An Analysis of Avian Population Trends in Metro Vancouver's Stanley Park

By
Paul Chiu

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF SCIENCE

in

THE FACULTY OF SCIENCE

(Honours Animal Biology)

THE UNIVERSITY OF BRITISH COLUMBIA

April 2017

We accept this thesis as conforming to the required standard

_____

_____

_____

_____

_____

Table of Contents

1. Abstract

Stanley Park is a haven for birdwatchers. As many as 236 species have appeared in the park over the years even with its proximity to an urbanized area thanks to its location along the heavily-trafficked Pacific Flyway. With the biodiversity prevalent in the park as well as its importance for local tourism, the Stanley Park Ecology Society (SPES) monitors the population of flora and fauna in Stanley Park and uses this data to guide their efforts in maintaining the park's biodiversity. Past research has indicated that avian species that are more habituated to disturbances may be able to increase in abundance. I performed a comprehensive analysis on the avian populations of Stanley Park using data collected from four sites (Beaver Lake, Lost Lagoon, Devonian Park, and the Seawall) by the SPES. My results indicated that the general avian populations at all four sites were experiencing temporal trends in abundance and richness but not diversity (quantified by the Simpson's Index of Diversity), that disturbance-adapted birds did not always experience stability or increasing abundance (although their richnesses were mostly stable), and that the birds less adapted to disturbances did not always experience decreasing abundance. In fact, the birds that are less adapted were usually stable in abundance and also richness. However, these results may not represent the true avian population of Stanley Park due to the methodology. Future surveys should include another study site based entirely inside a forested area and should also be conducted at a higher frequency. Future analyses should also be objective as I determined temporal trends mostly by eye.

2. Introduction

In recent years, human activities have caused many global changes to biogeochemical cycles (such as the carbon cycle) and land topography (through processes like clearcutting), which have resulted in phenomena such as global warming and widespread habitat loss, respectively (Chapin III *et al.*, 2000). In turn, these change the biodiversity of many communities (Chapin III *et al.*, 2000). These changes can have ecological effects and ecosystem processes can be affected. For example, Tillman (1999) found that the primary productivity of a community was positively correlated with plant species richness. In another example, the overhunting of sea otters (*Enhydra lutris*) in Alaska affected interspecies interactions, resulting in an increase in population density for their sea urchin (*Strongylocentrotus* sp.) prey, which in turn caused the overgrazing and destruction of kelp from the *Macrocytis* genus (Estes and Palmisano, 1974). Altered biodiversity can also influence the temporal stability of a community in terms of population size, species richness, and other community parameters (Proulx *et al.*, 2010) as well as the community's ability to resist invasive species (Stachowicz *et al.*, 2002).

Changes in biodiversity also have sociological consequences for humans. Once species go extinct, humans cannot learn from or appreciate them (Chapin III *et al.*, 2000). In addition, Clergeau *et al.* (2001) found a positive relationship between the degree of avian biodiversity one is exposed to and the degree of appreciation for nature they have. There is a major problem, however. Humans living in an urban setting have a high chance of experiencing "biological poverty", a term used to describe seeing below-average levels of native species biodiversity (Melles, 2005; Turner *et al.*, 2004). Urbanization is problematic as it has been shown to decrease the amount of native bird species as there are fewer resources available for them (Blair, 1996). Only urban exploiters (e.g. *Columbia livia*/rock pigeon) or urban adapters (e.g. *Manorina melanocephala*/noisy miner), species that are able to survive

in urbanized landscapes by either completely depending on urban resources if they are exploiters or using a mix of urban and natural resources if they are adapters, can tolerate urbanization and all of the anthropogenic disturbances associated with it (McKinney, 2006).

Urbanization also fragments habitats into patches where residents often cannot persist, although it depends on how small the patches are as well as their proximity to buildings (Dickman, 1987). Many parks, however, are able to sustain species even if they are in densely populated urban areas (Fernández-Juricic *et al.*, 2001; Melles *et al.*, 2003), although large-bodied species often are unable to persist in smaller green spaces like urban gardens (Goddard *et al.*, 2009). Therefore, parks represent opportunities for city dwellers to directly interact with nature. These interactions are important; Bixler *et al.* (2002) found that without them, humans, especially children, are less likely to have positive perceptions of natural environments. Their results, combined with those of Clergeau *et al.* (2001), illustrate the need to monitor the populations of species residing in parks. Doing so would allow managers of parks and other natural attractions to gauge the attraction's ecological health and determine the required conservation efforts, thus allowing them to prevent negative sociological as well as ecological effects.

Metro Vancouver, Canada, is home to one such urban park: Stanley Park. Attracting approximately eight million visitors annually (City of Vancouver, 2016a; Tourism Vancouver, 2016), it contains 400 hectares of temperate forest with 27 km of trails and a wide variety of avian species, from raptors like the bald eagle (*Haliaeetus leucocephalus*) to songbirds like the Steller's Jay (*Cyanocitta stelleri*). An 8.8 km seawall lines its coastline and provides views of English Bay, Burrard Inlet, and a huge biodiversity of waterfowl, with great blue herons (*Ardea herodias*), mallards (*Anas platyrhynchos*), and Canada geese (*Branta canadensis)* being common sights. In total, visitors can observe over 230 avian species throughout the year (City of Vancouver, 2016b; SPES, 2007), leading BirdLife

International to designate the waters surrounding Stanley Park as an Important Bird Area, an area distinguished as essential for Canada's bird populations (IBA, 2016). This biodiversity is a result of the park's proximity to the Pacific Flyway, a route stretching from the Alaskan Arctic to the southernmost tip of South America that is used by millions of migratory birds each year (BirdLife International, 2015; SPES, 2016b). The organization in charge of monitoring the biodiversity of Stanley Park is the Stanley Park Ecological Society (SPES).

The SPES is a non-profit charity that aims to promote stewardship and awareness of Stanley Park's variety of organisms and environments by exposing the public to nature via educational and volunteer programs (SPES, 2016a; Worcester, 2010b). In addition, they organize several projects that attempt to conserve the biodiversity that can be found in the semi-natural environments of Stanley Park. These programs involve restoring habitats (e.g. removing invasive *Hedera helix*/English ivy and replanting native species) and monitoring animal populations.

One such program monitors the population of the park's birds using bird counts. These counts have been occurring since 2001, but only one publicly released study analyzing the collected data exists. Worcester (2011) examined wintering waterbirds that occur along the Seawall. To do this, she compared bird count data from two different periods of time: the winter of 2001/2002 and the winter of 2010/2011. She found that most waterbirds experienced population decreases over time, reasoning that they were unable to cope with disturbances originating from humans (e.g. off-leash dogs and watercraft disturbing the water where waterbirds were feeding). These disturbances may have negatively affected the waterbirds by inhibiting their feeding in preferred areas (Gander and Ingold, 1997; Sutherland and Crockford, 1993) or by decreasing the rate of successful breeding (Giese, 2006). Waterbirds, like double-crested cormorants (*Phalacrocorax auritus*) and Canada geese, that experienced population increases were thought to have habituated to human

disturbances. Other factors that were thought to be drivers of the population decreases were climate change, water pollution, and urbanization (Worcester, 2011).

The SPES also publicly released a State of the Park Report for the Ecological Integrity of Stanley Park, a report analyzing the populations of all animals in the park as well as the status of their habitats, in 2010. With this information, the SPES can inform itself on the park's ecological health and identify gaps in their ecological knowledge. Doing so allows them to prioritize and adjust their conservation efforts. The next iteration of the report will be released in 2017. In my thesis, I will collaborate with the SPES to analyze all available bird count data that has been collected by the SPES and to determine whether there have been any temporal changes in the various observed avian populations. Specifically, I will be testing for temporal trends in various measures of biodiversity (e.g. abundance, richness, Simpson's Index of Diversity). This will complement Worcester (2011), although, unlike her study, I will be analyzing all available data collected between 2001 and 2016 as opposed to comparing only data collected at two different time periods. In addition, I will also be analyzing data collected from other areas besides the Seawall, specifically Lost Lagoon, Beaver Lake, and Devonian Park. Based on the conclusions of Worcester (2011), I expect that my analysis will uncover decreases in the biodiversity species populations that have not habituated to disturbances and increases or stability in ones that have.

3. Methods

3.1 Stanley Park

Located on the border of downtown Vancouver, Canada, Stanley Park has been described as an urban oasis, which is understandable considering its 400 hectares of temperate rainforest as well as the fact that the surrounding waters are a designated Important Bird Area (BirdLife International, n.d.; City of Vancouver, 2016a). Park visitors may be able to spot a wide variety of animals and plants as they walk along the Seawall, the trails, or the

park's water bodies as the Stanley Park Ecology Society (SPES) reports that 30 mammalian, 236 avian, 10 amphibian and reptilian, and 72 fish species call the park home (Worcester, 2010b).

Four sites were used by the SPES to monitor Stanley Park's avian species: Beaver Lake, Lost Lagoon, Devonian Park, and the Seawall (all labelled in **Figure 1**). Beaver Lake is one of the two water bodies inside the park. Although it has a surface area of 3.95 hectares and a depth less than 0.5 m in 80-90% of the lake area (Vancouver Board of Parks and Recreation and SPES, 2013), the creeks and streams that are connected to it form the largest watershed in the park. Currently, the lake's depth is decreasing as a result of sediments (brought in by the creeks) and dead plants (which would have floated on the water when they were living) sinking to the bottom. Over time, the buildup will form islands, and without any preventative measures the lake will slowly turn into a swamp and eventually a forest (Vancouver Board of Parks and Recreation and SPES, 2013). Because of this, the Vancouver Board of Parks and Recreation and the SPES have planned projects to prevent this natural development, with a possible course of method involving the dredging of the lake bottom). These plans, at the time this thesis was written, are still currently being developed. However, there are other projects that are underway in Beaver Lake. The SPES has programs focused on removing water lilies from the lake and replanting native bog species (SPES, 2013). The lake's resident beavers are also chipping in on the effort. The beavers, considered a keystone species in Stanley Park by the SPES, are known to dredge up the lake bottom and remove water lilies, to the benefit of native animals and plants (Worcester, 2010b). On top of their role as an "ecosystem engineer", the SPES have also noted the ecotouristic role that the beavers play. To them, the beavers provide opportunities for wildlife observations, photography, and education among the park visitors who decide to walk along the 1.0 km

pedestrian path that circles around the lake or bike along the bicycle path that runs tangent to the lake's northern side (Vancouver Board of Parks and Recreation, 2011) (**Figure 2**).

The other large body of water that lies in the park is Lost Lagoon. Originally a mud flat, the construction of the Stanley Park Causeway in 1916 isolated it from Coal Harbour (Worcester, 2010b). Subsequent years saw the area being filled with runoff water, although this stopped in 1929 as constant evaporation and a lack of flow increased the salinity to the point where aquatic life could not be supported (Worcester, 2010b). To solve this problem, Lost Lagoon was converted into a freshwater lake in 1929, and trout were introduced (and still remain in the lagoon today) for the purpose of sport fishing. As one might expect, the fish species that reside there are mostly invasive. This too applies to the herptiles as American bullfrogs and red-eared sliders call the lagoon their home. Invasive non-submergent vegetation species, the focus of the SPES' removal efforts, are prevalent too. Thanks to the lagoon's susceptibility to the occasional salt water inflow, barely any submergent vegetation is observed (Worcester, 2010b). A wide variety of birds, however, are observed, but this brings its own problems. Feces from the lagoon's waterbirds have been identified, along with runoff sediments, as the cause for a progressive infilling in the lagoon that has been noted by park staff. In addition to increasing the risk of flood (which has already occurred several times in recent years), the decreased depth may also alter the lagoon's chemical and physical properties in ways that negatively affect the flora and fauna (e.g. increased temperature and decreased oxygen content). Another factor that negatively alters the lagoon's water is runoff water. As a result of its proximity to downtown Vancouver and the Stanley Park Causeway (one of the only two roads that directly connect Vancouver and North Vancouver), the runoff water can contain harmful chemicals from motor vehicles (Worcester, 2010b), leading to the creation of a stormwater treatment wetland. The treatment wetland, completed in 2001, uses settling ponds and aquatic vegetation to biofilter out the

harmful chemicals from runoff water (Worcester, 2010b). Although this project was seen as successful, the lagoon's water may not entirely be optimal for the residing flora and fauna. Regardless, park visitors are still attracted to the Lost Lagoon, with a 1.8 km pedestrian path that circles around the lagoon providing great views of the lagoon's natural offerings (City of Vancouver, 2017b) (**Figure 1, inset**).

Devonian Park is not technically a part of Stanley Park. However, it has been described as a gateway between downtown Vancouver and the larger and more popular Stanley Park (City of Vancouver, 2017a). Although Devonian Park is small -- it has an area of 4.42 hectares -- it still has enough space for a small pond and provides views of the eastern coastline of Stanley Park, as one side of Devonian Park borders the Vancouver Harbour (**Figure 3**). In contrast to Beaver Lake and Lost Lagoon, Devonian Park consists mostly of open grassland that does not contact any forest. The park also has the highest potential for anthropogenic disturbances. A road fragments the park, the Stanley Park Causeway runs along one side of it, the part of the harbour that borders another side of it is filled with boats and other anthropogenic water-related activity, and visitors and off-leash dogs are allowed to roam and walk all over the grassland. In general, Devonian Park has been considered to not have much value as a habitat for wildlife (Worcester, 2010a).

Described as Vancouver's most popular fresh air attraction (City of Vancouver, 2017c), the Seawall is a 22 km pathway from Kitsilano Beach all the way to Coal Harbour, with an 8.8 km section that runs along the coastal perimeter of Stanley Park (City of Vancouver, 2016a; Tourism Vancouver, 2017). With panoramic views of English Bay, the Burrard Inlet, and the Vancouver Harbour as well as several points of interest (like Siwash Rock) that run along it, the Seawall is quite beneficial for tourism, but it has more adverse effects for wildlife. Its creation has fragmented or completely destroyed the shoreline and intertidal habitats along the park (Worcester, 2010b). In addition to these negative effects,

wildlife must also deal with tanker traffic as well as watersport activity. While shoreline and intertidal habitats may have been irreversibly changed by the Seawall, they are still able to accumulate a wide variety of habitats (e.g. beaches with various sizes of sediment) as well as abundant food sources, like blue mussels. As a result, Stanley Park's shoreline is still able to attract a wide variety of waterbirds to the area to the point where it is considered a part of the English Bay-Burrard Inlet Important Bird Area (Worcester, 2014).

3.2 Survey Methods

The SPES has used three different monitoring programs to monitor the four sites described above, with programs at Beaver Lake, Lost Lagoon, and the Seawall still ongoing. For Beaver Lake and Lost Lagoon, surveys have been done as early as the early 2000s. However, the protocol was only standardized around 2005/2006. The surveys are now conducted monthly by 5-12 people, with some being volunteers and others being SPES staff. As volunteers are used, a consistent set of birdwatchers could not be utilized over the span of the monitoring program. Instead, a wide range of birdwatchers of various ages and skill levels were used. Surveys for Beaver Lake and Lost Lagoon are conducted on the same day. Starting from the SPES' Nature House at 10 am on the second Sunday of every month, Lost Lagoon is surveyed first, with survey groups moving clockwise along the pedestrian path that encircles the lagoon. Afterwards, Beaver Lake is surveyed, with the group utilizing the path that circles around the lake. Usually, three hours are used to survey both water bodies. Throughout the survey, birds heard or seen between the trail and halfway into the lagoon/lake are identified and counted. Birds that are seen flying against the direction of the birdwatchers are identified and counted, but not birds that are flying along the same direction, as they may be double recounted. If birds are grouped up, the number of individuals are estimated. Throughout the survey, the birdwatchers are discouraged from staying too long in one place, as this may increase the chance of birds being recounted. For Beaver Lake, data collected

from February 2001 to July 2002 and from July 2005 to December 2016 were obtained. The protocol for the collection of data in 2001 and 2002 is not known. In addition, counts that were performed in 2001 and 2002 were more frequent than counts between 2005 and 2016. For Lost Lagoon, data collected between January 2005 and December 2005 was obtained.

While the SPES is designated as the primary monitor of Devonian Park, they do not regularly monitor the area, as Devonian Park is not actually a part of Stanley Park. Regardless, enough bird counts were conducted between December 2009 and December 2014 to infer population trends that occurred during those times. In these counts, the birdwatchers proceeded along a path that took them around the park, with the survey expected to take around a half hour. The start time for the survey was not recorded in the obtained dataset.

Early winter waterbird surveys saw students from the British Columbia Institute of Technology's Fish, Wildlife, and Recreation program surveying birds found along the Seawall on a weekly basis. Starting in 2008, the survey became an annual event, with the BCIT students collaborating with SPES volunteers and staff each November to record the total number of birds seen between the wall and 500 m off the shoreline. No other consistent surveying protocol for the winter waterbird surveys could be found.

3.3 Data Analysis

3.3.1 General Population Trends

To examine avian population trends and determine whether the population increased, decreased, was stable, or did not experience a temporal trend, species were categorized using four different tiers of taxonomic specificity. The first tier contained all observed species in the survey. For this tier, in order to quantify the biodiversity of Stanley Park three measures of biodiversity were analyzed: species abundance, species richness, and the Simpson's Index of Diversity. The Simpson's Index of Diversity was used instead of the Shannon's Index as it accounts for evenness (Nagendra, 2002). With the prevalence of species in the data that

appeared rarely as well as the fact that some species (such as mallards or surf scoters) tend to dominate the study sites with significantly higher numbers that go above 500 or even 1000 individuals, I felt that the Simpson's index was a better representative of each site's biodiversity. In some months (usually in 2001 and 2002), more than one survey was conducted. To account for the increased number of surveys, all surveys conducted in a month were averaged. In essence, for each recorded species, the mean number of individuals spotted per count was calculated.

Four graphs were created for each measure of biodiversity using Microsoft Excel 2016. The first graph plotted the measures of biodiversity chronologically, allowing trends that occurred over the entirety of the data collection period to be observed. Values of the measure of biodiversity were on the y-axis while their associated times (i.e. the month and year) were on the x-axis. Trends in the graph were determined by eye. To complement the assessment, a linear regression was also performed on the graph using R version 3.3.1 and RStudio version 0.99.903, but decisions were not based entirely on the result of the regression. More weight was placed on the initial subjective assessment. An alpha value of 0.05 was used for each regression. In the second graph, the mean value of the measure of biodiversity per month was calculated for each year using Microsoft Excel 2016. In essence, the values for each month of a year was averaged into a mean value for the year. The mean values were then plotted on the y-axis against their respective years on the x-axis. Standard error values were also calculated with Microsoft Excel 2016 to create error bars for the mean values. This graph would complement the first graph in allowing one to determine population trends. The third graph organized up the collected values for the measures of biodiversity according to their month. The 12 groups of values were then plotted on the y-axis against their respective years on the x-axis. This graph would also complement the first graph. If the 12 lines were generally increasing, this would indicate that the measure of biodiversity was

increasing over time. Likewise, if they were decreasing, the measure of biodiversity would be declared as decreasing over time. The fourth graph was similar to the third graph. However, instead of grouping up the collected values for the measures of biodiversity according to months, the values were grouped up according to years and then plotted on the y-axis against their respective months on the x-axis. This would denote migration timings. If seasonal variation was consistent throughout the years (i.e. all years experienced peaks and troughs of the measure of biodiversity during the same months), migration timings have stayed the same. However, if the peaks and troughs are constantly changing their timings, migration timings have been changed over time.

In total, 12 graphs were created for each data set, with the exception of the Seawall's. Because the Seawall counts are annual, only one graph was created for each measure of biodiversity. These graphs simply plotted the measure on the y-axis against the year on the x-axis.

3.3.2 Population Trends for the Seven Taxonomic Groups

For the second tier of taxonomic specificity, all species were divided into seven different groups that Dr. Jankowski and I felt represented the main avian groups of Stanley Park -- raptors, Anseriformes, non-Anseriformes waterbirds, Passeriformes, hummingbirds, Columbiformes, Piciformes. In this tier, only abundance values and richness values were analyzed, with two graphs created (with Microsoft Excel 2016) for both measures of biodiversity. The first graph chronologically plotted the measure of biodiversity, with the values for the measure of diversity on the y-axis and their associated months and years on the x-axis. Like with the first tier, population trends were assessed by eye. The second graph plotted the mean values of the measure of biodiversity per month (calculated with Microsoft Excel 2016) on the y-axis against their associated years on the x-axis. Error bars based on standard error (which was calculated with R version 3.3.1 and RStudio version 0.99.903)

were also created and added to the graphs. In total, four graphs were done for Beaver Lake, Lost Lagoon, and Devonian Park. As the Seawall counts are annual, the measures of biodiversity were just plotted against their respective year.

3.3.3 Population Trends for Subgroups of the Seven Taxonomic Groups

For the third tier of taxonomic specificity, most of the species were further divided into different groups based on the recommendations of Dr. Jankowski and the SPES. Raptors remained undivided. Anseriformes were divided into dabbling, diving, perching, and sea ducks as well as a group containing both geese and swans. Non-Anseriformes waterbirds were divided into seabirds, kingfishers, loons and grebes, Rallidae, Pelecaniformes, and shorebirds. Passerines were split into aerial insectivores and forest birds, which also included the hummingbirds, the Piciformes, and the band-tailed pigeon. Some Passeriformes, specifically the European starling (*Sturnus vulagris*), the northwestern crow (*Corvus caurinus*), and the house sparrow (*Passer domesticus*), were not categorized as forest birds. Instead, they were combined with the rock pigeon to form their own group, the disturbance-adapted birds. Primary cavity nesters, which contained forest birds; secondary cavity nesters, which contained a combination of species from a variety of groups; Piciformes; Laridae (part of the seabirds), gulls (part of Laridae) were also analyzed as their own individual groups. Species were categorized as primary cavity nesters based on a list provided by the Worcester and Titaro (2012), as secondary cavity nesters based on information provided by the Worcester and Titaro (2012) and Cafferata-Coe (2014), as seabirds based on the CCNAB (2017), and as disturbance-adapted birds based on Dr. Jankowski's and my opinions.

To analyze trends in the groups, values of abundance and species richness were separately chronologically graphed. The values for the measures of biodiversity were plotted on the y-axis while their associated times -- the month and year for Beaver Lake, Lost Lagoon, and Devonian Park but only the year for the Seawall -- were plotted on the x-axis.

To assess temporal trends in the measures of biodiversity, the following guidelines were used. Only groups that have been observed in the last two years and have either appeared in at least 50% of the counts or occurred at least once a year for three consecutive years were analyzed. Otherwise, their population trends were marked as "Not Available". For a group's abundance to be determined as stable, at least 80% of the values recorded in the surveys must be found in a range where the least abundant survey and the most abundant survey must not have a difference in the number of individuals counted greater than 10. For the richness to be determined as stable, at least 80% of the values recorded in the surveys must be found in a range that is four species wide. Otherwise, the values for the measures of biodiversity were either described as increasing over time, decreasing over time, or not having a temporal trend.

3.3.4 Species-Specific Trends

For the fourth tier of taxonomic specificity, individual species were examined. To assess temporal trends in the measures of biodiversity, the guidelines used to analyze the third tier were also used in this tier. Only abundance was analyzed in this tier.

4. Results

4.1 Did the General Avian Populations Experience Any Temporal Trends?

All trends found were summarized in **Table 1**.

4.1.1 Abundance

Beaver Lake appears to have experienced a slight increase in abundance (**Figure 5A**), with an accompanying linear regression indicating that it is significant ($y = 0.44 + 52$, $R^2 = 0.049$, $p = 0.012$). This is corroborated by how the mean abundance per month was higher in 2015 and 2016 than between 2005 and 2009 (**Figure 5B**) and by how surveys conducted in February, March, and December recorded higher abundances when conducted in the later years (**Figure 6A**). Beaver Lake's abundance also experienced seasonal variation; February

and November or December were peaks while the summer months were troughs. (**Figure 6B**).

Lost Lagoon's abundance oscillated over the years but no overall increase or decrease occurred. A linear regression suggested there was a decrease, but it was insignificant ($y = -0.46 + 540$, $R^2 = 9.0 \times 10^{-3}$, $p = 0.28$). The mean abundance per month also oscillated over the years, with the value not changing drastically, although it did drop in 2016. Abundances also experienced seasonal variation; January, July and December experienced peaks while May and September experienced troughs.

No temporal trends were determined for Devonian Park's abundance as the abundance was variable over time, although a linear regression indicated an insignificant increase ($y = -0.13 + 74$, $R^2 = 1.8 \times 10^{-3}$, $p = 0.76$). The mean abundance per month increased between 2010 and 2012, dropped in 2013, and recovered in 2014. All surveys recorded lower abundances in 2013. Again, there was seasonal variation; January and December were peaks and the summer months were troughs.

The Seawall's abundance did not seem to have experienced any temporal relationship. However, it experienced the highest abundance of all sites, followed by Lost Lagoon, then Beaver Lake, and finally Devonian Park.

4.1.2 Richness

Beaver Lake's richness increased slightly, with a linear regression suggesting that it was significant ($y = 0.040 + 12$, $R^2 = 0.075$, $p = 1.8 \times 10^{-3}$), The mean abundance per month as well as the monthly abundance in January, March, April, October, and November also increased over the years. There was seasonal variation, with April and December being peaks and August being a trough.

Lost Lagoon's richness also increased slightly, and its linear regression suggested that it was significant ($y = 0.048 + 27$, $R^2 = 0.11$, $p = 1.5 \times 10^{-4}$). The mean abundance per month

and the monthly abundance in January, February, March, and December increased over the years. April and December were also peaks as well as August being a trough.

Devonian Park's richness decreased slightly over time, with a linear regression suggesting it was significant ($y = -0.12 + 13$, $R^2 = 0.19$, $p = 8.2 \times 10^{-4}$). The mean abundance per month increased between 2010 and 2011 before decreasing to 2012. The value did not change much between 2012 and 2014. All monthly abundances followed this trend. Again, April was a peak for richness and August was a trough. December was also a trough, with November and January being peaks

The Seawall's richness oscillated without any overall increase or decrease. Surveys consistently recorded the Seawall and Lost Lagoon experiencing at least 25 different species, the highest of all sites. A higher number of species was recorded consistently at Beaver Lake compared to Devonian Park. At least 123 species were identified in Lost Lagoon over time (i.e. from 2005 to 2016); at least 93 species were identified in Beaver Lake over time (from 2005 to 2016), with the number increasing to 98 species when surveys in 2001 and 2002 are counted; at least 57 species were identified in Devonian Park over time (from December 2009 to 2014); and at least 69 species were identified in the annual surveys at the Seawall (between 2008 and 2015), with the number increasing to 76 when surveys in 2001 are counted. Combining all the surveys, at least 150 species have been identified by surveyors, with the number increasing to 155 when surveys in 2001 and 2002 are counted.

4.1.3 Simpson's Index of Diversity

Beaver Lake's Simpson's Index of Diversity (SID) mostly fluctuated between 0.6 and 0.9, indicating a lack of a temporal trend. Its associated linear regression indicated an insignificant stability ($y = -8.1 \times 10^{-5} + 0.79$, $R^2 = 5.8 \times 10^{-4}$, $p = 0.79$). The mean SID per month was generally stable over time. In 2010, the value dropped but recovered in 2011 before decreasing in 2014. The value did not change much between 2014 and 2016, relative

to the other years. The monthly SID fluctuated over the years, but did not fluctuate within a year (i.e. no seasonal variation could be discerned).

Lost Lagoon's SID also mostly fluctuated between 0.6 and 0.9, indicating a lack of a temporal trend. Its complementary linear regression indicated a slight insignificant increase ($y = 3.6 \times 10^{-4} + 0.75$, $R^2 = 0.027$, $p = 0.059$). The mean SID per month was oscillated over time, with 2008 and 2013 being a discernible peak and discernible trough respectively. The monthly SID fluctuated over time, and there was no seasonal variation.

Devonian Park's SID mostly fluctuated between 0.1 and 0.9, showing a lack of a temporal trend. A linear regression suggested a slight and insignificant decrease ($y = -2.8 \times 10^{-3} + 0.68$, $R^2 = 0.060$, $p = 0.072$). The mean SID per month experienced a drop in 2012, recovered in 2013, and decreased again in 2014. This trend was reflected by the monthly abundances. There was no seasonal variation.

The Seawall's SID did not appear to have experienced a temporal trend.

4.1.4 Trends of the seven main taxonomic groups

As an additional question, the general avian population of Stanley Park was split into seven taxonomic groups -- raptors, Anseriformes, non-Anseriformes waterbirds (NAWs), Passeriformes, hummingbirds, Columbiformes, and Piciformes -- to determine the general taxa that were experiencing a temporal trend (or lack thereof) in biodiversity. All trends were summarized in **Table 2**.

The abundance and richness of raptors at Beaver Lake were both stable, with at least one individual/species (a bald eagle) spotted in most surveys. The raptors' abundance and richness was also stable at Lost Lagoon. One or two individuals were usually seen, and a bald eagle was usually observed. Raptors (specifically one bald eagle) have only been seen in Devonian Park on December 2009. At the Seawall, the abundance and richness were stable, with bald eagles being the most frequently spotted and most abundant.

The abundance of Anseriformes increased at Beaver Lake (**Figure 7**), while its richness remained stable as most surveyors found two to five species (**Figure 8**). The abundance appears to have decreased at Lost Lagoon since 2013, and the richness was stable. Four to twelve different species were usually found, with this wide range being the result of seasonal variation. More species were consistently observed around December. In Devonian Park, the abundance did not seem to have followed a temporal trend, although the richness was stable. Three to four different species were usually found by surveyors, although surveyors in December saw more. At the Seawall, the abundance did not seem to have follow a temporal trend, while the richness appeared to have decreased over time.

The abundance and richness of NAWs were both stable at Beaver Lake, with most counts seeing one or two different species. At Lost Lagoon, the abundance appeared to decrease over time, but the richness was stable as three to six different NAW species were usually observed by surveyors. At Devonian Park, both abundance and richness decreased after 2012. At the Seawall, the abundance did not seem to have followed a temporal trend, while the richness increased.

The category of Passeriformes was the most abundant and the most species rich out of the seven groups. At Beaver Lake, the abundance mostly fluctuated between 20 and 60 individuals and did not appear to have followed any temporal trend. However, it may also be interpreted as having increased. The richness also did not appear to have followed any temporal trend; it mostly fluctuated between five and 17 species, with summer surveys finding more species. At Lost Lagoon, the abundance and richness also did not appear to have followed any temporal trend, and the former mostly fluctuated between 50 and 200 individuals. Summer surveys usually observed more species. At Devonian Park, the abundance did not seem to have followed any temporal trend, while the richness appeared to

have decreased over time. At the Seawall, abundance, again, did not come across as having followed any temporal trend, while the richness was stable.

The abundance and richness of hummingbirds were stable in both Beaver Lake and Lost Lagoon, with most surveys in the two sites finding at one species (usually the Anna's hummingbird/*Calypte anna*). Hummingbirds (specifically an Anna's hummingbird) have only been spotted on February 2011 in Devonian Park. They have never been observed at the Seawall.

In Beaver Lake, the Columbiformes (specifically the rock pigeon) have only been seen twice: on July 2005 and December 2012. In Lost Lagoon, the abundance decreased while the richness remained stable, with one species (usually the rock pigeon) being seen by most surveys. The rock pigeon was the only member of the Columbiformes seen in Devonian Park and at the Seawall, appearing in the former only on August 2010, September 2010, July 2011, and September 2011 and the latter only in 2010, 2013, 2014, and 2015.

The abundance and richness of the Piciformes was stable in both Beaver Lake and Lost Lagoon, with at least one species usually being found each survey. They have never appeared in Devonian Park and have only appeared at the Seawall in 2009 (represented by the downy woodpecker/*Dryobates pubescens* and the northern flicker/*Colaptes auratus*).

4.2 Did the Disturbance-Adapted Species Experience Increases/Stability in Biodiversity?

The seven general taxonomic groups were further divided and rearranged into several subgroups, with one of them containing species that can adapt to disturbances easily and interacted a lot with humans. The northwestern crow, rock pigeon, European starling, and house sparrow were all grouped into the human-associated subgroup. As a subgroup, the abundance of the human-associated birds was stable in Beaver Lake (**Figure 9A**) and Devonian Park. It decreased at the Seawall and did not experience any temporal trend at Lost Lagoon. Richness was stable; one or two disturbance-adapted species were usually seen in

most of the surveys at all sites (**Figure 9B**). Lost Lagoon experienced the highest abundance of disturbance-adapted species, then the Seawall, then Beaver Lake, and finally Devonian Park. These results are summarized in **Table 3**.

On an individual species level, the northwestern crow was the most frequently seen as well as the most abundant. Northwestern crows experienced a stable abundance at Beaver Lake (**Table 4**) and Devonian Park (**Table 6**). Their abundance did not appear to follow a temporal trend at Lost Lagoon (**Table 5**) and the Seawall (**Table 7**). Rock pigeons were rarely seen in all sites except for Lost Lagoon, where their abundance did not seem to have experienced a temporal trend (**Table 5**). European starlings were seen in Beaver Lake, Lost Lagoon, and Devonian Park. They were rarely seen in Beaver Lake, while their abundance did not appear to follow a temporal trend in Lost Lagoon (**Table 5**) and was stable in Devonian Park (**Table 6**). House sparrows were seen in all sites except Beaver Lake. They were rarely seen in Lost Lagoon and at the Seawall, but their abundance was stable at Devonian Park (**Table 6**).

Other disturbance-adapted species included in other non-human-associated subgroups can be considered too, like the double-crested (*Phalacrocorax auritus*) and pelagic cormorants (*Phalacrocorax pelagicus*) based on the results of Worcester (2011), Canada goose, mallard, and gulls. Double-crested cormorants were seen in all sites except Beaver Lake. They were rarely seen in Devonian Park, and their abundance was stable and decreasing in Lost Lagoon (**Table 5**) and at the Seawall (**Table 7**) respectively. Pelagic cormorants were seen at Lost Lagoon, Devonian Park, and the Seawall. They were rarely seen at Lost Lagoon and Devonian Park. They were more abundant than double-crested cormorants at the Seawall, and their abundance did not seem to have followed any temporal trend. Canada geese appeared in all four sites. Its abundance was stable at Beaver Lake , increasing at Lost Lagoon, decreasing at Devonian Park, and not following any temporal

trend at the Seawall (**Tables 4, 5, 6, & 7 respectively**). Most of the gulls that were observed were not identified. Their collective abundance was stable in Beaver Lake **(Table 4**), decreasing in Lost Lagoon and Devonian Park (**Tables 5 & 6 respectively**), and not following a temporal trend at the Seawall (**Table 7**).

4.3 Did the Less Disturbance-Adapted Species Experience Decreases in Biodiversity?

In most cases, the other non-human-associated subgroups did not experience decreases (**Tables 8-10**). Most of decreases were experienced by the seabirds. That was, however, linked with the gulls' collective decreases. Dabbling ducks also experienced decreases in Lost Lagoon, but that was linked to the mallard's own decrease. The only subgroup that experienced any decrease that could not be linked to any species habituated to disturbances was the Rallidae in Lost Lagoon. When looking at the individual trends of the less disturbance-adapted species, few of them experienced decreases. A majority of them were either stable or appeared too rarely to allow the judgement of a temporal trend. The subgroups of primary and secondary cavity nesters also did not experience any decreases in abundance (**Table 3**). Their richnesses were usually stable, with the exception of the primary cavity nesters in Devonian Park, which decreased.

5. Discussion

Initially, I predicted that my analysis would show that general avian populations of Stanley Park were experiencing temporal trends in various measures of biodiversity, specifically abundance, richness, and the Simpson's Index of Diversity (SID). This prediction was somewhat supported by my results. In addition, I also predicted that the species that were more habituated to disturbances would have experienced increasing or stable abundances over time, while the birds that were less habituated would have experienced decreasing abundances. The latter two were based off of the results of Worcester (2011), who had found that more habituated birds (like cormorants and Canada geese) appeared to have been

increasing in abundance. However, based off of my own results, both of these predictions could not be completely supported.

Combining all birds into one general population for each site showed that all sites experienced temporal trends in abundance and species richness, with the only exception being Devonian Park's abundance. However, none of the sites seem to have experienced any temporal trend in the Simpson's Index of Diversity, as the index constantly fluctuated over time. As a result, I can reasonably conclude that the general avian populations of Stanley Park experienced temporal trends in abundance and richness but not in the Simpson's Index of Diversity.

Splitting the birds into seven general taxonomic groups showed that most of them actually experienced stable abundances or appeared too rarely to determine temporal abundance trends. However, at all four sites (with the possible exception of Lost Lagoon), the abundance of the Passeriformes did not follow any temporal trend. On the other hand, the richness of the seven general groups were mostly stable or they appeared too rarely to determine temporal richness trends. This time, fewer taxonomic groups did not experience any temporal trend. This occurred to the Anseriformes in Lost Lagoon, and the Passeriformes in Beaver Lake and Lost Lagoon. The lack of any trend was linked to seasonal variation in the first two cases.

The abundance of all disturbance-adapted species -- the European starling, house sparrow, northwestern crow, and rock pigeon -- combined were temporally stable in Beaver Lake and Devonian Park. However, it appeared to have decreased in the Seawall surveys and seemed to not have followed any temporal trend in Devonian Park. Examining each disturbance-adapted species showed that their abundance at a site was usually either stable, not following a temporal trend, or very low to the point where no trends could be discerned. If other species that are habituated to disturbances but were placed in another group were

considered, the results are more mixed. The two cormorant species (pelagic and double-crested) recorded in the surveys did not appear to have increased in abundance over time. Instead, across all four sites, they were usually rarely seen. For the double-crested cormorant, it had experienced a stable abundance and a decreasing one in Lost Lagoon and the Seawall surveys respectively. For the pelagic cormorant, its abundance did not appear to have followed any temporal trend in the Seawall surveys. The Canada goose can also be considered, and its abundance mixes the results even more; it was stable in Beaver Lake, increased in Lost Lagoon, decreased in Devonian Park, and did not appear to have experienced any temporal trend in the Seawall surveys. Another species, the mallard, was also a mixed case. Their abundance increased in Beaver Lake, decreased in Lost Lagoon, and did not experience any temporal trends in Devonian Park and the Seawall surveys. In addition, the gulls, another kind of bird that has habituated to humans, have experienced decreases in Lost Lagoon and Devonian Park in general although they were stable in Beaver Lake and had not experienced any temporal trend in Seawall surveys. Combining all of these results together shows that while some avian species that are more habituated to disturbances experienced a stable or increasing abundance, others have actually decreased or had not experienced any temporal trends. As a result, I cannot reasonably conclude that birds that are habituated to disturbances experienced increasing abundances over time. However, I do note that some species were able to experience stability.

When looking at each of the species individually, a majority of species that are less habituated to disturbances were either stable or appeared too rarely to allow the judgement of a temporal trend. Few of these species were judged to have had abundances that decreased over time. In addition, very few of the subgroups of the seven main taxonomic groups experienced decreases in abundance. The ones that did were the seabirds, the dabbling ducks, and the Rallidae. However, the Rallidae's decrease was the only one that was not linked to

the decrease in the abundance of any of the disturbance-adapted species. Because most of the less-habituated species were not experiencing any decreases, I cannot conclude that they experienced decreases in abundance over time.

One potential reason why my conclusions go against those of Worcester (2011) may lie in her methodology. To determine the population trends of the birds sighted off the Seawall, Worcester and her team of surveyors compared data from bird counts conducted in two periods of time -- from October 2001 to March 2002 and from October 2010 to March 2011. One pattern apparent in my results is that some years will experience high abundances of birds while others will experience low abundances, sometimes without any apparent pattern. Without looking at the intermediate years between the two periods, Worcester (2011) cannot reasonably determine temporal trends as the abundances observed between 2010 and 2011 may only have been one a part of the low years.

Many factors have been identified as general causes for decreasing biodiversity. For example, climate change has been cited as a major cause of biodiversity changes by studies such as Thomas *et al.* (2004) and Harley (2011). Climate change may shift temperatures beyond some species' tolerance ranges. However, other species may still be able to resist the temperature shifts moreso than other species, leading to changes in interspecific interactions and subsequently alterations in community composition and biodiversity. Pollution by pesticides, oils, and other toxins (Czech and Krausman, 1997; Wilcove *et al.*, 1998) and urbanization (Czech and Krausman, 1997; Luniak, 1994; Marzluff, 2001) have also been acknowledged as factors. In addition, human disturbances can decrease biodiversity (Czech and Krausman, 1997; Kitahara and Fujii, 1994). Less disturbances lead to a more stable environment, which allows more niches to develop and more organisms to specialize into them without running the risk of dying off due to the environment (and subsequently the niches) changing (Kitahara and Fujii, 1994). In addition, disturbances can decrease breeding

success rates (Giese 1996) and discourage organisms from feeding in preferred areas (Gander and Ingold, 1997; Sutherland and Crockford, 1993), lowering the populations of disturbed species. In fact, Worcester (2010a) believed disturbances to be the main reason why Devonian Park is not good at supporting wildlife. Also, Worcester (2011) attributed all of the observed decreases in abundances to all factors. Another factor touched upon by Worcester (2010b) is the water quality; as both Beaver Lake and Lost Lagoon are currently experiencing decreases in their depth, their chemical and physical properties may change in ways that harm local flora and fauna (e.g. increased temperature and decreased oxygen content). However, while this may explain why some of the species and taxonomic groups experienced decreases in the measures of biodiversity, this does not explain the increases or the stability that other species and groups experienced.

Stability and increases in the measures of biodiversity may be explained by actions taken by the SPES and the city of Vancouver that maintain the environment. One of these actions was the establishment of the stormwater treatment plant in Lost Lagoon, which filters out harmful chemicals (like motor oil) from the runoff water that comes from the road (Worcester, 2010b). Other actions include the programs run by the SPES that remove water lilies, ivy, and other invasive plant species while replanting native species. This frees up more resources for native plant species to use, increasing or maintaining their abundance and subsequently benefiting those that prey on them. Beavers are also helping maintain the habitats. In addition to removing the water lilies, they also dredge up the bottom of the water bodies, restoring their depth. However, the described contributors to stability and increases (as well as the described contributors to decreases) are only possibilities. Future research should be conducted in the park to determine if these factors are in fact contributors to the biodiversity.

In addition, the trends and lack thereof that I observed may have been influenced by the methodology of the surveys. One possible improvement to them would be to increase their frequency of conduction. Doing so may allow species that were present in the park during the month but not spotted during the survey to be recorded. Another possible improvement would be to randomize the time of day that the survey starts as well as the order by which the surveys are conducted because different species may be observed at different times. Surveys could also be performed in forest sites that do not contain any water bodies, as all available park sites that were monitored included them. These factors may explain why only 150 avian species were recorded in the dataset, as opposed to the 236 species that have appeared in the park according to Worcester (2010b). For data filing, some factors like the number of observers, weather conditions, and time of day could also be noted on the off-chance that observed population trends are linked to them. Trends may also have been mis-analyzed because they were decided subjectively. An objective method for determining trends could be developed for future analyses on population trends in Stanley Park.

In reality, the trends determined in this project may not be completely accurate, due to many issues with methodology as well how bird surveys may not be reliable in general (Johnson, 2008). However, with the rarity of a comprehensive analysis on avian populations in Stanley Park (as well as any park in the Pacific Northwest in general), the results of this project may still be useful in providing some idea about the populations.

6. Acknowledgements

First of all, I would like to thank my supervisor Dr. Jill Jankowski for her feedback and support during the entire process of analyzing the populations of Stanley Park. I am very surprised that she managed to understand most of my ramblings during our meetings. I would also like to thank Maria Egerton (the Conservation Projects Manager) for allowing me the privilege of analyzing many years of survey data collected by the SPES, Vanessa Smith (the Conservation Technician) for listening to me cough and stumble my way through a few hours in an attempt to summarize all of the trends I found, and the rest of the staff at the SPES (especially Maria's dog). In addition, I would like to thank Dr. Darren Irwin, Dr. Agnes Lacombe, and all of my friends and other Honour's students for their help and support. I would list them all out but I feel like I already have way too many acknowledgements. Most of all, I would link to thank my mom for giving me rides to the SPES and helping me not die. If you're still reading this, thank you to you too! It's a long thesis, unfortunately, but hopefully you came away with an understanding that there are way more birds at Stanley Park than you'd expect.

7. Literature Cited

BirdLife International (n.d.) *Pacific Americas Flyway* [PDF document]. Retrieved Mar 26, 2015, from http://www.birdlife.org/datazone/userfiles/file/sowb/flyways/1_Pacific_Americas_Factsheet.pdf

Bixler, R.D., Floyd, M.F., & Hammitt, W.E. (2002). *Environment and Behaviour* 34: 795-818.

Blair, R.B. (1996). Land use of avian species diversity along an urban gradient. *Ecological Applications* 6: 506-519.

Cafferata-Coe, F. (2014). *Cavity-Nesting Birds and Small Woodlands*. Corvallis, OR: Woodland Fish & Wildlife, Oregon State University.

CCNAB (2017). *Seabirds*. Retrieved Mar 5, 2017, from http://www.birds-of-north-america.net/seabirds.html

Chapin III, F.S., Zavaleta, E.S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L., … Diaz, S. (2000). Consequences of changing biodiversity. *Nature* 405: 234-242

City of Vancouver (n.d. a). *Stanley Park*. Retrieved Dec 9, 2016, from http://vancouver.ca/parks-recreation-culture/stanley-park.aspx

City of Vancouver (n.d. b). *Wildlife*. Retrieved Dec 9, 2016, from http://vancouver.ca/parks-recreation-culture/wildlife-.aspx

City of Vancouver (n.d. a). *Devonian Harbour Park*. Retrieved Mar 5, 2017, from http://covapp.vancouver.ca/parkfinder/parkdetail.aspx?inparkid=18

City of Vancouver (n.d. b). *Lost Lagoon Destination Walk*. Retrieved Mar 5, 2017, from http://vancouver.ca/parks-recreation-culture/stanley-park-lost-lagoon.aspx

City of Vancouver (n.d. c). *Seawall Destination Walk*. Retrieved Mar 5, 2017, from http://vancouver.ca/parks-recreation-culture/stanley-park-seawall.aspx

Clergeau, P., Mennechez, G., Sauvage, A., & Lemoine, A. (2001). Human perception and appreciation of birds: a motivation for wildlife conservation in urban environments of France. In J.M. Marzluff, R. Bowman, and R. Donnelly (eds.), *Avian Ecology and Conservation in an Urbanizing World* (pp. 69-88). New York City, NY: Springer US.

Czech, B. & Krausman, P.R. (1997). Distribution and causation of species endangerment in the United States. *Science* 277: 1116-1117.

Dickman, C.R. (1987). Habitat fragmentation and vertebrate species richness in an urban environment. *Journal of Applied Ecology* 24: 337-351.

Estes, J.A. & Palmisano, J.F. (1974). Sea otters: Their role in structuring nearshore communities. *Science* 185: 1058-1060

Fernández-Juricic, E., Jimenez, M.D., & Lucas, E. (2001). Bird tolerance to human disturbance in urban parks of Madrid (Spain): management implications. In J.M. Marzluff, R. Bowman, and R. Donnelly (eds.), *Avian Ecology and Conservation in an Urbanizing World* (pp. 259-273). New York City, NY: Springer US.

Gander, H. & Ingold, P. (1997) Reactions of male chamois *Rupicapra r. rupicappa* to hikers, joggers and mountainbikers. *Biological Conservation* 79: 107–109.

Giese, M. (1996) Effects of human activity on Adélie penguin Pygoscelis adeliae breeding success. *Biological Conservation* 75: 157–164.

Goddard, M.A., Dougill, A.J., & Benton, T.G. (2009). Scaling up from gardens: biodiversity conservation in urban environments. *Trends in Ecology and Evolution* 1175: 1-9.

Harley, C.D.G. (2011). Climate change, keystone predation, and biodiversity loss. *Science* 334: 1124-1127.

IBA (n.d.). *Important Bird Areas in Canada*. Retrieved Dec 9, 2016, from http://www.ibacanada.ca/

Johnson, D.H. (2008). In defense of indices: The case of bird surveys. *Journal of Wildlife Management* 72: 857-868.

Kitahara, M. & Fujii, K. (1994). Biodiversity and community structure of temperate butterfly species within a gradient of human disturbance: an analysis based on the concept of generalist vs. specialist strategies. *Researches on Population Ecology* 36: 187-199.

Luniak, M. (1994). The development of bird communities in new housing estates in Warsaw. *Memorabilia Zoologica* 49: 257-267.

Marzluff, J.M. (2001). Worldwide urbanization and its effects on birds. In J.M. Marzluff, R. Bowman, and R. Donnelly (eds.), *Avian Ecology and Conservation in an Urbanizing World* (pp. 19-47). New York City, NY: Springer US.

McKinney, M.L. (2006). Urbanization as a major cause of biotic homogenization. *Biological Conservation* 127: 247-260.

Melles, S., Glenn, S., & Martin, K. (2003). Urban bird diversity and landscape complexity: Species-environment associations along a multiscale habitat gradient. *Conservation Ecology*, *7*, 5. [online] URL: http://www.consocol.org/vol7/iss1/art5

Melles, S.J. (2005). Urban bird diversity as an indicator of human social diversity and economic inequality in Vancouver, British Columbia. *Urban Habitats* 3: 25-48.

Nagendra, H. (2002). Opposite trends in response for the Shannon and Simpson indices of landscape diversity. *Applied Geography* 22: 175-186.

Proulx, R., Wirth, C., Voigt, W., Weigelt, A., Roscher, C.,...Schmid, B. (2010). Diversity promotes temporal stability across levels of ecosystem organization in experimental grasslands. *PLoS One*, *5*, e13382. doi:10.1371/journal.pone.0013382

Pyle, P. & DeSante, D.F. (2017). *Four-letter (English name) and six-letter (scientific name) alpha codes for 2127 bird species (and 98 non-species taxa) in accordance with the 57th AOU supplement (2016), sorted by English name* [PDF document]. Retrieved Apr 7, 2017, from http://www.birdpop.org/docs/misc/Alpha_codes_eng.pdf

SPES (n.d. a). *About Us*. Retrieved Dec 9, 2016, from http://stanleyparkecology.ca/about-us/

SPES (n.d. b). *Bird Watching in Stanley Park*. Retrieved Dec 9, 2016, from http://stanleyparkecology.ca/conservation/urban-wildlife/bird-watching/

SPES (2007 Dec). *Stanley Park bird list* [PDF document]. Retrieved Mar 15, 2016, from http://stanleyparkecology.ca/wp-content/uploads/downloads/2012/03/Stanley-Park-Bird-Checklist.pdf

SPES (2013 Jan). *Stanley Park Ecology Society invasive plant management plan* [PDF document]. Retrieved Mar 5, 2017, from http://stanleyparkecology.ca/wp-content/uploads/downloads/2014/06/SPES_StanleyParkISMP_5June2014.pdf

Stachowicz, J.J., Fried, H., Osman, R.W., & Whitlatch, R.B. (2002). Biodiversity, invasion resistance, and marine ecosystem function: reconciling pattern and process. *Ecology* 83: 2575-2590.

Sutherland, W.J. & Crockford, N.J. (1993) Factors affecting the feeding distribution of red-breasted geese *Branta ruficollis* wintering in Romania. *Biological Conservation* 63: 61–65.

Thomas, C.D., Cameron, A., Green, R.E., Bakkenes, M., Beaumont, L.J., Collingham, Y.C., …, & Williams, S.E. (2004). Extinction risk from climate change. *Nature* 427: 145-148.

Tilman, D. (1999). The ecological consequences of changes in biodiversity: a search for general principles. *Ecology* 80: 1455-1474.

Tourism Vancouver (n.d.). *Stanley Park*. Retrieved Dec 9, 2016, from http://www.tourismvancouver.com/activities/stanley-park/

Tourism Vancouver (n.d.). *Hiking Around the Seawall*. Retrieved Mar 5, 2017, from https://www.tourismvancouver.com/activities/hiking/vancouver-seawall/

Turner, W.R., Nakamura, T., & Dinetti, M. (2004). Global urbanization and the separation of humans from nature. *Bioscience* 54: 585-590.

Vancouver Board of Parks and Recreation (2011). *Beaver Lake nature walk* [PDF document]. Retrieved Mar 5, 2017, from http://vancouver.ca/files/cov/beaver-lake-walking-tour-guide.pdf

Vancouver Board of Parks and Recreation & SPES (2013 Nov). *Ecologically and culturally sensitive enhancement of Beaver Lake* [PDF document]. Retrieved Mar 5, 2017, from http://vancouver.ca/files/cov/Beaver-Lake-enhancement-proposal.pdf

Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A., & Losos, E. (1998). Quantifying threats to imperiled species in the United Species. *BioScience* 48, 607-615.

Worcester, R. (2010a). Stanley Park's first State of the Park Report. *Stanley Park Ecology Society*. Retrieved from http://stanleyparkecology.ca/wp-content/uploads/downloads/2012/02/newsLetterSpring2010.pdf

Worcester, R. (2010b). *State of the park report for the ecological integrity of Stanley Park* [PDF document]. Retrieved from http://stanleyparkecology.ca/wp-content/uploads/downloads/2012/03/State-of-the-Park-Report-for-the-Ecological-Integrity-of-Stanley-Park-full-report.pdf

Worcester, R. (2011 Nov). *Trends in the abundance of wintering waterbirds along the Stanley Park shoreline between 2001/2002 and 2010/2011* [PDF document]. Retrieved from http://stanleyparkecology.ca/wp-content/uploads/downloads/2012/02/SPES_-Winter-Waterbird-Trend-Report-6-Dec-20111.pdf

Worcester, R. & Titator, B. (2012 Jun). *Best management practices for species of significance in Stanley Park* [PDF document]. Retrieved from http://stanleyparkecology.ca/wp-content/uploads/downloads/2012/11/Worcester_SPES_SOSReport-2012.pdf

Worcester, R. (2014 Dec). *Winter waterbird survey 2014* [PDF document]. Retrieved from http://stanleyparkecology.ca/wp-content/uploads/downloads/2014/12/2014-Winter-Waterbird-Report-2.pdf

8. Figures

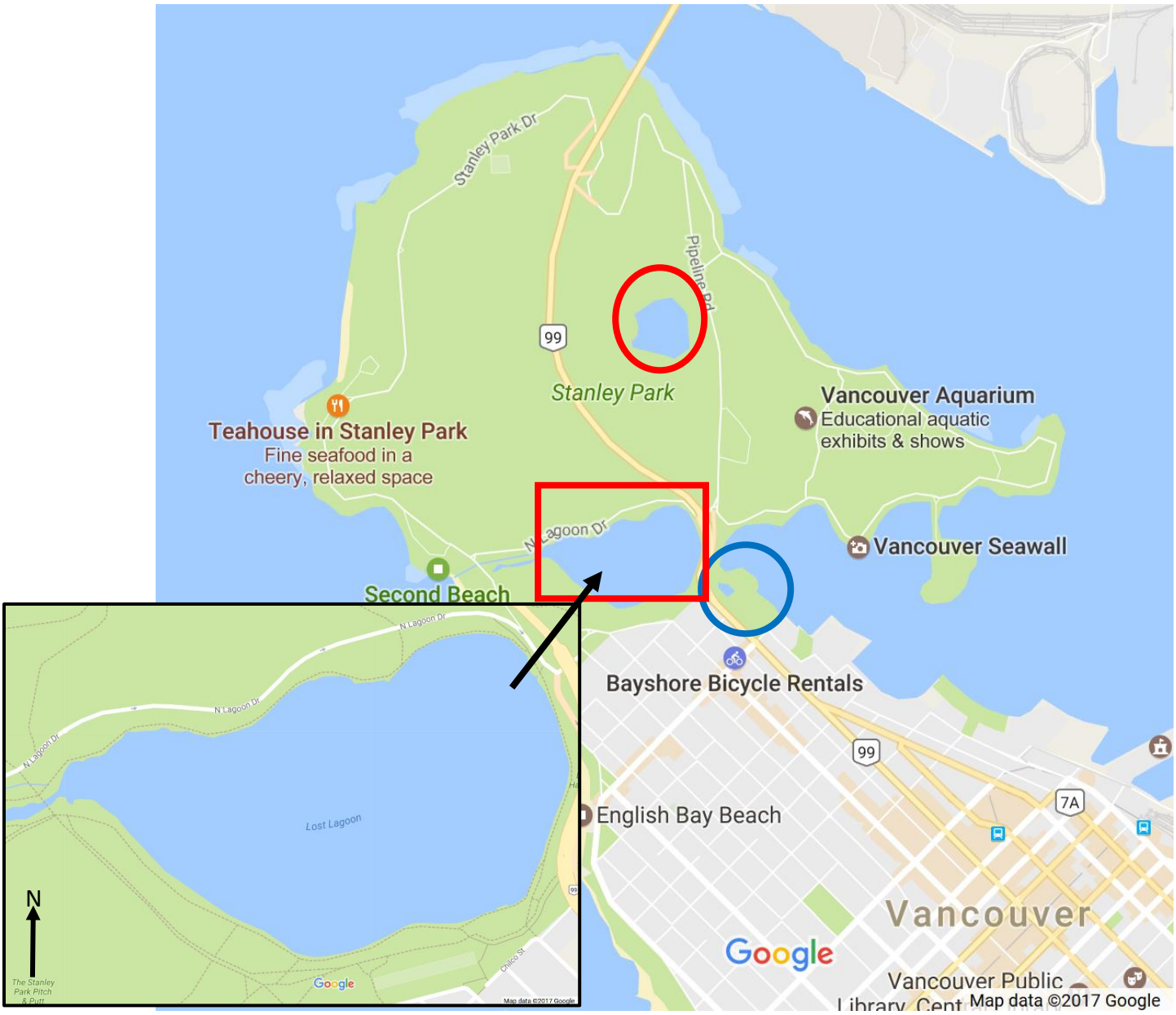


Figure 1. A map of Stanley Park generated by Google Maps. Downtown Vancouver lies southeast of the park, English Bay lines the western coast of the park, and the Vancouver Harbour lines the eastern coast of the park. The Stanley Park Causeway is a highway (denoted by the number 99) that cuts through the park. Beaver Lake is circled in red, Lost Lagoon is boxed in red, Devonian Park is circled in blue, and the Seawall lines the entire coastline of Stanley Park. Inset is a map of Lost Lagoon generated by Google Maps that shows a pedestrian pathway that loops around the lagoon, which is at 49.2959539, -123.140559 latitude, longitude.

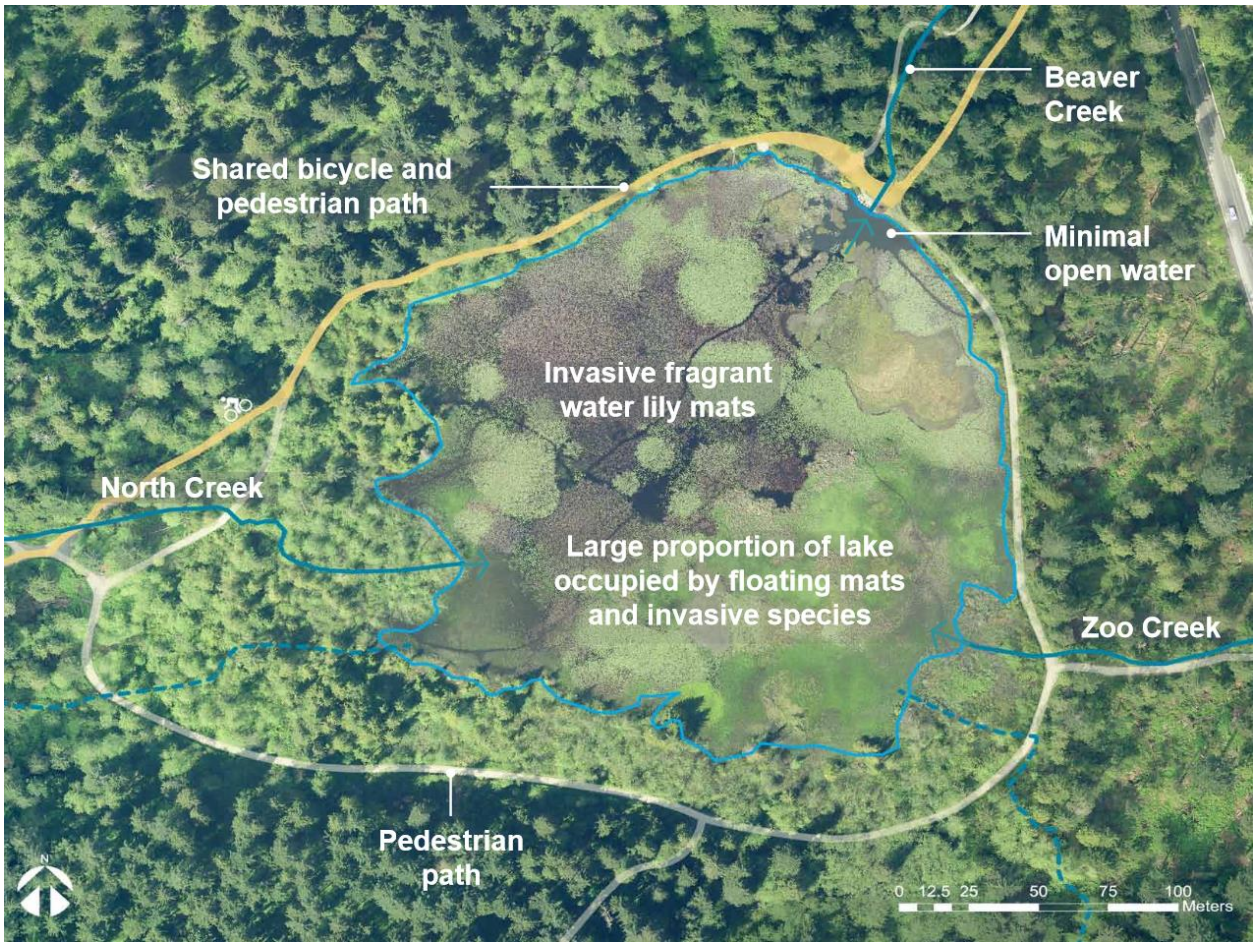


Figure 2. A map of Beaver Lake that highlights the water fauna and paths that the visitors may use to observe the lake's natural offerings. The lake is at 49.3040087, -123.1390617 latitude, longitude. Taken from Vancouver Board of Parks and Recreation and SPES (2013).

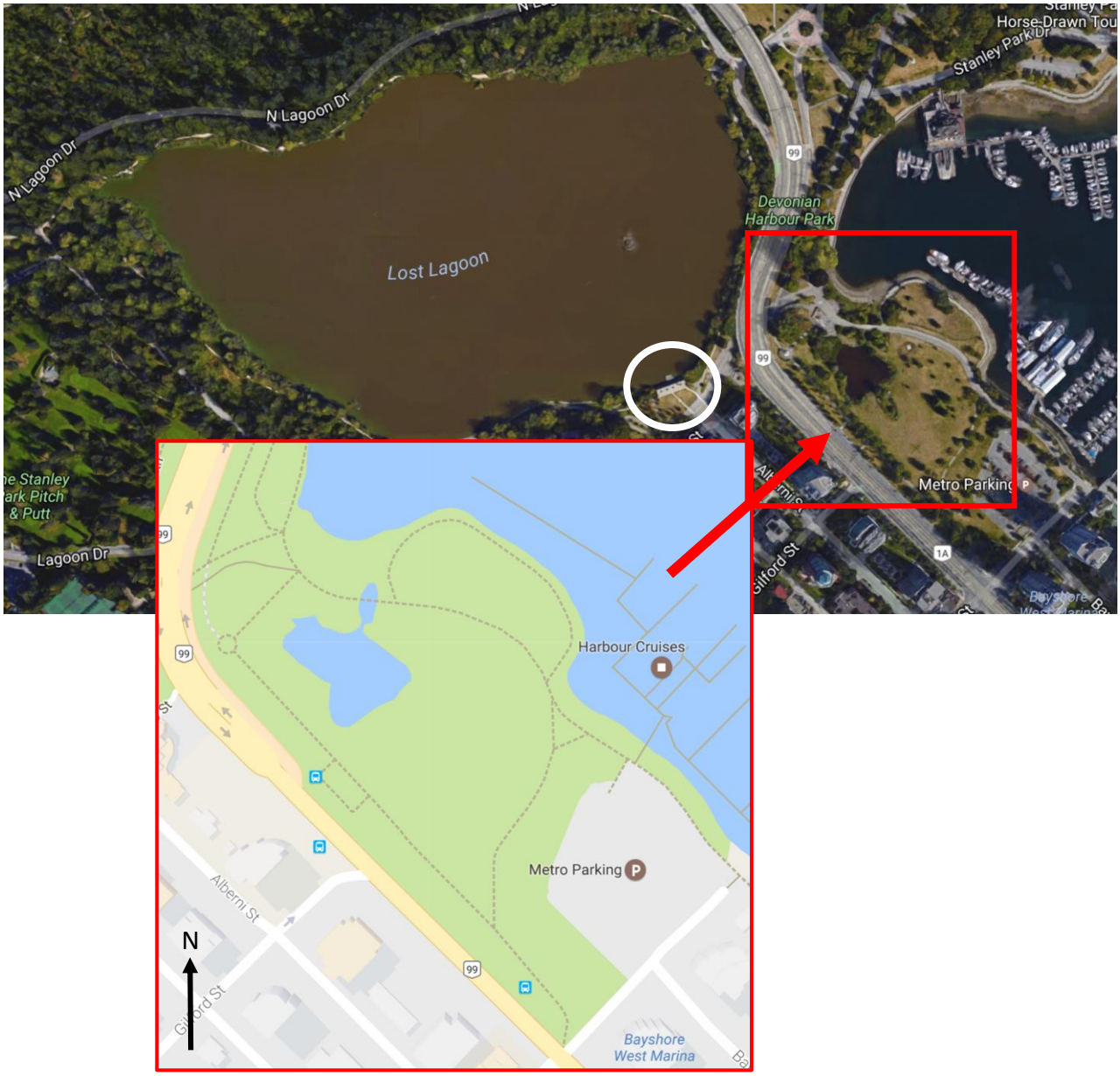
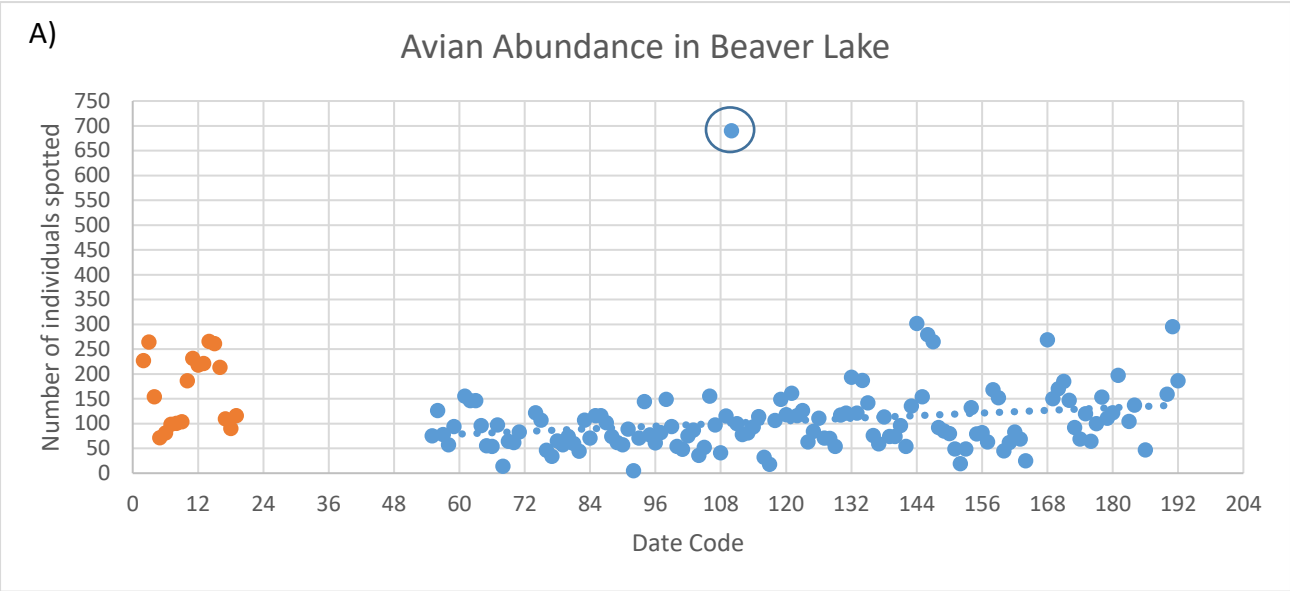


Figure 3. Satellite imagery of Lost Lagoon and Devonian Harbour Park generated by Google Maps. The Stanley Park Nature House is circled. The Stanley Park Causeway can be seen between the two sites, as denoted by the number 99. The Lagoon is at 49.2959539, -123.140559 latitude, longitude, while Devonian Park is located at 49.2959016, -123.1362896 latitude, longitude. Inset in red is a map of Stanley Park also generated by Google Maps.



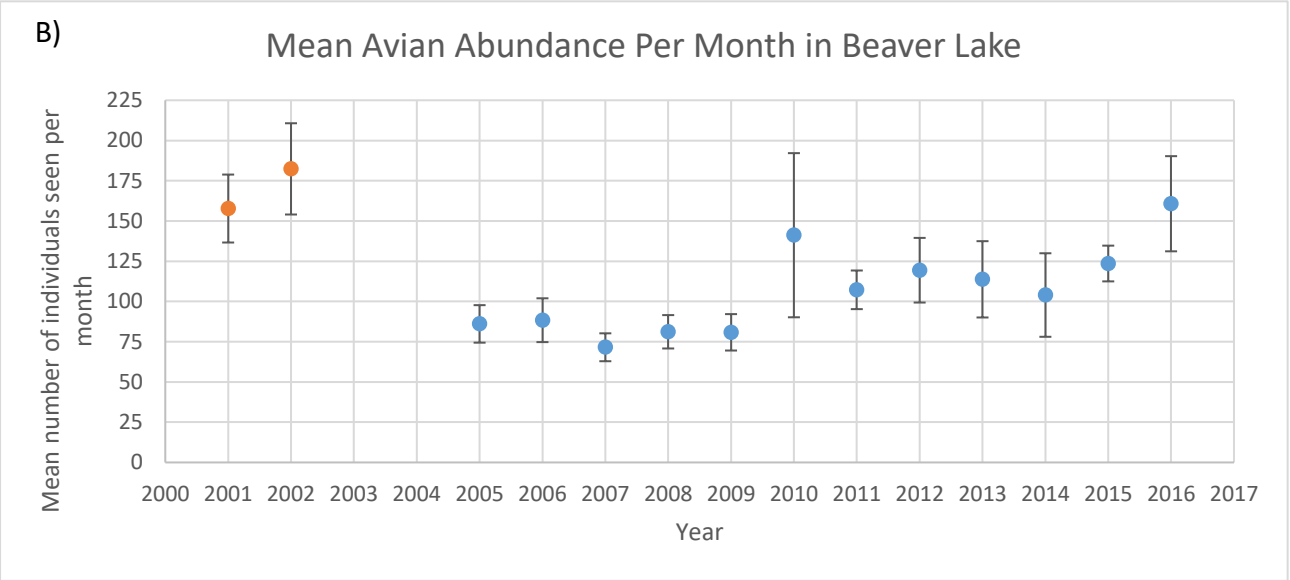


Figure 5. A) The abundance of all birds spotted and B) the mean amount of all birds spotted per month for each year in Beaver Lake. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2001. 2 = February 2001. 12 = December 2001. Orange dots represent abundance values from surveys performed in 2001 or 2002. The dotted line represents a linear regression ($y = 0.44 + 52$, $R^2 = 0.049$, $p = 0.012$). On February 2010 (circled in blue), the abundance was much higher than usual as a result of more pine siskins (in a group of 550 individuals) visiting the site than usual. For B), error bars represent ± one standard error value. Similar graphs were created for the other study sites and measures of biodiversity and are included in the appendix.

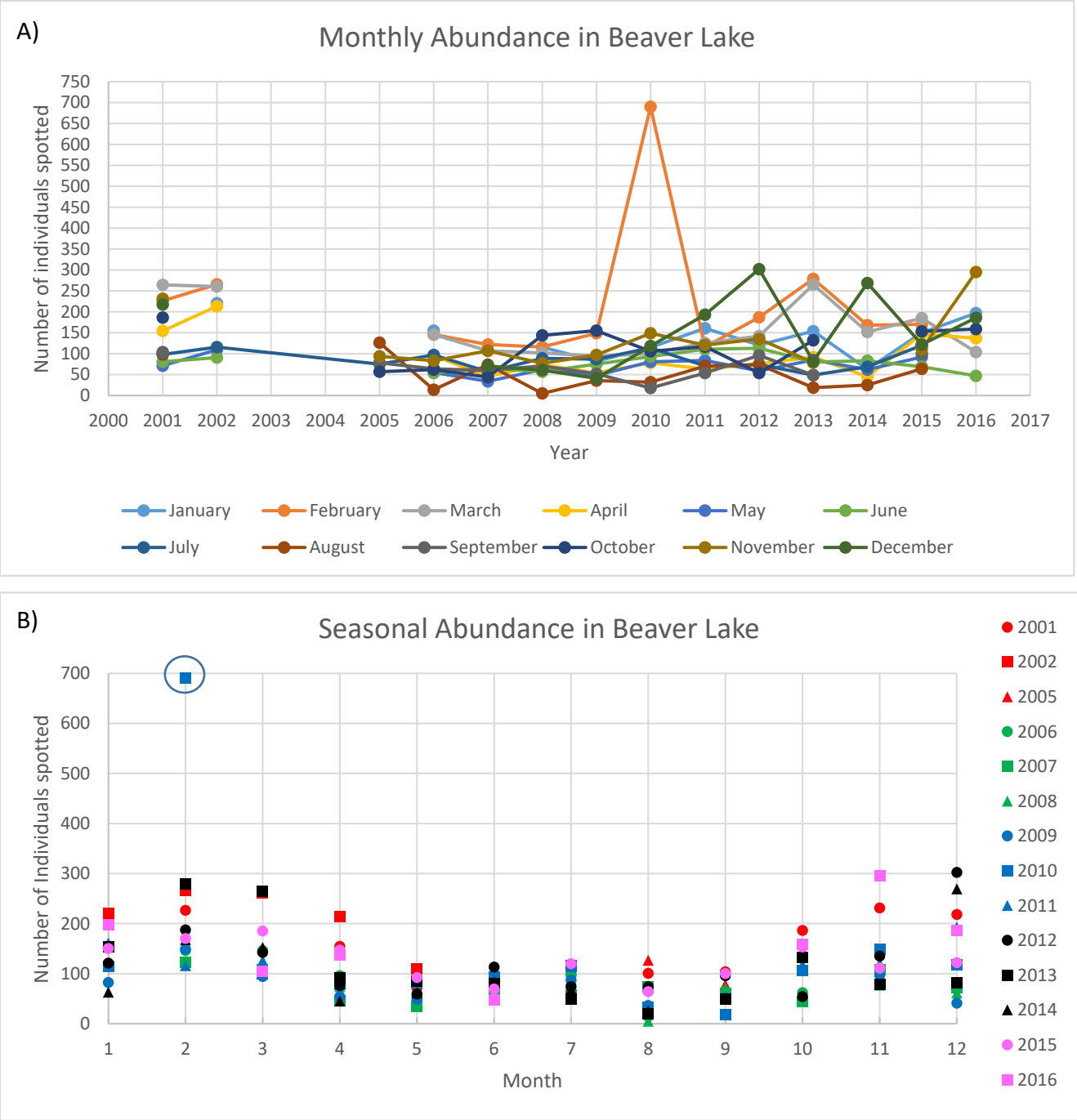


Figure 6. A) A line graph of each month's respective abundances throughout the years in Beaver Lake. B) An overlay of each year's monthly abundances in Beaver Lake. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December. On February 2010 (circled in blue), the abundance was much higher than usual as a result of more pine siskins (in a group of 550 individuals) visiting the site than usual. Similar graphs were created for the other study sites and measures of biodiversity and are included in the appendix.

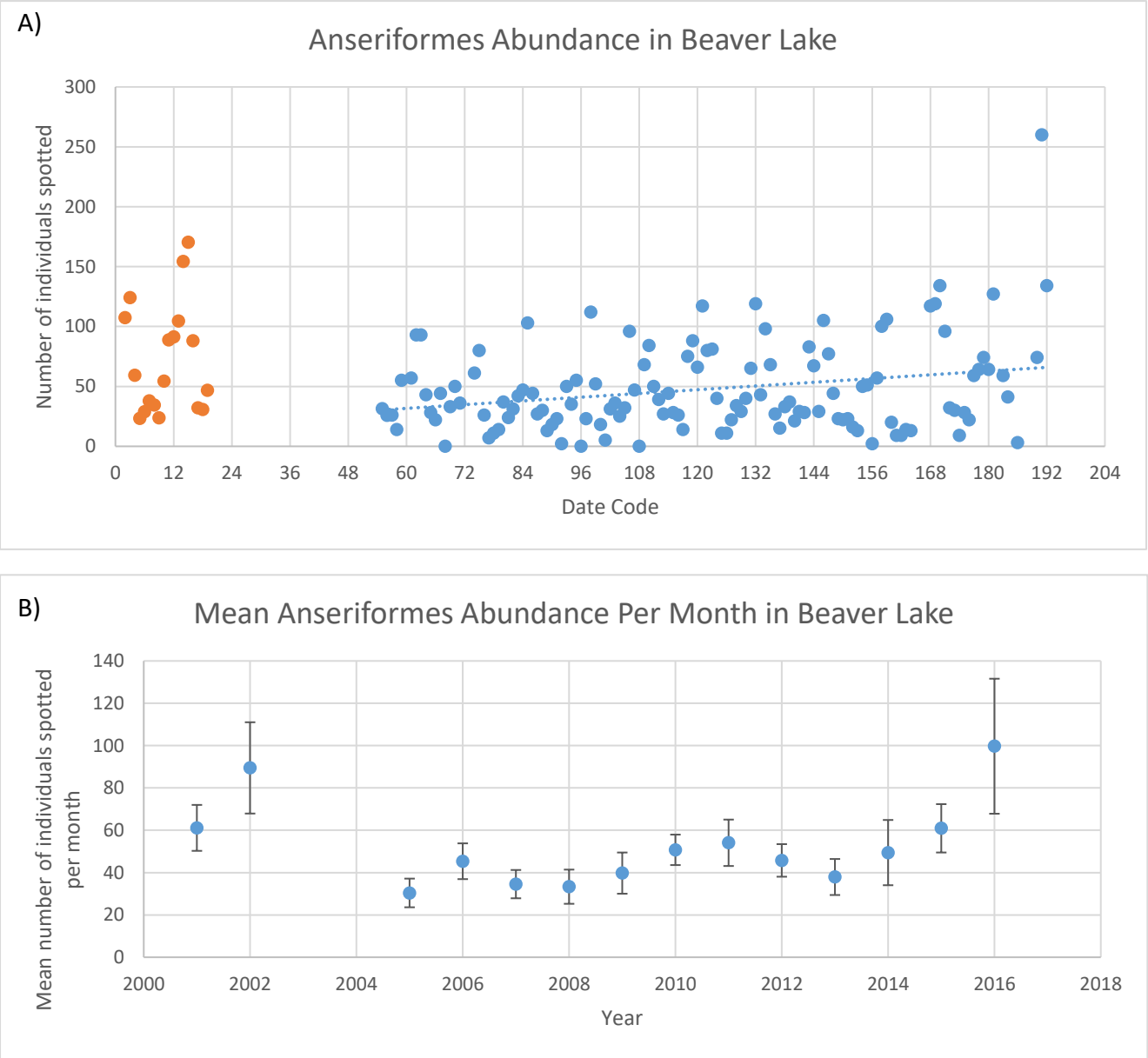


Figure 7. A) The abundance of Anseriformes species over time and B) the mean number of Anseriformes individuals spotted per month in Beaver Lake. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2001. 2 = February 2001. 12 = December 2001. Orange dots represent surveys conducted in 2001 or 2002. The dotted line represents a linear regression ($y = 0.26 + 16$, $R^2 = 0.068$, $p = 3.0 \times 10^{-3}$). For B, error bars represent ± one standard error value. Similar graphs were created for the other sites and six taxonomic groups, but are not shown in this thesis for conciseness.

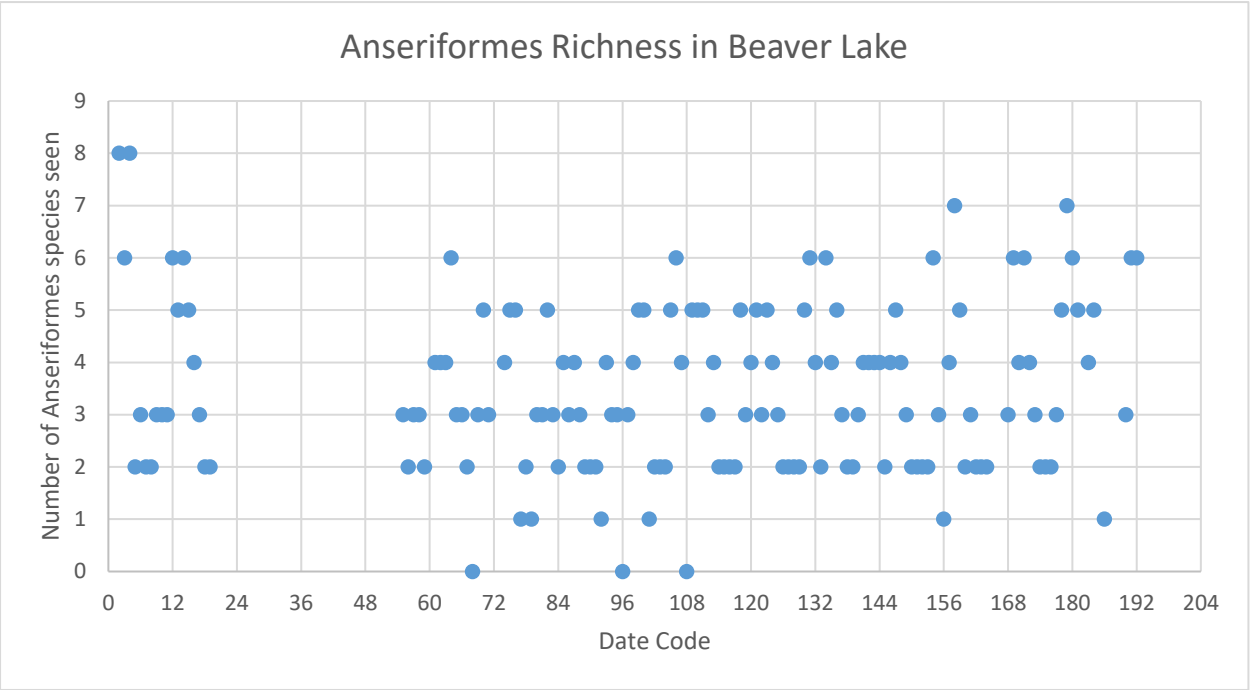
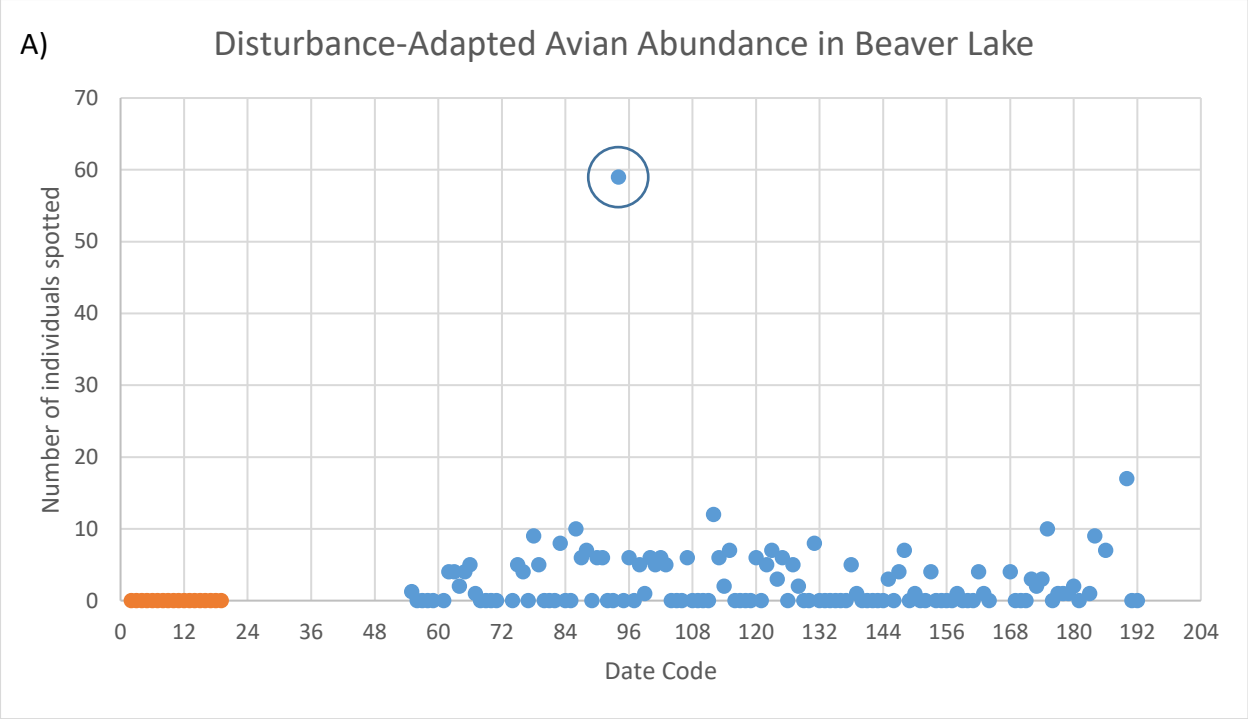


Figure 8. The species richness of Anseriformes species in Beaver Lake. The month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2001. 2 = February 2001. 12 = December 2001. Similar graphs were created for the other sites and six taxonomic groups, but are not shown in this report for conciseness.



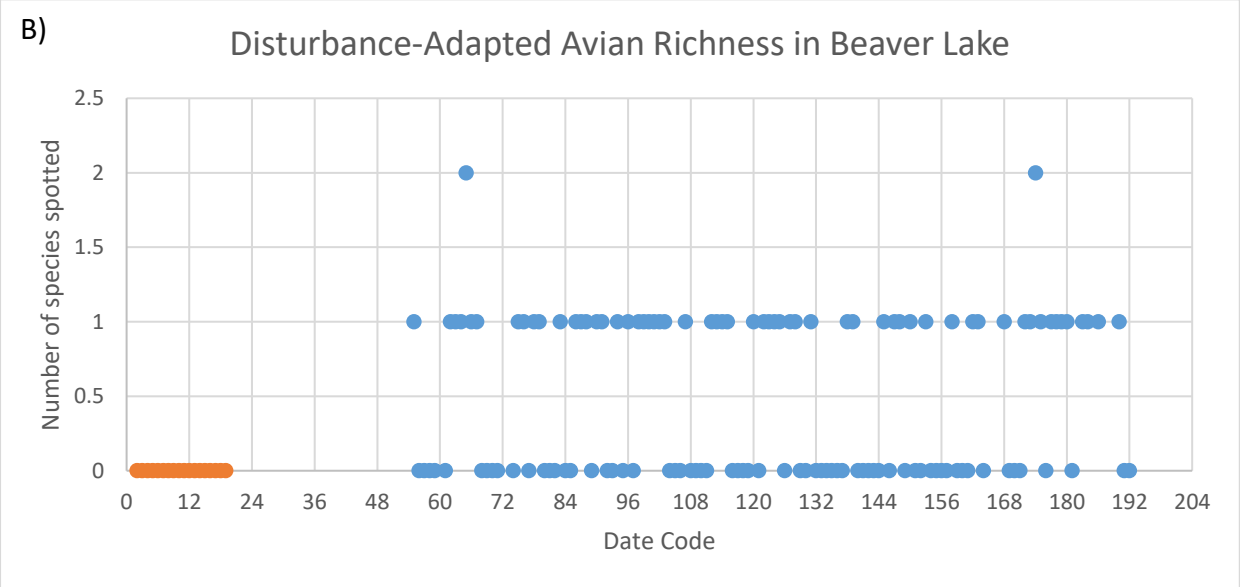


Figure 9. The abundance (A) and richness (B) of disturbance-adapted species over time in Beaver Lake. The month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2001. 2 = February 2001. 12 = December 2001. Orange dots represent surveys conducted in 2001 or 2002. On October 2008 (circled in blue), the higher abundance of disturbance-adapted birds was a result of more northwestern crows (in a group of 59) being seen by surveyors than usual. Similar graphs were created for the other sites and subgroups. However, only the abundance and richnesses for the disturbance-adapted subgroup have been included in the appendix.

9. Tables

Table 1. A summary of the general population trends for the values of three measures of biodiversity taken from four different sites in Stanley Park – Beaver Lake (BL), Lost Lagoon (LL), Devonian Park (DP), and the Seawall (WW, which stands for Winter Waterbirds). Population trends were based on data collected from Beaver Lake between July 2005 and December 2016, from Lost Lagoon between January 2005 and December 2016, from Devonian Park between January 2009 and December 2014, and from the Seawall in annual counts between 2008 and 2015. NR = no temporal relationship/trend was found.

Study Site	**BL**	**LL**	**DP**	**WW**
Abundance	Increasing	Stable	NR	NR
Richness	Increasing	Increasing	Decreasing	Stable
Simpson's Index of Diversity	NR	NR	NR	NR

Table 2. A summary of the population trends for the abundance and richness values of the seven main groups of species in Stanley Park. The values were recorded in four different sites in Stanley Park – Beaver Lake (BL), Lost Lagoon (LL), Devonian Park (DP), and the Seawall (WW, which stands for Winter Waterbirds). Population trends were based on data collected from Beaver Lake between July 2005 and December 2016, from Lost Lagoon between January 2005 and December 2016, from Devonian Park between January 2009 and December 2014, and from the Seawall in annual counts between 2008 and 2015. NAWs = Non-Anseriformes Waterbirds. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

Abundance	**BL**	**LL**	**DP**	**WW**
Raptors	Stable	Stable	NA	Stable
Anseriformes	Increasing	Decreasing	NR	NR
NAWs	Stable	Decrease	Decrease	NR
Passeriformes	NR	May be Increasing or NR	NR	NR
Piciformes	Stable	Stable	None	NA
Hummingbirds	Stable	Stable, but may be increasing	NA	None
Columbiformes	NA	Decreasing	NA	NA
Richness	**BL**	**LL**	**DP**	**WW**
Raptors	Stable	Stable	NA	Stable
Anseriformes	Stable	NR (related to seasonal variation)	Stable	Decreasing
NAWs	Stable	Stable	Decreasing	Increasing
Passeriformes	NR (caused by seasonal variation)	NR	Decreasing	Stable
Piciformes	Stable	Stable	None	NA
Hummingbirds	Stable	Stable	NA	None
Columbiformes	NA	Stable	NA	Stable

Table 3. A summary of the population trends for the abundance and richness values of the primary cavity nesters, the secondary cavity nesters, and the disturbance-adapted birds. The values were recorded in four different sites in Stanley Park – Beaver Lake (BL), Lost Lagoon (LL), Devonian Park (DP), and the Seawall (WW, which stands for Winter Waterbirds). Population trends were based on data collected from Beaver Lake between July 2005 and December 2016, from Lost Lagoon between January 2005 and December 2016, from Devonian Park between January 2009 and December 2014, and from the Seawall in annual counts between 2008 and 2015. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

Abundance	**BL**	**LL**	**DP**	**WW**
Primary Cavity Nesters	Stable	Increasing	Stable	NA
Secondary Cavity Nesters	Increasing	NR	Stable	Increasing
Disturbance-adapted	Stable	NR	Stable	Decreasing
Richness	**BL**	**LL**	**DP**	**WW**
Primary Cavity Nesters	Stable	Stable	Decreasing	NA
Secondary Cavity Nesters	Stable	NR	Stable	Stable
Disturbance-adapted	Stable	Stable	Stable	Stable

Table 4. A list of species in Beaver Lake that either experienced a temporal increase, a temporal decrease, temporal stability, or no temporal trend in abundance. Species that did not have enough data to determine whether they were experiencing a temporal trend or lack thereof are also included. The data used to determine the trends or lack thereof were collected between July 2005 and December 2016. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

Legend: Raptor, Anseriformes, Non-Anseriformes Waterbird, Passeriformes, **Piciformes,** *Hummingbird*, Columbiformes							
Increase	MALL	WODU					
Stable	BAEA	NOPI	AMGO	FOSP	PUFI	SWTH	**NOFL**
	MERL	RNDU	AMRO	GCKI	RBNU	VATH	**PIWO**
	AMWI	GBHE	BARS	NOCR	RCKI	VGSW	**RBSA**
	BUFF	Gull sp.	BRCR	NOFL	RWBL	VIRA	*ANHU*
	CAGO	GWGU	BUSH	NRWS	SOSP	WIFL	
	GWTE	PBGR	CORA	PAWR	SPTO	YRWA	
	HOME	WISN	DEJU	PSFL	STJA	**DOWO**	
Decrease							
NR	BCCH	CBCH	RECR				
NA	BADO	COME	DCCO	BTYW	HUVI	TOWA	WIWA
	COHA	EUWI	Kinglet sp.	CEWA	MACW	TRSW	YEWA
	Hawk sp.	GADW	LBDO	COYE	MAWR	TUVU	**HAWO**
	OSPR	LESC	PESA	EUST	OCWA	UEFL	**Woodpecker sp.**
	PEFA	NSHO	AMDI	GCSP	OSFL	WAVI	*Hummingbird sp.*
	RTHA	AMCO	BEWR	HAFL	PISI	WCSP	*RUHU*
	SSHA	BEKI	BHCO	HETH	Swallow sp.	WETA	ROPI
	BWTE	BHGR	BTGW	HOFI	TOSO	WEWP	

Table 5. A list of species in Lost Lagoon that either experienced a temporal increase, a temporal decrease, temporal stability, or no temporal trend in abundance. Species that did not have enough data to determine whether they were experiencing a temporal trend or lack thereof are also included. The data used to determine the trends or lack thereof were collected between January 2005 and December 2016. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

Legend: Raptor, Anseriformes, Non-Anseriformes Waterbird, Passeriformes, **Piciformes,** *Hummingbird*, Columbiformes							
Increase	CAGO	TRSW	WODU	PBGR	BRCR	SOSP	SPTO
Stable	BAEA	NOSH	MEGU	Flycatcher sp.	PAWR	VATH	*ANHU*
	COHA	RNDU	RBGU	FOSP	PSFL	WAVI	*RUHU*
	BUFF	BEKI	AMRO	GCKI	RBNU	WCSP	
	COME	COGO	BRCR	GCSP	RCKI	WIWA	
	GWFG	DCCO	CBCH	HOFI	RWBL	**DOWO**	
	GWTE	GBHE	CEWA	NRWS	STJA	**NOFL**	
	HOME	PBGR	CORA	OCWA	SWTH	**RBSA**	
Decrease	MERL	MALL	MUSW	AMCO	Gull sp	BUSH	PISI
NR	AMWI	LESC	AMGO	BCCH	EUST	VGSW	ROPI
	Duck sp.	GWGU	BARS	DEJU	NOCR	YRWA	
NA	BADO	CACG	TUDU	WISN	BUOR	PUFI	WIFL
	MERL	CANV	CATE	BOGU	CORE	RECR	WTSP
	OSPR	EUWI	COTE	HERG	COYE	SASP	YEWA
	PEFA	GADW	GRHE	THGU	GRYE	SPSA	**HAWO**
	RTHA	GRSC	HOGR	BEWR	HAFL	Swall sp.	**PIWO**
	SSHA	NOPI	Kinglet sp.	BHCO	HETH	TOWA	*Hummingbird sp.*
	TUVU	RUDU	LESA	BHGR	HOSP	VIRA	BTPI
	BAGO	SNGO	PECO	BTGW	NOWA	Vireo sp	
	BWTE	TRUS	RNPH	BTYW	OSFL	WETA	

Table 6. A list of species in Devonian Park that either experienced a temporal increase, a temporal decrease, temporal stability, or no temporal trend in abundance. Species that did not have enough data to determine whether they were experiencing a temporal trend or lack thereof are also included. The data used to determine the trends or lack thereof were collected between January 2009 and December 2014. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

Legend: Raptor, Anseriformes, Non-Anseriformes Waterbird, Passeriformes, **Piciformes,** *Hummingbird*, Columbiformes							
Increase	AMWI	BUSH					
Stable	BUFF	LESC	GBHE	EUST	NOCR	SOSP	
	HOME	MALL	AMRO	HOSP	RWBL	**NOFL**	
Decrease	CAGO	Gull sp.	BCCH				
NR							
NA	BAEA	GADW	WODU	GWGU	COYE	SAVS	*ANHU*
	BAGO	GRSC	AMCO	RBGU	DEJU	SPTO	*Hummingbird sp.*
	BWTE	GWTE	COLO	AMGO	Flycatcher sp.	TRSW	ROPI
	CANV	Mandarin Duck	Cormorant sp.	BARS	GCSP	VGSW	
	COGO	NOPI	DCCO	BHCO	HOFI	WCSP	
	COME	RNDU	HOGR	CEWA	NRWS	WIWA	
	Duck sp.	TRUS	PECO	Chipping Sparrow	PAWR	YRWA	

Table 7. A list of species on the Seawall that either experienced a temporal increase, a temporal decrease, temporal stability, or no temporal trend in abundance. Species that did not have enough data to determine whether they were experiencing a temporal trend or lack thereof are also included. The data used to determine the trends or lack thereof were collected in annual counts between 2008 and 2015. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

Legend: Raptor, Anseriformes, Non-Anseriformes Waterbird, Passeriformes, **Piciformes,** *Hummingbird*, Columbiformes							
Increase	BAGO	BUFF					
Stable	BAEA	HOME	BEKI	HOGR	RBGU	SOSP	
	GRSC	WWSC	BLOY	WEGR	PAWR		
Decrease	COLO	DCCO	HADU				
NR	AMWI	COGO	SUSC	GULL	MEGU	NOCR	
	CAGO	MALL	BOGU	GWGU	PECO		
NA	COHA	Domestic duck	MUSW	WODU	MAMU	BUSH	SPTO
	MERL	GADW	NOPI	AMCO	PALO	CBCH	STJA
	OSPR	GWFG	NOSH	BLTU	PBGR	DEJU	WCSP
	RTHA	GWTE	RBME	EAGR	RNGR	EUST	**DOWO**
	CACG	LESC	RNDU	GBHE	RTLO	GCKI	**NOFL**
	CANV	LTDU	Scaup sp	HEGU	AMRO	HOSP	ROPI
	COME	Merganser sp	Swan sp	LOON sp	BCCH	PISI	

Table 8. A summary of the population trends for the abundance and richness values of the five groups of Anseriformes in Stanley Park. The values were recorded in four different sites in Stanley Park – Beaver Lake (BL), Lost Lagoon (LL), Devonian Park (DP), and the Seawall (WW, which stands for Winter Waterbirds). Population trends were based on data collected from Beaver Lake between July 2005 and December 2016, from Lost Lagoon between January 2005 and December 2016, from Devonian Park between January 2009 and December 2014, and from the Seawall in annual counts between 2008 and 2015. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

Abundance	**BL**	**LL**	**DP**	**WW**
Dabbling Ducks	NR (caused by seasonal variation)	Decreasing	NR	NR
Diving Ducks	Stable	NR (related to seasonal variation)	NA	Stable
Perching Ducks	Increasing	Increasing	NA	NA
Sea Ducks	Stable	NR (related to seasonal variation)	Stable	NR
Geese & Swans	Stable	NR	NR	NR
Richness	**BL**	**LL**	**DP**	**WW**
Dabbling Ducks	Stable	Stable	Stable	Stable
Diving Ducks	Stable`	Stable	Stable	Stable
Perching Ducks	Stable	Stable	NA	NA
Sea Ducks	Stable	Stable	Stable	Stable
Geese & Swans	Stable	Stable	Stable	Stable

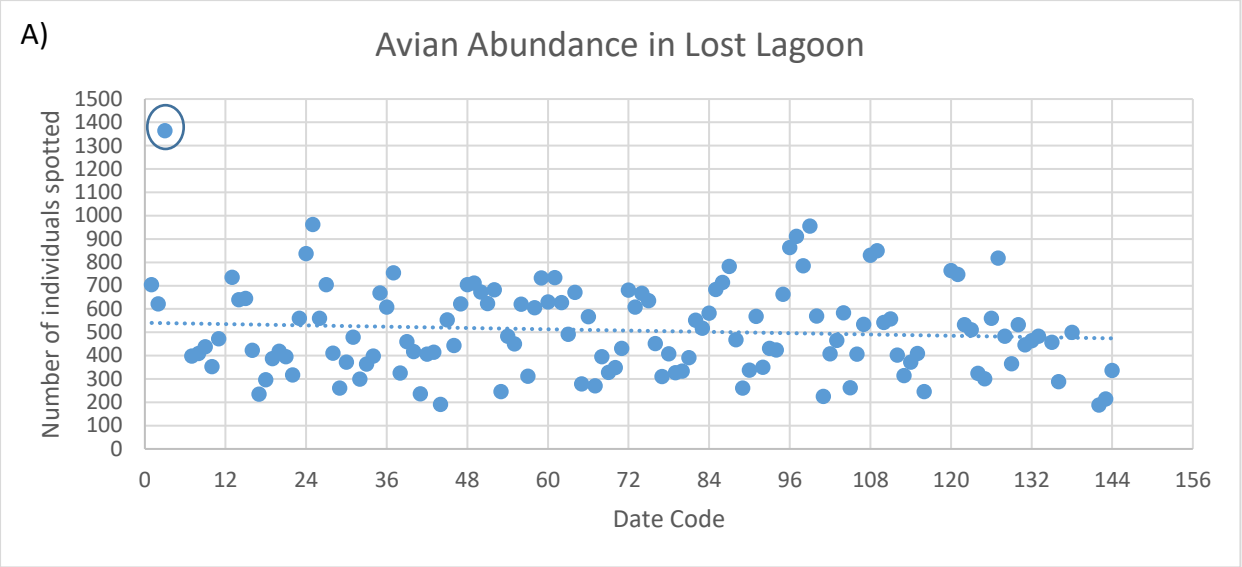
Table 9. A summary of the population trends for the abundance and richness values of the six groups of non-Anseriformes waterbirds as well as the Laridae and gulls in Stanley Park. The values were recorded in four different sites in Stanley Park – Beaver Lake (BL), Lost Lagoon (LL), Devonian Park (DP), and the Seawall (WW, which stands for Winter Waterbirds). Population trends were based on data collected from Beaver Lake between July 2005 and December 2016, from Lost Lagoon between January 2005 and December 2016, from Devonian Park between January 2009 and December 2014, and from the Seawall in annual counts between 2008 and 2015. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

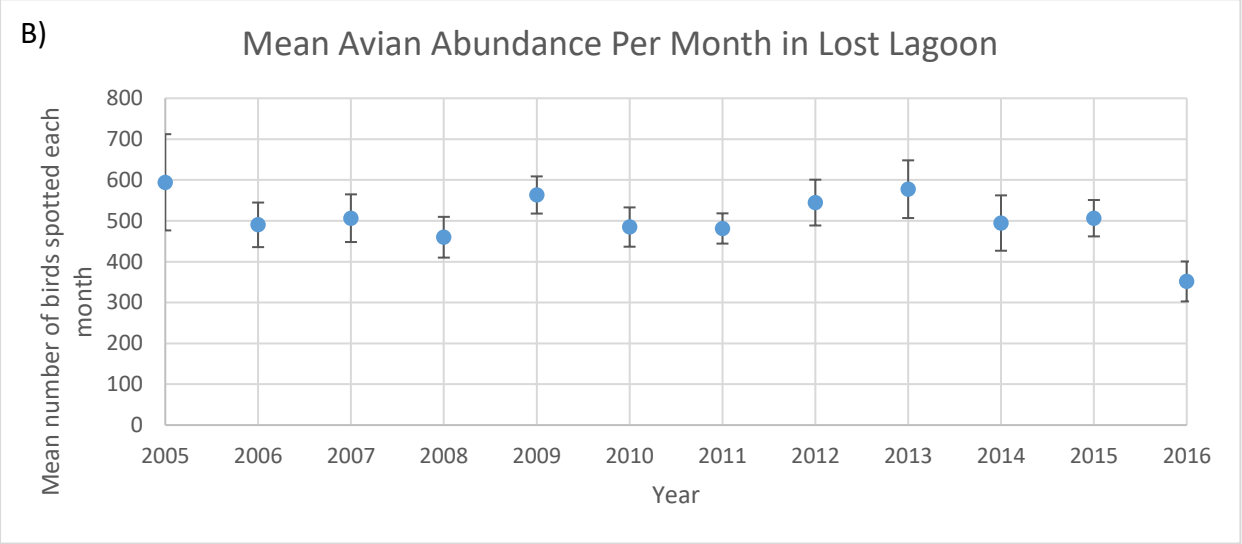
Abundance	**BL**	**LL**	**DP**	**WW**
Seabirds	Stable	Decreasing	Decreasing	NR
Subgroup: Laridae	Stable	Decreasing (similar to **Gulls**)	Stable	Stable
Sub-subgroup: Gulls	Stable	Decreasing	Decreasing	NR
Kingfishers	NA	Stable	None	Stable
Loons & Grebes	Stable	NA	NA	Stable
Rallidae	NA	Decrease	NA	NA
Pelecaniformes	Increasing	Stable	Stable	NA
Shorebirds	NA	NA	None	NR
Richness	**BL**	**LL**	**DP**	**WW**
Seabirds	Stable	Stable	Decrease	Stable
Subgroup: Laridae	Stable	Stable	Stable	Stable
Sub-subgroup: Gulls	Stable	Stable	Stable	Stable
Kingfishers	NA	Stable	None	Stable
Loons & Grebes	Stable	Stable	NA	Stable
Rallidae	NA	Stable	NA	NA
Pelecaniformes	Stable	Stable	Stable	Stable
Shorebirds	NA	Stable	None	Stable

Table 10. A summary of the population trends for the abundance and richness values of the aerial insectivores and forest birds. The values were recorded in four different sites in Stanley Park – Beaver Lake (BL), Lost Lagoon (LL), Devonian Park (DP), and the Seawall (WW, which stands for Winter Waterbirds). Population trends were based on data collected from Beaver Lake between July 2005 and December 2016, from Lost Lagoon between January 2005 and December 2016, from Devonian Park between January 2009 and December 2014, and from the Seawall in annual counts between 2008 and 2015. NR = no temporal relationship/trend was found. NA = not enough data was available to determine any trends or lack thereof. None = no appearances in the site.

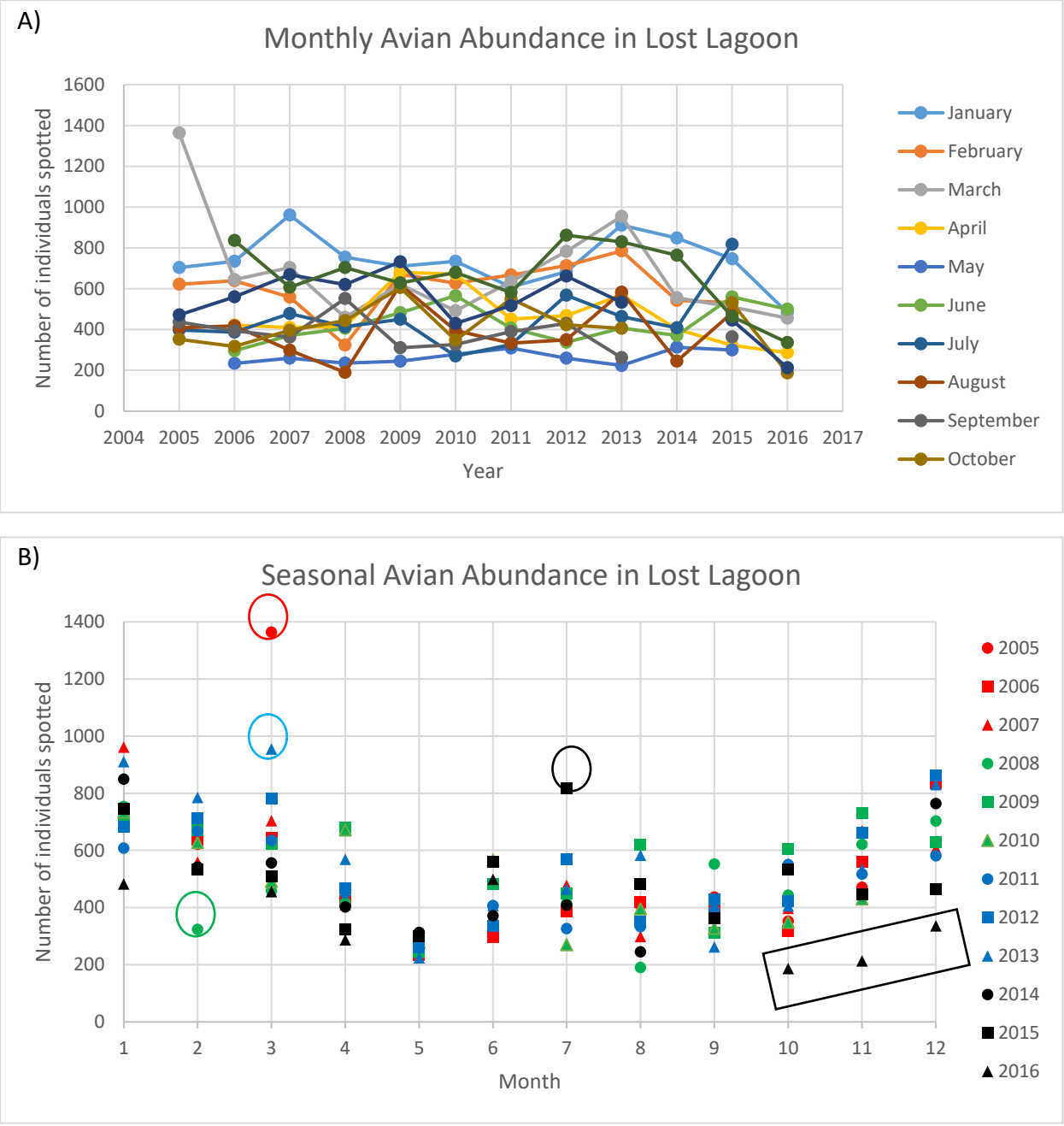
Abundance	**BL**	**LL**	**DP**	**WW**
Aerial Insectivores	Stable	NR	Stable	None
Forest Birds	Increasing	Increasing	NR	Stable
Richness	**BL**	**LL**	**DP**	**WW**
Aerial Insectivores	Stable	Increasing	Stable	None
Forest Birds	Increase	NR	Stable	Stable

10. Appendix

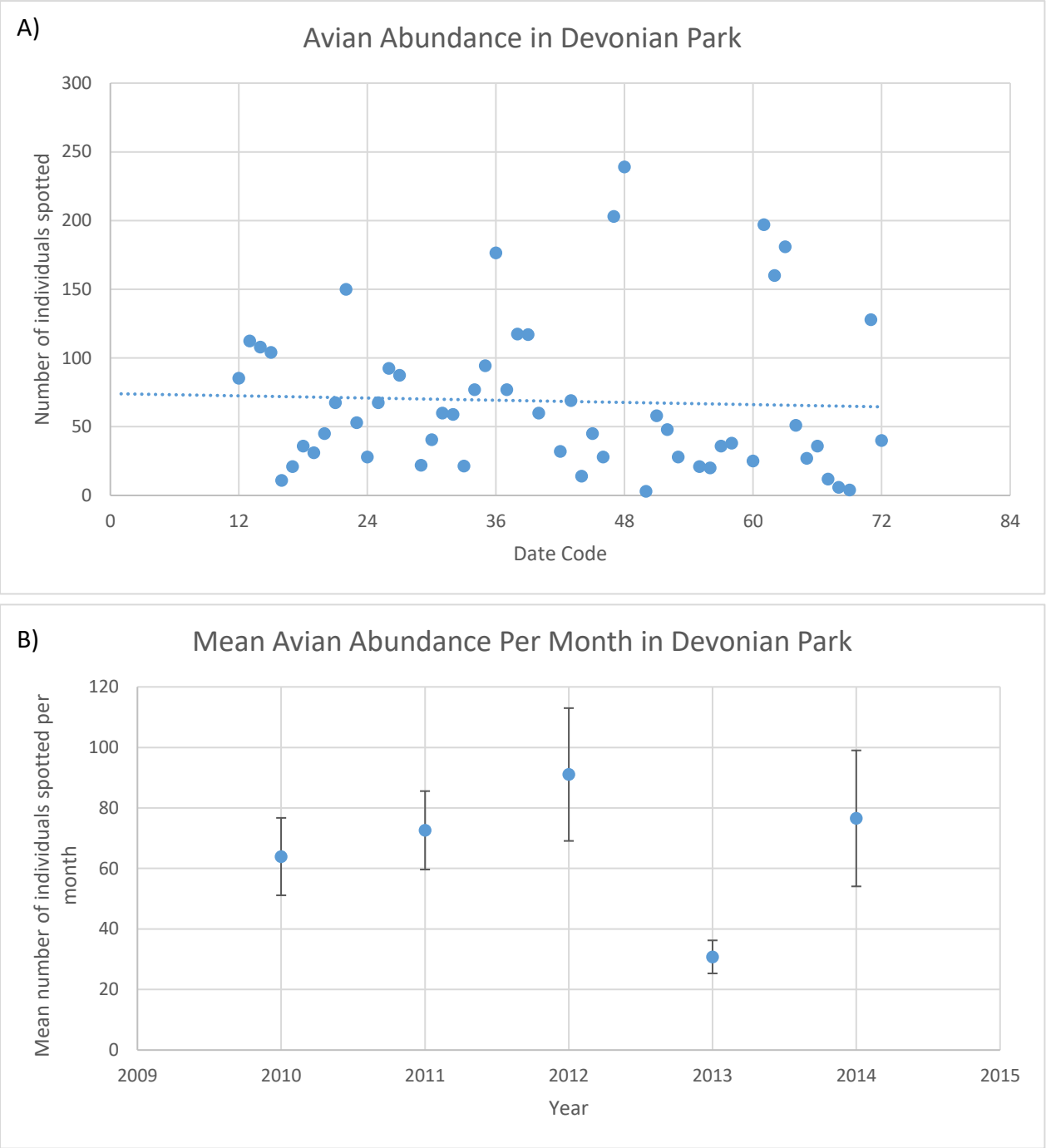




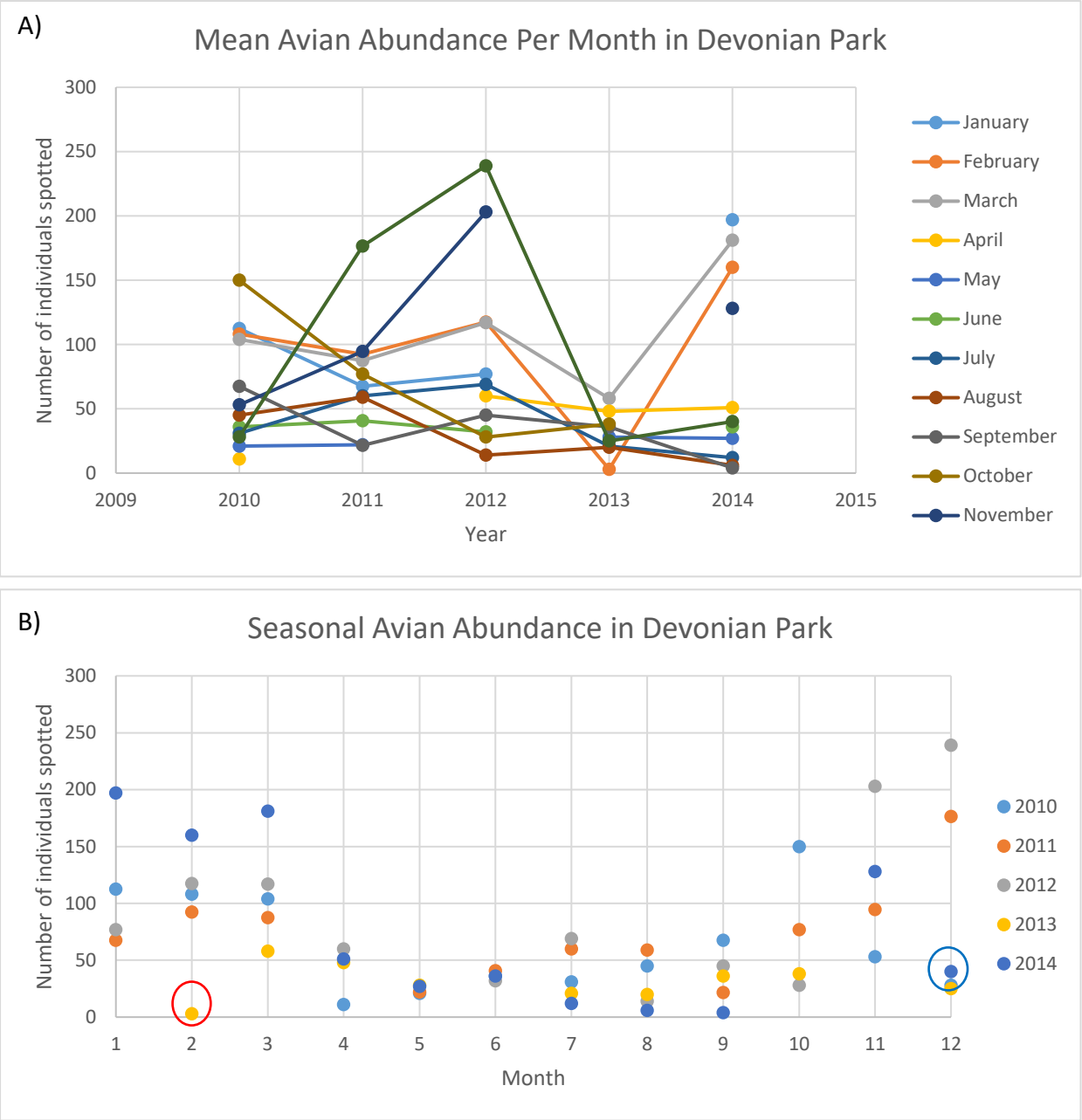
Appendix A. A) The abundance of all birds spotted and B) the mean amount of all birds spotted per month for each year in Lost Lagoon. For A), the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2005. 2 = February 2005. 12 = December 2005. The dotted line represents a linear regression ($y = -0.46 + 540$, $R^2 = 9.0 \times 10^{-3}$, $p = 0.28$). On March 2005 (circled in blue), the abundance was much higher than usual as a result of more lesser scaups (in a group of 750 individuals) visiting the site than usual. For B), error bars represent one ± standard error value.



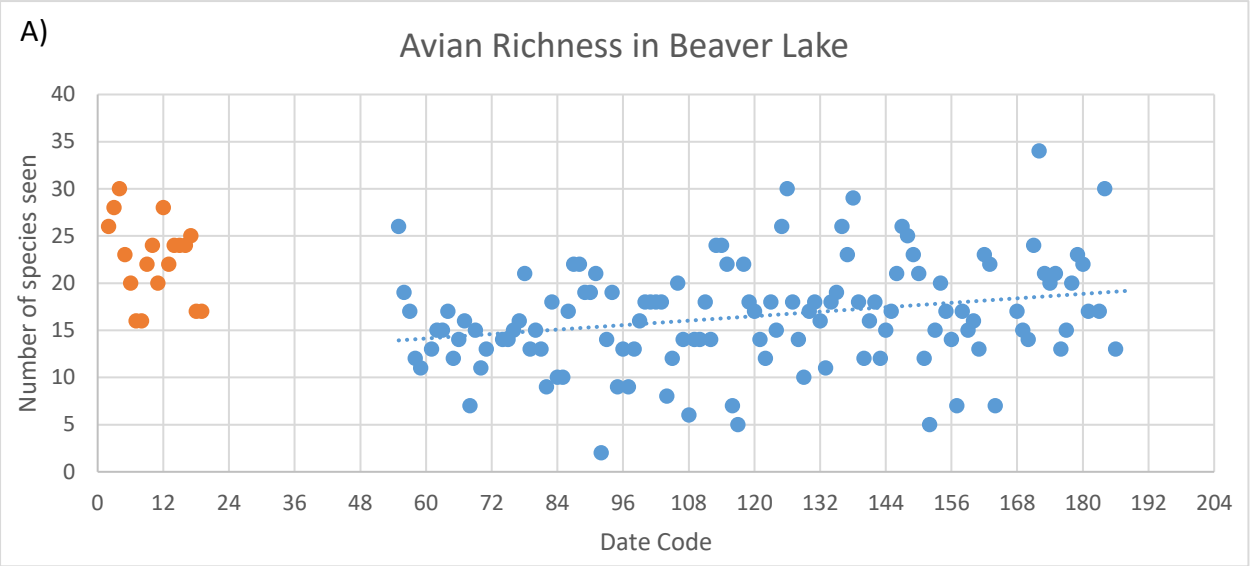
Appendix B. A) A line graph of each month's respective abundances throughout the years in Lost Lagoon. B) An overlay of each year's monthly abundances in Lost Lagoon. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December. On February 2008 (circled in green), less mallards were seen than usual. On March 2005 (circled in red), more lesser scaups were seen than usual. On March 2013 (circled in blue), more red crossbill, pine siskins, and lesser scaups were seen than usual. On July 2015 (circled in black), more mallards, barn swallows, Canada geese, and song sparrows were seen than usual. Between October and December 2016 (squared in black), less black-capped chickadees, Canada geese, golden-crowned kinglet, mallards, and northwestern crows were seen than usual.

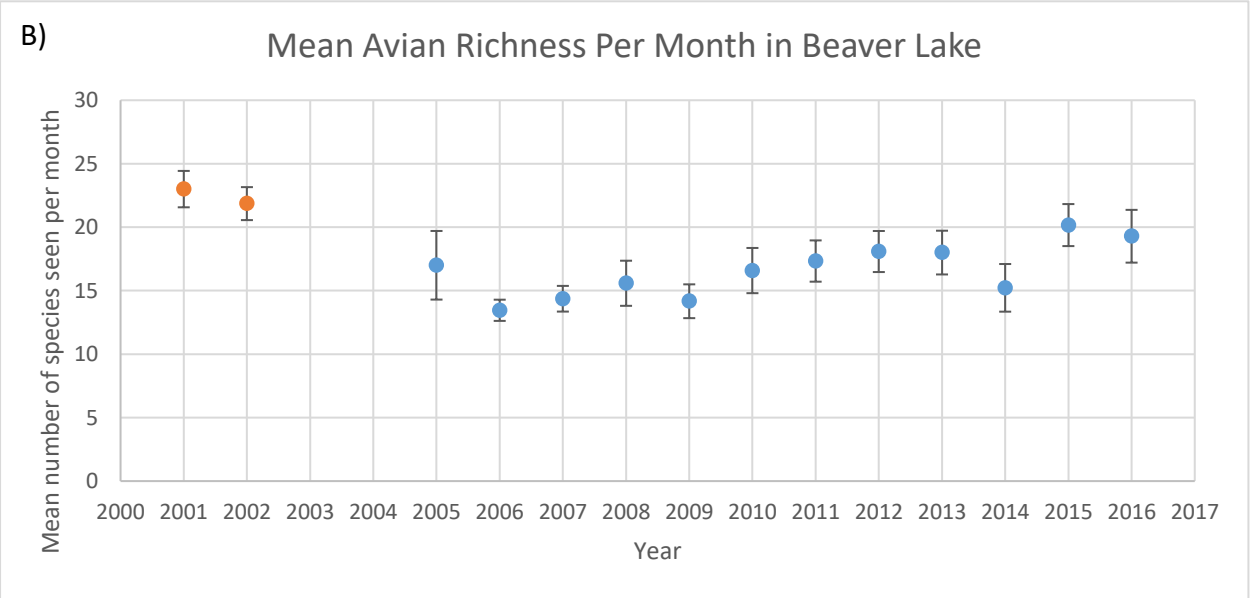


Appendix C. A) The abundance of all birds spotted in Devonian Park and B) the mean amount of all birds spotted per month for each year in Devonian Park. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2009 = 1. 2 = February 2009. 12 = December 2009. The dotted line represents a linear regression ($y = -0.13 + 74$, $R^2 = 1.8 \times 10^{-3}$, $p = 0.76$). For B, error bars represent one ± standard error value.

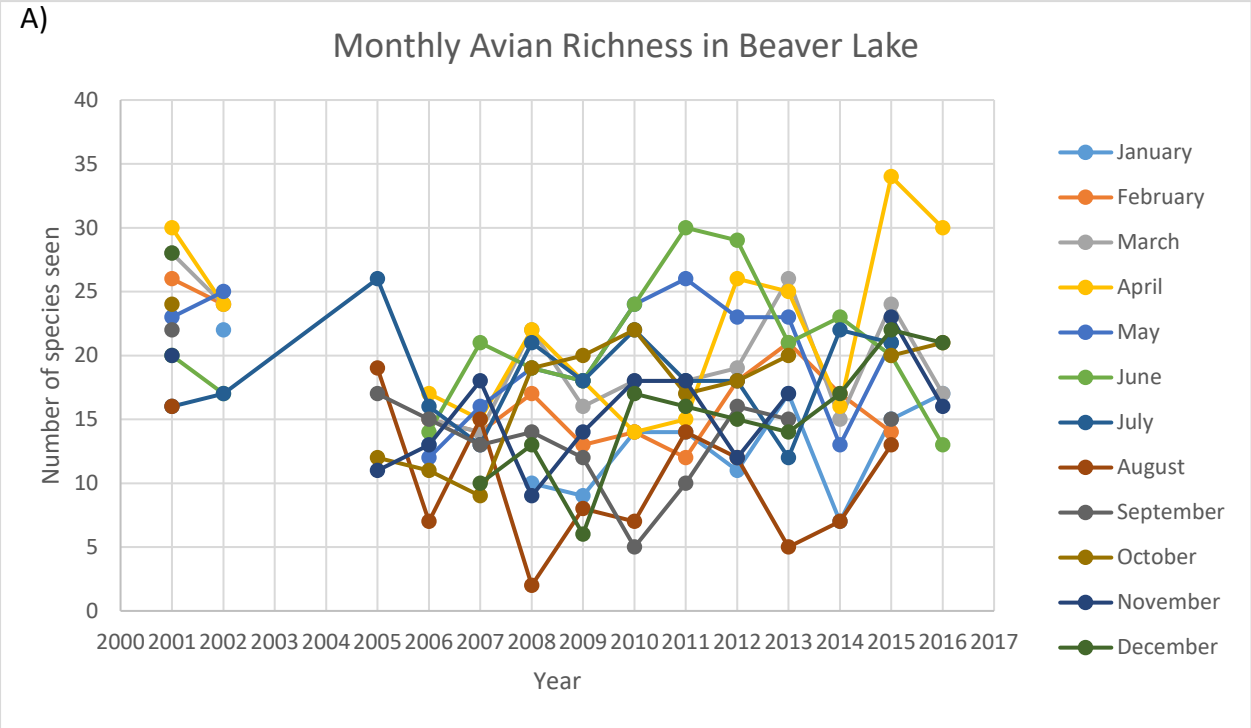


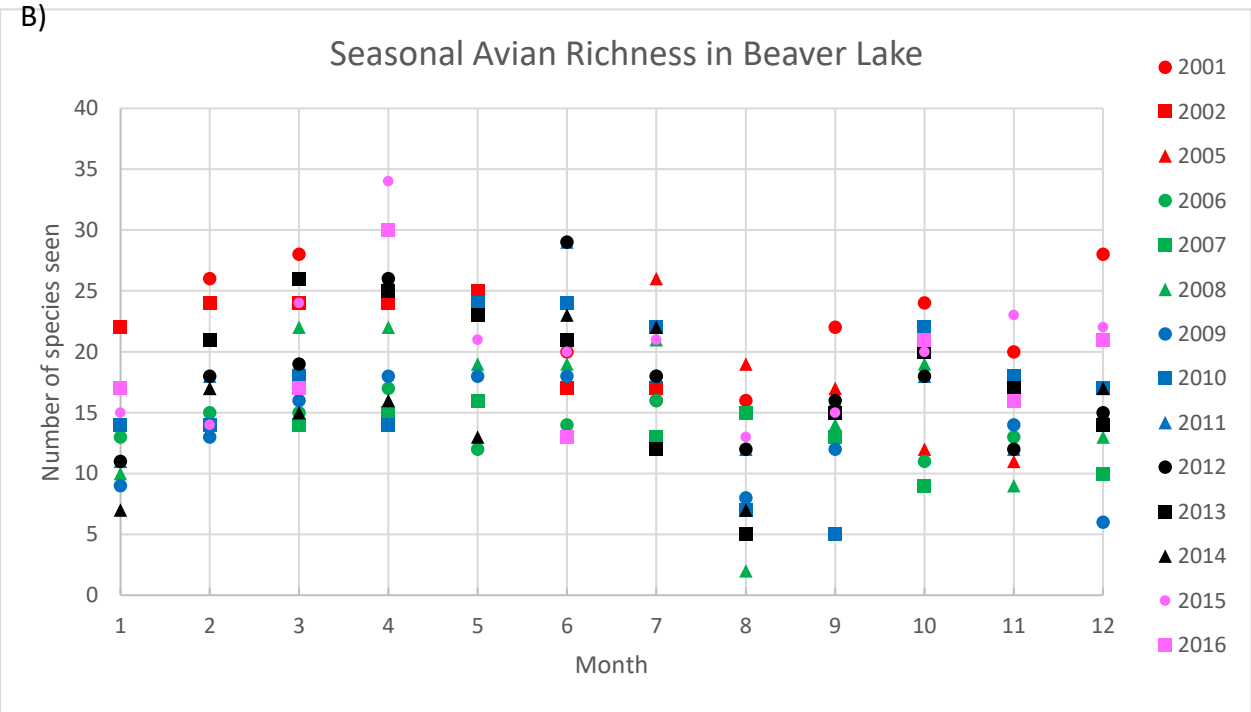
Appendix D. A) A line graph of each month's respective abundances throughout the years in Devonian Park. B) An overlay of each year's monthly abundances in Devonian Park. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December. The lower abundances on March 2013 (circled in red) and on the December of 2010, 2013, and 2014 (circled in blue) are linked to fewer American wigeons appearing to surveyors.



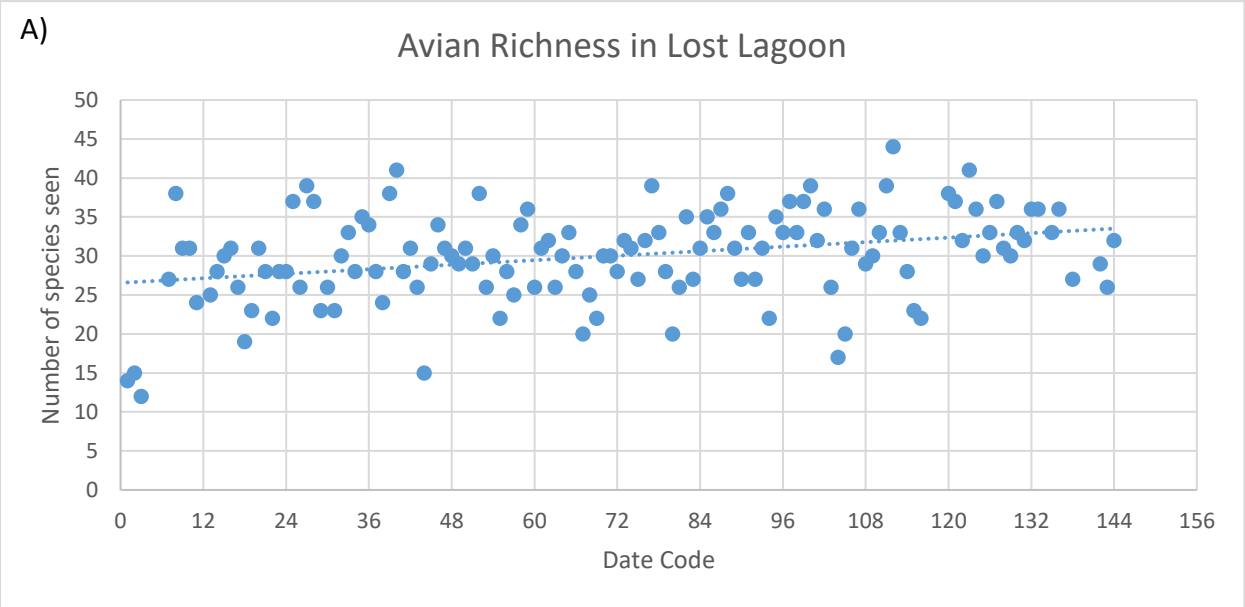


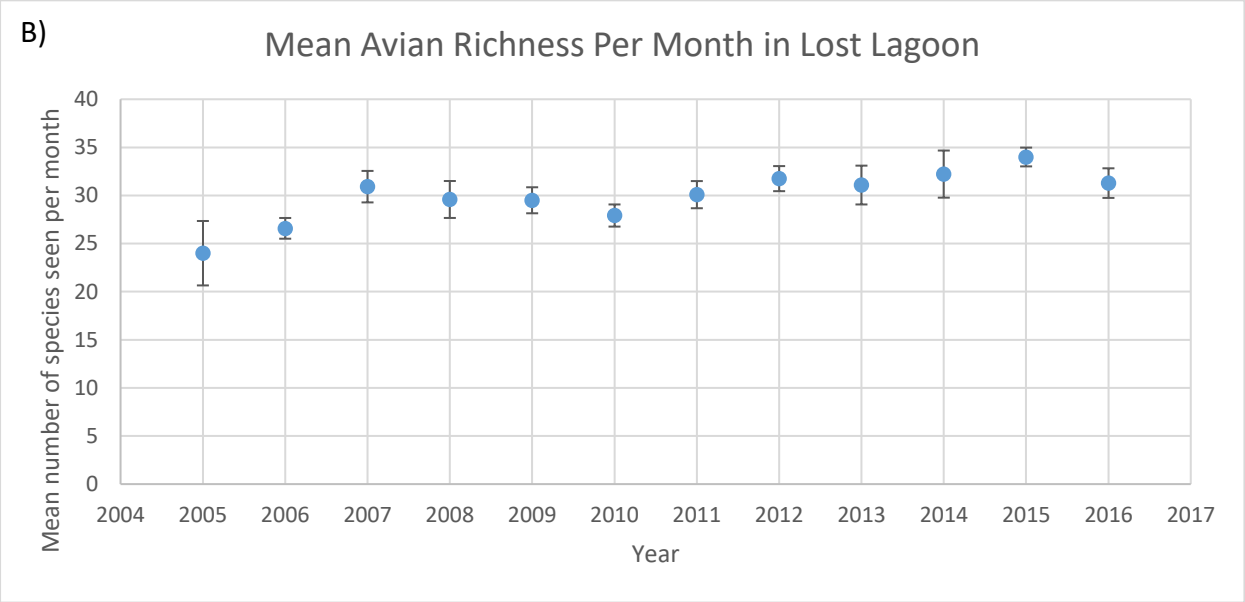
Appendix E. A) The species richness of birds and B) the mean species richness of all birds spotted per month for each year in Beaver Lake. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2001. 2 = February 2001. 12 = December 2001. Orange dots represent abundance values from surveys performed in 2001 or 2002. The dotted line represents a linear regression ($y = 0.040 + 12$, $R^2 = 0.075$, $p = 1.8 \times 10^{-3}$). For B, error bars represent one ± standard error value.



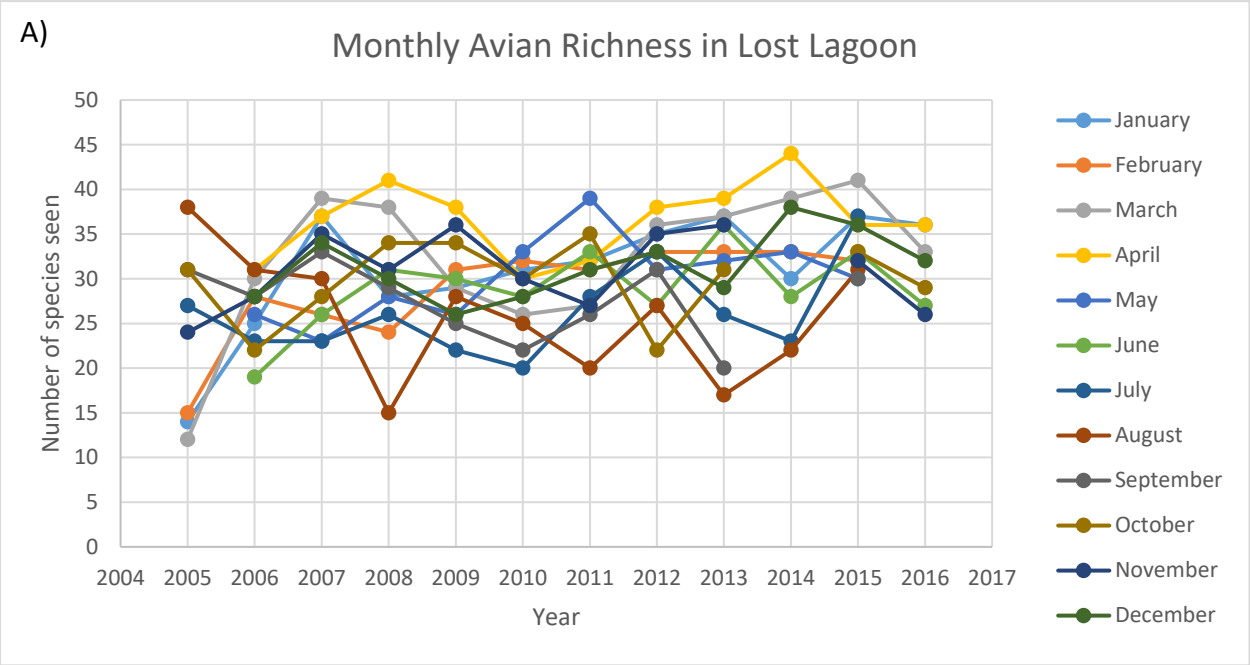


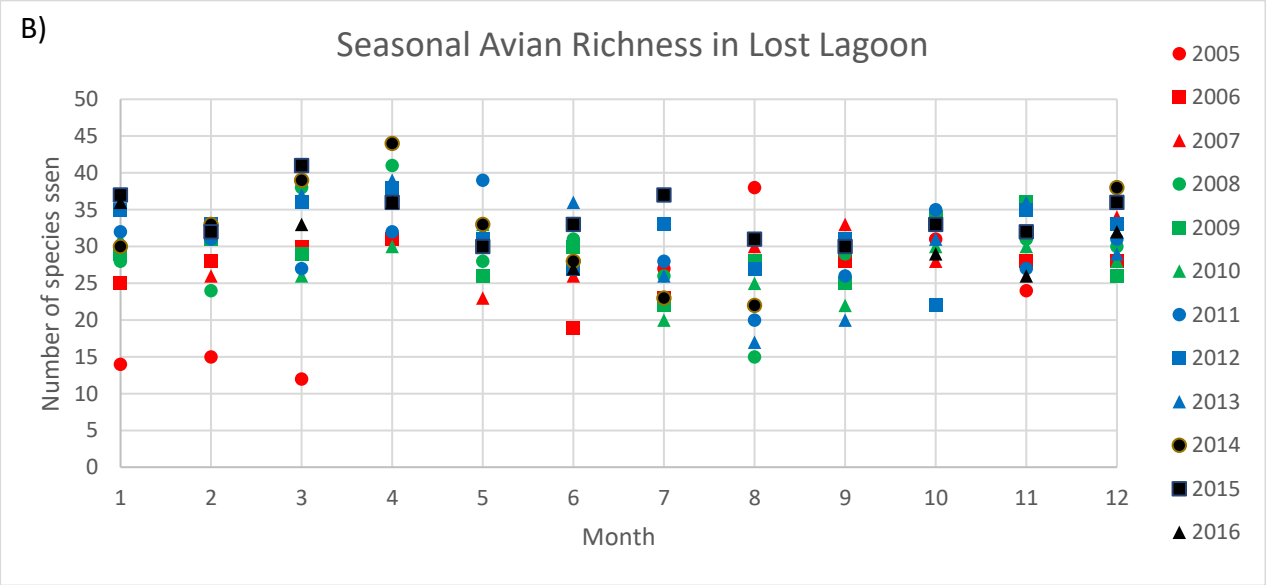
Appendix F. A) A line graph of each month's respective species richness of birds throughout the years in Beaver Lake. B) An overlay of each year's monthly species richness in Beaver Lake. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December.



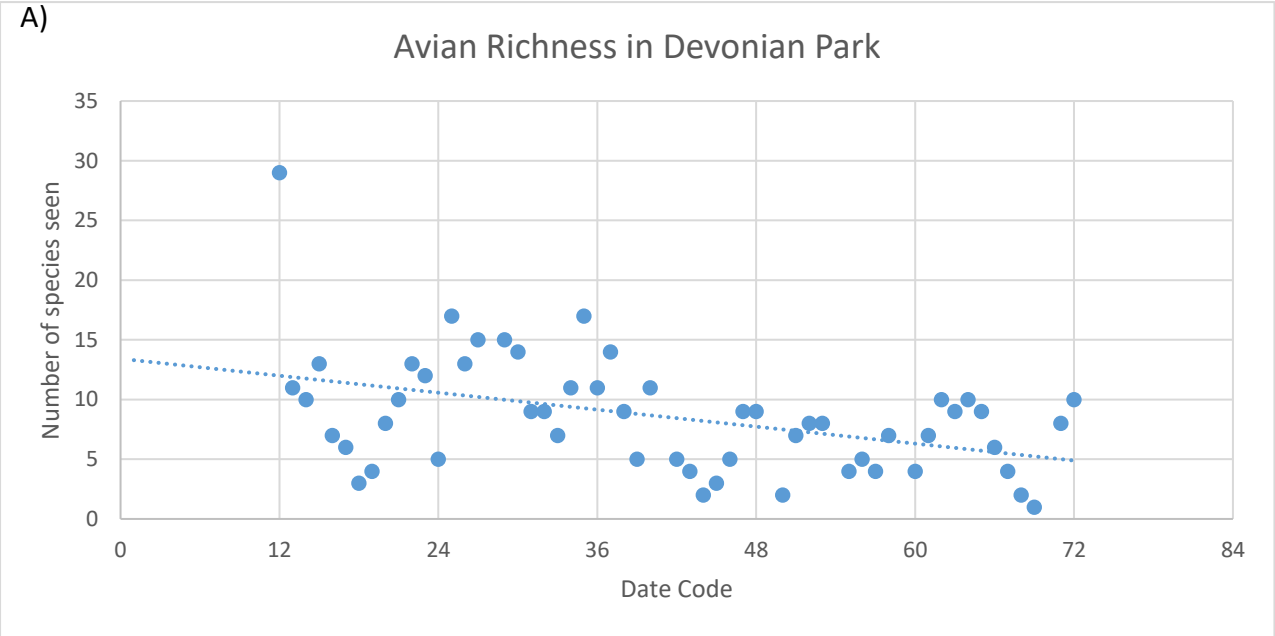


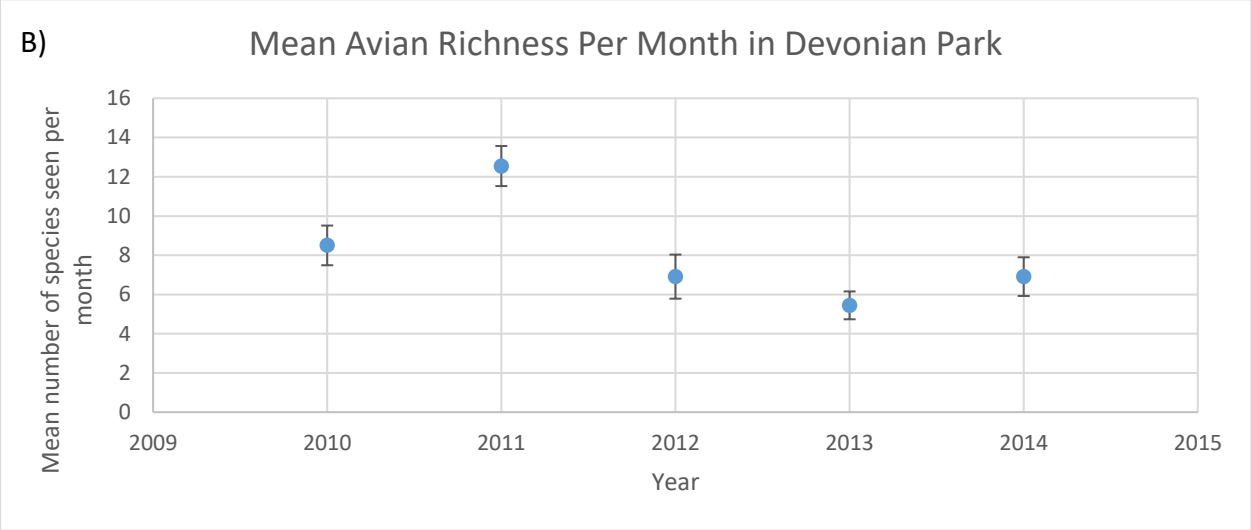
Appendix G. A) The species richness of birds and B) the mean species richness of all birds spotted per month for each year in Lost Lagoon. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2005. 2 = February 2005. 12 = December 2005. The dotted line represents a linear regression ($y = 0.048 + 27$, $R^2 = 0.11$, $p = 1.5 \times 10^{-4}$). For B, error bars represent one ± standard error value.



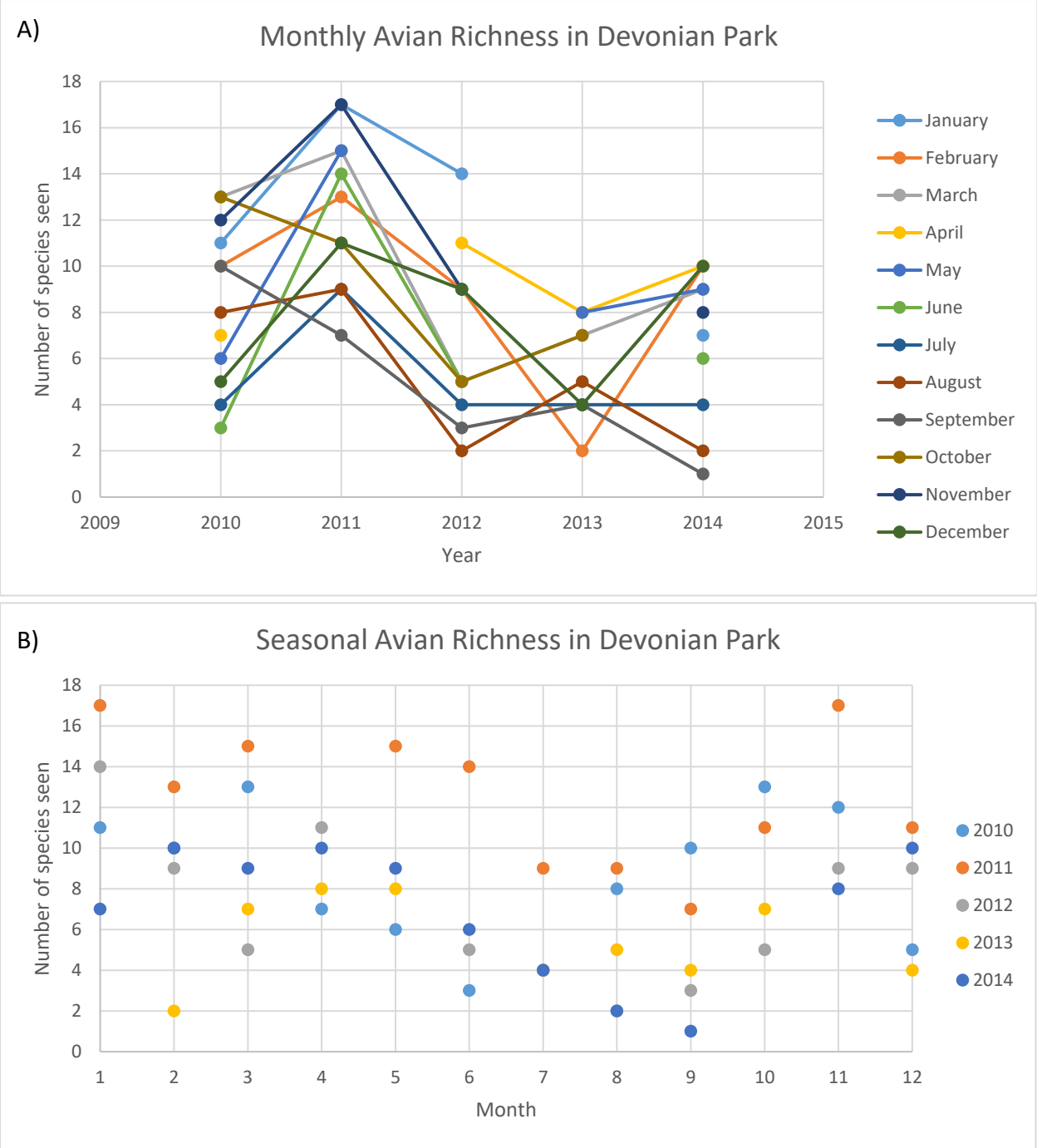


Appendix H. A) A line graph of each month's respective species richness of birds throughout the years in Lost Lagoon. B) An overlay of each year's monthly species richness of birdsin Lost Lagoon. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December. The amount of species seen in surveys conducted between January and March 2005 are lower than usual, possibly because the SPES were unable to obtain experienced birdwatchers during the beginning months of the bird monitoring program at Lost Lagoon.

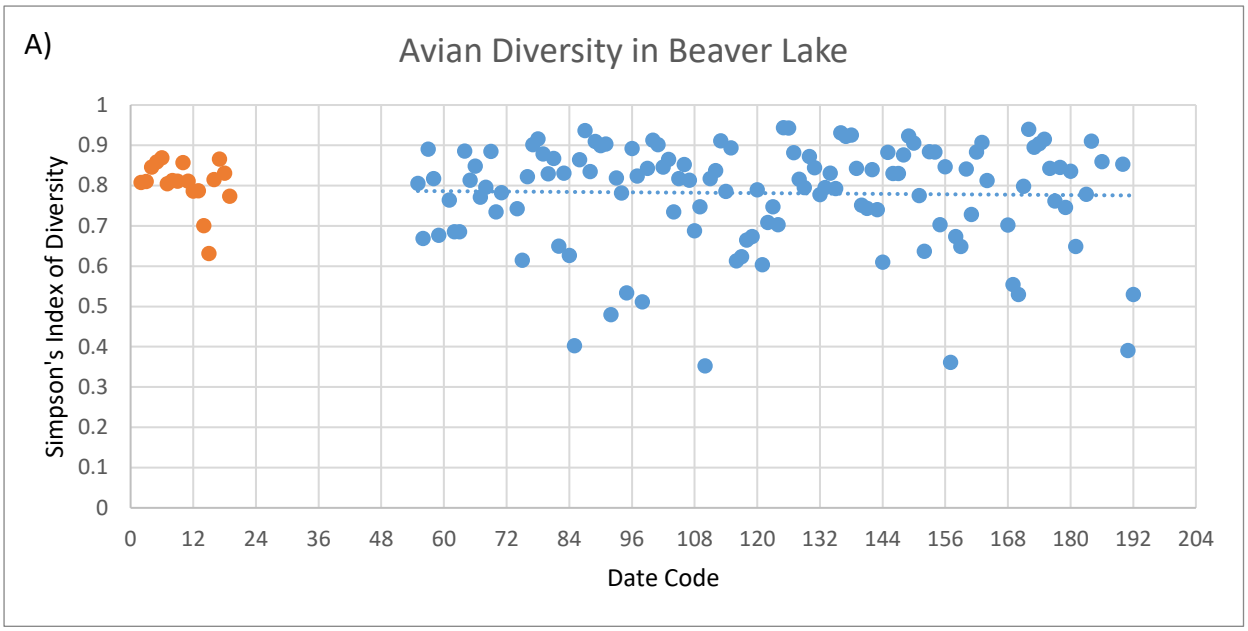


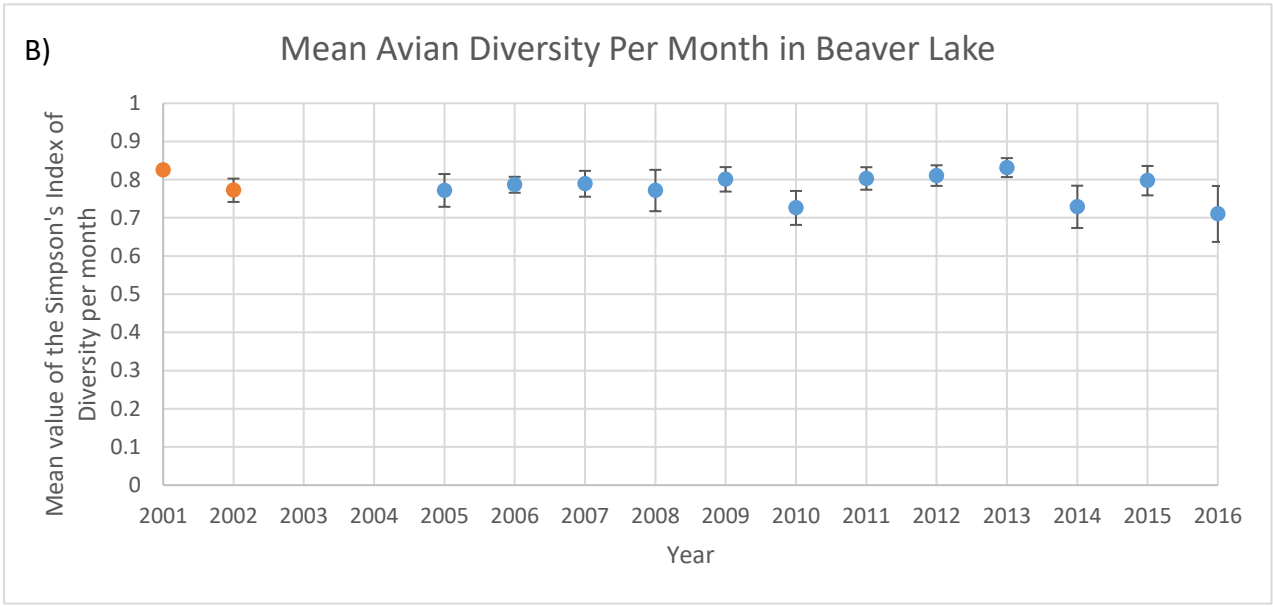


Appendix I. A) The species richness of birds and B) the mean species richness of all birds spotted per month for each year in Devonian Park. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2009. 2 = February 2009. 12 = December 2009. The dotted line represents a linear regression ($y = -0.12+ 13$, $R^2 = 0.19$, $p = 8.2 \times 10^{-4}$). For B, error bars represent one ± standard error value.

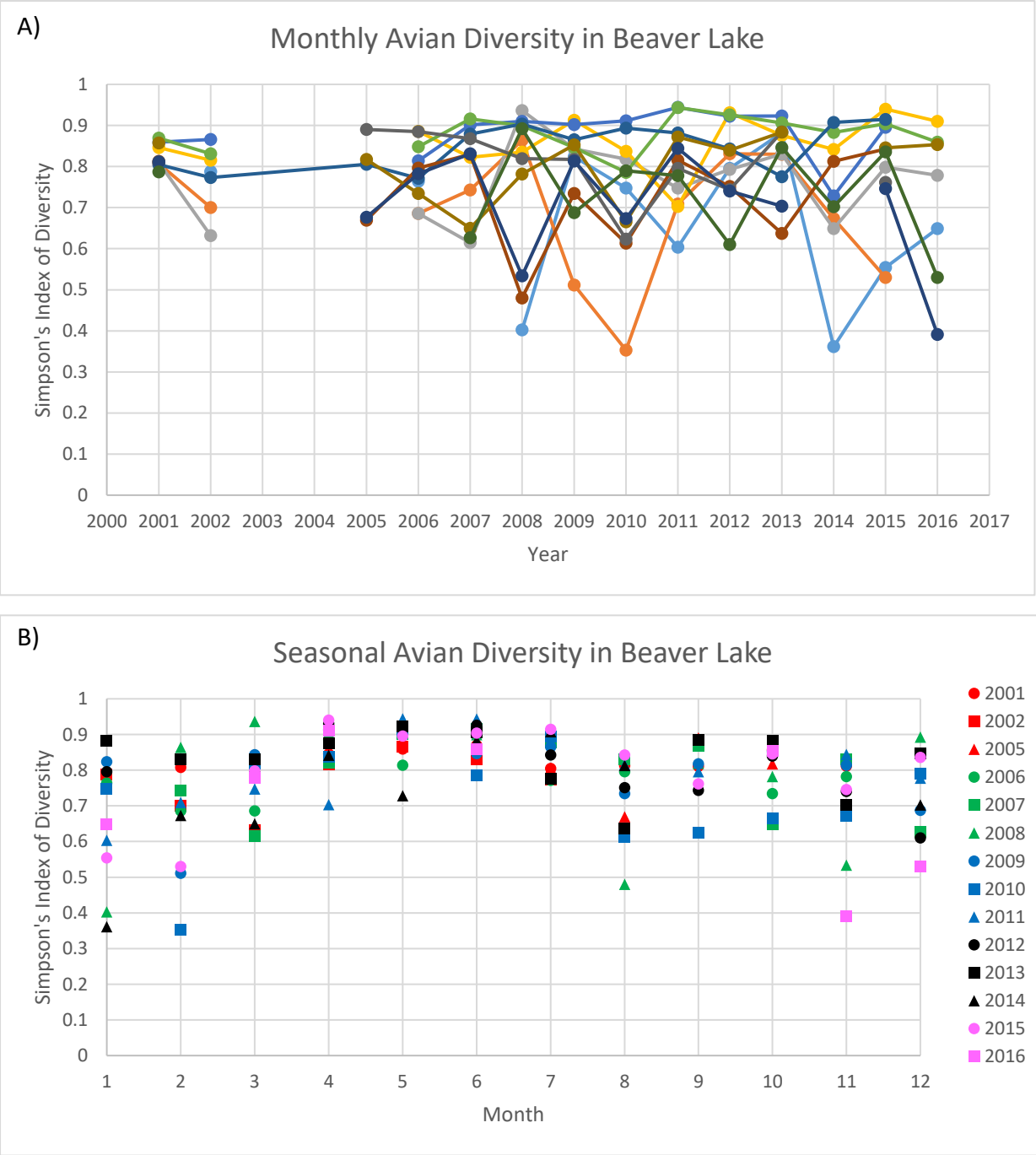


Appendix J. A) A line graph of each month's respective species richness of birds throughout the years in Devonian Park. B) An overlay of each year's monthly species richness of birds in Devonian Park. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December.

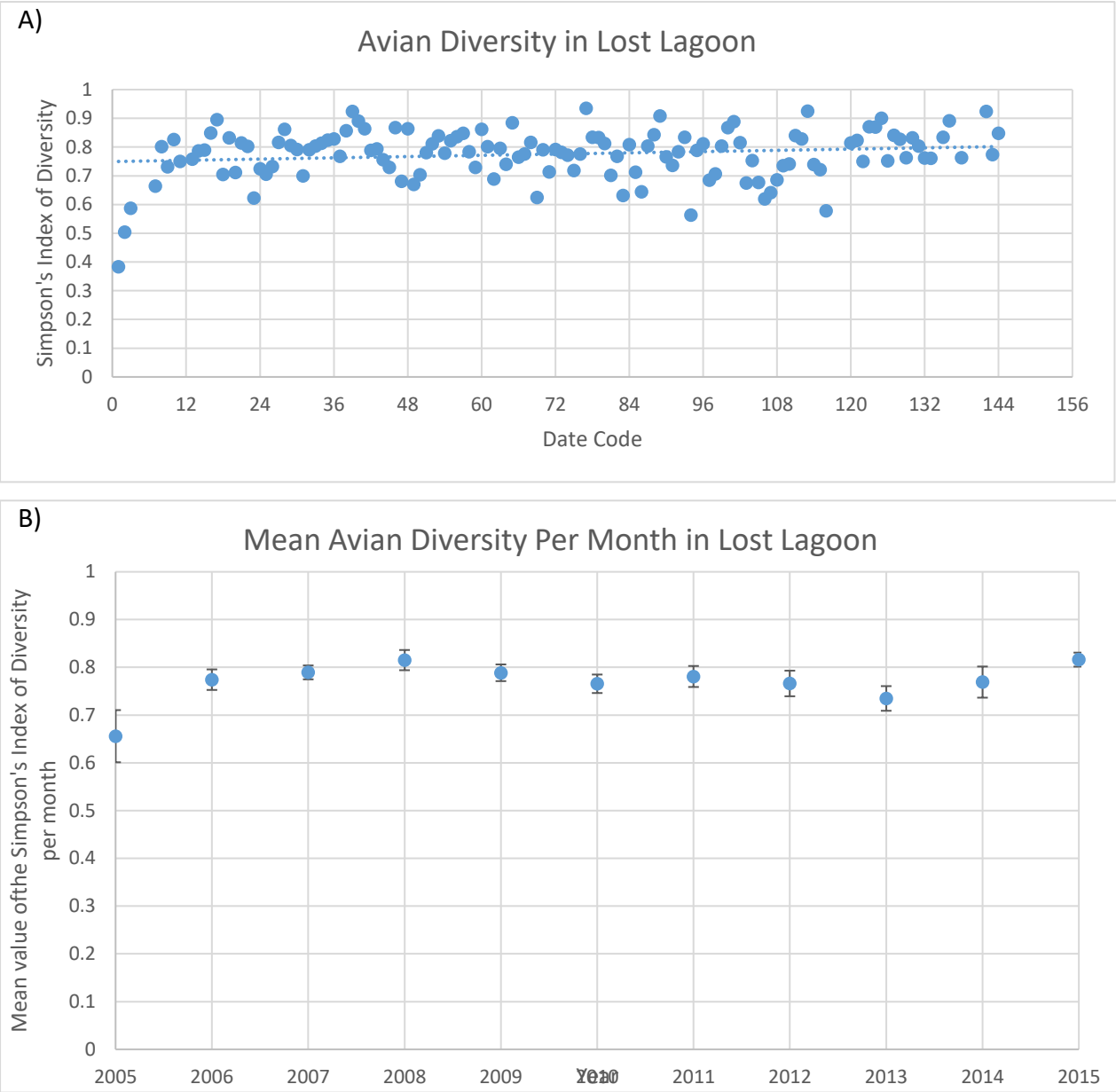




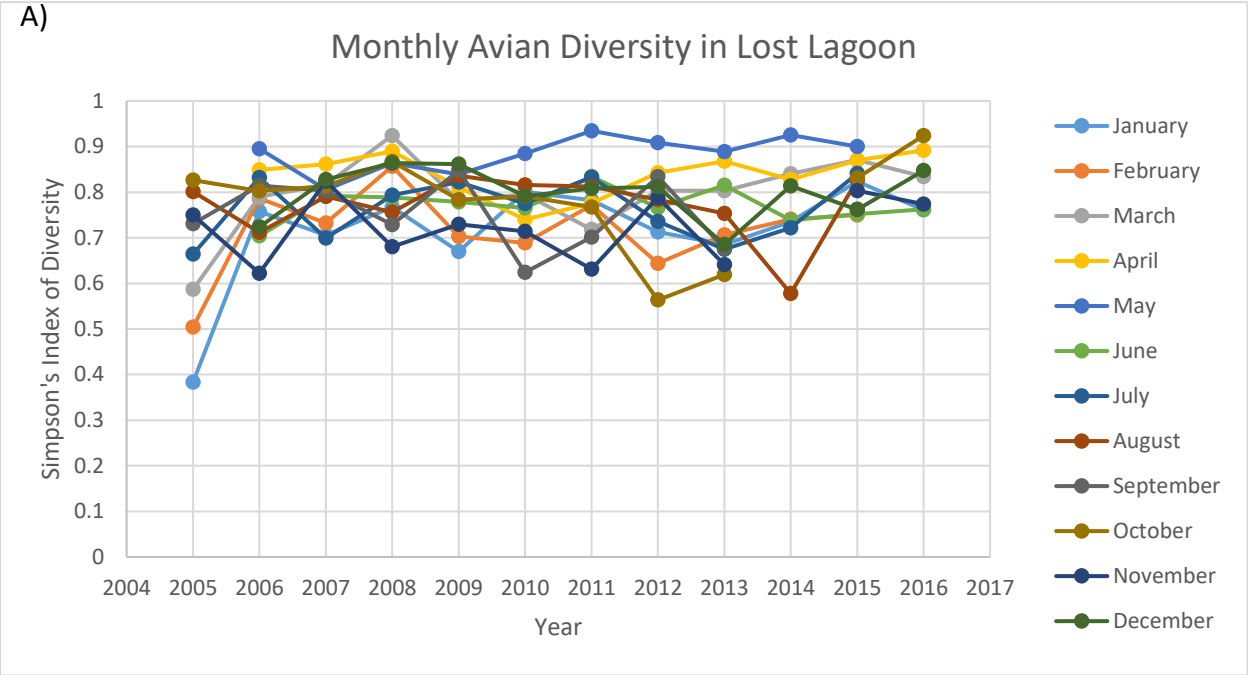
Appendix K. A) The species diversity of birds as quantified by the Simpson's Index of Diversity and B) the mean Simpson's Index of Diversity per month for each year in Beaver Lake. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2001. 2 = February 2001. 12 = December 2001. Orange dots represent abundance values from surveys performed in 2001 or 2002. The dotted line represents a linear regression ($y = -8.1 \times 10^{-5} + 0.79$, $R^2 = 5.8 \times 10^{-4}$, $p = 0.79$). For B, error bars represent one ± standard error value.

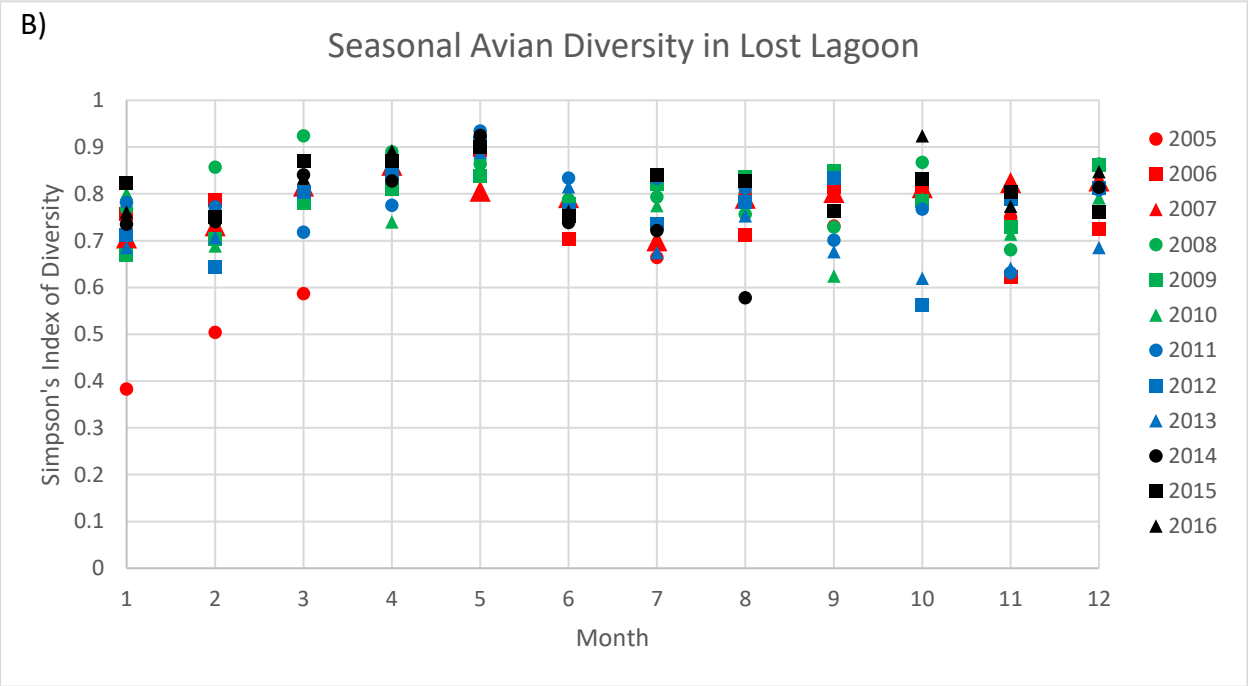


Appendix L. A) A line graph of each month's respective species diversity, quantified by the Simpson's Index of Diversity, throughout the years in Beaver Lake. B) An overlay of each year's monthly species diversity of birds, quantified by the Simpson's Index of Diversity, in Beaver Lake. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December.

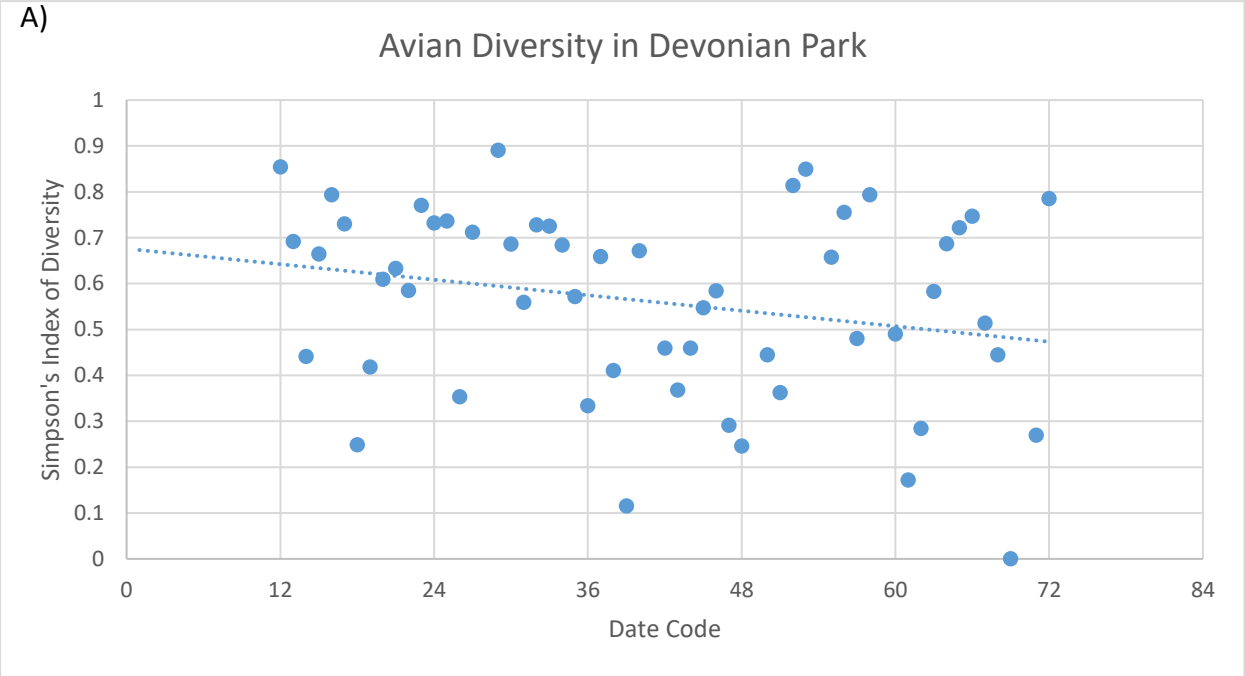


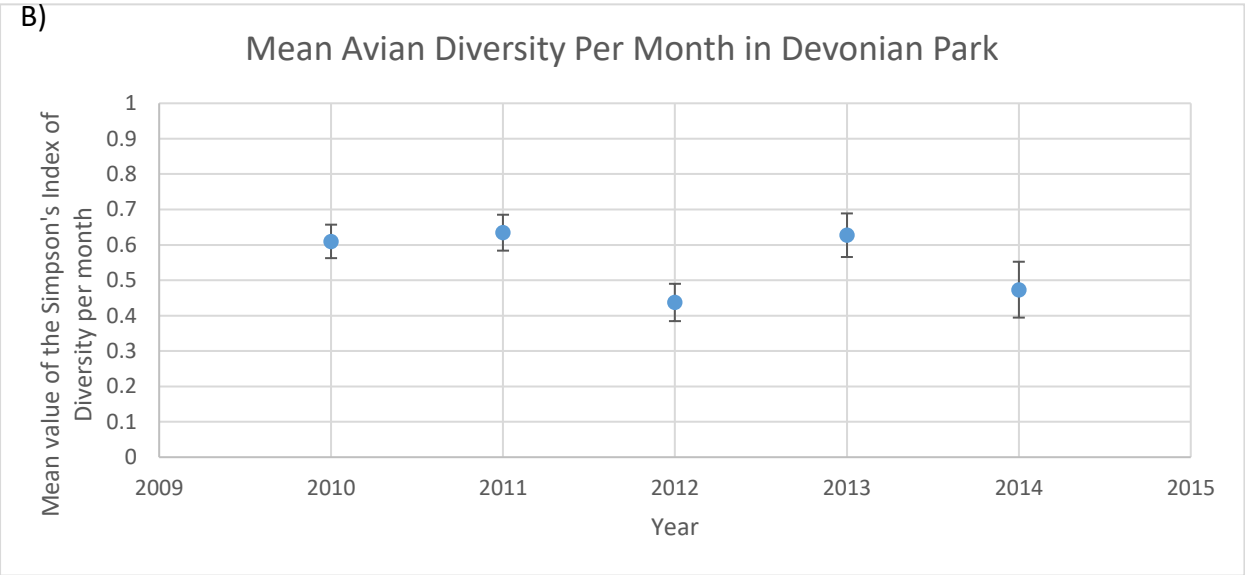
Appendix M. A) The species diversity of birds as quantified by the Simpson's Index of Diversity and B) the mean Simpson's Index of Diversity per month for each year in Lost Lagoon. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2005. 2 = February 2005. 12 = December 2005. The dotted line represents a linear regression ($y = 3.6 \times 10^{-4} + 0.75$, $R^2 = 0.027$, $p = 0.059$). For B, error bars represent one ± standard error value.



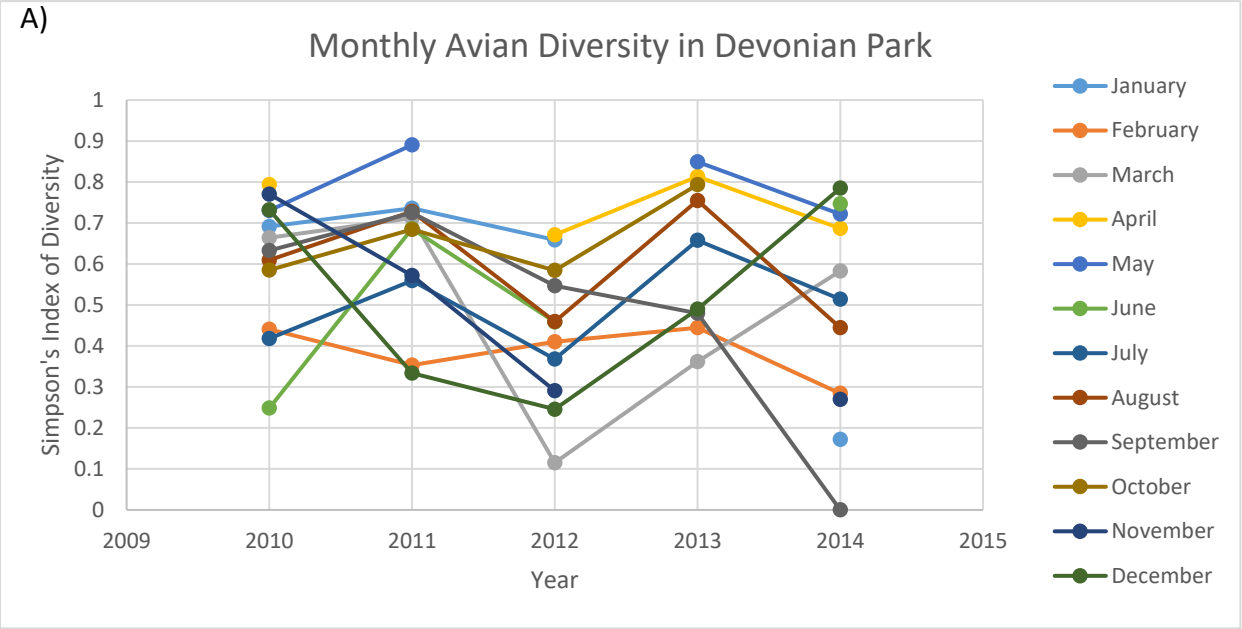


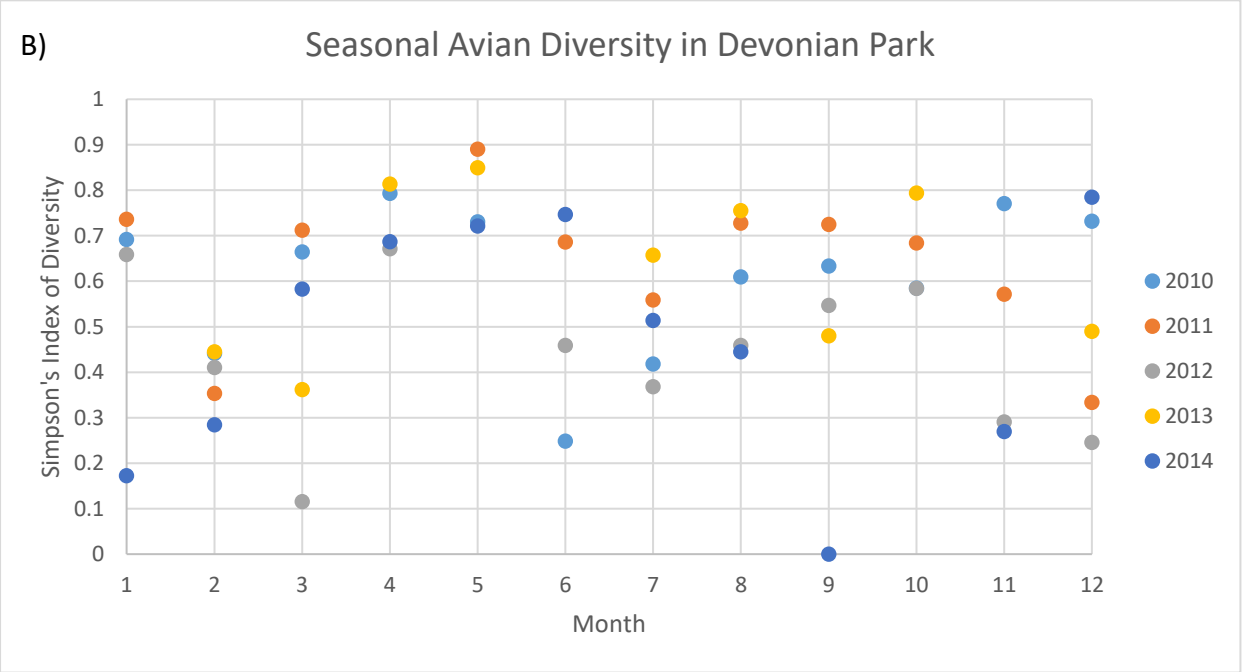
Appendix N. A) A line graph of each month's respective species diversity, quantified by the Simpson's Index of Diversity, throughout the years in Lost Lagoon. B) An overlay of each year's monthly species diversity of birds, quantified by the Simpson's Index of Diversity, in Lost Lagoon. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December.



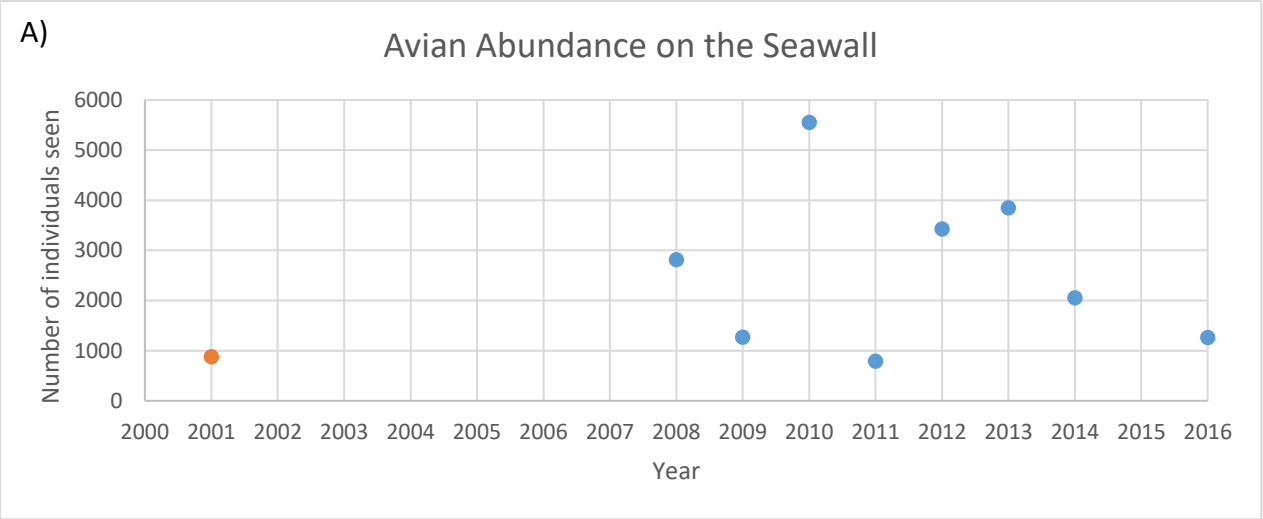


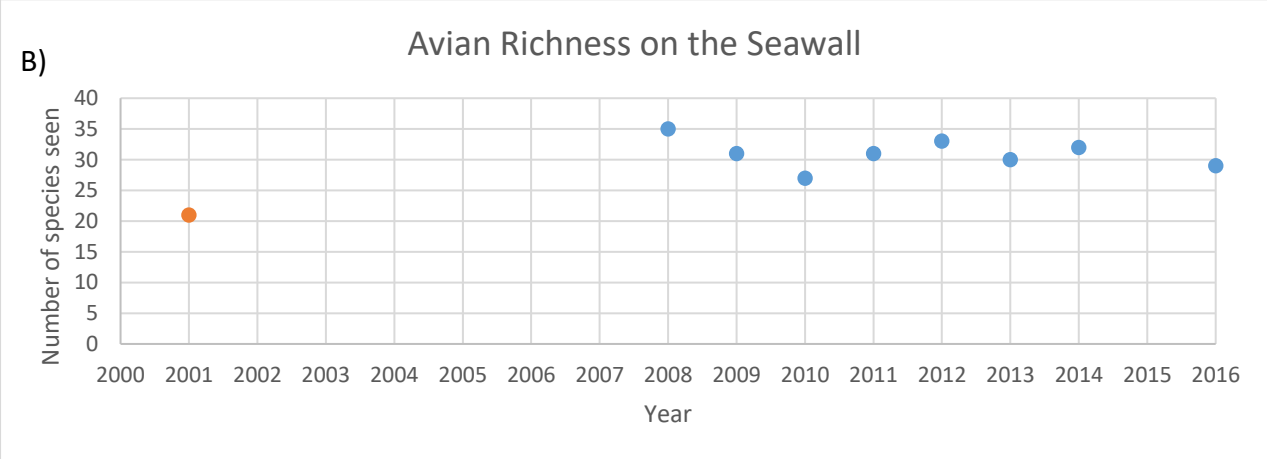
Appendix O. A) The species diversity of birds as quantified by the Simpson's Index of Diversity and B) the mean Simpson's Index of Diversity per month for each year in Devonian Park. For A, the month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2009. 2 = February 2009. 12 = December 2009. The dotted line represents a linear regression ($y = -2.8 \times 10^{-3} + 0.68$, $R^2 = 0.060$, $p = 0.072$). For B, error bars represent one ± standard error value.

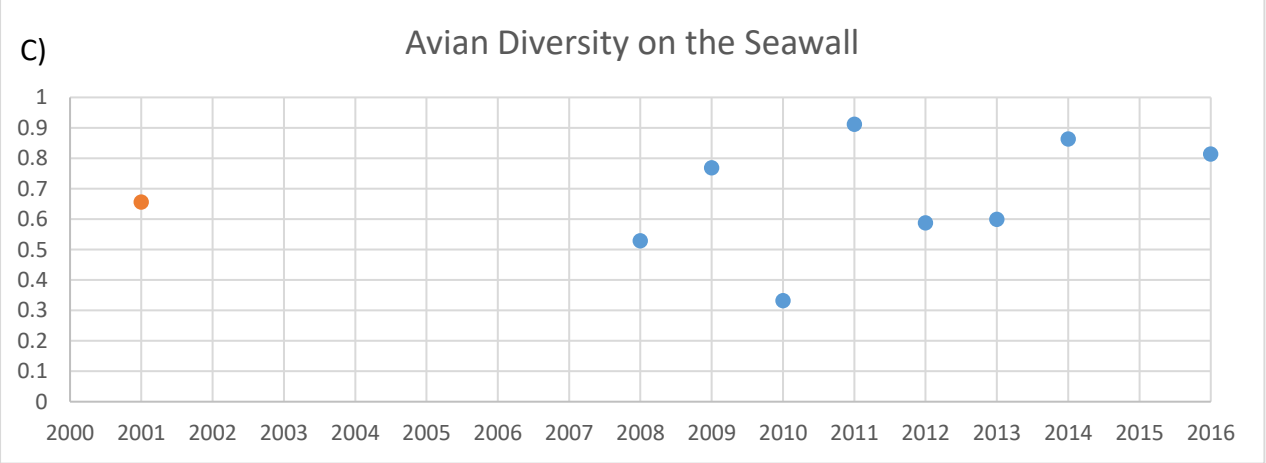




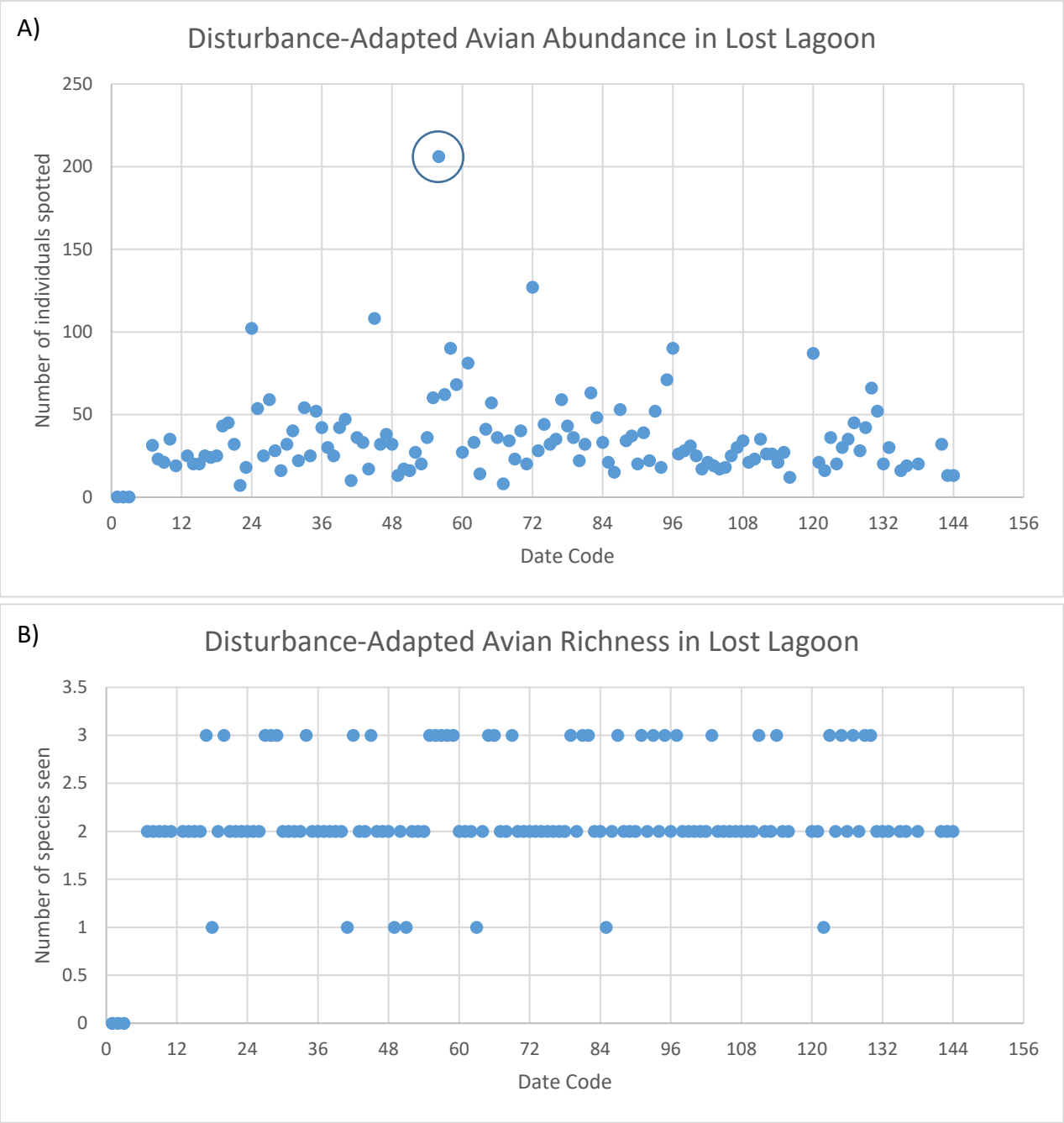
Appendix P. A) A line graph of each month's respective species diversity, quantified by the Simpson's Index of Diversity, throughout the years in Devonian Park. B) An overlay of each year's monthly species diversity of birds, quantified by the Simpson's Index of Diversity, in Devonian Park. Months were translated to a numeric value. 1 = January. 2 = February. 12 = December.



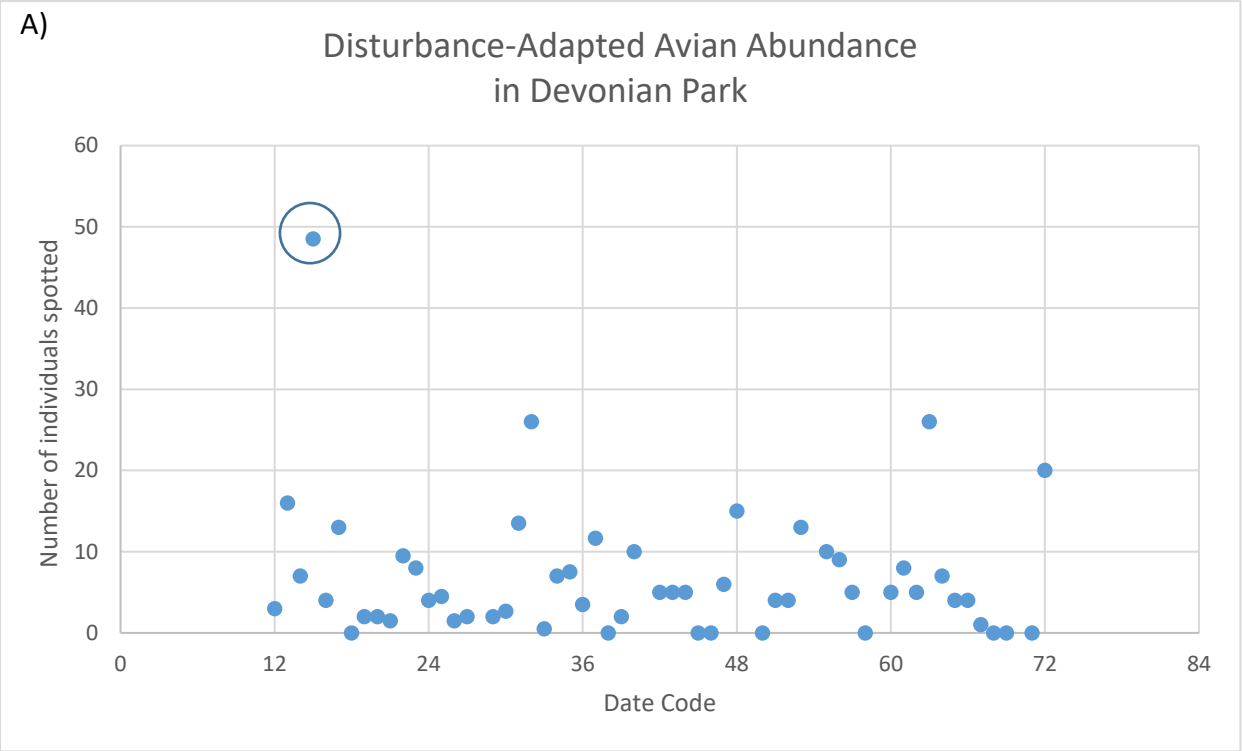


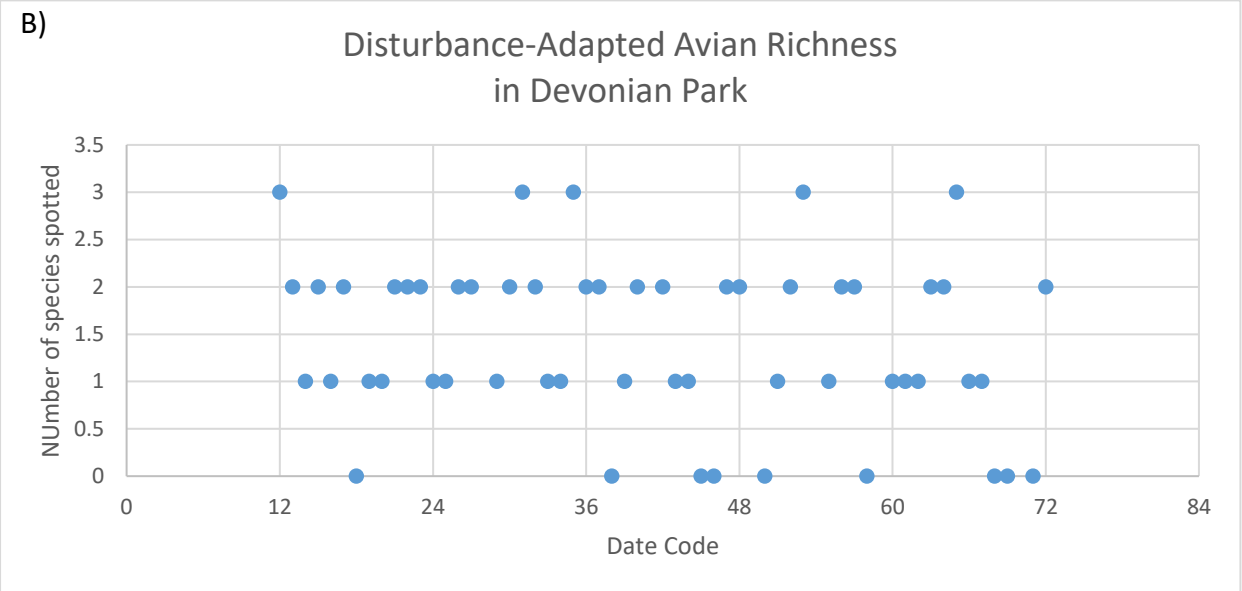


Appendix Q. The abundance (A), richness (B), and diversity (quantified by the Simpson's Index of Diversity) (C) of all birds spotted in the annual counts on the Seawall. The survey conducted in 2001 is highlighted in orange.

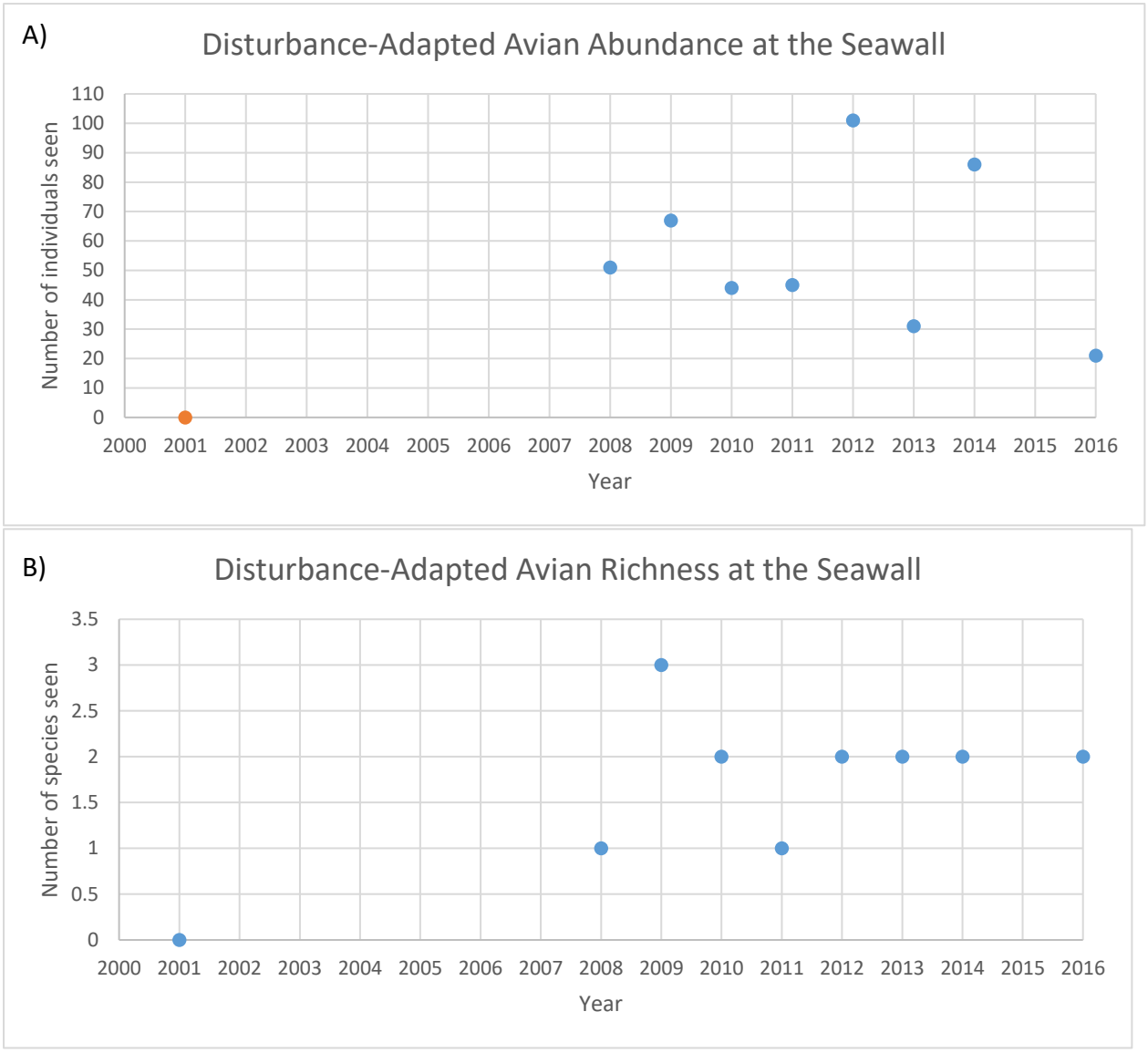


Appendix R. The abundance (A) and richness (B) of disturbance-adapted species over time in Lost Lagoon. The month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2005. 2 = February 2005. 12 = December 2005. On August 2009 (circled in blue), the higher abundance of disturbance-adapted birds was a result of more European starlings (in a group of 186) being seen by surveyors than usual.





Appendix S. The abundance (A) and richness (B) of disturbance-adapted species over time in Devonian Park. The month and year have been translated to a numeric value, where an increment of one is equivalent to one month. 1 = January 2009. 2 = February 2009. 12 = December 2009. On March 2010 (circled in blue), the higher abundance of disturbance-adapted birds was a result of more European starlings being seen by surveyors than usual.



Appendix T. The abundance (A) and richness (B) of disturbance-adapted species over time in the annual surveys on the Seawall.

Appendix U. A list of the raptors spotted in Beaver Lake between February 2001 and July 2002 and between July 2005 and December 2016, in Lost Lagoon between January 2005 and December 2016, in Devonian Park between January 2009 and December 2014, and on the Seawall in counts from 2001 and annual counts between 2008 and 2015. The alpha codes used were taken from Pyle and Desante (2017). Bolded codes represent the most consistently found raptor species at their respective sites.

Beaver Lake	**Lost Lagoon**	**Devonian Park**	**The Seawall**
BADO	BADO	**BAEA**	**BAEA**
BAEA	**BAEA**		COHA
COHA	COHA		MERL
Hawk sp.	MERL		OSPR
MERL	OSPR		RTHA
OSPR	PEFA		
PEFA	RTHA		
RTHA	SSHA		
SSHA	TUVU		
TUVU			

Appendix V. A list of the Anseriformes species spotted in Beaver Lake between February 2001 and July 2002 and between July 2005 and December 2016, in Lost Lagoon between January 2005 and December 2016, in Devonian Park between January 2009 and December 2014, and on the Seawall in counts from 2001 and annual counts between 2008 and 2015. The species are divided into five different subgroups. The alpha codes used were taken from Pyle and Desante (2017). Bolded codes represent the most consistently found Anseriformes species at their respective sites. The underlined codes represent the most abundant of the consistently found species. In Lost Lagoon, mallards were more abundant than Canada geese.

	Beaver Lake	**Lost Lagoon**	**Devonian Park**	**The Seawall**	
Dabbling	AMWI	**AMWI**	**AMWI**	**AMWI**	
	BWTE	BWTE	BWTE	GADW	
	EUWI	EUWI	GADW	GWTE	
	GADW	GADW	GWTE	**MALL**	
	GWTE	GWTE	**MALL**	NOPI	
	MALL	**MALL**	NOPI	NOSH	
	NOPI	NOPI			
	NSHO	NOSH			
Diving	LESC	CANV	CANV	CANV	
	RNDU	GRSC	GRSC	GRSC	
		LESC	LESC	LESC	
		RNDU	RNDU	RNDU	
		TUDU		Scaup sp.	
Perching	**WODU**	**WODU**	WODU	WODU	
			Mandarin Duck		
Sea	BUFF	BAGO	BAGO	**HADU**	HOME
	COME	BUFF	BUFF	**BAGO**	LTDU
	HOME	COGO	COGO	**BUFF**	Merganser sp.
		COME	COME	**COGO**	**SUSC**
		HOME	HOME	COME	WWSC
Swans + Geese	CAGO	CACG	CAGO	CACG	
		CAGO		**CAGO**	
		MUSW		GWFG	
		SNGO		MUSW	
		TRUS		Swan sp.	

Appendix W. A list of the non-Anseriformes waterbirds (NAWs) spotted in Beaver Lake between February 2001 and July 2002 and between July 2005 and December 2016, in Lost Lagoon between January 2005 and December 2016, in Devonian Park between January 2009 and December 2014, and on the Seawall in counts from 2001 and annual counts between 2008 and 2015. The species are divided into seven different subgroups. The alpha codes used were taken from Pyle and Desante (2017). Bolded codes represent the most consistently found NAW at their respective sites. The underlined codes represent the most abundant of the consistently found species.

	Beaver Lake	**Lost Lagoon**		**Devonian Park**	**The Seawall**
Seabirds ***Laridae*** *are italicized*	*Gull sp.*	*CATE*		***Gull sp.***	*BOGU*
	GWGU	*BOGU*		*GWGU*	***Gull sp.***
	DCCO	*CAGU*		*RBGU*	***GWGU***
	DCCO	*COTE*		DCCO	*HEGU*
		Gull sp.		PECO	***MEGU***
		GWGU			*RBGU*
		HEGU	*THGU*		**DCCO**
		MEGU	DCCO		**PECO**
		RBGU	PECO		MAMU
Kingfishers	BEKI	BEKI			BEKI
Loons + Grebes	PBGR	HOGR		COLO	COLO
		PBGR		HOGR	HOGR
					Loon sp.
					PALO
					PBGR
					RNGR
					RTLO
					WEGR
Rallidae	AMCO	**AMCO**		**AMCO**	AMCO
		VIRA			
Pelecaniformes	**GBHE**	**GBHE**		GBHE	GBHE
		GRHE			
Shorebirds	LBDO	GRYE	WISN		BLOY
	PESA	LESA			BLTU
	WISN	RNPH			SAND
		SPSA			

Appendix X. A list of the aerial insectivores (a part of the Passeriformes), hummingbirds, and Columbiformes species spotted in Beaver Lake between February 2001 and July 2002 and between July 2005 and December 2016, in Lost Lagoon between January 2005 and December 2016, in Devonian Park between January 2009 and December 2014, and on the Seawall in counts from 2001 and annual counts between 2008 and 2015. The alpha codes used were taken from Pyle and Desante (2017).

	Beaver Lake	**Lost Lagoon**	**Devonian Park**	**The Seawall**
Aerial Insectivores	BARS	BARS	BARS	
	HAFL	Flycatcher sp	TRSW	
	NRWS	NRWS	VGSW	
	OSFL	OSFL	NRWS	
	PSFL	PSFL	Flycatcher sp.	
	Swallow sp.	Swallow sp.		
	TRSW	TRSW		
	UEFL	VGSW		
	VGSW			
	WIFL			
Hummingbirds *Also included in* ***Forest Birds***	ANHU	ANHU	ANHU	
	RUHU	RUHU		
	Hummingbird sp.	Hummingbird sp.		
Columbiformes	ROPI	BTPI	ROPI	ROPI
		ROPI		

Appendix Y. A list of the forest birds (a part of the Passeriformes) spotted in Beaver Lake (BL) between February 2001 and July 2002 and between July 2005 and December 2016, in Lost Lagoon (LL) between January 2005 and December 2016, in Devonian Park (DP) between January 2009 and December 2014, and on the Seawall (WW, which stands for Wintering Waterbirds) in 2001 and in annual counts between 2008 and 2015. The alpha codes used were taken from Pyle and Desante (2017), with bolded ones representing consistently found species. Underlined species were the most abundant.

BL		**LL**		**DP**	**WW**
AMDI	MAWR	AMGO	NOFL	AMGO	AMRO
AMGO	NOFL	**AMRO**	NOWA	AMRO	BCCH
AMRO	OCWA	ANHU	OCWA	ANHU	BUSH
ANHU	PAWR	**BCCH**	PAWR	BCCH	CBCH
BCCH	PISI	BEWR	PISI	BHCO	DEJU
BEWR	PIWO	BHCO	PIWO	BUSH	DOWO
BHCO	PUFI	BHGR	PUFI	CEWA	GCKI
BHGR	RBNU	BRCR	RBNU	Chipping	HOSP
BRCR	RBSA	BTGW	RBSA	Sparrows	NOFL
BTGW	RCKI	BTYW	RCKI	COYE	PAWR
BTYW	RECR	BUOR	RECR	DEJU	PISI
BUSH	RUHU	**BUSH**	RUHU	GCSP	**SOSP**
CBCH	RWBL	**CBCH**	RWBL	HOFI	SPTO
CEWA	**SOSP**	CEWA	SAVS	HOSP	STJA
CORA	**SPTO**	CORA	**SOSP**	Hummingbird	WCSP
COYE	STJA	CORE	**SPTO**	sp.	
DEJU	SWTH	COYE	STJA	NOFL	
DOWO	TOSO	**DEJU**	SWTH	PAWR	
FOSP	TOWA	DOWO	TOWA	**RWBL**	
GCKI	VATH	**FOSP**	VATH	SAVS	
GCSP	WAVI	**GCKI**	Vireo sp.	SOSP	
HAWO	WCSP	GCSP	WAVI	SPTO	
HETH	WETA	HAFL	WCSP	WCSP	
HOFI	WEWP	HAWO	WETA	WIWA	
Hummingbird	WIWA	HETH	WIFL	YRWA	
sp.	Woodpecker	HOFI	WIWA		
HUVI	sp.	HOSP	YEWA		
Kinglet sp.	YEWA	Hummingbird sp.	YRWA		
MACW	YRWA	Kinglet sp.			

Appendix Z. A list of the primary cavity nesters, secondary cavity nesters, and disturbance-adapted birds spotted in Beaver Lake between February 2001 and July 2002 and between July 2005 and December 2016, in Lost Lagoon between January 2005 and December 2016, in Devonian Park between January 2009 and December 2014, and on the Seawall in counts from 2001 and annual counts between 2008 and 2015. The alpha codes used were taken from Pyle and Desante (2017).

	Beaver Lake	**Lost Lagoon**	**Devonian Park**	**The Seawall**
Cavity Nesters (Primary) ***Piciformes*** *are italicized. They are also included in* ***Forest Birds***	*DOWO*	*DOWO*	BCCH	*DOWO*
	HAWO	*HAWO*		*NOFL*
	NOFL	*NOFL*		BCCH
	PIWO	*PIWO*		CBCH
	RBSA	*RBSA*		
	Woodpecker sp.	RBNU		
	BCCH	BCCH		
	CBCH	CBCH		
Cavity Nesters (Secondary)	BADO	BADO	BAGO	BAGO
	BUFF	BAGO	BUFF	BUFF
	COME	BUFF	COGO	COGO
	HOME	COGO	WODU	COME
	WODU	COME	COME	HOME
	TRSW	WODU	HOSP	HOSP
	VGSW	PSFL	TRSW	PAWR
	PSFL	HOME	HOME	WODU
	PAWR	HOSP	VGSW	
	BRCR	TRSW	BRCR	
		BRCR	PAWR	
		WGSW		
		PAWR		
Disturbance-adapted	EUST	EUST	ROPI	EUST
	NOCR	NOCR	NOCR	NOCR
	ROPI	BTPI	EUST	ROPI
		ROPI		

Appendix AA. A list of the species identified in Beaver Lake between February 2001 and July 2002 and between July 2005 and December 2016. Unidentified species (e.g. Gull sp., UEFL) were not included in the counts. All species found only in 2001 and 2002 are underlined. In total, a minimum of 98 species were found. The alpha codes used were taken from Pyle and Desante (2017).

AMCO	EUWI	OSFL	VIRA
AMDI	FOSP	OSPR	WAVI
AMGO	GADW	PAWR	WCSP
AMRO	GBHE	PBGR	WETA
AMWI	GCKI	PEFA	WEWP
ANHU	GCSP	PESA	WIFL
BADO	GWGU	PISI	WISN
BAEA	GWTE	PIWO	WIWA
BARS	HAFL	PSFL	WODU
BCCH	HAWO	PUFI	YEWA
BEKI	HETH	RBNU	YRWA
BEWR	HOFI	RBSA	
BHCO	HOME	RCKI	
BHGR	HUVI	RECR	
BRCR	LBDO	RNDU	
BTGW	LESC	ROPI	
BTYW	MACW	RTHA	
BUFF	MALL	RUHU	
BUSH	MAWR	RWBL	
BWTE	MERL	SOSP	
CAGO	NOCR	SPTO	
CBCH	NOFL	SSHA	
CEWA	NOPI	STJA	
COHA	NOSH	SWTH	
COME	NRWS	TOSO	
CORA	OCWA	TOWA	
COYE	OSFL	TRSW	
DCCO	OSPR	TUVU	
DEJU	PAWR	UEFL	
DOWO	PBGR	VATH	
EUST	OCWA	VGSW	

Appendix AB. A list of the species identified in Lost Lagoon between January 2005 and December 2016. Unidentified species (e.g. Gull sp., UEFL) were not included in the counts. A minimum of 123 species were found in total. The alpha codes used were taken from Pyle and Desante (2017).

AMCO	COME	MEGU	SAVS
AMGO	CORA	MERL	SNGO
AMRO	CORE	MUSW	SOSP
AMWI	COTE	NOCR	SPSA
ANHU	COYE	NOFL	SPTO
BADO	DCCO	NOPI	SSHA
BAEA	DEJU	NOSH	STJA
BAGO	DOWO	NOWA	SWTH
BARS	EUST	NRWS	THGU
BCCH	EUWI	OCWA	TOWA
BEKI	FOSP	OSFL	TRSW
BEWR	GADW	OSPR	TRUS
BHCO	GBHE	PAWR	TUDU
BHGR	GCKI	PBGR	TUVU
BOGU	GCSP	PECO	VATH
BRCR	GRHE	PEFA	VGSW
BTGW	GRSC	PISI	VIRA
BTPI	GRYE	PIWO	WAVI
BTYW	GWFG	PSFL	WCSP
BUFF	GWGU	PUFI	WETA
BUOR	GWTE	RBGU	WIFL
BUSH	HAFL	RBNU	WISN
BWTE	HAWO	RBSA	WIWA
CACG	HEGU	RCKI	WODU
CAGO	HETH	RECR	WTSP
CAGU	HOFI	RNDU	YEWA
CANV	HOGR	RNPH	YRWA
CATE	HOME	ROPI	
CBCH	HOSP	RTHA	
CEWA	LESA	RUDU	
COGO	LESC	RUHU	
COHA	MALL	RWBL	

Appendix AC. A list of the species identified in Devonian Park between January 2009 and December 2014 and on the Seawall in counts from 2001 and annual counts between 2008 and 2015. Unidentified species (e.g. Gull sp., UEFL) were not included in the counts. All species found only in 2001 are underlined. The alpha codes used were taken from Pyle and Desante (2017).

Devonian Park		The Seawall		
Minimum # of Species: 57		Minimum # of species: 69		
AMCO	GWTE	AMCO	GRSC	RNGR
AMGO	HOFI	AMRO	GWFG	ROPI
AMRO	HOGR	AMWI	GWGU	RTHA
AMWI	HOME	BAEA	GWTE	RTLO
ANHU	HOSP	BAGO	HADU	SAND
BAEA	LESC	BCCH	HEGU	SOSP
BAGO	MALL	BEKI	HOGR	SPTO
BARS	Mandarin Duck	BLOY	HOME	STJA
BCCH	NOCR	BLTU	HOSP	SUSC
BHCO	NOFL	BOGU	LESC	WCSP
BUFF	NOPI	BUFF	LTDU	WEGR
BUSH	NRWS	BUSH	MALL	WODU
BWTE	PAWR	CACG	MAMU	WWSC
CAGO	PECO	CAGO	MEGU	
CANV	RBGU	CANV	MERL	
CEWA	RNDU	CBCH	MUSW	
Chipping Sparrows	ROPI	COGO	NOCR	
COGO	RWBL	COHA	NOFL	
COLO	SAVS	COLO	NOPI	
COME	SOSP	COME	NOSH	
COYE	SPTO	DCCO	OSPR	
DCCO	TRSW	DEJU	PALO	
DEJU	TRUS	Domestic duck	PAWR	
EUST	VGSW	DOWO	PBGR	
GADW	WCSP	EAGR	PECO	
GBHE	WIWA	EUST	PISI	
GCSP	WODU	GADW	RBGU	
GRSC	YRWA	GBHE	RBME	
GWGU		GCKI	RNDU	

Appendix AD. A list of the species identified in Beaver Lake between February 2001 and July 2002 and between July 2005 and December 2016, in Lost Lagoon between January 2005 and December 2016, in Devonian Park between January 2009 and December 2014, and on the Seawall in counts from 2001 and annual counts between 2008 and 2015. Unidentified species (e.g. Gull sp., UEFL) were not included in the counts. A minimum number of 150 species were found. All species found only in 2001 are underlined. The alpha codes used were taken from Pyle and Desante (2017).

AMCO	CANV	GWFG	NOWA	RWBL	WODU
AMDI	CATE	GWGU	NRWS	SAND	WTSP
AMGO	CBCH	GWTE	OCWA	SAVS	WWSC
AMRO	CEWA	HADU	OSFL	SNGO	YEWA
AMWI	Chipping Sparrows	HAFL	OSPR	SOSP	YRWA
ANHU	COGO	HAWO	PALO	SPSA	
BADO	COHA	HEGU	PAWR	SPTO	
BAEA	COLO	HETH	PBGR	SSHA	
BAGO	COME	HOFI	PECO	STJA	
BARS	CORA	HOGR	PEFA	SUSC	
BCCH	CORE	HOME	PESA	SWTH	
BEKI	COTE	HOSP	PISI	THGU	
BEWR	COYE	HUVI	PIWO	TOSO	
BHCO	DCCO	LBDO	PSFL	TOWA	
BHGR	DEJU	LESA	PUFI	TRSW	
BLOY	Domestic duck	LESC	RBGU	TRUS	
BLTU	DOWO	LTDU	RBME	TUDU	
BOGU	EAGR	MACW	RBNU	TUVU	
BRCR	EUST	MALL	RBSA	VATH	
BTGW	EUWI	MAMU	RCKI	VGSW	
BTPI	FOSP	Mandarin Duck	RECR	VIRA	
BTYW	GADW	MAWR	RNDU	WAVI	
BUFF	GBHE	MEGU	RNGR	WCSP	
BUOR	GCKI	MERL	RNPH	WEGR	
BUSH	GCSP	MUSW	ROPI	WETA	
BWTE	GRHE	NOCR	RTHA	WEWP	
CACG	GRSC	NOFL	RTLO	WIFL	
CAGO	GRSC	NOPI	RUDU	WISN	
CAGU	GRYE	NOSH	RUHU	WIWA	