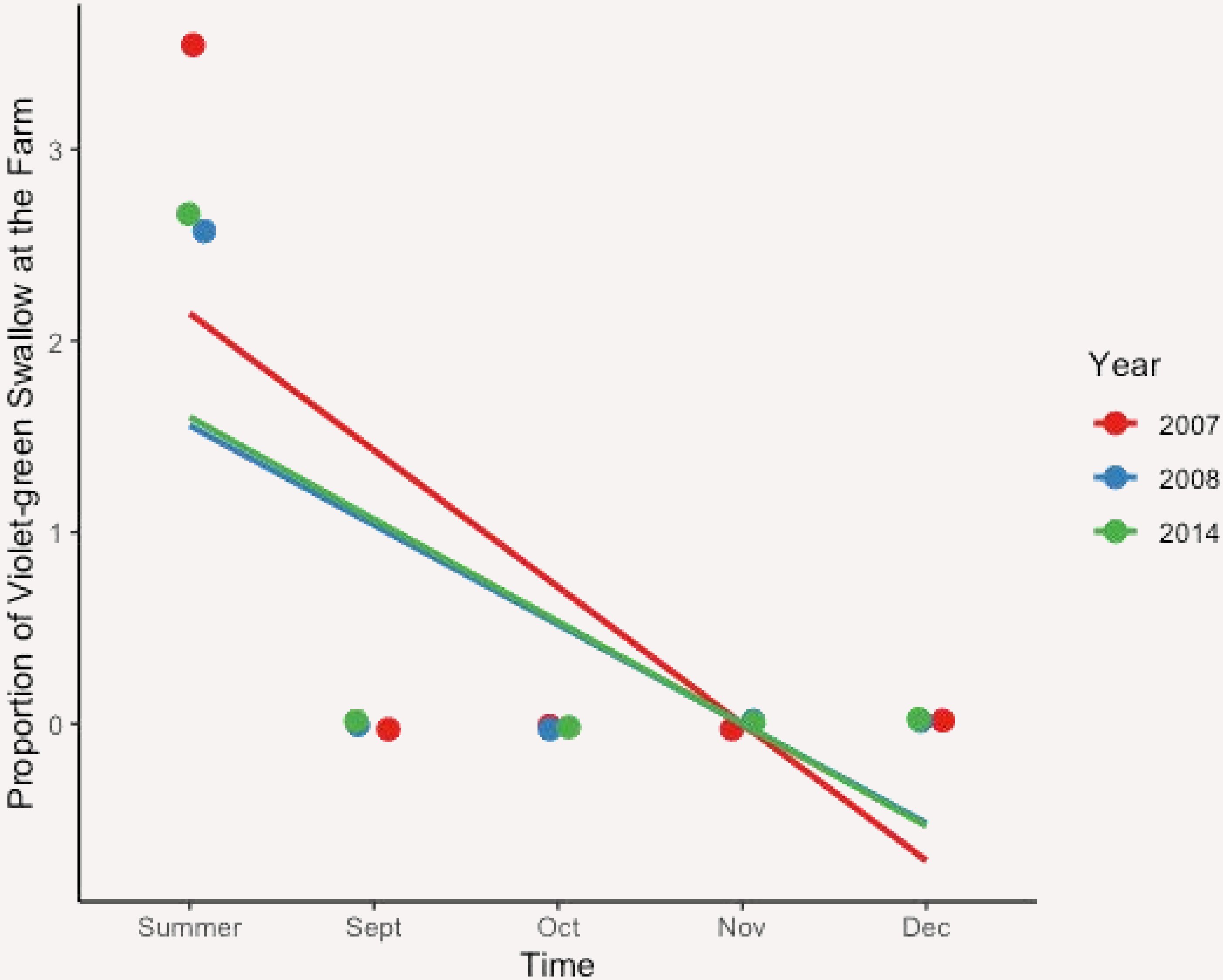


Figure 11. Plots of proportions of violet-green swallow at the UBC Farm over the years.

The figure demonstrates the decrease in violet-green swallows' proportions over the years at the UBC Farm. The ANCOVA results show that the slopes are significantly different from each other. Therefore, since the proportions of Violet-green swallows present at the UBC Farm are at zero after the summer months, this means that the only change between the years that is affecting the slopes is the summer mean counts.

Warbling Vireo

A adult warbling vireo perched on a branch in Duranceau Park, Franklin, Ohio, US County, Washington, USA (Danko, 2020).

Vireo gilvus

BC list: Yellow
General Status Canada: 4 - Secure

The Warbling Vireo is an insectivore that forages in trees and also occasionally feeds on berries (B.C. Conservation Data Centre, 1995). They are one of the most commonly occuring bird throughout the province (Weber, 2015). They nest usually in deciduous trees or shrubs at least 1-3.5 metres above the ground (B.C. Conservation Data Centre, 1995).

2.2.6 Warbling Vireo

Warbling Vireo Range Map

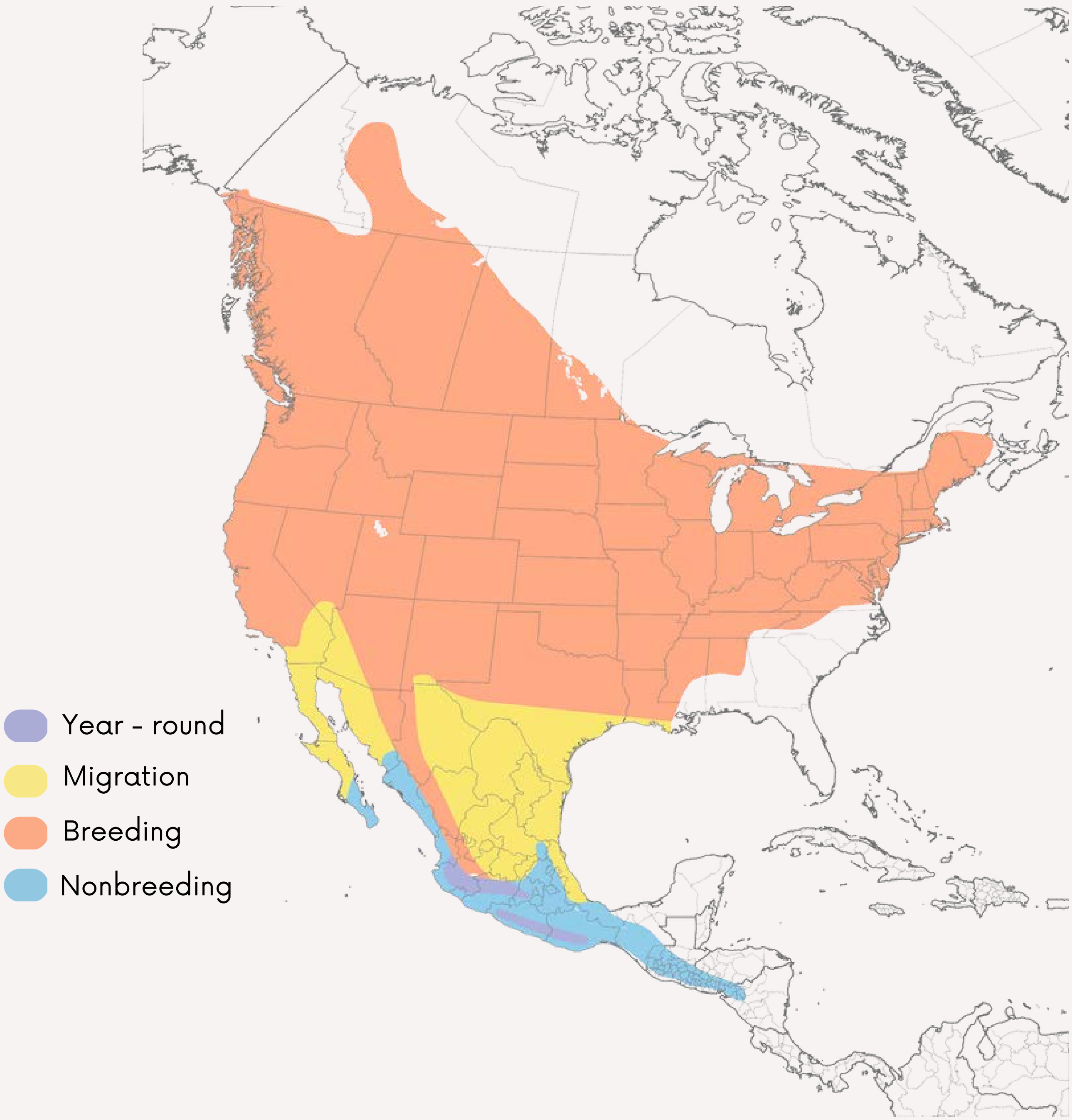


Figure 12. The distribution of the Warbling Vireo in North America (Gardali & Ballard, 2020)

2.2.6 Warbling Vireo

How does the migration for the Warbling Vireo change through time?

Table 6. The analysis of variance table produced on RStudio using ANCOVA analysis.

Analysis of Variance Table					
Source	**df**	**Sum Squared**	**Mean Squared**	**F value**	**Pr (>F)**
year	1	0.00004	0.00004	NaN	NaN
variable	**4**	**2.94367**	**0.73592**	**NaN**	**NaN**
year:variable	4	0.00015	0.00004	NaN	NaN
Residuals	0	0.00000	NaN		

The ANCOVA results show that the overall model is not significant, with all p-values being NaN. This is what occurred with the bald eagle data, due to there only being two comparable years, it is not possible to run the ANCOVA analysis.

How does the migration for the Warbling Vireo change through time?

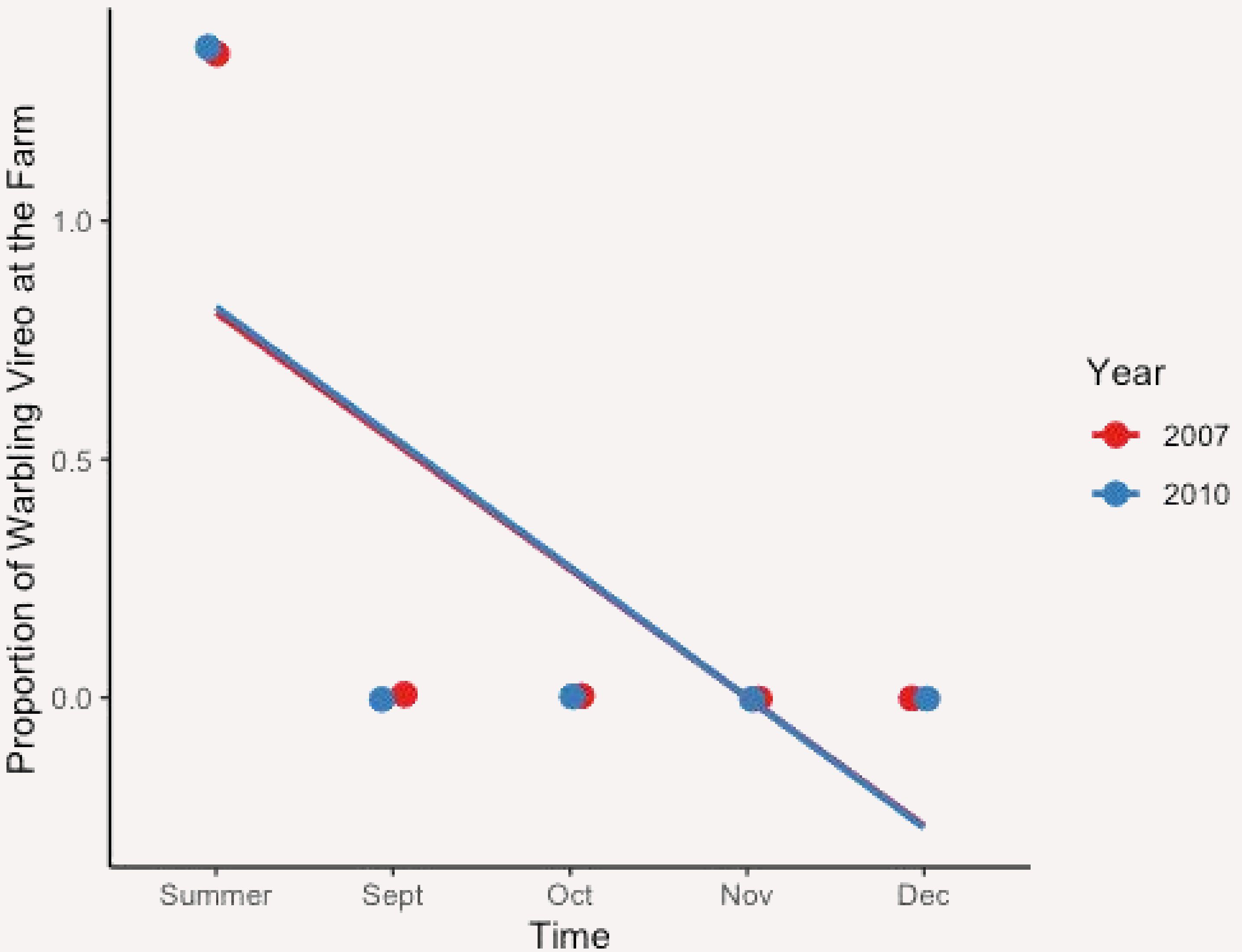


Figure 13. Plots of proportions of violet-green swallow at the UBC Farm over the years.

The figure shows no change in the slopes of the proportions of Warbling Vireo between the years 2007 and 2010.

What do these results say?

In conclusion, our analysis of migratory bird species at the UBC Farm provides valuable insights into the changes in their abundance and distribution over time. Our findings show changes in migration through the years for various migratory species which indicates that weather patterns can significantly affect the timing and pace of migration. Additionally, our analysis suggests that bird abundance and diversity can be influenced by changes in land use and management practices, highlighting the importance of implementing bird conservation strategies at the UBC Farm, such as installing more targetted bird boxes and creating a habitat for nesting and foraging.

By understanding how migratory birds are responding to changing environmental conditions, we can better protect and conserve these important species, as well as the habitats they depend on. Ultimately, our analysis contributes to the larger conversation about the importance of bird conservation and highlights the need for ongoing research and management efforts to ensure the survival and well-being of birds at the UBC Farm andbeyond .

Sooty Shearwaters flying over Avila Beach, California, USA (Harms, 2010)

3

Land-use

With the intensification of farmland management, there have been significant declines in general biodiversity, and bird abundance on farmlands has not been spared (Chamberlain et al., 2000). Mainstream industrial agriculture is a main driver of biodiversity loss throughout the world, as area of farmland and intensification of management are increasing (Zabel et al., 2019).

According to the Centre for Sustainable Food Systems (CSFS) at UBC (n.d.), the UBC Farm is the antithesis of these intense farming landscapes, as it is small-scale and holds a diversity of crops, a range of land-types, and thus supports a diversity of farmland organisms. The farm itself is 24-hectares in area and is created in a 90 year-old hemlock forest (CFSC, n.d.).

Dr. Kremen, a professor at UBC and an expert in working lands and biodiversity, describes the UBC Farm as an environment that explicitly promotes biodiversity for its complex land structure and diverse crop varieties (pers. comm., October 27, 2022).

Additionally, different bird species in British Columbia, require different nesting, feeding, and overwintering habitats (Wilson, 2004). Dr. Kremen (pers. comm., October 27, 2022) explains that a diversity of bird species on farmlands require many food sources, such as seeds, berries, fruits, soil organisms, insects, etc., and the UBC Farm is an example of land that provides all of these requirements. Furthermore, the Farm's variety in land-types and components (forest, crop fields with varying species and plants, heterogeneity, hedgerows, buildings, etc.) contribute to the bird diversity by providing nesting, overwintering, and breeding sites.

UBC Farm, n.d

3.1 Stations at the Farm

The station analysis performed was based on sampling regions delineated by Nature Vancouver. Although we use the terminology "station" to remain consistent with Nature Vancouver, it is important to note that stations are polygon areas on the farm rather than specific points. Table 7 outlines a description of each station.

Table 7. Bird survey stations and descriptions provided by Nature Vancouver as well as habitat classification as delineated by the ENVR 400 research team.

Station	Habitat Type	Description
1	Developed	Includes a parking lot, a tree with an eagles nest, and an entrance fields looking over wire fenced area that is sometimes used for chickens. Is along a small road just before a herb garden
2	Forest Edge	Includes a herb garden, greenhouse, children's garden, and a yurt. Encompasses the edge of trees before entering the forest and the fields below and edge of woodlot
3	Forest	Is the forest
4	Forest	Includes the forest where Christmas trees grows, arboretum trees, and surrounding shrubs. Includes a large work equipment storage barn and has immediate surrounding woods
5	Forest Edge	Includes a logger sports area, and a roadway heading back to the fields with forests on both sides
6	Forest Edge	Includes a First Nations Garden, cottonwood grove, blackberry bushes, and a small field edged by conifer grove
7	Farmscape	Includes big fields on both sides of pathway up to and including all of the conifer square-shaped woodlot, apple trees, and some forest edge
8	Farmscape	Includes large fields, two hedgerows, and visible forest
9	Farmscape	Includes fields northwards from hedgerows, blueberries, greenhouses, a large compost storage, hedgerows, and an oak tree

To simplify our analysis and make broader conclusions about the patterns observed at the farm, we categorized each of the nine stations into four habitat types. These habitat types were based on common features found at the farm and were qualitative in nature. We felt it important to include a wide variation of habitats for analysis, which would encompass features commonly found in urban regions as well as more natural environments - this being because the farm is a dynamic space that features urbanization, agriculture, and small forests. In addition to providing robust habitat groups for analysis, our categorization also tried to take into account the activities that occurred in each station and its proximity to other land use activities. For example, the developed group (station 1) was classified as such because of its proximity to the parking lot and construction in the Wesbrook area. Additionally, no other significant activities occurred in that region but it housed covered buildings intended for staff and guest activities.

Biodiversity Analysis

In order to determine biodiversity metrics such as species richness and shannon diversity, statistical methods were adapted from Flynn et al. (2008). Using the picante package in R (version 2022.12.0+353), diversity was analyzed using the Shannon-Weaver diversity index. This index can be used as a simple and intuitive tool for assessing biodiversity (Callaghan et al., 2020), and can be easily translated to a wider audience. Shannon diversity also takes into account abundance and evenness in its analysis, thus allowing it to be a sufficient measure of diversity for our purposes.

In addition, richness is an effective measure of biodiversity in a community or landscape. It has been shown to enhance ecosystem functioning and stability (Albrecht et al., 2021).

European goldfinch, photo by Andrea Lightfoot. Retrieved from: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.landfood.ubc.ca%2Findustrial-farms-toll-bird-diversity%2F&psig=AOvVaw1FOUKPEajjFCEuriyNUjyr&ust=1680666995126000&source=images&cd=vfe&ved=0CBEQjhxqFwoTCNjV-8uqj_4CFQAAAAAdAAAAABAJ

how does habitat type correlate with diversity and abundance?

Figure 14. Yearly distribution of the top three species found at a) forest landscapes and b) human modified landscapes observed at the UBC Farm from 2007-2022.

Species abundance

Average observations in the forest habitats are much lower than forest edge, farmscape, and developed (Figure 14), but this landscape also has the least variability in observations over the years and values have seen relatively low change from the start of the study period (2007) to the end (2022). The forest edge habitat is the only habitat that is exhibiting a decreasing trend (with the exception of peaks during 2012 and 2020 - Covid year). Developed and agricultural habitats are variable throughout the years but they stay consistent in having relatively high bird abundances among the four habitat types.

There is a high variability amongst the species composition at each habitat type, showing that some birds are preferentially selecting habitat. Some birds, such as the Pine siskin (*Spinus pinus*), European starling (*Sturnus vulgaris*) and Dark-eyed junco (*Junco hyemalis*) are dominating at most habitat types, which follows the patterns of these birds being highly generalist species and, particularly in the case of the Dark-eyed junco, have stable populations within BC. Looking at the variability between years at each habitat type, developed (number of unique species (n)=15) and forest edges (n=18) generally have a consistent species composition over the 16 year timescale while farmscapes and forests are greater in diversity in terms of dominating species (n=21; n=28 respectively). While house finches are likely found at all landscapes, they appear to only dominate in the developed habitat. Additionally, the northwestern/American crow and dark-eyed junco appears to do very well in farmscapes and pine siskin in forest edges. The forest habitat is unique because it remains highly variable over the 16 year period. We might be able to say that high numbers of Golden-crowned kinglet utilise the habitat but it is hard to conclude they are dominating because there are consistently less than 25 observations seen each year.

Species diversity

All stations have a shannon diversity above 2.0 and can be categorized as having high diversity (Figure 15). Station 1 and 2 have the highest diversity values (H = 2.81; H = 2.85) and station 9 and 3 have the lowest diversity values (H = 2.50; H = 2.56). It is important to note that the highest and lowest values differ by less than 0.5 so it is challenging to make any conclusive statements from our results. These patterns differ slightly when the same analysis is performed with habitat groupings. Developed landscapes have relatively low diversity (H = 2.81). There are slight differences in the highest diversity values, with forest edge groups having high diversity and farmscapes as the second highest diversity value (H = 3.14, H = 2.91). Species richness does not vary greatly between stations (Table 8). Values range from 60 to 83 with the highest values associated with station 2 and the lowest with station 5. Both are forest edge habitat, although station 5 is in closer proximity to coniferous forest habitats.

3.2.1 Species Abundance, Diversity, and Richness

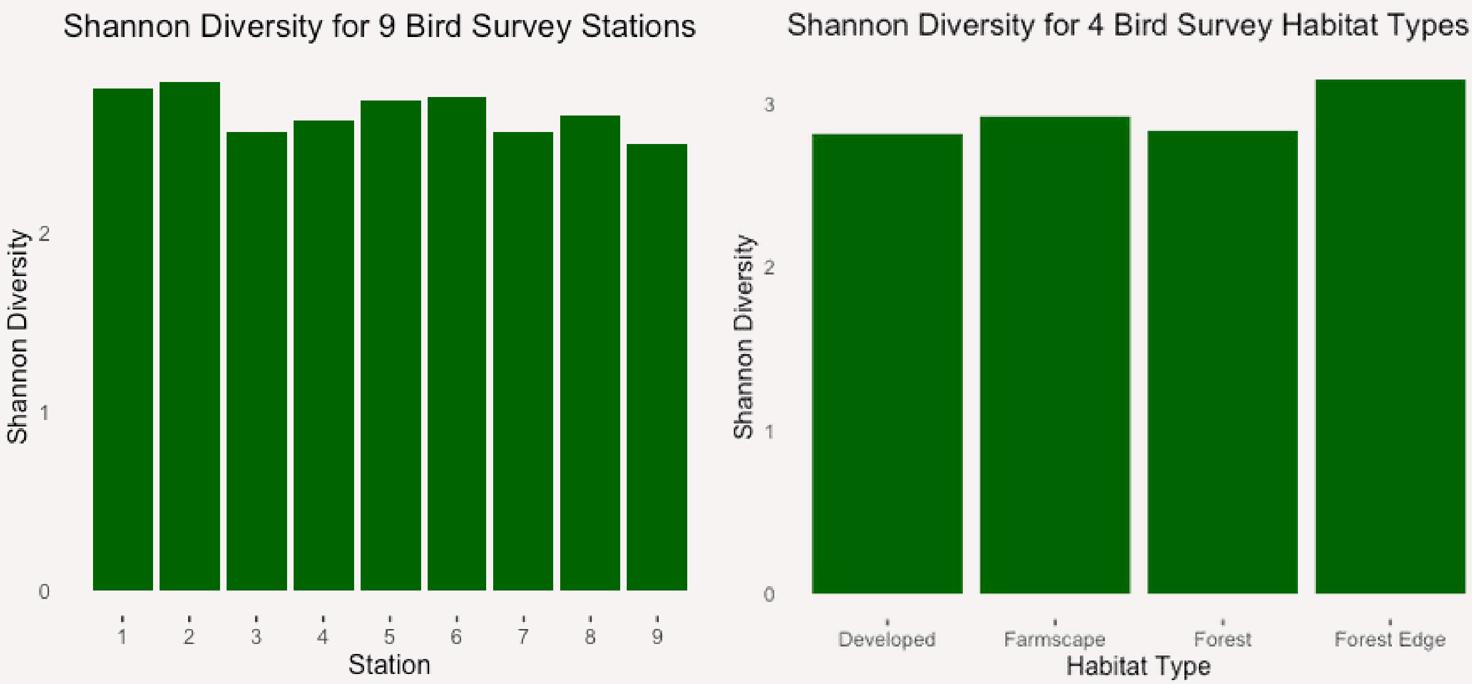


Figure 15. Shannon-Weaver diversity index at a) nine Nature Vancouver bird survey stations and b) four habitat types

Table 8. Species richness at nine Nature Vancouver bird survey stations

Station	Species Richness	Habitat Type
1	81	Developed
2	81	Forest Edge
3	83	Forest
4	79	Forest
5	60	Forest Edge
6	67	Forest Edge
7	73	Farmscape
8	70	Farmscape
9	71	Farmscape

3.2.1 Species Abundance, Diversity, and Richness

how does habitat type correlate with diversity and abundance?

Figure 16. Species richness for three time periods. Richness were calculated and averaged for each 5 year interval. Reference to habitat type is also provided.

These results compound all 16 years of data but by looking at richness in 5-year intervals, we're able to better observe the changes of richness over a longer timescale. Species richness has been incredibly variable from 2007-2022. The comparison of three time periods shows the transition from low species richness to high species richness in forest edge habitat and an inverse response in forest habitats and farmscapes, particularly in stations 4, 6 and 8.

how does habitat type correlate with diversity and abundance?

The amount of variability we see between habitat types suggests that birds are preferentially selecting habitats and the farm is able to support high populations of a variety of species. The year to year differences in community composition could be due to smaller changes on the farm, such as crop and flower production, bird migratory patterns, or other species interactions. Although we can see dominant species in a given year, the variability in observations between each year can also skew our results, for example the high abundance of european starling in the forest habitat in 2011 greatly skews the data. The dark-eyed junco is the second most abundant species observed at the farm but does not appear to have high numbers of abundance at the developed landscapes. Because oftentimes birds adapted to coniferous forests tend avoid developed regions (Jokimaki & Suhonen, 1998), we would expect to see the dark-eyed junco utilizing most habitat types with the expectation of the developed type, and the lack of juncos on developed lands agree with these trends.

The low abundance observed in the forest habitat could be indicative of the challenges that are associated with surveying birds in heavily canopied region. Although the use of the Merlin app can mitigate some sampling error, it's important to note that these results may be skewed by the limitations of human sampling. Despite this, studies have shown that migratory birds preferentially select for fragmented habitats (Buron et al., 2022), which may be another reason for the low abundance at forest landscapes in comparison to forest edges.

Ultimately, there are no clear trends where we see certain groups of birds occupying certain land types so we cannot make any conclusions about habitat use based on taxonomic groups. For example, house finches are only seen in the developed landscape (with only a few exceptions) but purple finch can be seen in a variety of habitat types. These inconclusive patterns allude to the idea that other ways to group birds such as feeding behaviours or nesting requirements may be more effective in drawing broader conclusions. The patterns seen in individual birds between habitat types shows that there is value in categorizing the nine sampling stations but a more quantitative classification could be utilized to see clearer trends. The Jaccard testing reveals that patterns of total species composition do not necessarily follow the patterns we would expect by visually classifying the different stations.

Are there significant trends of population changes observed with specific habitat types or stations?

There are no clear patterns of habitat types having significant changes in species abundance over the 16 year period. 29 unique species observed long-term changes in population sizes. At all nine stations, population increases were observed but all stations with the exception of station 4 also observed population decreases. Station 1 (developed habitat type) and 8 (farmscape) supported the greatest number of population increases with six species growing in abundance at both stations. These stations also had decreasing populations, with three species declining at station one and two species declining at station 8. Station 5 (forest edge) observed the most decreases in population and station 4 (forest) only observed population increases.

When comparing population trends at the farm to British Columbia's trends of increasing and decreasing populations (while excluding stable or unknown trends), there are six species at varying stations that do not follow expected provincial trends (Table 9). These include the Rufous hummingbird, Pileated woodpecker, Barn swallow, Downy woodpecker, Pacific-slope flycatcher and Bewick's wren. For the Pileated woodpecker, this may be notable because while there is a significant decrease in population at station 1, a significant increase is observed at station 6 (forest edge), which is what we would expect based on BC statistics (BC Breeding Bird Atlas). The other five species only have one significant change in population at one station, therefore it is challenging to determine if there are unique population changes occurring at the farm for those birds.

Table 9. Summary of significant changes in bird populations that differ from BC population trends

Scientific Name	Common Name	Station	Slope	P-value	BC Trend
Selasphorus rufus	Rufous Hummingbird	5	-2.347231	3.41E-02	Increase
Picoides pubescens	Pileated Woodpecker	1	-3.501313	3.53E-03	Increase
Picoides pubescens	Pileated Woodpecker	6	2.192683	4.57E-02	Increase
Picoides pubescens	Downy Woodpecker	3	3.209065	6.31E-03	Decrease
Picoides pubescens	Downy Woodpecker	2	2.804726	1.40E-02	Decrease
Thryomanes bewickii	Bewick's Wren	8	2.910426	1.14E-02	Decrease
Empidonax difficilis	Pacific-slope Flycatcher	4	2.150254	4.95E-02	Decrease

3.3.1 Birds of Interest

Are there significant trends of population changes observed with specific habitat types or stations?

The following section of the report aims to provide a more detailed look at the population changes of select bird species at the farm. While there were 28 occurrences of significant population change, a focus will be placed on species with significant changes at two or more stations. Additionally, birds of general interest to our group were selected.

To find populations with significant trends, a linear regression analysis was performed. The bird data was aggregated to find the average abundance per year for each species and station. A linear model was then fitted to the averaged bird count against 16 years (2007-2022) for each bird at each station. Statistically significant results ($p < 0.05$) were stored in a separate data frame and species of interests were presented in the results. A full list of bird populations exhibiting significant changes at the farm can be found in the appendix.

 UBC Farm, n.d

Are there significant trends of population changes observed with specific habitat types or stations?

Bald Eagle

A bald eagle found roosting (Allgood & Smith, 2018).

Haliaeetus leucocephalus

BC list: Yellow
General Status Canada: 4 - Secure

The bald eagle species have extensive migration in North America, breeding in Canada and northern America before migrating south for the winter (B.C. Conservation Data Centre, 2011). In British Columbia, they can be found throughout the province, especially near coastal regions or regions with rivers and lakeshores (Barry, 2015). Despite no population-level threats, individuals may still be vulnerable (Barry, 2015).

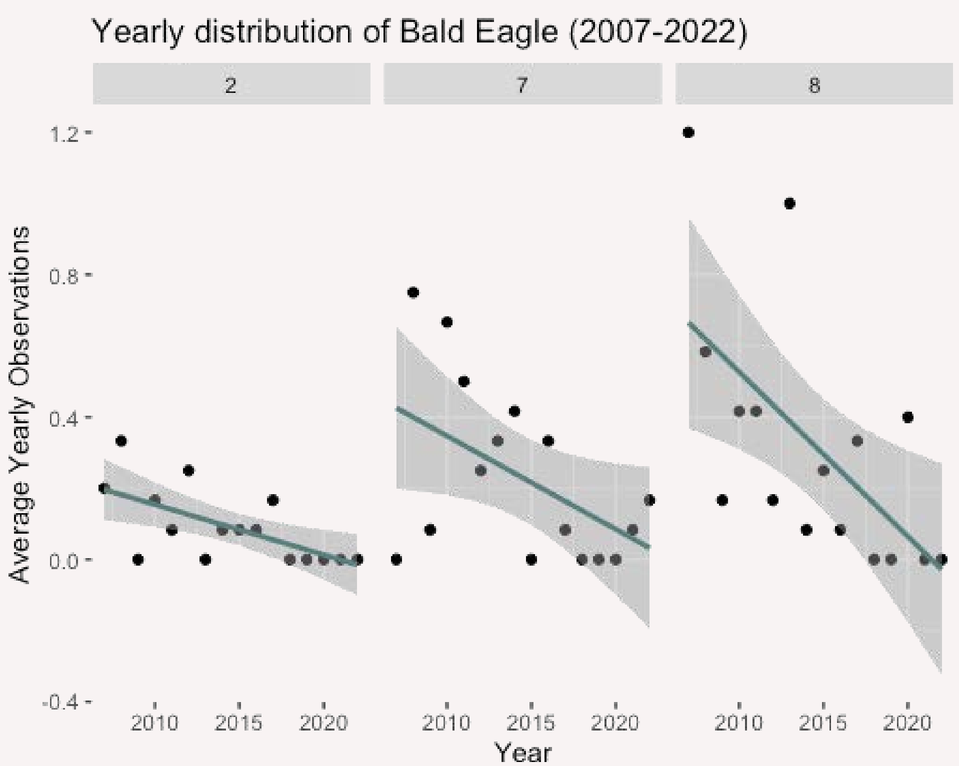


Figure 17. Yearly distribution of the bald eagle from 2007-2022 at three different stations. Grey shading represents 95% CI.

This figure provides a visualization of the bald eagles at the farm that is experiencing population changes. The Bald eagle (Haliaeetus leucocephalus) has experienced a significant decrease in population at multiple stations (forest edge and farmscape). Station 2 has the highest rate of decrease (-3.11 individuals/year) and station 7 has the lowest rate of decrease (-2.18 individuals/year). Although these slopes are relatively steep, average observations have generally been less than one since 2007 so small reductions in population can result in zero population counts.

Are there significant trends of population changes observed with specific habitat types or stations?

Anna's Hummingbird

Steven Mlodinow, Macaulay Library. Retrieved from: https://www.allaboutbirds.org/guide/Annas_Hummingbird/photo-gallery/303891201

Calypte anna

BC list: Yellow
General Status Canada: 4 - Secure

The Anna's hummingbird are the most common hummingbird in North America's west coast (The Cornell Lab, n.d). They are unique because these hummingbirds, unlike most, do not migrate. In British Columbia, they have been associated with human habitats and populations have generally increased in urban regions as the increase of feeders and calcium salts associated with population growth increases.

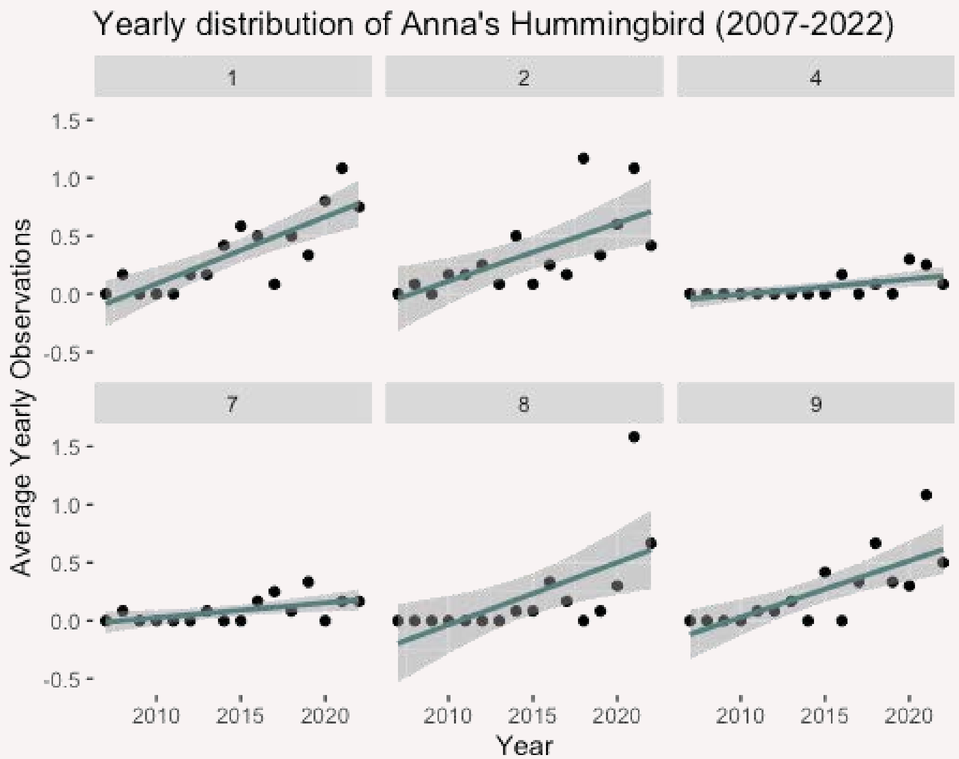


Figure 18. Yearly distribution of the Anna's hummingbird from 2007-2022 at six different stations. Grey shading represents 95% CI.

This figure provides a visualization of Anna's hummingbird populations at the farm that are experiencing population changes. The Anna's hummingbird is a species that has seen one of the greatest significant population changes at the farm. 6 stations show an increase in average yearly observations. Station 1 (developed) has been the site with the greatest increase (5.77 individuals/year) and other stations such as 2 (forest edge), 8, and 9 (farmscape). The rate of increase in station 4 and 7 are comparatively low (1.31 individuals/year; 1.27 individuals/year) and these are represented by forest and farmscape habitat types.

Are there significant trends of population changes observed with specific habitat types or stations?

Pileated Woodpecker

Lori McDonald, Macaulay Library. Retrieved from: https://www.allaboutbirds.org/guide/Pileated_Woodpecker/photo-gallery/60408751

Dryocopus pileatus

BC list: Yellow
General Status Canada: 4 - Secure

The pileated woodpecker is one of the largest woodpeckers in North America. They are often found foraging or roosting in large dead or downed trees of deciduous and coniferous forests. These are not migratory birds. Pileated woodpeckers stay in pairs and defend their territory year round. Their populations have steadily increased since 1966 although forest clearing and development have been identified as risks to the bird species (The Cornell Lab, n.d.)

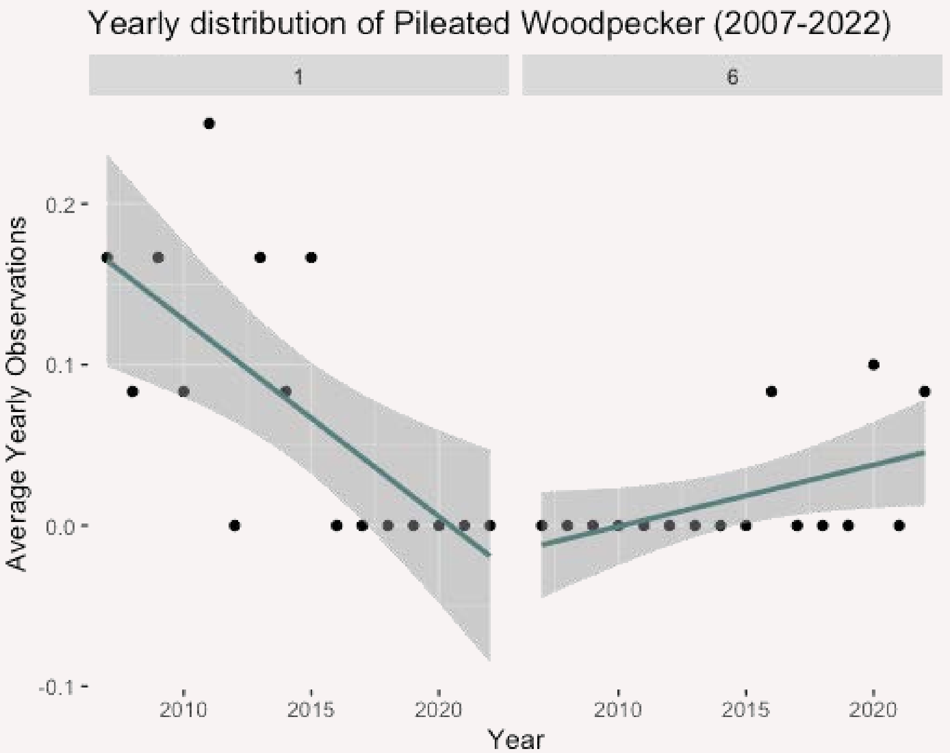


Figure 19. Yearly distribution of the pileated woodpecker from 2007-2022 at two different stations. Grey shading represents 95% CI.

This figure provides a visualization of pileated woodpecker populations at the farm that are experiencing population changes. The pileated woodpecker is unique because of the very different population trends being observed at different stations at the farm. Station 1 (developed) transitions from relatively high abundance until populations drop to 0 after 2015. Conversely, populations rise from 0 after 2015 at station 6 (forest edge).

Are there significant trends of population changes observed with specific habitat types or stations?

Violet-green Swallow

Alex Lamoreaux, Macaulay library. Retrieved from: https://www.allaboutbirds.org/guide/Violet-green_Swallow/photo-gallery/305585021

Tachycineta thalassina

BC list: Yellow
General Status Canada: 4 - Secure

The violet-green swallow is a small songbird that forages in large groups, often over fields and open woodlands. They are long distant migrants with distributions spanning Alaska to Mexico and population trends vary regionally. In British Columbia, violet-green swallow populations have generally increased while in much of western USA, populations have been slightly decreasing. This is due to the general threats that insecticides and climate change pose to aerial insectivores.

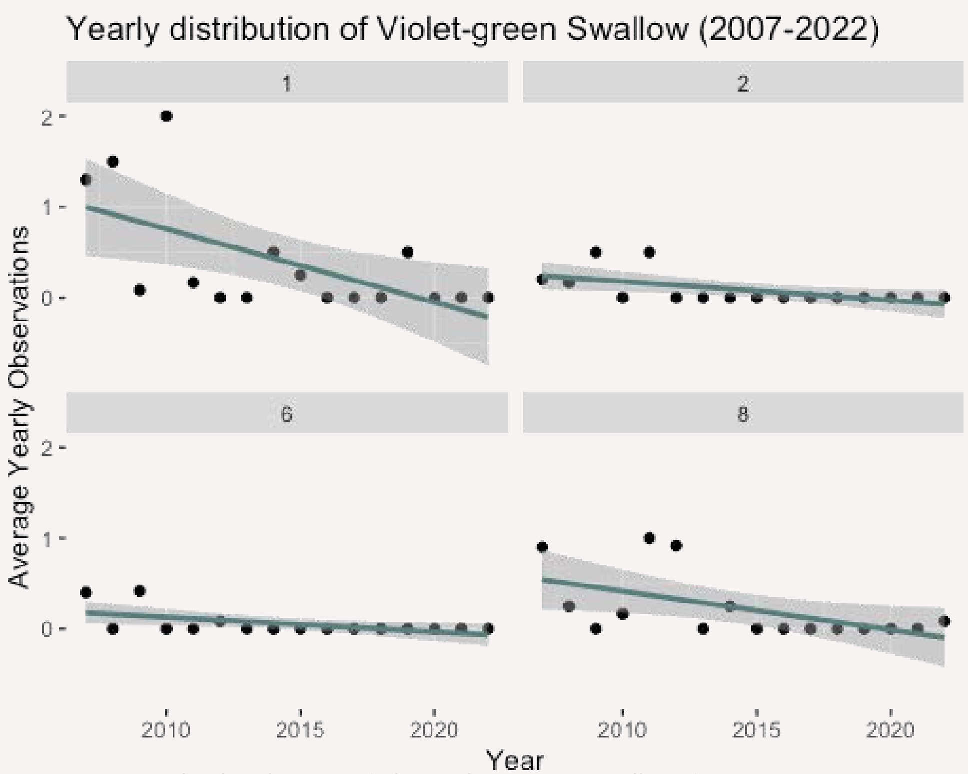


Figure 20. Yearly distribution of the violet-green swallow from 2007-2022 at two different stations. Grey shading represents 95% CI.

The violet-green swallow (latin name) has experienced significant changes in population at four stations (developed, forest edge, and farmscape). Station 1 has the highest rate of decrease (-2.84 individuals/year) and station 8 and 6 have the lowest rates of decrease (-2.48 individuals/year; -2.49 individuals/year). Observations at station 2, 6, and 8 have been consistently around 0 since 2013.

Are there significant trends of population changes observed with specific habitat types or stations?

What do these results say?

These results provide an insight into changes in individual bird abundance over a 16 year period. While there is inconclusive evidence to suggest that a specific land type has been more prone to population change, the discrepancy between BC's population trend for the Pileated woodpecker and the trends observed at station 1 further add to the conversation about the impact of development on coniferous adapted birds. These birds require large and tall trees for nesting and are an important species for nutrient cycling in forests.

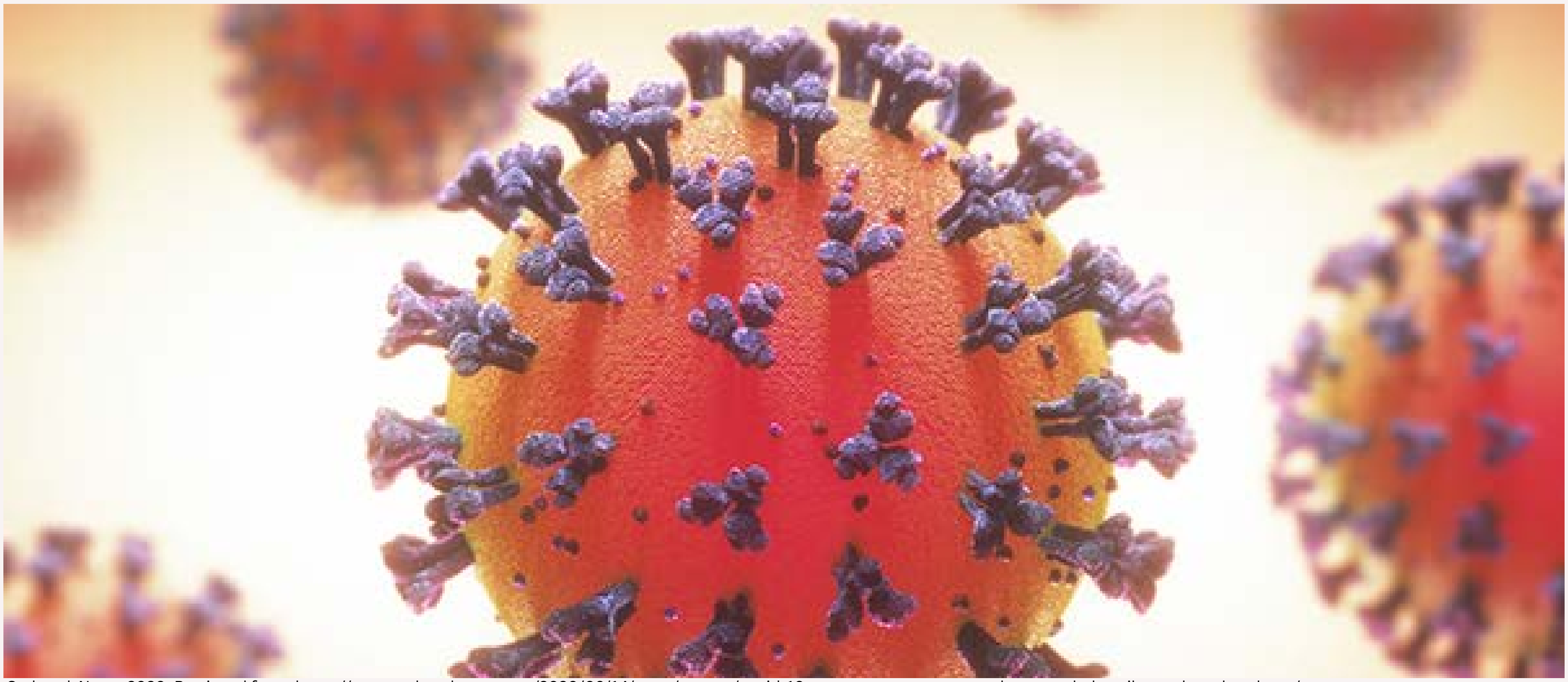
Trends of the bird diversity loss from the 1960s to 1980s in Europe determined that insectivorous birds experienced more negative trends than other feeding-type birds (Reif et al., 2021). Reif et al. claims that this is due to the decrease in food sources for these birds, which correlates to the increase of monoculture landscapes and organism-depleted soils (2021). According to Dr. Claire Kremen, as insectivorous birds are important for controlling pests, this loss can result in increased crop pests and increased use of pesticides (pers. comm., October 27, 2022). While a large percentage of population decreases are insectivorous birds, around 80% of significant population changes at the farm are population increases, and insectivorous birds are represented in these increases. Pests at the UBC Farm are controlled using beneficial insects and weeds are controlled mechanically or manually (UBC Farm, n.d), which unlike other farms that utilize harmful pesticides and insecticides, should benefit bird populations, particularly insectivorous birds. This analysis would be bolstered with an understanding of the land use changes that have occurred at the farm over the years. With this information, conclusions can be made between the population trends and farm activities.

4

COVID-19

February 2020 saw the start of what would become an unprecedented pandemic. Lockdowns prevented people from going about their usual routine and many businesses and schools went online, and the UBC farm halted most of its activities. However, when everyone was inside, nature became quite active, especially the birds. Noise pollution greatly affects a bird's ability to communicate effectively with one another, thus when streets became quiet, birds were found to produce songs more frequently and of higher quality at reduced amplitudes, greatly increasing the travel distance of the songs (Derryberry et al., 2020)

Additionally, other studies have found a relationship between a reduction in human activities with increased bird counts by citizen scientists using eBird (Schrimpf et al., 2021). This relationship was particularly strong in developed areas, near roads and industrial noise. This is a similar environment to that of the UBC farm as road traffic is clearly heard throughout and has had recent developments before the COVID-19 pandemic began.



Stabroek News, 2020, Retrieved from: https://www.stabroeknews.com/2020/08/14/news/guyana/covid-19-emergency-measures-to-be-extended-until-month-end-anthony/

4.1 Methods

Initial data preparation was required prior to analysis. This involved isolating the "date", "bird", "total", and "year" columns as all other columns were unnecessary. Since only total count was used, repeated rows for each of the 9 stations were present and were removed by keeping rows with distinct dates and birds so as to not have duplicate data. Lastly, only birds that were present for at least one year were kept.

To avoid analyzing all 133 birds within the data after preparation, we decided to perform significance testing through linear regression as a filter for further analysis. This involved using a linear regression model of the monthly total count as the dependent variable and year as the independent variable. If the p-value was less than or equal to 0.05, it was then corrected for type I errors that may be present in multiple tests of the same data using the Bonferroni correction method. If the p-value was still within a confidence interval of 95%, the bird was determined to have a significant change in abundance over the 16-year period. After significance testing was finished, "Kinglet Species" and "American Kestrel" were analyzed to be significant but very few observations were above zero throughout the data and as a consequence were removed from the list of significant birds. The initial data was then filtered to only include significant species.

To get an idea of the yearly trend of the birds, the yearly mean abundance was plotted against the year (figure 21). The mean abundance of every bird, every year was first calculated. Due to some birds having missing data, NA values were present and were changed to zero. The scatter plot and all subsequent plots were generated using the ggplot2 package.

In order to determine whether there was a change in abundance before the COVID-19 pandemic (2018-2019), during (2020-2021), and after (2022), the mean abundance of each bird for the respective groups of years was calculated. A bar graph was then generated for the time frame against the mean abundance (figure 22). Another bar graph was created for the sum of the abundance of all birds divided by the number of years each time frame included (figure 23).

4.2 Results

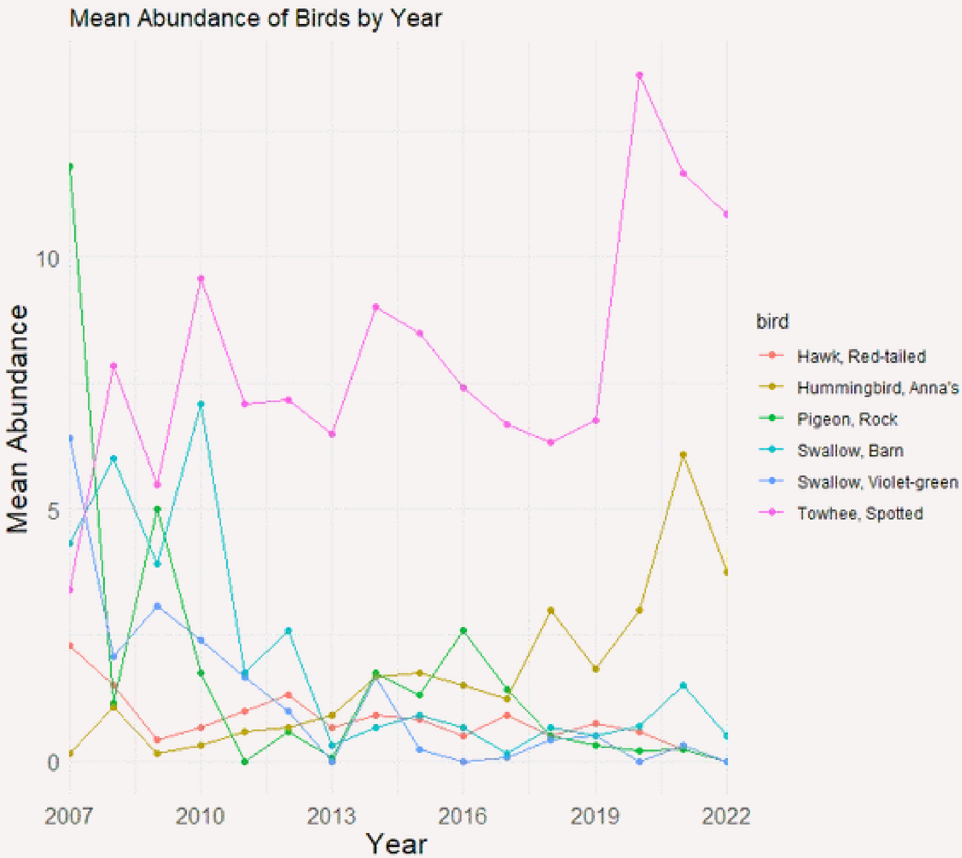


Table. 10 p-values of significant birds

Bird	p-value
Hawk, Red-tailed (*Buteo jamaicensis*)	0.02131164
Pigeon, Rock (*Columba livia*)	0.02131164
Swallow, Violet-green (*Tachycineta thalassina*)	0.02131164
Hummingbird, Anna's (*Calypte anna*)	0.02131164
Swallow, Barn (*Petrochelidon pyrrhonota*)	0.02131164
Towhee, Spotted (*Pipilo maculatus*)	0.02131164

Figure 21. Mean abundance of significant birds from 2007-2022

Significance testing through linear regression and Bonferroni correction as well as removing the "Kinglet Species" and "American Kestrel" resulted in six total species being regarded as having a significant change in abundance from 2007 to 2022. These are the Red-tailed hawk *(Buteo jamaicensis)*, Anna's Hummingbird *(Calypte anna)*, Rock pigeon *(Columba livia)*, Barn swallow *(Petrochelidon pyrrhonota)*, Violet-green swallow *(Tachycineta thalassina)*, and Spotted towhee *(Pipilo maculatus)*. Of these birds, only Anna's hummingbird (0.167 in 2007 to 3.75 in 2022) and Spotted towhee (3.40 in 2007 to 10.83 in 2022) had an observed positive trend with time, while the Red-tailed hawk (2.30 in 2007 to 0 in 2022), Rock pigeon (11.80 in 2007 to 0 in 2022), Barn swallow (4.33 in 2007 to 0.50 in 2022), and the Violet-green swallow (6.40 in 2007 to 0 in 2022) all experienced a negative trend with time.

4.2 Results

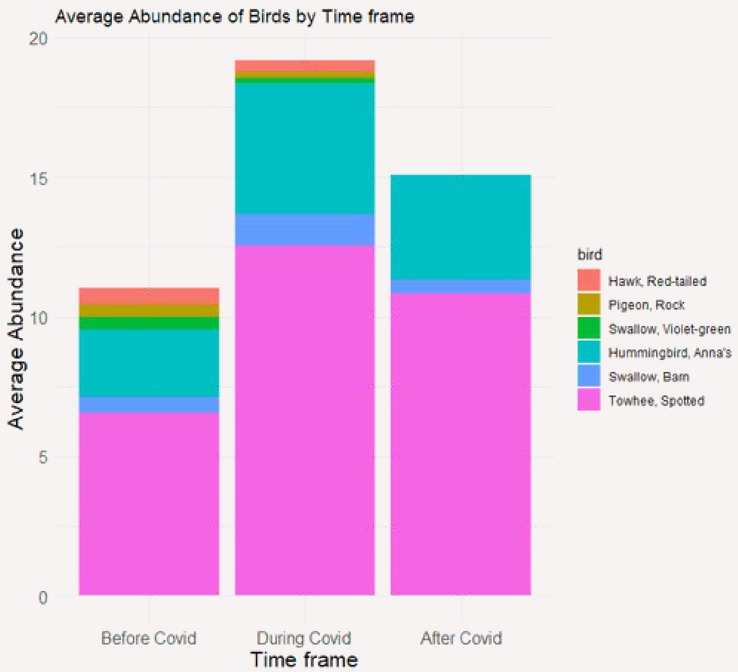


Figure 22. Mean abundance of significant birds before Covid (2018-2019), during Covid (2020-2021), and after Covid (2022).

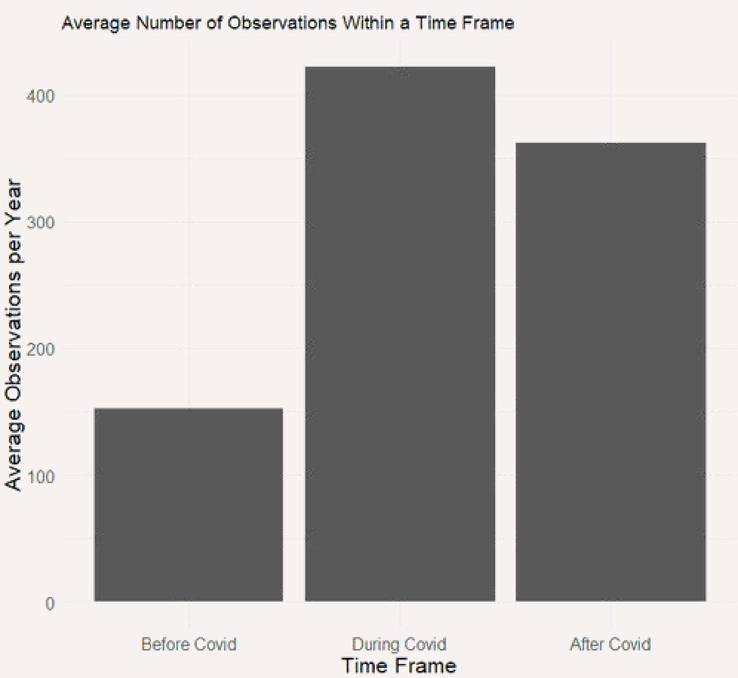


Figure 23. Mean total observations of all significant birds per year before Covid (2018-2019), during Covid (2020-2021), and after Covid (2022).

Between the three time frames, "During Covid" had the highest total mean abundance with a value of 19.18 compared to a mean abundance of 11.04 "Before Covid", and a mean abundance of 15.08 "After Covid". (Respective to before Covid, during Covid, and after Covid) The Red-tailed hawk (0.625, 0.409, 0), Rock pigeon (0.417, 0.227, 0), Violet-green swallow (0.458, 0.18, 0), and Barn swallow (0.583, 1.14, 0.05), all experienced declines in every time frame while Anna's hummingbird (2.417, 4.68, 3.75) and Spotted towhee (6.54, 12.55, 10.83) were observed to increase from before Covid to during Covid and decrease after Covid.

The total abundance of all the birds corrected for the number of years in each category shows a similar trend. Before Covid average observations per year were 132.5, during Covid it rose to 211.0, and after Covid, it decreased to 181.0.

However, it is important to note that these results may not be statistically significant as a t-test was not performed due to the nature of the data.

4.3 Discussion

Although we can not conclude why certain species are decreasing or increasing in mean abundance from 2007-2022 in relation to the COVID-19 pandemic, we can infer that we are currently at the start of a potential species regime change if trends continue (figure 21). Among the species analyzed, some have seen similar population trends in North America to what we have observed on the UBC farm, such as the Red-tailed hawk, whose migration populations have been observed to be decreasing in size (McClure et al., 2022). However, other studies have shown conflicting results, suggesting an increase in numbers within their breeding and wintering ranges and in Northwest USA (C. J. W., McClure, et al., 2023; Rosenberg et al., 2019). Additionally, Anna's hummingbird has been seen to be increasing in abundance since 1970, most prominently in recent years within the northern and western regions of their current range (English et al., 2021). Barn swallow abundance has also been seen to be decreasing in Canada due to decreasing migration numbers and warmer temperatures during their breeding season (Zhao et al., 2022). Other aerial insectivores, such as the Violet-green swallow have seen similar patterns due to decreases in prey, habitat loss, and phenological changes. However, it is currently not possible to determine whether these factors are significantly impactful on the farm.

Despite there being no statistically significant correlation between years before, during, and after the COVID-19 pandemic, there is a potential pattern here. Years during the pandemic had a noticeable increase in total mean abundance even though the Rock pigeon, Red-tailed hawk, and Violet-green swallow decreased significantly and eventually were not seen at all after. Birds such as the Spotted towhee that experienced an increase during the pandemic measures and a decrease after lockdowns ended may indicate that some species are more sensitive to human activity. Additionally, a similar trend to that of figure 22 can be seen in figure 23. However, more research is needed to conclude if human activity is at all correlated to species abundance and may be a point of interest for future analysis.

Conclusions

The UBC Farm is a research farm that supports agroecology and education (UBC Farm Centre for Sustainable Food Systems, n.d.). The UBC Farm is a unique place that provides an opportunity to monitor biodiversity, including mammals, birds, plants, and insects ("A Living Laboratory for Biodiversity Monitoring at UBC Farm," n.d.). By studying the birds at the UBC Farm, we can begin to understand their changes in diversity and abundance as well as how factors such as the COVID-19 lockdowns and varying land-use can have an effect.

UBC Farm, n.d

UBC Farm, n.d

Through our analysis, we were able to gain a better understanding of how birds at the UBC Farm are affected by COVID-19 lockdowns and different land uses, as well as how their migrational patterns vary throughout the years. We can better predict and manage future potential impacts on diversity and the Farm's ecosystem health.

Monitoring changes in bird migration patterns at the UBC Farm can guide us to pose further questions and study potential causes such as changing environmental conditions that could be affecting migratory bird abundance and distribution.

Through understanding how birds are affected by different land types, UBC Farm as well as other researchers can be informed about better land management practices, benefiting bird populations as well as the overall biodiversity.

Additionally, investigating how bird abundance changed during the COVID-19 pandemic can provide insights into the impacts of anthropogenic activity on the bird abundance and habitat use.

UBC Farm, n.d

From Findings to Action: Next Steps for Bird Monitoring at the UBC Farm

Despite all the work we have done, there was so much more we wanted to do with this dataset that we were unable to.

Firstly, our team members were very eager to partner with Musqueam knowledge, language, and story through a bird tour at the UBC Farm. Unfortunately, this was not feasible for us and our project. We consulted with Lerato Chondoma, the associate director of the Indigenous Research Support Initiative (IRSI), and while she showed interest in our project and our prospective partnership with Indigenous knowledge holders, she reminded us that Musqueam as a Nation and Musqueam individuals are overwhelmed with requests like this from the university.

Moreover, because our involvement in the project is discrete, there will be a challenge in forming connections between Musqueam and the ENVR 400 course. As we reached out to more people who might help us with this part of the project, we came back with no responses. After the conversation with Lerato and conversations with our supervisor, Michael Lipsen, we recommend that the ENVR 400 course (and Environmental Sciences as a program) create more concrete relationships with Indigenous groups, knowledge systems, and students, so that ENVR 400 students can easily approach these kinds of projects. This will moreover help Indigenous students in the course feel more supported. Additionally, we recommend that the UBC Farm and the Musqueam Garden improve communication between one another to further facilitate potential Indigenous knowledge education.

Additionally, our members wanted to incorporate an interactive map to publish on the UBC Farm website that would allow for engagement from the public as well as volunteers from Nature Vancouver who may have a keen interest in the bird abundance and diversity changes over the years. We had difficulty executing the map effectively and wish this was something we had more time and resources to accomplish.

Our team found that the dataset that we had access to was incredibly extensive and presented numerous opportunities for analysis and further study. We hope to see Nature Vancouver continue the monthly bird surveys throughout the years in order to maintain this valuable resource. Consistent long-term data collection can be difficult and rare but provides an incredible foundation for future research.

From Findings to Action: Next Steps for Bird Monitoring at the UBC Farm

Potential Areas of Research for Prospective Students

- Studying general population dynamics of birds at the UBC Farm
  - As we focused on the three overarching topics: Migration, Land-use, and Covid-19, there were many species of birds that may not have had any changes in migration or changes due to land use or COVID-19. Therefore, using resources such as COSEWIC, conducting some general literature review on birds of BC, and flagging various birds of interest to conduct a general analysis of population changes over time is useful.
- Studying weather and migration dynamics effects on birds at the UBC Farm
  - Although we looked at changes in migratory birds as well as the effects of weather, we did not look at how the weather could affect the migratory birds at the UBC Farm. For example, temperature changes due to climate change can impact ranges as well as bird migratory phenology.
  - Other climate-driven weather events that can be studied include changes in precipitation and the frequency and intensity of storm activity.
- Analyzing auditory data of birds
  - Audio data can improve sampling bias caused by poor visibility in heavily canopied regions. It can also allow for continuous data collection, which would be beneficial when trying to correlate results with other continuous data (i.e. temperature and precipitation).

Bird Conservation Recommendations for the UBC Farm

- Installation of bird-boxes
  - Installing more bird-boxes can help provide nesting opportunities for species that seem to be declining at the UBC farm such as the Violet-green Swallow.
- Heterogeneous landscapes and old growth forests
  - Many bird species found at the farm are commonly associated with long-lived coniferous and deciduous trees, thus the persistence of these forests are key to stable bird populations.
  - Birds at the farm also show favourability for heterogenous and diversified landscapes, which include forest edges, hedgerows, and shrubbery.

Acknowledgments

The partner working with us on the bird biodiversity analysis is Dr. Matthew Mitchell. Dr. Mitchell works in the Faculty of Land and Food Systems at UBC and leads the UBC Farm biodiversity monitoring program. We would like to thank Matt Mitchell for his valuable guidance and support throughout this project. We would also like to acknowledge Nature Vancouver and its volunteers for collecting the long-term bird survey data as well as Dr. Claire Kremen for providing valuable knowledge on working lands and biodiversity in agricultural systems. We would also like to acknowledge and thank Lerato Chondoma for taking the time to talk with our team and help us understand the nuances of working with Musqueam and other Indigenous knowledge holders. We would also like to extend our gratitude to Michael Lipsen, Tara Ivanochko, and Christina Draegar for their assistance and guidance.

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Appendix

Table A1. Migratory bird slopes from a linear regression analysis.

Bird	Year	Slope
Goldfinch, American	2007	-0.482373906
Goldfinch, American	2008	-0.836496456
Goldfinch, American	2010	-0.080284958
Goldfinch, American	2011	-0.033516757
Goldfinch, American	2012	0.202046965
Goldfinch, American	2013	-1.367388814
Goldfinch, American	2014	-0.248725165
Goldfinch, American	2015	-0.837928669
Goldfinch, American	2016	0.041107309
Goldfinch, American	2017	-0.438199766
Goldfinch, American	2018	0.201767906
Goldfinch, American	2019	0.195363656
Goldfinch, American	2020	-0.470817286
Goldfinch, American	2021	-0.885231026
Sparrow, White-crowned	2007	-0.591078714
Sparrow, White-crowned	2008	-0.058798793
Sparrow, White-crowned	2010	0.001113322
Sparrow, White-crowned	2014	-0.395229606
Sparrow, White-crowned	2015	0.017795137
Sparrow, White-crowned	2016	0.219309869
Sparrow, White-crowned	2017	0.112743495
Sparrow, White-crowned	2018	0.134386552
Sparrow, White-crowned	2019	-0.006853764
Sparrow, White-crowned	2020	0.134235102
Sparrow, White-crowned	2021	-0.036839964
Sparrow, White-crowned	2022	0.025247601
Swallow, Barn	2007	-0.669731994
Swallow, Barn	2008	-0.674478855
Swallow, Barn	2010	-0.639489652
Swallow, Barn	2011	-0.856890918
Swallow, Barn	2015	-1.213974531
Swallow, Barn	2020	-1.367388814
Swallow, Barn	2021	-1.000025378
Swallow, Violet-green	2007	-0.700003565
Swallow, Violet-green	2008	-0.963082883
Swallow, Violet-green	2014	-0.936255331
Thrush, Swainson's	2007	-0.687301127
Towhee, Spotted	2007	-0.281367095
Towhee, Spotted	2008	-0.100631671
Towhee, Spotted	2010	0.341863195
Towhee, Spotted	2011	0.365792491
Towhee, Spotted	2013	0.483479737
Towhee, Spotted	2014	-0.219234749
Towhee, Spotted	2015	-0.287240388
Towhee, Spotted	2016	-0.003784824
Towhee, Spotted	2017	0.502754079
Towhee, Spotted	2018	0.330982257
Towhee, Spotted	2019	-0.116977768
Towhee, Spotted	2020	0.318115007
Towhee, Spotted	2021	-0.289392537

Vireo, Warbling	2007	-1.856563962
Vireo, Warbling	2010	-1.829887648
Wren, Pacific (Winter)	2007	0.294814857
Wren, Pacific (Winter)	2008	0.467536107
Wren, Pacific (Winter)	2010	0.381243083
Wren, Pacific (Winter)	2022	-0.014120098
Eagle, Bald	2008	0.197391342
Eagle, Bald	2011	0.535179119
Nuthatch, Red-breasted	2008	-0.804775168
Nuthatch, Red-breasted	2010	-0.447185562
Nuthatch, Red-breasted	2011	0.274697249
Nuthatch, Red-breasted	2012	0.01991831
Nuthatch, Red-breasted	2014	0.033212016
Nuthatch, Red-breasted	2015	-0.622344878
Nuthatch, Red-breasted	2016	-0.449503874
Nuthatch, Red-breasted	2018	-0.45739851
Nuthatch, Red-breasted	2019	-1.099001568
Nuthatch, Red-breasted	2020	0.473473878
Nuthatch, Red-breasted	2021	-0.63484879
Sparrow, Song	2008	0.18698954
Sparrow, Song	2010	0.3775839
Sparrow, Song	2014	0.229866618
Sparrow, Song	2021	0.157970164
Waxwing, Cedar	2008	-0.850618742
Waxwing, Cedar	2010	-0.752272565
Waxwing, Cedar	2011	-1.015981162
Waxwing, Cedar	2020	-0.804036324
Waxwing, Cedar	2021	-0.764086703
Hummingbird, Rufous	2010	-1.057180115
Hummingbird, Rufous	2011	-1.367388814
Hummingbird, Rufous	2012	-1.273264288
Hummingbird, Rufous	2013	-0.936394797
Cowbird, Brown-headed	2011	-1.12126404
Flicker, Northern	2011	0.027858972
Starling, European	2011	0.062726702
Starling, European	2021	-0.484004569
Hummingbird, Anna's	2013	-0.387324687
Hummingbird, Anna's	2016	-0.18245674
Hummingbird, Anna's	2021	-0.322421073
Creeper, Brown	2015	-0.90384528
Creeper, Brown	2021	-0.638136283
Flycatcher, Pacific-slope	2018	-1.034697513
Flycatcher, Pacific-slope	2021	-0.801615402
Flycatcher, Pacific-slope	2022	-0.917938277
Crow, American	2019	-0.388764457
Crow, American	2020	-0.011904811
Crow, American	2022	-0.037492583
Grosbeak, Black-headed	2019	-1.367388814
Vireo, Hutton's	2019	-1.187630946

Table A2. Summary table of significant bird population changes at the farm.

Scientific Name	Common Name	Station	Slope	p-value	BC Population Trend
Poecile atricapillus	Chickadee, Black-capped	1	3.000065	9.55E-03	increase
Poecile atricapillus	Chickadee, Black-capped	3	-2.476448	2.67E-02	decrease
Empidonax difficilis	Flycatcher, Pacific-slope	4	2.150254	4.95E-02	decrease
Spinus tristis	Goldfinch, American	5	-2.619022	2.02E-02	decrease
Accipiter striatus	Hawk, Sharp-shinned	1	2.14625	4.99E-02	increase
Ardea herodias	Heron, Great Blue	2	-2.678503	1.80E-02	decrease
Calypte anna	Hummingbird, Anna's	1	5.43789	8.74E-05	increase
Calypte anna	Hummingbird, Anna's	9	4.322209	7.03E-04	increase
Calypte anna	Hummingbird, Anna's	2	3.419217	4.15E-03	increase
Calypte anna	Hummingbird, Anna's	4	3.049144	8.66E-03	increase
Calypte anna	Hummingbird, Anna's	8	2.978879	9.96E-03	increase
Calypte anna	Hummingbird, Anna's	7	2.634087	1.96E-02	increase
Selasphorus rufus	Hummingbird, Rufous	5	-2.347231	3.41E-02	increase
Sitta canadensis	Nuthatch, Red-breasted	5	2.835038	1.32E-02	increase
Zonotrichia atricapilla	Sparrow, Golden-Crowned	8	3.44787	3.92E-03	increase
Zonotrichia atricapilla	Sparrow, Golden-Crowned	1	2.262229	4.01E-02	increase
Petrochelidon pyrrhonota	Swallow, Barn	1	-2.27183	3.94E-02	decrease
Pipilo maculatus	Towhee, Spotted	8	3.550123	3.20E-03	increase
Pipilo maculatus	Towhee, Spotted	1	3.012436	9.32E-03	increase
Pipilo maculatus	Towhee, Spotted	6	2.873595	1.23E-02	increase
Pipilo maculatus	Towhee, Spotted	2	2.696657	1.74E-02	increase
Pipilo maculatus	Towhee, Spotted	4	2.161073	4.85E-02	increase
Vireo gilvus	Vireo, Warbling	5	2.815984	1.37E-02	increase
Picoides pubescens	Woodpecker, Downy	3	3.209065	6.31E-03	decrease
Picoides pubescens	Woodpecker, Downy	2	2.804726	1.40E-02	decrease
Picoides pubescens	Woodpecker, Pileated	1	-3.501313	3.53E-03	increase
Picoides pubescens	Woodpecker, Pileated	6	2.192683	4.57E-02	increase
Thryomanes bewickii	Wren, Bewick's	8	2.910426	1.14E-02	decrease

Additional Analysis

Along with the analysis done in the rest of the report, we also looked at the relationship between ENSO and bird abundance on the UBC Farm. This was going to be apart of the seasonal analysis of the bird biodiversity data, but due to unforeseen circumstances, the team could not produce a a full analysis and conclusion of weather data and the ENSO data. Below are some plots produced looking at the the total bird abundance, migratory bird abundance, and a specific example of the Anna's hummingbird (*Calypte anna*) abundance in relation to ENSO from 2007 to 2022.

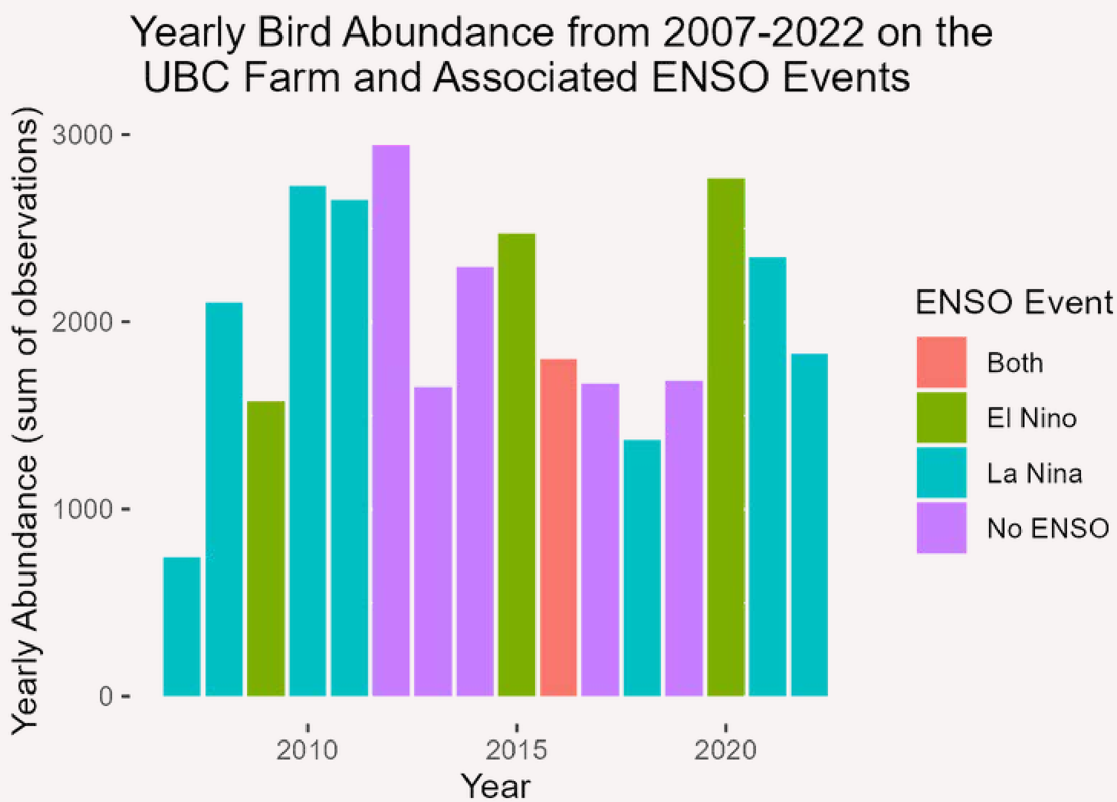

Figure A1. The total yearly bird abundance on the UBC Farm from 2007 to 2022 related to the primary ENSO event of that year. The yearly abundances were determined by summing the total bird species observations of that year. The primary ENSO event of each year was determined by the event (El Nino or La Nina) that was most often present during the year.

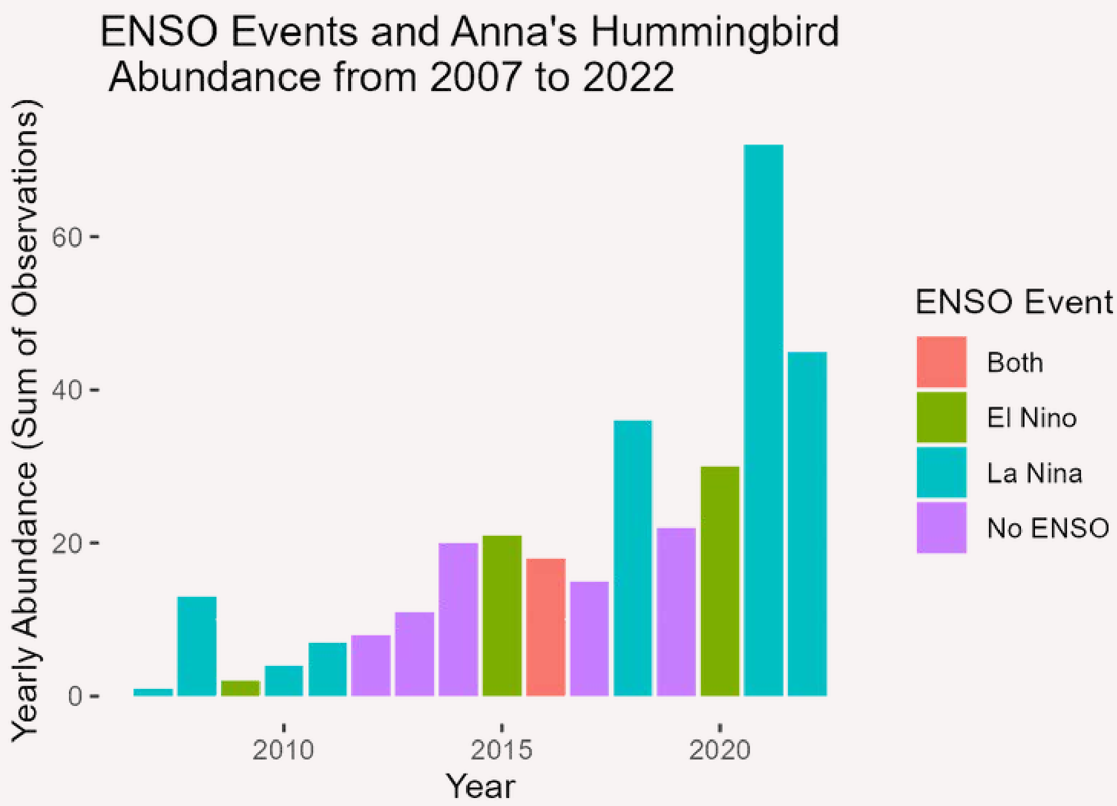

Figure A2. The yearly abundance of Anna's Hummingbird (*Calypte anna*) and the relationship to ENSO events. Anna's Hummingbird's abundance was observed as an example of looking at specific species' abundances and their

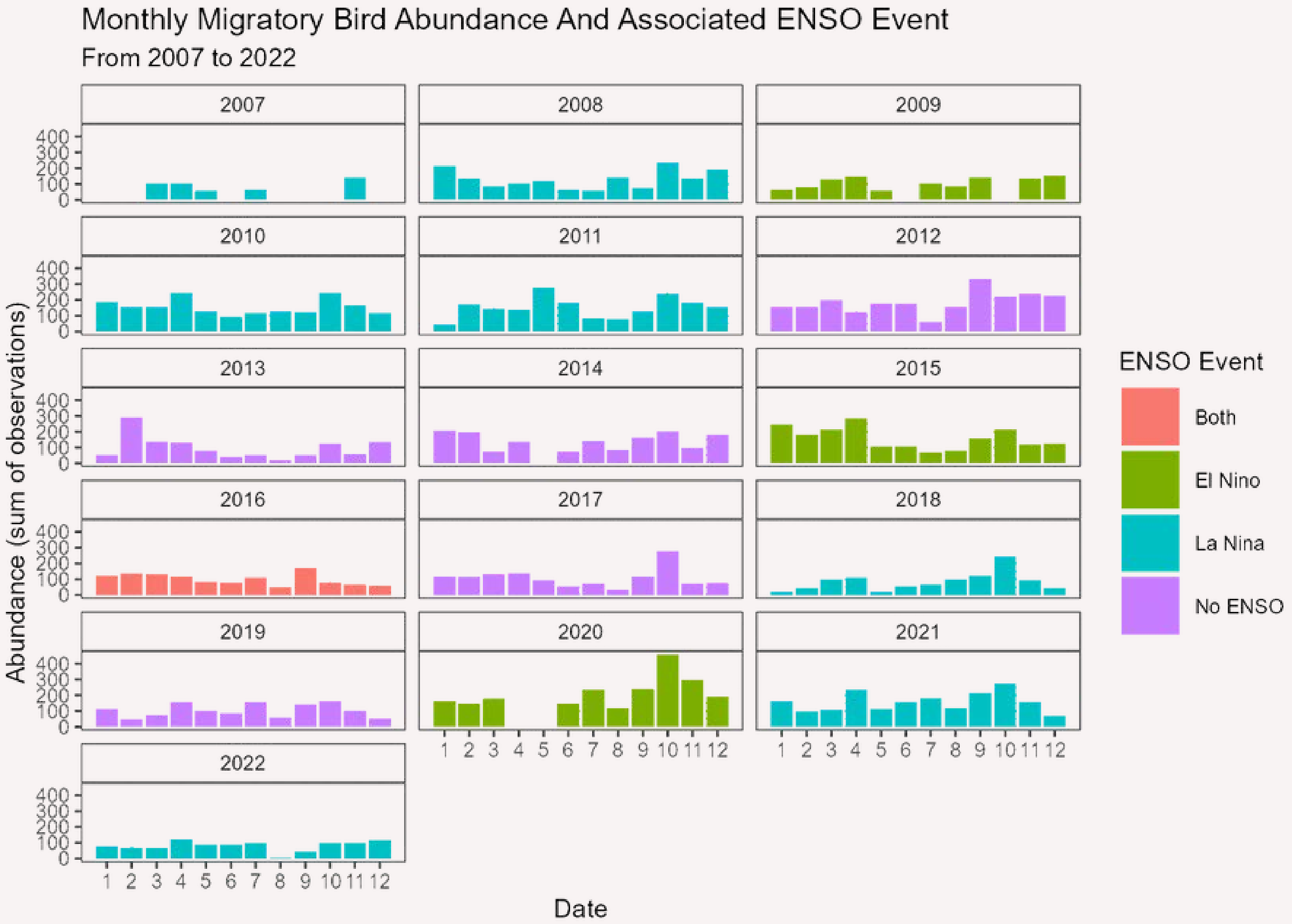

Figure A3. The monthly abundance of migratory birds on the UBC Farm from 2007 to 2022 compared to the monthly ENSO event. "Date" indicates the month of the year. The months are indicated by their number rather than their alphabetical names (January is "1", February is "2", etc.)

Table A3. Uncorrected p-values of all birds for the correlation analysis between year and abundance seen on page 60

Bird	p value
Bushtit	4.24E-01
Crow, Northwestern	8.92E-01
Eagle, Bald	4.43E-02
Finch, House	3.45E-01
Goldfinch, American	4.66E-01
Gull Species	3.02E-01
Hawk, Red-tailed	2.28E-05
Hummingbird species	4.94E-01
Hummingbird, Rufous	1.53E-01
Junco, Dark-eyed	2.08E-01
Killdeer	6.98E-01
Kinglet, Golden-crowned	6.29E-01
Kinglet, Ruby-crowned	7.72E-01
Owl, Barred	6.19E-02
Raven, Common	9.52E-01
Pigeon, Rock	5.88E-06
Robin, American	9.24E-01
Sparrow, Golden-Crowned	1.83E-02
Sparrow, Savanna	2.73E-01
Sparrow, Song	1.14E-02
Sparrow, White-crowned	5.52E-03
Siskin, Pine	4.73E-01
Starling, European	3.40E-02
Swallow, Violet-green	2.55E-06
Warbler, Orange-crowned	9.74E-01
Wren, Bewick's	7.08E-01
Wren, Pacific (Winter)	9.71E-02
Chickadee	2.05E-01
Dove, Mourning	4.92E-01
Flycatcher, Pacific-slope	2.25E-01
Heron, Great Blue	1.30E-02
Sparrow, Chipping	1.23E-01
Thrush, Swainson's	9.99E-01
Warbler, Wilson's	5.72E-01
Chickadee, Black-capped	8.65E-02
Chickadee, Chestnut-backed	1.70E-02
Cowbird, Brown-headed	2.91E-02
Creeper, Brown	3.44E-02
Crossbill, Red	7.30E-01
Falcon, Peregrine	7.13E-01
Finch, Purple	4.16E-01
Flicker, Northern	7.75E-01
Flicker, Northern hybrid	9.83E-01
Flycatcher, Hammond's	6.50E-01
Flycatcher, Olive-sided	1.30E-01
Flycatcher, Willow	5.95E-01
Goose, Canada	3.90E-02
Grosbeak, Black-headed	1.50E-01
Grosbeak, Evening	3.68E-02
Gull, Glaucous-winged	7.02E-01
Gull, Ring-billed	1.30E-01
Gull, Thayer's	2.13E-03
Harrier, Northern	1.45E-01
Hawk, Cooper's	5.34E-01
Hawk, Sharp-shinned	9.92E-01
Hummingbird, Anna's	6.60E-15
Jay, Steller's	3.35E-01
Junco, Oregon	2.09E-02
Junco, Slate-colored	2.01E-01
Kestrel, American	2.02E-04
Kingfisher	8.21E-01

Full Dataset

The complete Nature Vancouver dataset can be accessed using this link:
https://docs.google.com/spreadsheets/d/1yqENfG423sXHvvgd5bgNGKeQF4NXCZgDpJKeuqBn5Gg/edit?usp=sharing