Iona Island Bird Observatory
2010-2015 Cumulative Report

Report prepared for WildResearch by:

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Iona Island Bird Observatory (IIBO) is a program run by non-profit organization, WildResearch.

WildResearch's mission is to build, train, and educate a community that contributes to conservation science.

The IIBO is situated at Iona Regional Park. Use of the park is permitted by Metro Vancouver Regional Parks.

Funding support for IIBO between 2010-2105 was generously provided by:

Volunteer scheduling software for IIBO in 2011-2014 was donated by:

Purchase of volunteer scheduling software, Better Impact, for 2015 and beyond was made possible by:

Dedication

This report is dedicated to the many Citizen Scientists who generously donate their time to support the Iona Island Bird Observatory (IIBO) between 2010 and 2015 to assist with banding, extraction, data recording, site preparation and maintenance, photography etc. IIBO could not operate efficiently without the help of these dedicated volunteers. We absolutely could not run IIBO without our truly fantastic volunteers, and we admire your enthusiasm and dedication to the program.

A tribute to all volunteers that have contributed to IIBO from 2010 to 2015 is provided within (Appendix 1).

Acknowledgements

Significant thanks and gratitude is owed to many supporters of IIBO, including the following individuals and collaborators:

WildResearch Board of Directors that have served as volunteer IIBO Program Managers since program inception included Mike Boyd, Paul Leveque, and Christine Rock. Countless hours of behind the scenes work has been completed by IIBO Program Managers to ensure annual permitting and grant obligations were completed, contractor and data management; program and volunteer outreach; support to authors/review of annual IIBO reports; scheduling banding demonstration group visits; managing collaborations, overseeing site maintenance, and managing WildResearch's IIBO Operations Committee. Christine Rock completed contract management, and review of the current report.

Metro Vancouver Regional Park has supported and facilitated use of Iona Beach Regional Park for IIBO. Big thanks to Iona Beach Regional Park Facilitators, Melanie Blendell and Joe Soluri, for assistance with lane clearing, and path upgrades, and Markus Merkens, Parks West Area Natural Resource Management Specialist for permitting and general support.

Funding received toward the IIBO has allowed for program expansion and increased program capacity. Major funding was generously provided the Sitka Foundation from 2013 to 2015, allowing for equipment purchase, and wages towards seasonally hired contractors (bander-in-charge and assistant banders), and authors of the current report. The provincial Habitat Conservation Trust Fund's Public Conservation Assistance Fund (PCAF) provided funding towards the purchase of a banding structure in 2013. Further upgrades were made possible by a grant from BC Nature and BC Naturalists' Foundation towards the purchase of a solar panel system in 2014. In 2010 and 2011, Bird Studies Canada's Baillie Fund and PCAF provided initial seed money for the purchase of IIBO equipment.

Volunteer scheduling software for IIBO was made possible by BC Nature's facilitation of a donation from WhenToHelp, and a grant from the Mountain Equipment Co-op (MEC) for purchase Better Impact. Mikaela Davis, Elly Knight, and Christine Rock have volunteered countless hours towards scheduling and responding to the volunteer scheduling requests.

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Finally, several banders contributed to IIBO as paid contractors or volunteers between 2010-2015, including Andrew Huang, Anna Szeitz, Azim Shariff, Catherine Jardine, Christine Rock, Dan Froehlich, David Hodkinson, Jeremiah Kennedy, Ian Thomas, Leena Tirrul, Paul Levesque, Paul Preston, Mike Boyd, and Samantha Franks.

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Executive Summary

WildResearch is a membership based charitable non-profit organization that operates Iona Island Bird Observatory (IIBO). WildResearch's mission is to build, train, and educate a community that contributes to conservation science through its programs and events. WildResearch develops and runs citizen science programs like IIBO because it enables us to conduct conservation science research while offering skills to our membership, and engaging the public with the nature around them.

IIBO conducts avian monitoring in three seasonal programs over the year – the Winter Songbird Monitoring Program (WSMP), the Spring Migration Monitoring Program (SMMP), and the Fall Migration Monitoring Program (FMMP). These three programs were initiated in 2010 and, with the exception of the WSMP, have been conducted annually since then, resulting in six years of data for the majority of the programs. The WSMP was conducted annually until 2014 when the program was not conducted, however an abbreviated program ran in the winter of 2015.

The objective of the WSMP was to measure overwintering survival of resident species, and to gain insight into species diversity (the number of different species and their individual abundance) at Iona Beach Regional Park over the winter season. The park provided valuable habitat for resident songbirds in an otherwise urban environment. An improved understanding of how different species benefited from the park will help to inform future management decisions.

The SMMP and FMMP focus on neo-tropical migrant bird species that use Iona Island Beach Park for 1-14 days during their migration to or from their wintering grounds in the southern United States, Mexico, Central or South America to breeding grounds in North America, including British Columbia. These programs aimed to establish the timing of arrival of different migrant species and how they benefited from stopovers at Iona Beach Regional Park. This could be essential information for the conservation of these migrant species, which may are facing increasing threats from habitat loss, climate change, pesticide use, etc.

The current report presents a series of analyses on the six years of data collected at IIBO from 2010-2015. Firstly, we conducted an analysis of the mark recapture data to assess overwintering and annual survival of five song bird species – song sparrow, fox sparrow, spotted towhee, black-capped chickadee and ruby-crowned kinglet. Survival rates were comparable with other published studies. Generally, after hatch-year birds (birds in their second year or later) had higher survival than hatch-year birds (birds less than one year old). Weather conditions (mean temperature and precipitation) were important variables affecting overwinter survival.

Due to reduced monitoring in the winters of 2014 and 2015, these data could not be used in the mark recapture analyses. A key recommendation resulting from this report is to alter the monitoring protocol to fit a robust design mark recapture framework, whereby monitoring is conducted for a period of time at the beginning of the winter, and again at the end of the winter. This will allow for clear start and end points between which overwintering survival can be measured. However, limitations in fair weather days suitable for bird banding have made this a challenging survey standard to achieve.

The second analysis presented explored whether birds increased in fat content through time for all three programs. A key result was that migrating warbler species showed significantly increased fat reserves the longer they remained at Iona Beach Regional Park during the course of their migration. This result indicated that migrant species are benefiting from the park and this resource likely contributed to their overall migration success and survival. Interestingly, unlike other species assessed, sparrow species did not show significant changes in fat content over time.

The final analysis conducted was on the arrival dates of migrating warblers and sparrows. There was no indication that arrival dates had shifted over the course of the past six years. However, there were significant differences between different sexes, with males arriving before females, and in bird age, with older birds arriving before younger birds. These results supported other patterns observed in peer-reviewed literature.

This information will be useful in the future as a baseline for avian species that use IIBO either as a migration stop-over point, or year-round. As the effects of climate change and habitat loss intensify, these programs may contribute to management decisions at Iona Beach Regional Park and other natural areas in the metro Vancouver area, in order to maintain avian species diversity.

Another essential aspect to the 2010-2015 dataset was the effect that WildResearch's outreach and environmental education has had on the success of the program. In 2010, 60 volunteers contributed to data collection and by 2015, increased to almost 100 annual volunteers. These data would not exist without the hard work and dedication of many volunteers, and it is encouraging to note the growth in popularity of IIBO.

1. BACKGROUND

WildResearch, a charitable non-profit organization, was founded in 2010 by a group of six biologists and graduate students from Simon Fraser University. The founding Directors wanted to create a platform where biologists could contribute independently to conservation science. WildResearch's first citizen science program was the Iona Island Bird Observatory (IIBO). WildResearch believed that citizen science was an effective tool for conservation because it enabled systematic, widespread monitoring and research of flora and fauna while offering skills and training to community members and fostering a connection with nature.

The IIBO program was initiated at Iona Beach Regional Park in the spring of 2010. Iona Beach Regional Park is located in Richmond, British Columbia. Nestled in Greater Vancouver, this area has seen significant change over the last few decades resulting in limited natural habitat for birds and other wildlife. The park provides riparian, meadow and woodland habitat that has become essential for many bird species throughout the year, including both residential birds and birds that pass through via migration routes. It has been designated as an Important Bird Area (IBA) by BirdLife International, and local organizations, Bird Studies Canada and BC Nature (Plate 1). The bird community at Iona Beach Regional Park is well documented (Toochin 2014).

Plate 1. The IIBO is situated at Iona Beach Regional Park, which was designated as an Important Bird Area.

Through the three annual programs, IIBO aimed to learn more about the different species using the park and their abundance (i.e. avian diversity). The establishment of a long term data set was designed to improve our knowledge of the ecology of various species, as well as identify population trends and metrics on individual birds, such as age, body condition, and survival. This information will allow for management decisions to be made regarding bird populations that may be under stress or are declining, or alternatively, populations that are stable or increasing. In addition, outreach programs and contributions made by volunteers that aid in data collection increased public knowledge and awareness of how wildlife use natural spaces in an urban area, and the importance of conserving this habitat.

The three seasonal programs conducted at IIBO by WildResearch were:

1. The Winter Songbird Monitoring Program (WSMP)
2. The Spring Migration Monitoring Program (SMMP)
3. The Fall Migration Monitoring Program (FMMP)

Across all three seasons, data were collected using mist net surveys and an established banding protocol (Boyd, 2012). The ability to identify individual birds results in a powerful dataset whereby each bird can potentially be assessed multiple times. Knowing the species, age, sex and condition of a single bird across multiple years allowed for in-depth analyses on population composition and survival.

1.1. Program Effort

1.1.1. Winter Songbird Monitoring Program (WSMP)

The WSMP was based on the Monitoring Avian Winter Survival and MoSI programs run by the Institute for Bird Populations in the southern United States and Central America (de Sante et al. 2009). Vancouver's mild climate allowed for favorable periods of data collection during the winter months, although days were cancelled due to high winds or heavy rains. A pilot study at IIBO in the winter of 2010/2011 indicated that this program would be a useful way to measure overwinter survival and body condition, which could be an indication of the quality of the habitat and resources that Iona Beach Regional Park provides for songbirds during the winter months. The SMMP program was generally run from November to March in 2010 to 2014 (Figure 1; Table 1). However, the program was inactive between November 2014 and March 2015, and active again in November 2015 to December 2015 (Figure 1).

1.1.2. Spring Migration Monitoring Program (SMMP)

The objectives of the SMMP were to measure the arrival dates, abundance, and species diversity of neo-tropical migrants as they annually migrate from their wintering grounds in the southern United States, Mexico, Central or South America to breeding grounds in North America, including British Columbia. This was the first program initiated by WildResearch at IIBO in spring 2010. Sampling occurred between early April and the end of June, except for 2011, when sampling was conducted between mid-March to mid-April on a trial basis to ensure that the monitoring period was adequately capturing migrants (Figure 1; Table 1).

1.1.3. Fall Migration Monitoring Program (FMMP)

The FMMP monitoring was conducted between mid-August and late-October. This program was set up to collect data on neo-tropical migrants as they migrate south for overwintering, including age, body condition and stopover duration, and to gain population metrics on migrating species using Iona Beach Regional Park as a migration stopover point. The FMMP program began in mid-August and concluded at the end of October, with the exception of 2010, when the program ended in mid-October, and in 2011, when the program continued into November (Figure 1; Table 1).

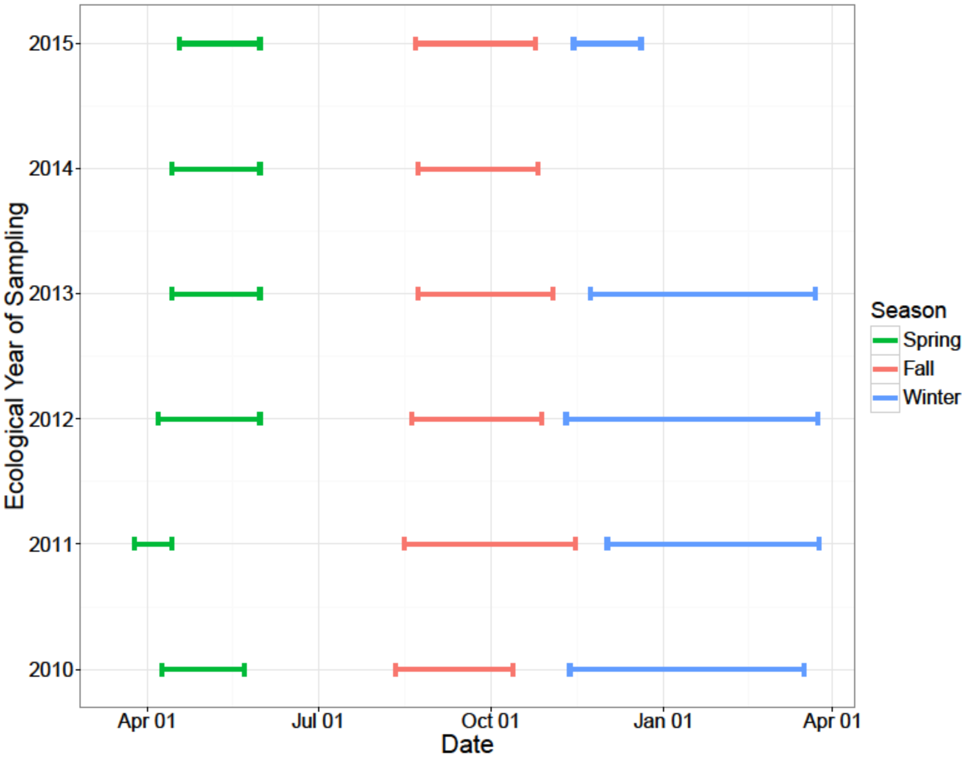


Figure 1. Dates for sampling for each seasonal program across six years. Ecological Year of Sampling refers to the year in which sampling began. The is specified as the winter program (WSMP) frequently occurred over the course of two calendar years - the end of one and the beginning of the next.

Table 1. The date range for each of the three seasonal monitoring programs.

Program	Start Date	End Date	Target Coverage Amount
Winter Songbird Monitoring Program (WSMP)	November 1	March 31	Min. 4 full days per month
Spring Migration Monitoring Program (SMMP)	April 1	May 31	Daily
Fall Migration Monitoring Program (FMMP)	August 1	October 31	Daily

2. METHODS

2.1. Recording Volunteers Hours

A significant aspect of WildResearch's mandate includes engaging the public in conservation science and data collection. IIBO's current target audience includes, but is not limited to: college and university students pursuing biological or environmental education and training, naturalists, birdwatchers, and any members of the general public wishing to become involved with or educated about conservation efforts or to who want to learn more about the natural environment.

IIBO operations were overseen under the collective governance of the volunteer WildResearch Board, and under the direct guidance of the Board Representative/Program Manager and Master or Station banding permit holder, including Mike Boyd, Paul Levesque, and Christine Rock. Seasonal contractors were hired by WildResearch between 2012 and 2015, and included one Bander-in-charge (i.e., Supervisor) who is federally and provincially permitted to band birds, and in some years/programs, one additional Assistant Bander-in-charge (i.e., Assistant Supervisor). These employees provided oversight and training in songbird identification, capture, handling, banding, and body measurement to 2-8 volunteers daily, as well as provided effective training and educational experiences to the general public through group visits and casual individual drop ins. The overall running of the IIBO program was made possible through in-kind donations made by the volunteers that in turn received training benefits through the program.

The collection of the data that is presented and analyzed in this report is the result of many hours of work contributed by volunteers over the years. Figure 2 below shows the number of volunteer hours and the number of volunteers for each year of data collection based on volunteer scheduling records collected in scheduling software packages, WhenToHelp and Better Impact. Most noticeable was the increase in the number of volunteers between 2012 and 2013, and again from 2014 to 2015. This exemplified the growth in popularity that WildResearch experienced since the organization was founded in 2010 and the importance of public outreach in engaging members of the public in conservation initiatives.

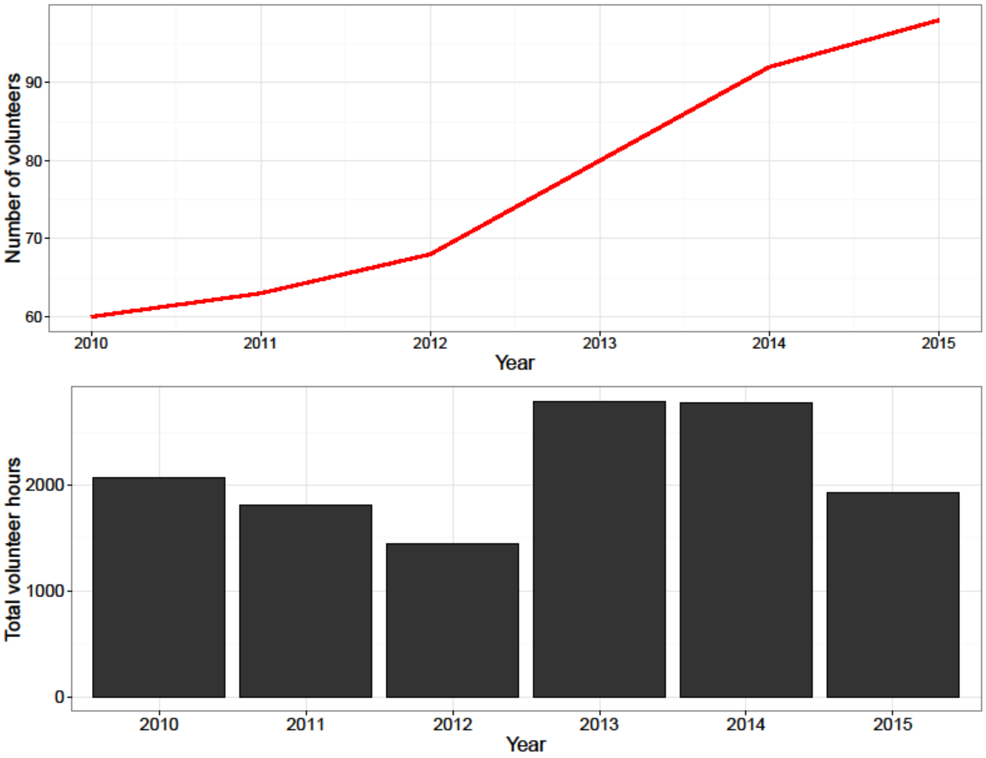
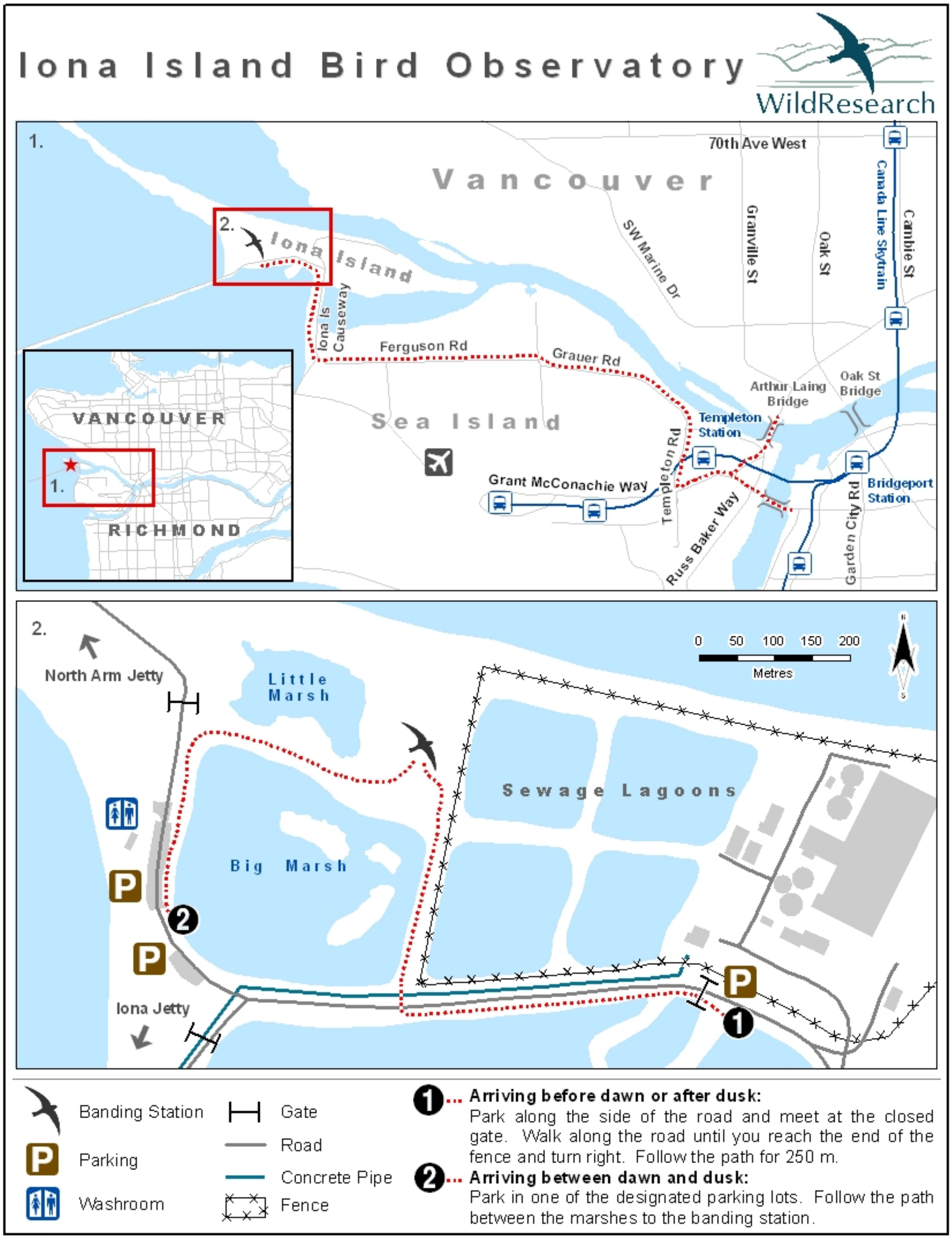


Figure 2. Number of volunteers and the total volunteer hours contributed over the past six years of monitoring.

2.2. Field Sampling Protocol

The Iona Island Bird Observatory is located within the metro Vancouver area, British Columbia at Iona Beach Regional Park, near Vancouver International Airport, Richmond BC (Figure 3).



❶ **Arriving before dawn or after dusk:**
Park along the side of the road and meet at the closed gate. Walk along the road until you reach the end of the fence and turn right. Follow the path for 250 m.

❷ **Arriving between dawn and dusk:**
Park in one of the designated parking lots. Follow the path between the marshes to the banding station.

Figure 3. Location of the Iona Island Bird Observatory

2.2.1. Mist Net Locations

All mist-nets used at IIBO were 30-32 mm wide and 12 m long. Nets were placed around the woodlot at the northeast corner of the park and between the two ponds in the centre of the park (Figure 4). The majority of nests remained stationary between 2010-2015, however two nets changed locations in 2012 (Figure 4). Net locations cover the varied habitat types represented at Iona Beach Regional Park, including marshland and riparian vegetation, and cottonwood forest. The area contains invasive species including Himalayan Blackberry (*Rubus armeniacus*), Scotch broom (*Cytisus scoparius*) and Reed Canary Grass (*Phalaris arundinacea*; Shariff 2014, Bishop & Forrester 2012). Since 2012, the area covered by Himalayan Blackberry, has expanded (Shariff 2014).

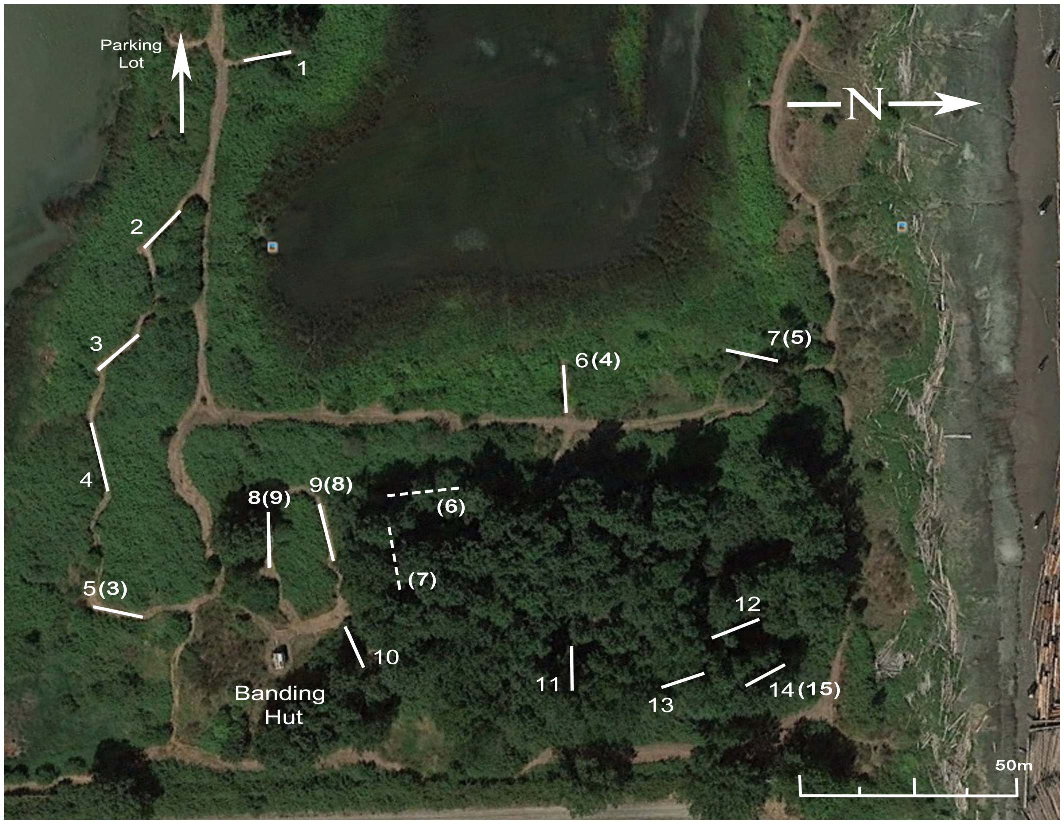


Figure 4. Mist net locations around Iona Beach Regional Park. Numbers indicate net numbers as of spring 2015, numbers in brackets represent former net numbers (spring 2010-spring 2015). Dotted lines represent nets that were no longer in use, as of 2012.

2.2.2. Data Collection

Nets were opened 30 minutes before sunrise and remained open for a maximum of six hours. Nets were checked every 20-30 minutes (depending on weather conditions and temperature) in a repeated order. After removing birds from nets, birds were taken to the banding table (2010-2012) or facility (2013-2015) for processing (Plate 2). For each bird captured in a net, the following data were recorded: band number (new or recapture), species, age, how aged, sex, how sexed, wing length, fat content, skull, weight, capture time and date, net number, and bander. For the purpose of this report, only methods for fat content are discussed below as the other parameters were not utilized in the analyses.

Plate 2. The IIBO infrastructure from 2010 to 2012.

Plate 3. The IIBO infrastructure from 2013 to 2015.

Age

Age was determined following Pyle (1997) and Pyle (2008), using the numeric age classes and descriptions in Table 2 below. The method used to determine the age of a bird is presented in Appendix A, Table 1.

Table 2. Numeric age classes and descriptions for birds

Numeric Age Class	Alpha Translation	Description
0	Unknown	A bird of an unknown age, and may only be used after the breeding season and December 31st.
4	Local	A young bird incapable of sustained flight, ie. local to the banding area.
2	Hatch-year	A bird hatched in the calendar year it was banded.
1	After hatch-year	A bird hatched before the calendar year it was banded.
5	Second-year	A bird known to have hatched in the previous calendar year in which it was banded.
6	After second-year	A bird known to have hatched in an earlier year than the year prior to the year it was banded, i.e. hatched 2009 and banded in 2011.
7	Third-year	A bird known to have hatched in the calendar year two years prior to the year it was banded.
8	After third-year	A bird known to have hatched prior to two years prior to the year of banding, now in at least its fourth calendar year of life.

Sex

Sex (gender) was determined through an assessment of several cues that vary by age, species, and time of year (Pyle 1997; Pyle 2008). Additionally, during the SMMP, birds were assessed for signs of breeding that would confirm sex, including a cloacal protuberance (CP) in males (swelling of the genitals to store sperm) and a brood patch (BP) in females (loss of feathers on the abdomen). During mating, males generally have a CP of 2 or 3 (on the scale below), whereas females usually have a CP of 0 or 1. Males may have a CP, are generally paired with females. General plumage coloration can also be used in combination with CP and BP to to distinguish between sexes.

Brood Patch scale:

0 no brood patch
1 smooth skin; a loss of breast and some abdomen feathers, but most of the area is still rather smooth and dark red (Plate 4.)
2 vascularlized; abdominal skin thickened with increased fluid and vascularization (peak of incubation)
3 wrinkled; abdominal skin thinning, wrinkly and scaly
4 moulting; new pin feathers in area (end of nesting)

Cloacal Protuberance scale:

0 no cloacal protuberance

1	small cloacal protuberance
2	medium cloacal protuberance
3	large cloacal protuberance

Plate 4. Example of a brood patch.

Measuring Fat Content

The amount of fat reserve was measured on each bird using standard protocol in which the feathers covering the furculum (neck area) were blown apart to assess if there was fat present. The bird was assigned a 'Fat Level' according to the degree of fat seen (Table 3). Fat was indicated by colour and/or filled space. For birds with fat levels greater than 4, fat reserves under the wings and around the cloaca were also assessed and used for determining rankings greater than 4.

Table 3. Numeric codes for fat levels in birds (IIBO protocol, WildResearch, 2012)

Fat Level	Description
0	No fat present in the furculum.
1	A slight amount of fat present in the furculum, <5% filled. Typically only a hint of fat either on the bottom or sides, formerly known as Trace.
2	Typically, the bottom of the furculum is filled with fat, approximately 5-33% of the furculum is filled.
3	Typically the furculum is half filled, but it may vary from 33-80% filled.
4	Typically the furculum is completely filled, but it may vary from 80-100% filled.
5	The furculum is bulging with fat, but little fat under the wings or around the cloaca.
6	The furculum is bulging with fat, as are the area under the wings and around the cloaca.
7	Fat connects between the furculum, under the wings and to the cloaca; essentially the entire body is covered in a layer of fat.

2.2.3. Weather Data

Mean daily temperature and precipitation data from Vancouver International Airport was used in all analyses, given the close proximity of the Airport's weather station to IIBO. This was downloaded from the BC government website (http://climate.weather.gc.ca/; accessed on February 1st, 2016).

2.3. Mark Recapture Analysis

We used banding data from 2010 to 2015 WSMPs to estimate overwintering survival and annual survival for the five resident species with the most recaptures among all years; fox sparrow (FOSP), ruby-crowned kinglet (RCKI), song sparrow (SOSP), spotted towhee (SPTO) and black-capped chickadees (BCCH). To estimate overwintering survival, we used a robust design framework (Kendall et al. 1995) in which primary capture occasions were those within a month, and secondary occasions were between months. We limited the analysis to 2010-2013, because there were very few capture occasions in the winter of 2015 and no captures in the winter of 2014-2015, and models therefore did not converge. In cases where there were less than three primary capture occasions within a month, we either dropped that month from the analysis, or combined those capture occasions with another month if they occurred within ten days of the preceding or proceeding month. Thus survival periods represented survival between one or more months.

For the purpose of these analyses, age was classified into two classes: hatch-year (HY) and after hatch-year (AHY). This was the approach for two main reasons: 1) there were not enough recaptures of birds of different age classes (second-year, third-year, etc.) to model each age class separately, and 2) we predicted that the biggest differences in overwintering survival would be between HY and AHY, which we did have enough data to model in most cases.

To estimate overwintering survival and annual survival, we ran all combinations of models which included survival (φ), initial capture probability (p), and recapture probability (c) as a function of time, age, mean monthly temperature, and mean monthly precipitation. Robust design models also contain parameters to estimate temporary emigration (when an animal leaves the study area for a brief period of time over the course of the sampling period), and temporary immigration (when an individual enters the study site for a brief period of time over the course of the sampling period). Temporary emigration and immigration are defined in the models as γ'' (gamma double prime) and $1-\gamma'$ (gamma prime) respectively, however for our analyses, we fixed $\gamma''=0$ and $\gamma'=1$, so that there was no emigration or immigration from the study site between months (Cooch and White 2015), a reasonable assumption given the short time frame. We estimated survival over the winter months separately for each year, and for each analysis, if there was no clear top model (> 50% of the AIC weight), we model averaged all models that contained 95% of the cumulative AIC weight (Burnham and Anderson 2002).

For annual survival, we collapsed capture occasions within each month during the overwintering period (November to March) into two categories: whether or not a bird was caught in a given month. Thus, both an individual caught three times within a month and an individual captured 1 time within a month are both considered ‘present’, while a bird not captured during that month is considered ‘absent’. We then used these condensed capture occasions to estimate survival outside of the overwintering period (April through October) in a Robust design framework. Once again we fixed $\gamma''=0$ and $\gamma'=1$, given that these are assumed to be resident birds. We did not include weather covariates for these analyses, because there were no reasonable weather metrics to estimate over the course of the year. Age was not included as a covariate because it was a multi-year assessment and birds aged throughout the study period. We looked at whether φ, p, and c, varied as a function of time across years. As with the monthly winter survival estimates, we model averaged if there was no clear top model.

2.4. Fat Content Analysis

For this analysis, we focused on the change in fat content between the first and last capture events of an individual captured on at least two occasions within a season. Data across all years were combined and year was included as a variable in the model. We limited data to birds in which the first and last capture was within 10 days, because birds with greater than 10 days between first and last capture were statistical outliers.

Fat content was analyzed using general linear models, which are used to describe the statistical relationship between one or more predictors (or factors) and a continuous response variable (in this case, change in fat content). Data were separated into seasonal programs (WSMP, SMMP, FMMP) and individuals were then grouped into species guilds. For example, all warbler species were grouped into the ‘warbler’ species group. This was done to increase the sample size, thus strengthening the dataset. Additionally, the way that fat is measured is a relative measure (see Table 3) that would be expected to be consistent across species. We focused on two species groups for fat content analysis, Warblers and Sparrows (Table A2 & A3).

For each season and species group, the maximum model was:
‘Fat Content’ ~ Number of days + Mean temperature + Precipitation + Sex, where number of days refers to the number of days between first and last capture, and mean temperature and precipitation are mean values of the days between first and last capture for each individual.

Data were checked for model suitability by assessing whether the residuals were normally distributed, which they were in all cases. With each iteration of the model, the least significant term was removed and the model was rerun (including checking again for normality), until all terms were significant, i.e. the minimal model.

2.5. Arrival Dates

Boxplots were generated to depict the median arrival date and date range for several warbler and sparrow species in each season and across all sampling years. For the purposes of this analysis, sparrows that were present during any WSMP programs, in any year, were classified as 'resident' and were not included in the arrival date analysis or plots.

We used linear models to analyze arrival dates. A model was run for each species group looking at whether arrival date varied by age, with species and year as additional terms in the model. For the fall season, hatch-year (HY) and after hatch-year (AHY) birds were used for the analysis. In the spring, birds that were classified as second-year (SY) or after second-year (ASY) were used, in order to compare first year migrants (SY) with more mature birds that had migrated at least once previously. For warblers, a second model was run to look at the effect of sex on arrival date. This was not done for sparrows as there was no sex data recorded, because with the exception of spotted towhees, sparrow species captured at IIBO are monomorphic (male and female look visually similar and are indistinguishable by sight, unless displaying a brood patch or cloacal protuberance).

The maximum model in each case was:
Day of year ~ Sex + Species + Year
Day of year ~ Age + Species + Year

The residuals of the data were normally distributed confirming that the data met the assumptions of linear models. Each time the model was run, the least significant term was removed until all remaining terms were significant.

2.6. Statistical Analyses

We used the statistical program R (version 3.2.3) to conduct all analyses and generate figures. Mark recapture analyses were run using the package RMark (version 2.1.14) in R.

3. RESULTS

3.1. Program Summaries

3.1.1. Spring Migration Monitoring Program

Since 2010, the average species diversity during the SMMP was 38 species (range: 26-47 species) each year, with the most abundant migrant species being Wilson's warbler, yellow-rumped warbler, orange-crowned warbler, yellow warbler, and violet-green swallows (Figure 5). Species that are known to reside locally over the winter were also captured during the SMMP, including fox and song sparrows, spotted towhees, and ruby-crowned kinglets.

3.1.2. Fall Migration Monitoring Program

The highest species diversity across all three programs was recoreded during the FMMP, with an average species diversity of 44 species (range: 41-47) captured each year. The most numerous migrant species captured included warbler species: yellow warbler, yellow-rumped warbler, and orange-crowned warbler, common yellowthroat; and house finch, whilst other species captured in highest numbers were song sparrow and Lincoln's sparrows, spotted towhees, and ruby-crowned kinglets (Figure 6). A wide variety of sparrows were captured during the FMMP (Plate 5).

3.1.3. Winter Songbird Monitoring Program (WSMP)

Monitoring for the WSMP usually began in early-mid November and continued until mid-March, aside from the winters of 2014 and 2015 as discussed in Section 1.1.1. Over the latter five winter seasons, the average species diversity of captured birds was 23 species, (range 21-25 species) per year. The most common species present were fox sparrows, song sparrows, black-capped chickadees, spotted towhees, and ruby-crowned kinglets (Figure 7).

Plate 5. Example of the wide variety of sparrow species captured at IIBO during the FMMP (Photo credit: Kim Gilbert).

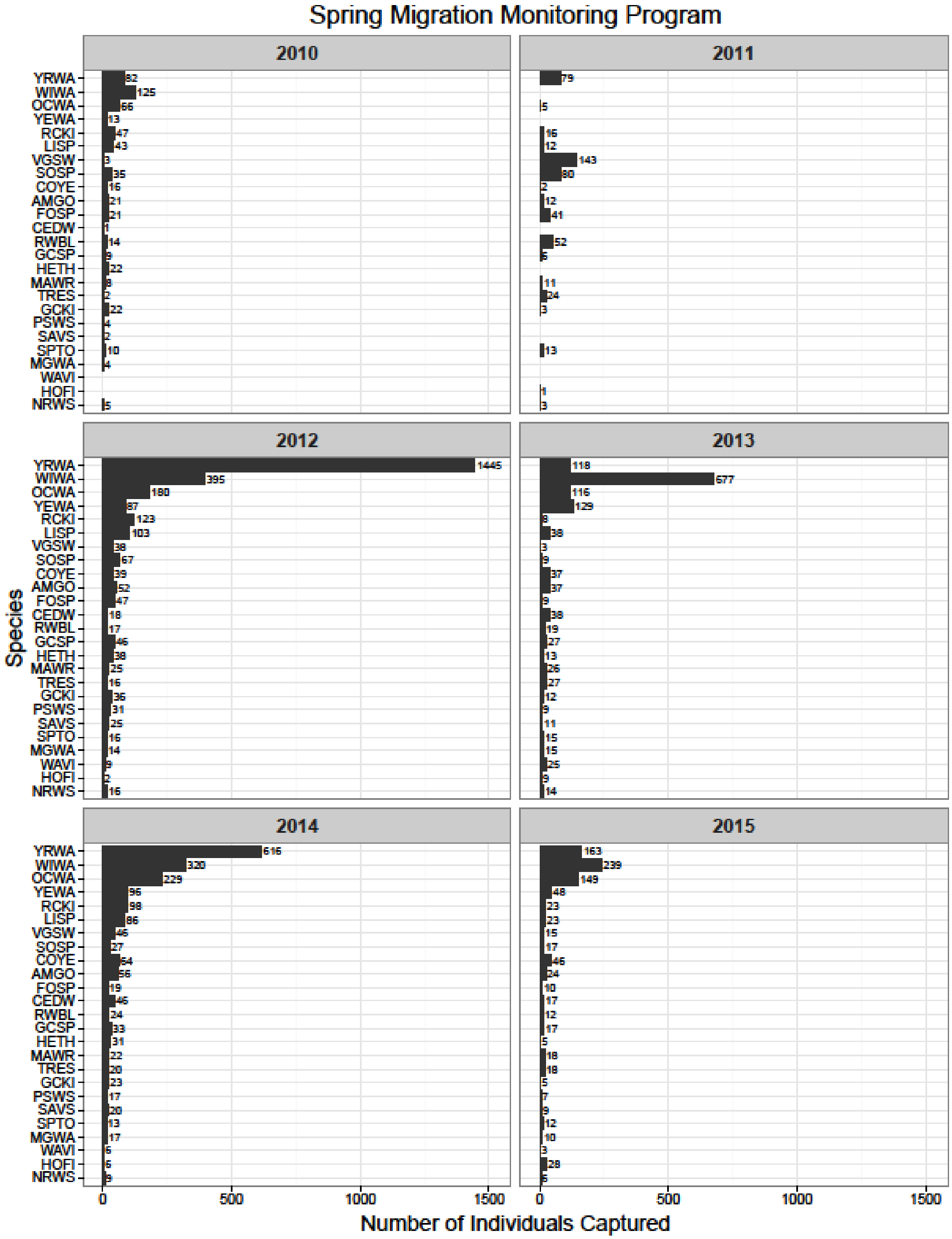


Figure 5. Summary of birds captured in the Spring Migration Monitoring Program from 2010-2015. The numbers on the bars indicate the number of individuals caught, and do not include recaptures of the same individual. Species for which fewer than fifteen individuals were captured in all years have been excluded (n=50). Species codes can be found in Appendix A.

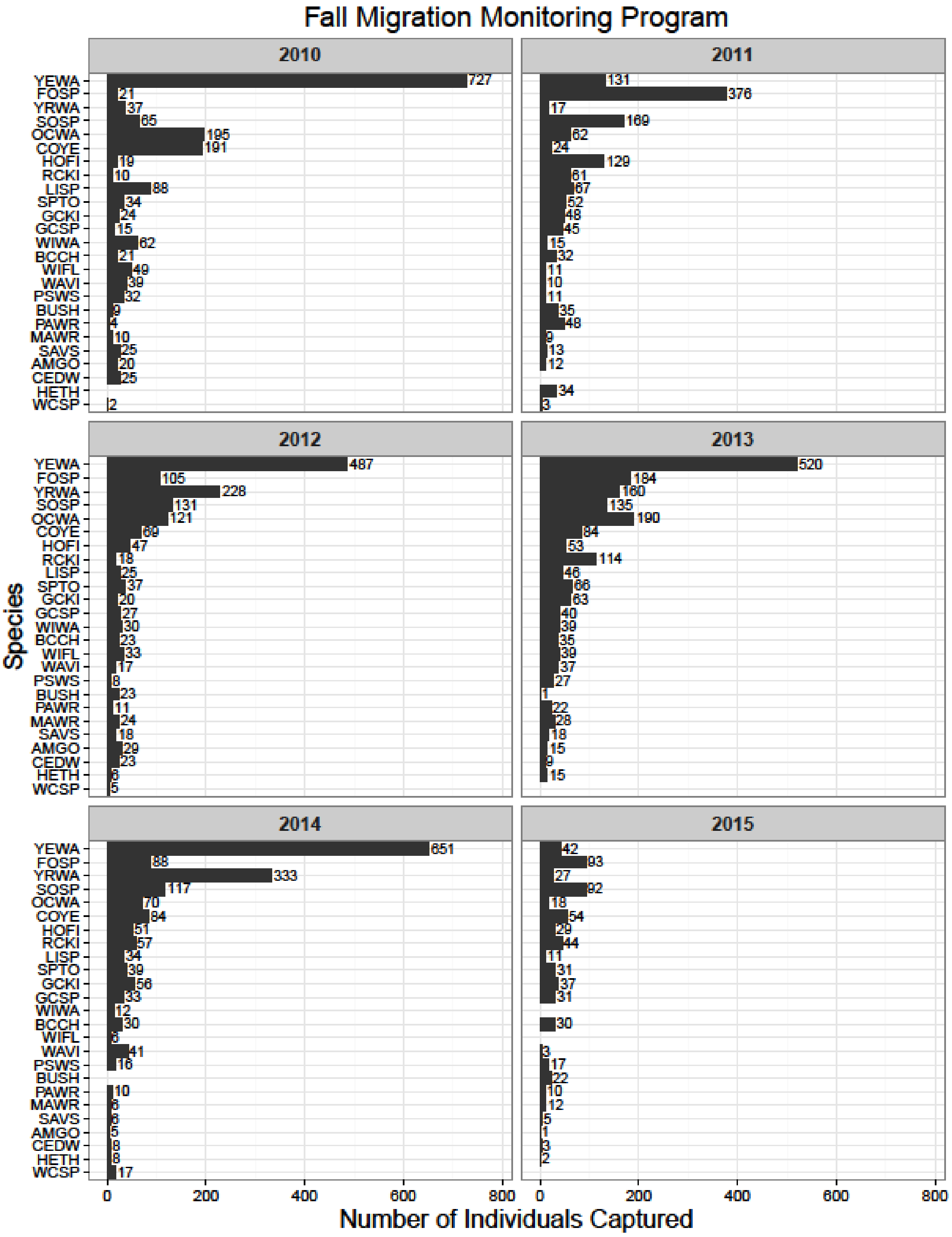


Figure 6. Summary of birds captured in the Fall Migration Monitoring Program from 2010-2015. The numbers on the bars indicate the number of individuals caught, and do not include recaptures of the same individual. Species for which fewer than fifteen individuals were captured in all years have been excluded (n=48). Species codes can be found in Appendix A.

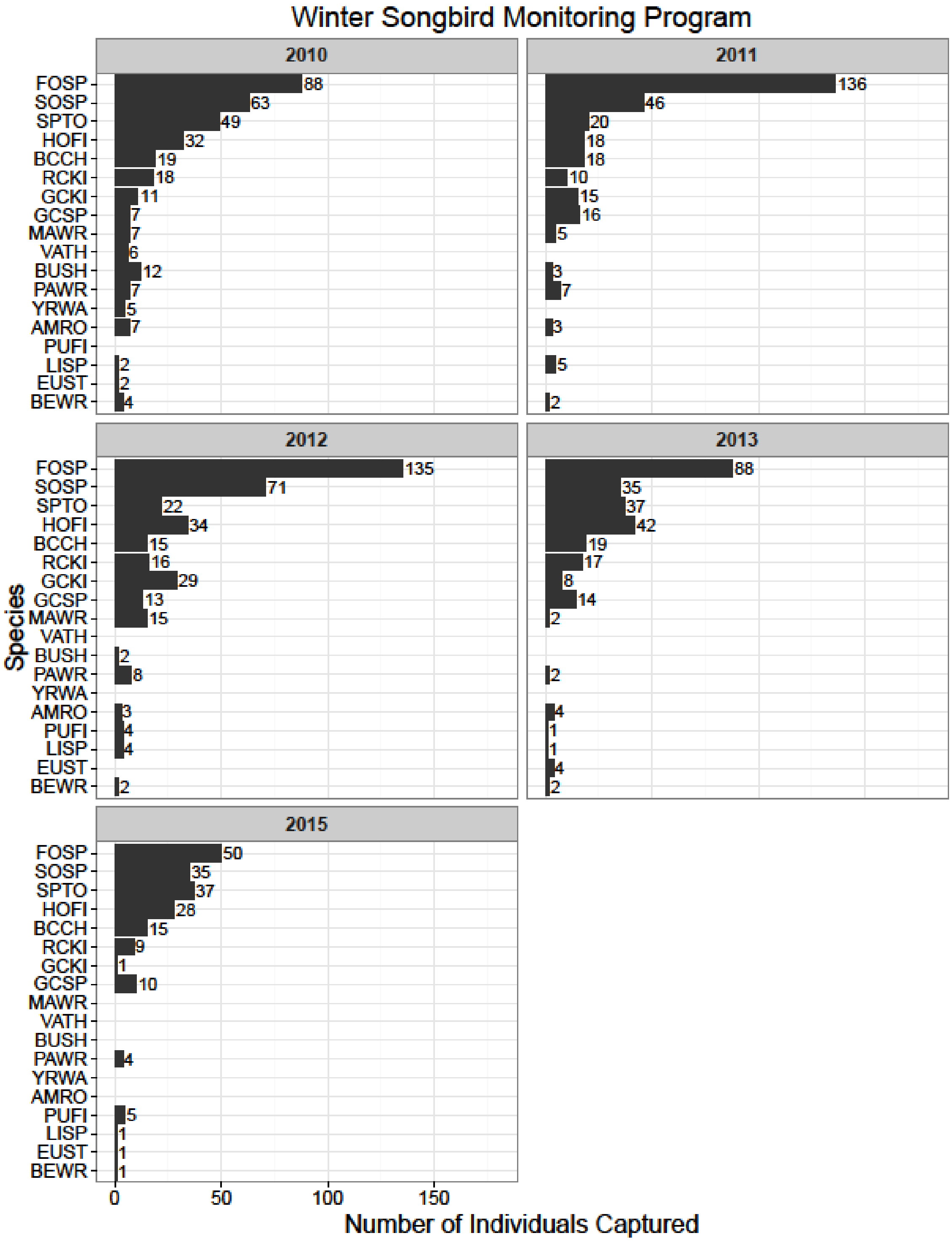


Figure 7. Summary of birds captured in the Winter Songbird Monitoring Program from 2010-2015. The numbers on the bars indicate the number of individuals caught, and do not include recaptures of the same individual. Species for which fewer than three individuals were captured in all years have been excluded (n=21). Species codes can be found in Appendix A. Note that the WSMP was not conducted in 2014.

3.1. Mark Recapture Analysis

3.1.1. Fox Sparrow

The capture data allowed for an estimation of fox sparrow (Plate 6). winter survival for four time periods in winter 2010, three time periods in winter 2011, and three time periods in winter 2012 (Figure 8). In 2010 and 2011, survival periods represented one month intervals, whereas in 2012 survival was estimated from November to January (two month period) and then for one month intervals for the remaining two time periods. This was necessary because there were not enough capture occasions in December 2012 to estimate survival for this month alone. Thus, we used the capture occasions in November and January to estimate survival over the course of that time period.

Plate 6. Fox sparrow captured at IIBO.

In general, HY survival was lower than AHY, and there was support for models in which survival was a function of HY, temperature, and precipitation. There were no top models (i.e. a single model with a ΔAIC less than 2) across any of the years, and thus we model averaged those that contained 95% of the weight. In 2010, HY appeared in 22 of the 45 top models (49%), while temperature appeared in 15 (33%), and precipitation appeared in 9 (20%). In 2011, HY appeared in 67 of the 109 top models (61%), temperature appeared in 29 (27%), and precipitation appeared in 28 (26%). Finally, in 2012, HY appeared in 39 of the top 101 models (39%), temperature appeared in 18 (18%) and precipitation appeared in 30 (30%).

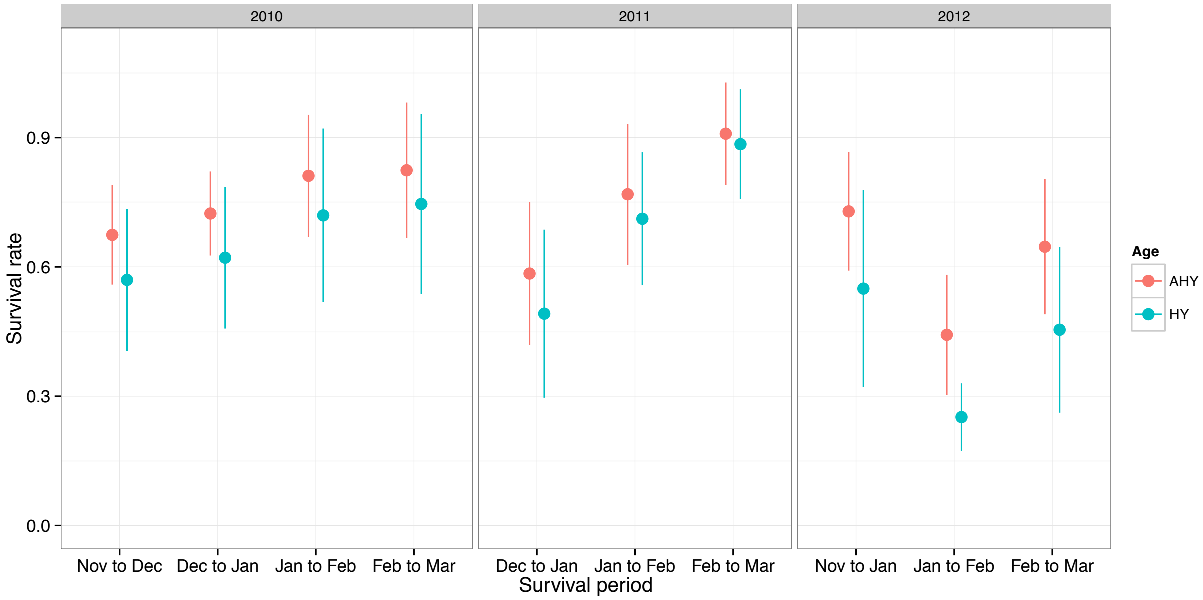


Figure 8. Fox sparrow survival rate across three or four sampling periods and during three years (2010, 2011, and 2012) with Standard Error bars. Hatch-year (HY) birds are shown in blue and birds that were older than hatch-year (AHY) are in pink.

In 2010 and 2011, survival increased through the winter for both HY and AHY, and ranged between 0.58 and 0.91 for AHY and between 0.49 and 0.88 for HY (Figure 8). In 2012, survival was lower from January to February and February to March for both HY and AHY and ranged from 0.44 to 0.73 and 0.25 to 0.55 for AHY and HY respectively (Figure 8). As a rough estimate of total overwintering survival, we multiplied survival rates from each time period within a year. We estimated total overwintering survival for AHY FOSP to be between 0.33 and 0.46, and between 0.06 and 0.46 for HY (Table 4).

For annual survival outside of the winter period, which we defined as April through October, there was a clear top model (weight = 0.81). Survival was constant across time, and was 0.52 (+/- .11 Standard Error (SE)).

Table 4.Overall overwintering survival for fox sparrows (FOSP)

Age	Year	Estimate
AHY	2010	0.33
AHY	2011	0.34
AHY	2012	0.46
HY	2010	0.24
HY	2011	0.46
HY	2012	0.06

3.1.2. Song sparrow

For song sparrows, we estimated survival for four time periods in 2010, two in 2011, and three in 2012. In 2010, the survival was estimated over a one month period, whereas in 2011 we estimated survival in two distinct periods: from December to February (two month period) and from February to March (one month period), and in 2012 we estimated survival from November to January (two months) and then from January to February (one month) and February to March (one month). We model averaged coefficients for models containing 95% of the weight.

In 2010, models with climate data were not supported. In 2011, models containing HY, precipitation, and temperature had relatively high support. In 2011 23 of the 88 (26%) contained precipitation, 57% of the models (50 of 88) contained HY, and 38 of 88 (43%) contained temperature. In 2012, Forty-eight of the 85 models (56%) contained HY, while 18 (21%) contained temperature and 24 (28%) contained precipitation.

Interestingly, survival was higher for HY individuals relative to AHY in 2010, and ranged between 0.60 and 0.87 for AHY in 2010 and between 0.73 and 0.84 for HY (Figure 9). In 2011, survival decreased, ranging from 0.33 to 0.37 for AHY and ~0.18 for HY individuals (Figure 9). Survival increased in 2012, and AHY individuals survived at higher rates than HY individuals. Estimates in 2012 ranged between 0.51 and 0.68 for AHY, and between 0.49 and 0.65 for HY individuals (Figure 9). Overall overwintering survival ranged between 0.12 and 0.29 for AHY and between 0.03 and 0.28 for HY (Table 5)

Table 5. Total overwintering survival for song sparrows (SOSP)

Age	Year	Estimate
AHY	2010	0.29
AHY	2011	0.12
AHY	2012	0.21
HY	2010	0.48
HY	2011	0.03
HY	2012	0.18

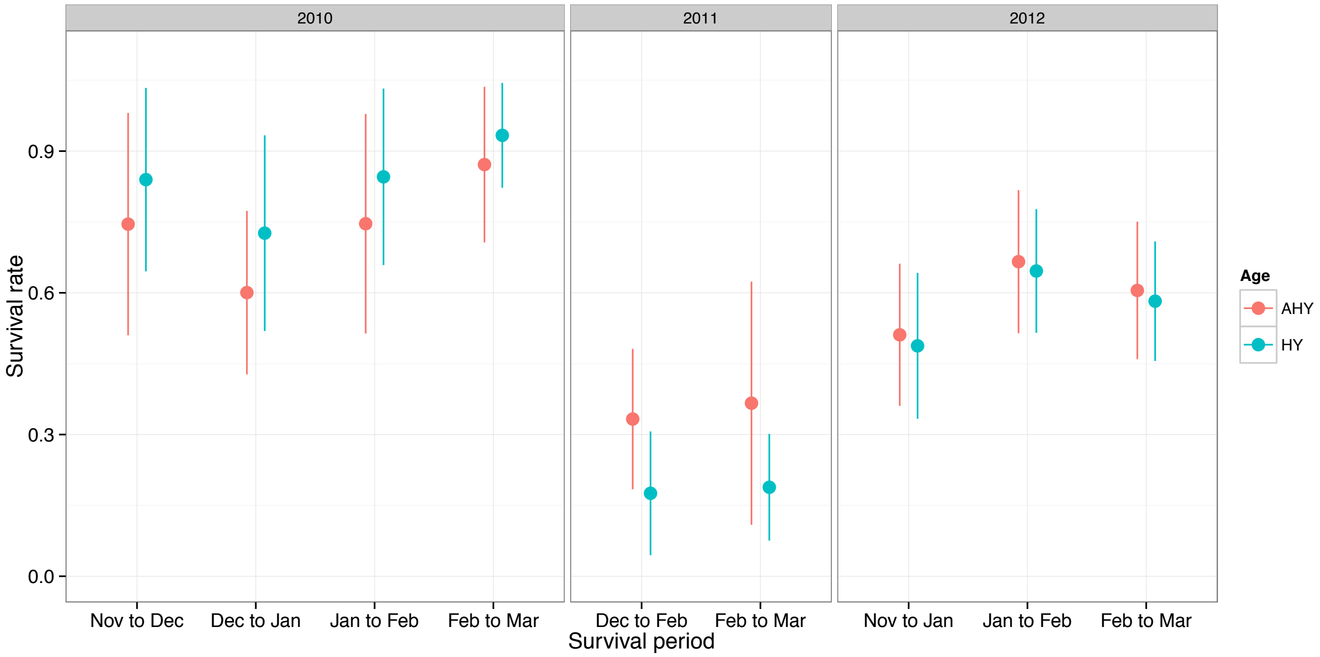


Figure 9. Song sparrow survival rate across two to four sampling periods over three years (2010 to 2012) with standard error bars. Hatch-year (HY) birds are shown in blue and birds that were older than hatch-year (AHY) are in pink.

For annual survival outside of the winter period, the top model had 74% of the weight (Table 6), so we did not model average. The top model was a time varying survival model, and survival was extremely low; 0.12 (+/- 0.04 SE) in 2010, 0.28 (+/- 0.06 SE) in 2011, and 0.03 (+/- 0.02 SE) in 2012 (Figure 10). This may be a result of a low sample size, as there were relatively few recaptures of mark individuals between years (n= 3).

Table 6. AIC results for annual song sparrows (SOSP) survival estimates outside the winter period (2010 to 2013).

model	npar	AICc	DeltaAICc	weight
Φ(t)Υ''(.)Υ'(.)p(t)c(.)	10	-118.87	0.00	0.74
Φ(t)Υ''(.)Υ'(.)p(t)c(t)	13	-116.56	2.31	0.23
Φ(t)Υ''(.)Υ'(.)p(.)c(.)	9	-111.18	7.69	0.02

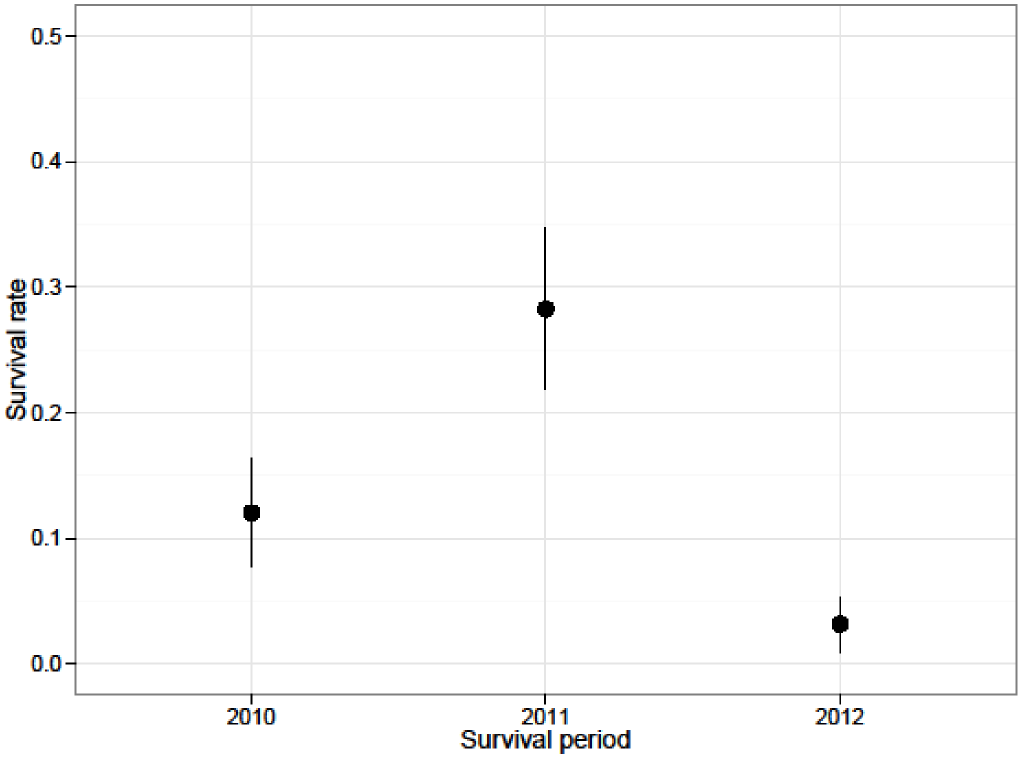


Figure 10. Song sparrow annual survival outside of the winter period (2010 to 2012) across three years of sampling with standard error bars.

3.1.3. Ruby-crowned Kinglet

We were unable to estimate survival in 2011 and 2012 for ruby-crowned kinglet because not enough individuals were captured, and models would not converge. In 2010, we estimated overwintering survival by estimating monthly survival from December to March; however there were not enough captures to estimate survival separately for HY and AHY. The top model (ΔAIC < 2) held 50% of the weight, and thus we did not model average. Survival and probability of capture did not vary by time and the survival estimate was 0.75 (SE +/ 0.09). Thus, total overwintering survival for ruby-crowned kinglet in 2010 was 0.32 (0.75^4=0.32).

For annual survival outside the overwintering period, there was also a clear top model that held 55% of the weight and survival did not vary across years. Annual survival was 0.26 (SE +/- 0.07).

Table 7. AIC table for monthly survival estimates of ruby-crowned kinglets in 2010.

model	npar	AICc	DeltaAICc	weight
Φ(.)Y''(.)Y'(.)p(.)c(.)	8	149.88	0.00	0.50
Φ(temp)Y''(.)Y'(.)p(.)c(.)	9	152.58	2.70	0.13
Φ(precip)Y''(.)Y'(.)p(.)c(.)	9	152.78	2.90	0.12
Φ(.)Y''(.)Y'(.)p(t)c(.)	10	152.78	2.91	0.12
Φ(.)Y''(.)Y'(.)p(.)c(t)	10	154.88	5.00	0.04
Φ(temp)Y''(.)Y'(.)p(t)c(.)	11	155.62	5.75	0.03
Φ(precip)Y''(.)Y'(.)p(t)c(.)	11	155.97	6.09	0.02
Φ(temp)Y''(.)Y'(.)p(.)c(t)	11	157.87	8.00	0.01
Φ(precip)Y''(.)Y'(.)p(.)c(t)	11	158.07	8.19	0.01
Φ(t)Y''(.)Y'(.)p(.)c(.)	11	158.28	8.40	0.01
Φ(.)Y''(.)Y'(.)p(t)c(t)	12	158.38	8.51	0.01
Φ(temp)Y''(.)Y'(.)p(t)c(t)	13	161.56	11.68	0.00
Φ(t)Y''(.)Y'(.)p(t)c(.)	13	161.58	11.70	0.00
Φ(precip)Y''(.)Y'(.)p(t)c(t)	13	161.90	12.03	0.00
Φ(t)Y''(.)Y'(.)p(.)c(t)	13	164.21	14.33	0.00
Φ(t)Y''(.)Y'(.)p(t)c(t)	15	168.26	18.38	0.00

Table 8. AIC table for annual survival for ruby-crowned kinglets outside of the winter months

model	npar	AICc	DeltaAICc	weight
Φ(.)Yt(.)Y'(.)p(t)c(.)	8	176.92	0.00	0.55
Φ(.)Yt(.)Y'(.)p(t)c(t)	11	179.89	2.97	0.12
Φ(.)Y''(.)Y'(.)p(.)c(.)	7	179.91	2.99	0.12
Φ(.)Y''(.)Y'(.)p(t)c(.)	10	180.02	3.10	0.12
Φ(.)Y''(.)Y'(.)p(.)c(t)	10	182.72	5.81	0.03
Φ(t)Y''(.)Y'(.)p(.)c(.)	9	183.05	6.13	0.03
Φ(t)Y''(.)Y'(.)p(t)c(t)	13	183.32	6.40	0.02
Φ(t)Y''(.)Y'(.)p(.)c(t)	12	186.18	9.27	0.01

3.1.4.Spotted Towhee (SPTO)

We estimated survival for four time periods in 2010, two time periods in 2011, and two time periods in 2012 for spotted towhee (Figure 11). In 2011, there were not enough recaptures of HY individuals to estimate survival separately for HY and AHY. We estimated survival for monthly time periods in 2010, from December to February (two months) and February to March (one month) for 2011, and November to January (two months) and January to February (one month) in 2012.

Overall, survival was lower for HY, and survival decreased through the years. In 2010, survival was above 50% every month and in 2012 it was less than 50% for both HY and AHY in both time periods (Figure 11).

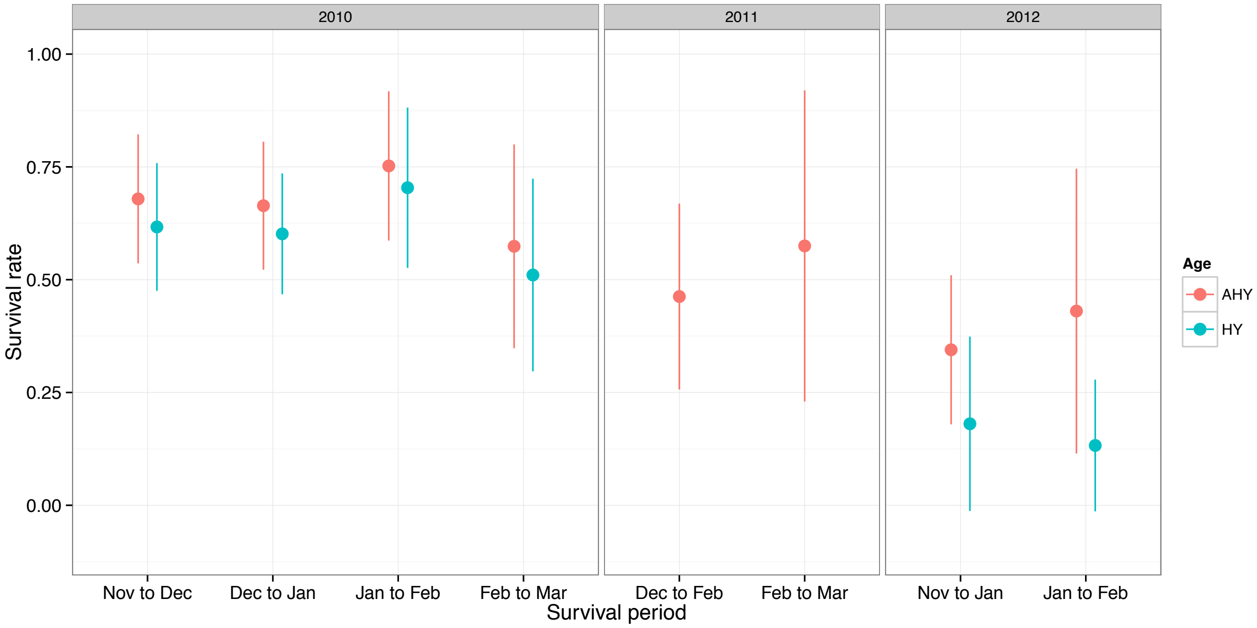


Figure 11. Spotted towhee survival rates with standard error bars across two to four sampling periods and during three years (2010, 2011, and 2012). Hatch-year (AHY) birds are shown in pink and birds that were older than hatch-year (HY) are in blue.

We model averaged because there was no top ranked model (ΔAIC <2). In 2010, 12 of the 16 models contained HY (75%), 5 contained temperature (31%), and 7 contained precipitation (44%). There was no top model for annual survival from April to October so we model averaged. Survival was less than 50% for all three years, lowest in 2010, and highest in 2011 (Figure 12).

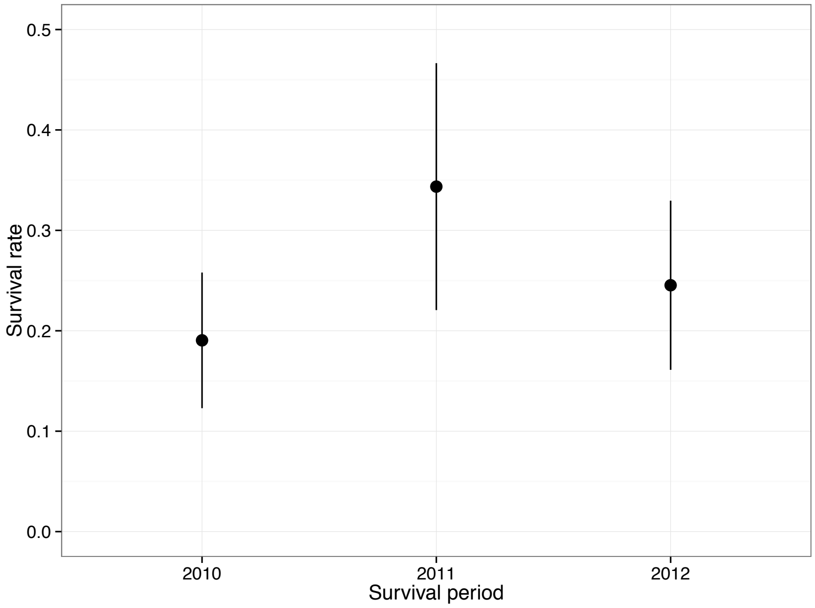


Figure 12. Annual survival for spotted towhee outside the overwintering period.

3.1.5. Black-capped Chickadee

For black-capped chickadee, we estimated survival using model averaged estimates from the models that held 95% of the weight for four time periods in 2010, three time periods in 2011 (Dec to Jan, Jan to Feb, Feb to Mar), and two time periods in 2012 (Nov to Jan, Jan to Feb). HY survival was higher than AHY survival in 2010, and survival was fairly constant over the winter months in 2010, dropped over time in 2011, and increased through time in 2012 (Figure 13). In in all years, survival for both HY and AHY was above 0.50, except for the February to March period in 2011, in which HY survival was approximately 25%, and AHY survival was approximately 40%. We estimated total overwintering survival by multiplying survival periods for each year (Table 9).

In 2010, HY appeared in 35 of the 57 top models (62%), and both temperature and precipitation appeared in 16 of the models (28%). There was no clear top model for annual survival of black-capped chickadee, so we model averaged using the models that contained 95% of the weight. Survival was lowest in the 2010 and 2011 (17% +/- 8% SE), and highest in 2012 (~ 31 % +/- 13% SE (Figure 14).

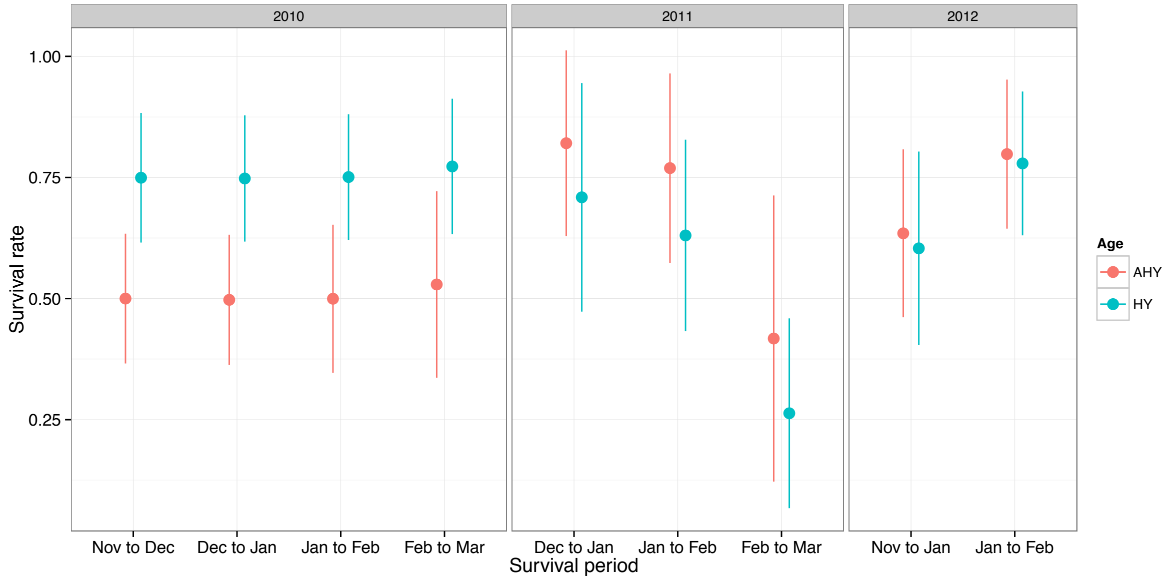


Figure 13. Black-capped chickadee survival rates with standard error bars for three year (2010, 2012, and 2012). Sampling periods vary by year. Hatch-year (HY) birds are shown in blue and birds that were older than hatch-year (AHY) are in pink.

Table 9. Black-capped chickadee total overwintering survival

Age	Year	Estimate
AHY	2010	0.07
AHY	2011	0.26
AHY	2012	0.51
HY	2010	0.33
HY	2011	0.12
HY	2012	0.47

3.1. Fat Content Analysis

3.1.1. Spring Migration

For warblers in spring, there was a significant, positive relationship between the number of days between first and last capture events and change in fat content (Figure 15, Table 10). Individuals that stayed longer at IIBO during the spring migration gained more fat than those who stayed for a shorter period of time. For each third of a day that a bird spent at IIBO, it would move up a category in fat content (Estimate=0.291, Table 10). However, the R-Squared value is very low (0.076) indicating that several other unmeasured variables affect fat content.

There were no significant effects on the fat content of sparrows in the spring season.

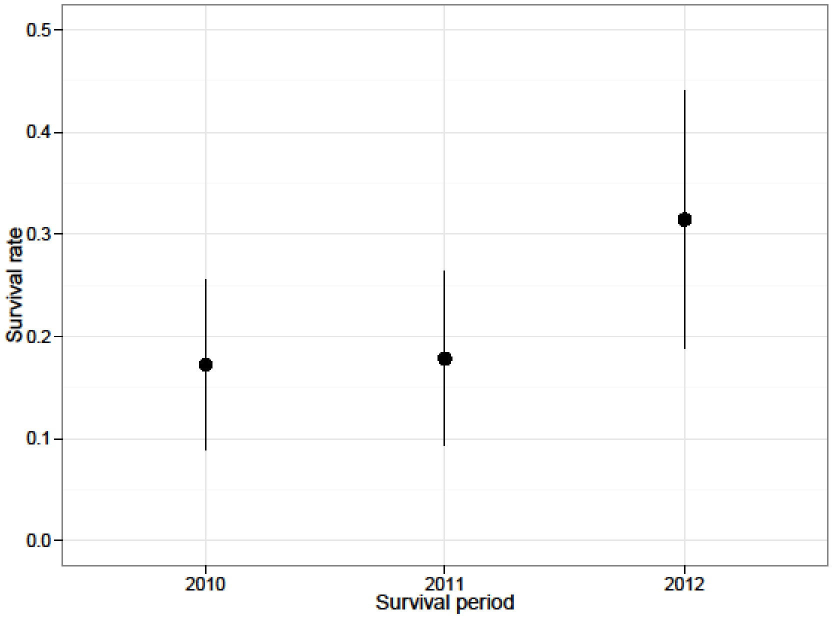


Figure 14. Annual survival estimate of black-capped chickadees across three sampling years (2010, 2011, and 2012) with standard error bars.

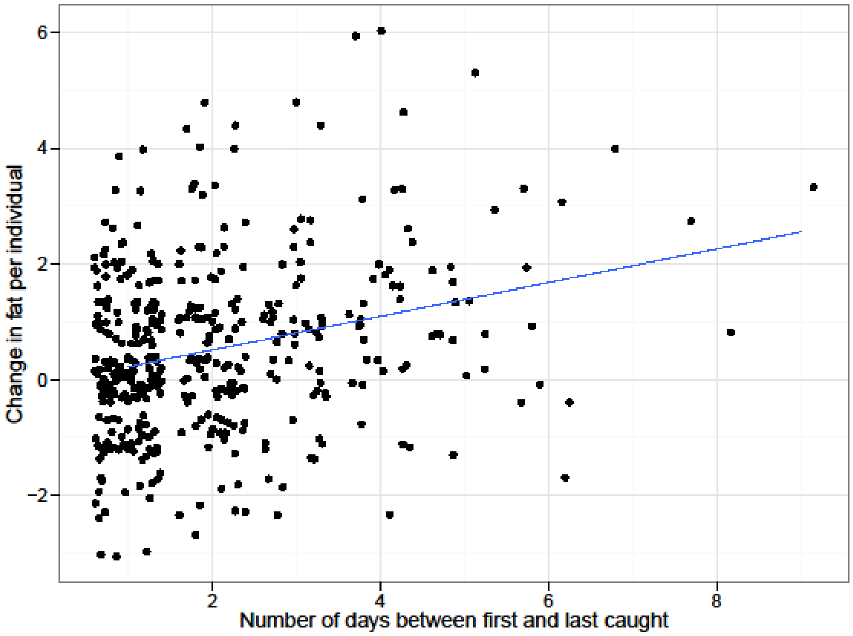


Figure 15. The change in fat content of individual warblers (all species and years combined) in response to the number of days between first and last capture during the Spring Migration Monitoring Program.

3.1.2. Fall Migration

In the FMMP, there was a significant positive relationship between fat change in warblers and number of days between the first and final capture event (Figure 16, Table 10). In the fall this effect was smaller than in the spring, as a bird would have to stay for half a day in order to move up one category of fat content (Estimate=0.374, Table 10). Neither temperature nor precipitation had a significant effect on the change in fat content, and change in fat content did not differ between years. Once again, the R-Squared value of the model is fairly low (0.250), which means that this model only explains 25% of the variation seen in warbler fat content in the fall season.

Interestingly, there was no significant change in fat content across any of the model terms, for sparrows during the fall or winter seasons.

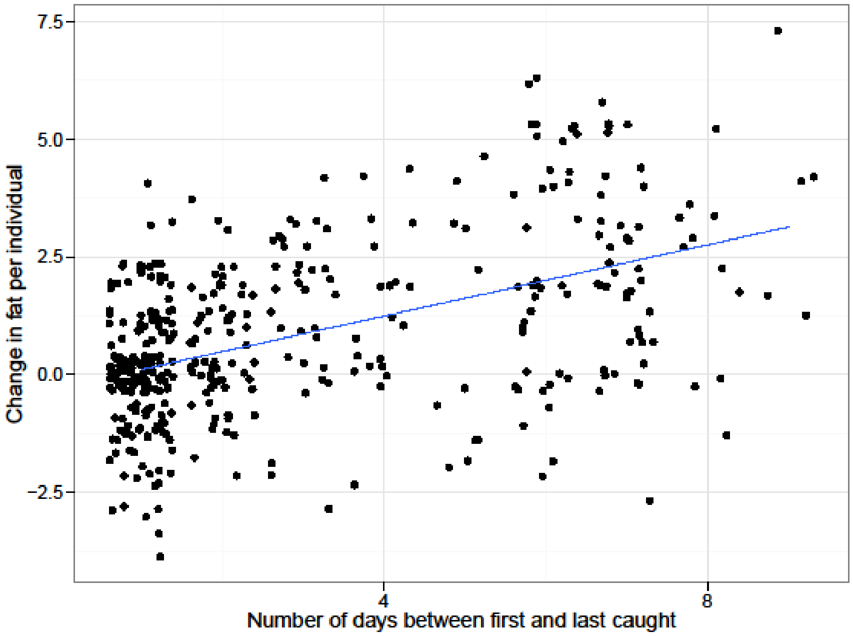


Figure 16. The change in fat content of individual warblers (all species combined) in response to the number of days between first and last capture during the Fall Migration Monitoring Program. Data from all years have been combined.

Table 10. Model output for the minimal model for change in fat content analysis. The difference in days between first and last caught was the only significant predictor variable for change in fat content of warblers in spring and in fall.

Season	Species Guild	R Squared	Predictor Variable(s)	Estimate	Std. Error	t value	Pr(>|t|) P value	
Spring	Warblers	0.075	Difference in days between first and last caught	0.291	0.117	-0.678	<0.0001	***
Fall	Warblers	0.250	Difference in days between first and last caught	0.374	0.031	11.97	<0.0001	***

**** indicates significant effect P<0.0001*

3.2. Arrival Dates

3.2.1. Warblers

Spring Migration Monitoring Program

Different species of warbler arrived at different times during the spring season, with black-throated grey warblers (BTYW) and yellow-rumped warblers (YRWA; includes Audubon's warbler, myrtle warbler and unknown yellow-rumped warbler subspecies) being the first to arrive in April, and yellow warblers (YEWA; Plate 7) generally being the last to arrive in late May (Figure 17). Although arrival dates varied from year to year, there were no clear directional patterns seen in any species across all years.

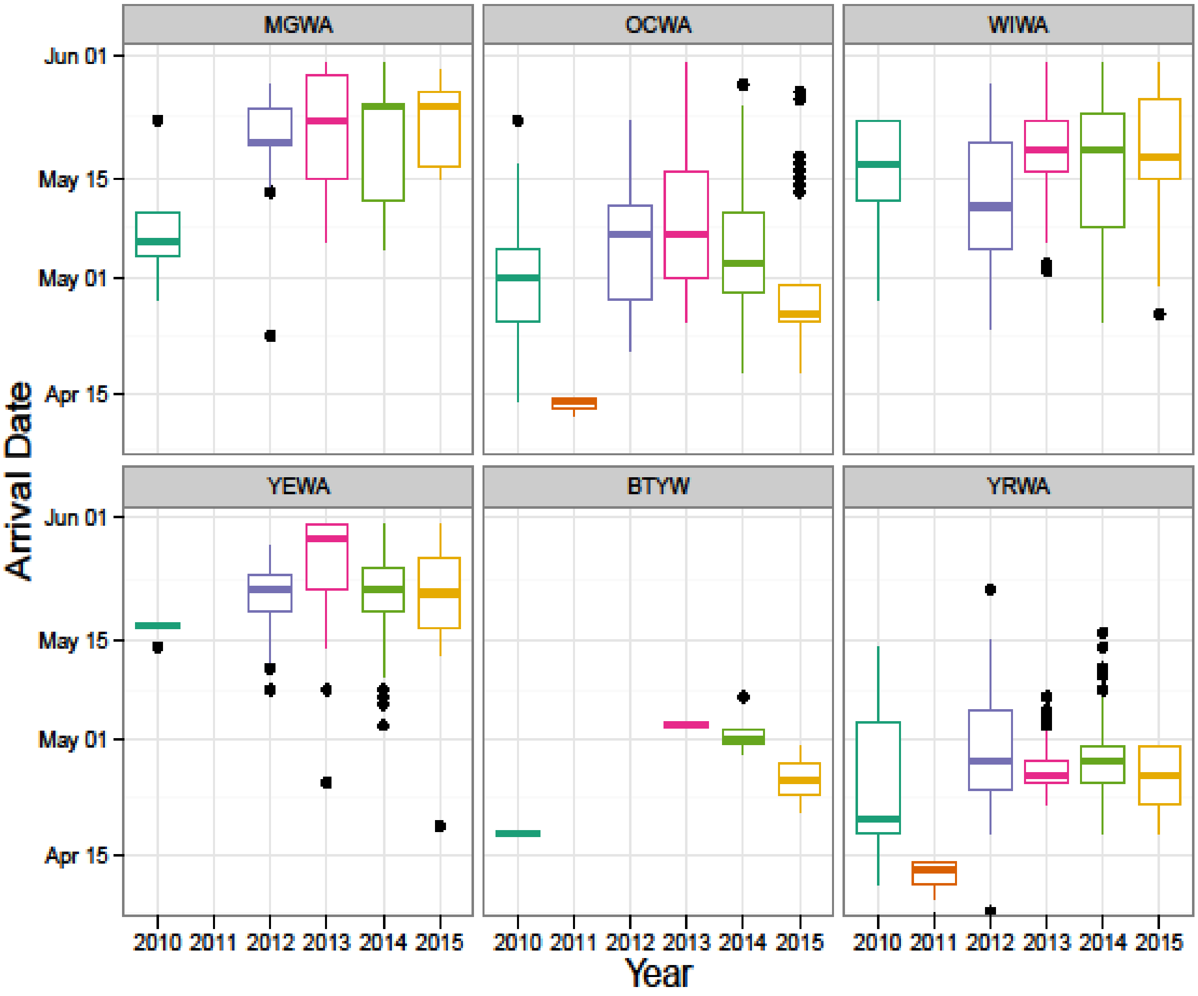


Figure 17. The arrival dates of different warbler species in the spring across six sampling years (2010-2015). The thick line of the boxplot indicates the median of the population. Colours depict different years. Species depicted by the four letter codes are as follows: MGWA – MacGillivray's warbler; OCWA – orange-crowned warbler; WIWA – Wilson's warbler; YEWA – yellow warbler; BTYW – black-throated gray warbler; YRWA – yellow-rumped warbler (including subspecies).

Plate 7. Yellow Warbler captured at IIBO.

Arrival dates for the four most abundant warbler species varied significantly by sex, with males arriving sooner than females (Figure 18, Table 11). In all species analyzed, males arrived approximately five days before females. Arrival dates also differed significantly across species, as would be expected with the staggered arrival dates seen in Figure 17 (Table 11).

Age group also had a significant effect on the arrival date of warblers in the spring monitoring program. Older birds arrived sooner than younger birds in all the four species analyzed. Birds that were in their second year, and therefore likely completing their first migration, arrived approximately two and a half days after birds that had migrated at least once previously (Figure 19; Table 11).

Table 11. Model results from one-way ANOVA to analyze the effect of sex and species, and age and species, on Warbler spring arrival dates respectively. Adjusted R-squared values indicate the proportion of variation explained all the terms in each model.

	Model term	Estimate	Std. Error	t value	P value Pr(>|t|)	
model~sex+species	(Intercept)	125.505	0.2786	450.47	<2e-16	***
	Sex	-5.039	0.1979	-25.46	<2e-16	***
	SpeciesWIWA	13.8366	0.3089	44.79	<2e-16	***
	SpeciesYEWA	19.6164	0.4484	43.75	<2e-16	***
	SpeciesYRWA	-4.454	0.2969	-15	<2e-16	***
	Adjusted R-squared: 0.6549					
model~age+species	(Intercept)	121.4204	0.3114	389.97	<2e-16	***
	Age group	2.6205	0.2137	12.26	<2e-16	***
	SpeciesWIWA	13.2499	0.3365	39.38	<2e-16	***
	SpeciesYEWA	19.2327	0.4835	39.78	<2e-16	***
	SpeciesYRWA	-5.234	0.3215	-16.28	<2e-16	***
	Adjusted R-squared: 0.6242					

**** indicates a significant effect (P<0.0001)*

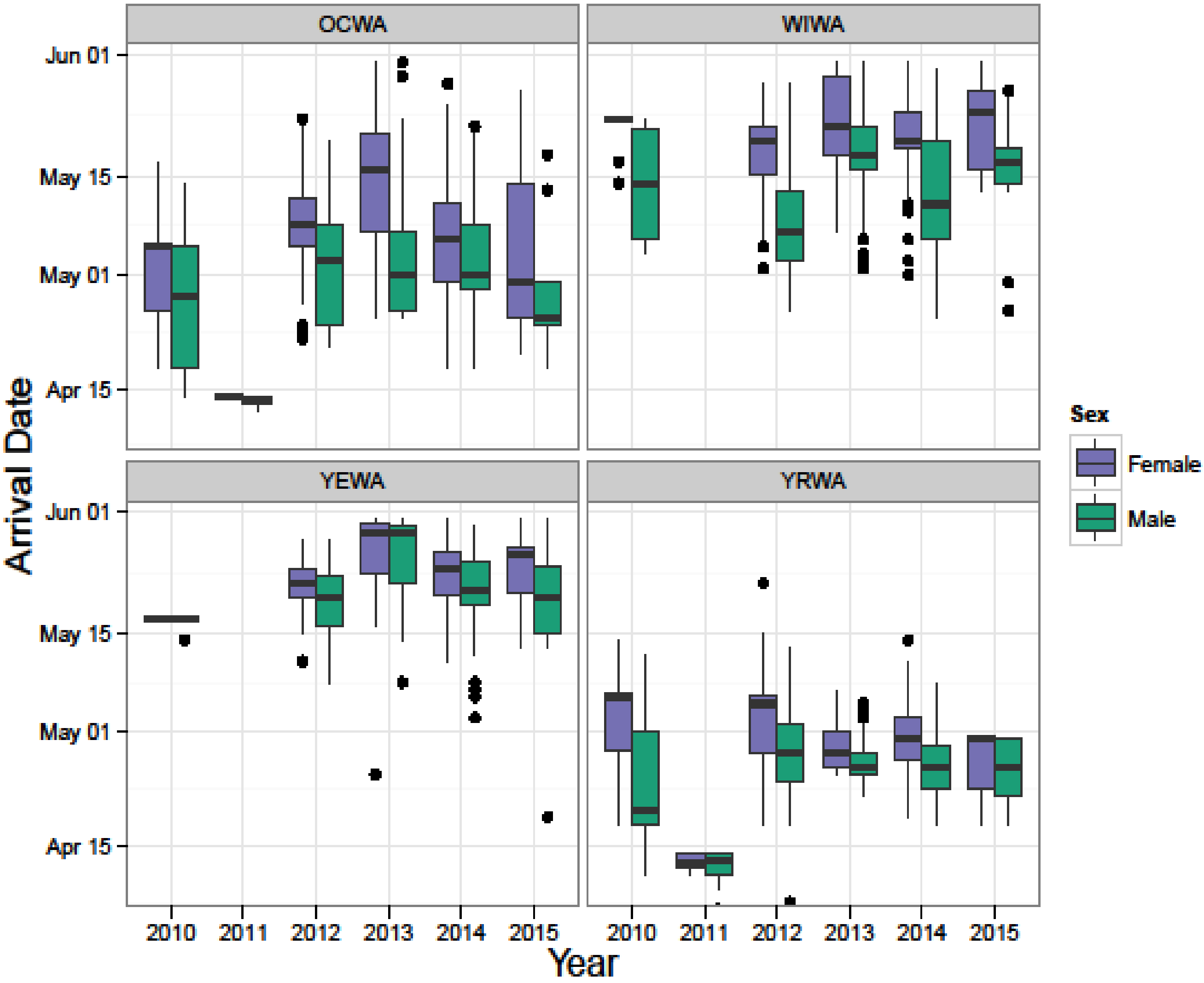


Figure 18. Spring arrival dates for the four most abundant warbler species by sex across the six years of sampling (2010-2015). Female birds are shown in purple and male birds are shown in green. The thick line in the middle of the box indicates the median arrival date. Species depicted by the four letter codes are as follows: OCWA – orange-crowned warbler; WIWA – Wilson's warbler; YEWA – yellow warbler; YRWA – yellow-rumped warbler (including subspecies).

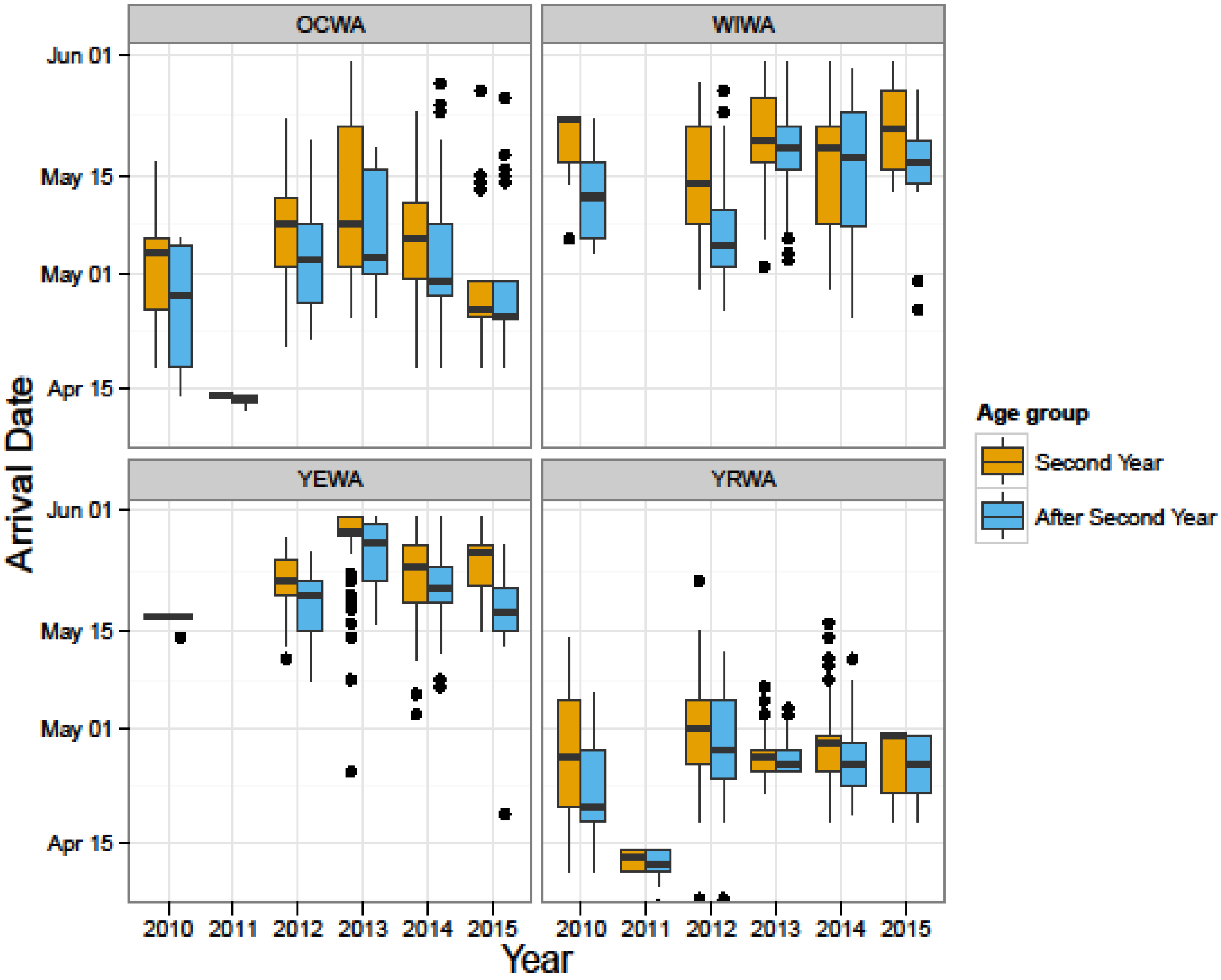


Figure 19. The spring arrival dates of the four most abundant warbler species, by age group across six years (2010-2015). Note: only birds confirmed to be second-year or after second-year were included in these data. Second-year birds are shown in orange with after second-year birds in blue. Species depicted by the four letter codes are as follows: OCWA – orange-crowned warbler; WIWA – Wilson's warbler; YEWA – yellow warbler; YRWA – yellow-rumped warbler (including subspecies).

Fall Migration Monitoring Program

Again, arrival dates in the fall varied by warbler species. MacGillivray's warblers (MGWA) were the earliest to arrive in late August, whereas yellow-rumped warblers tended to arrive only towards the end of September and into October (Figure 20). No clear directional patterns were seen across years in warbler species during the fall migration.

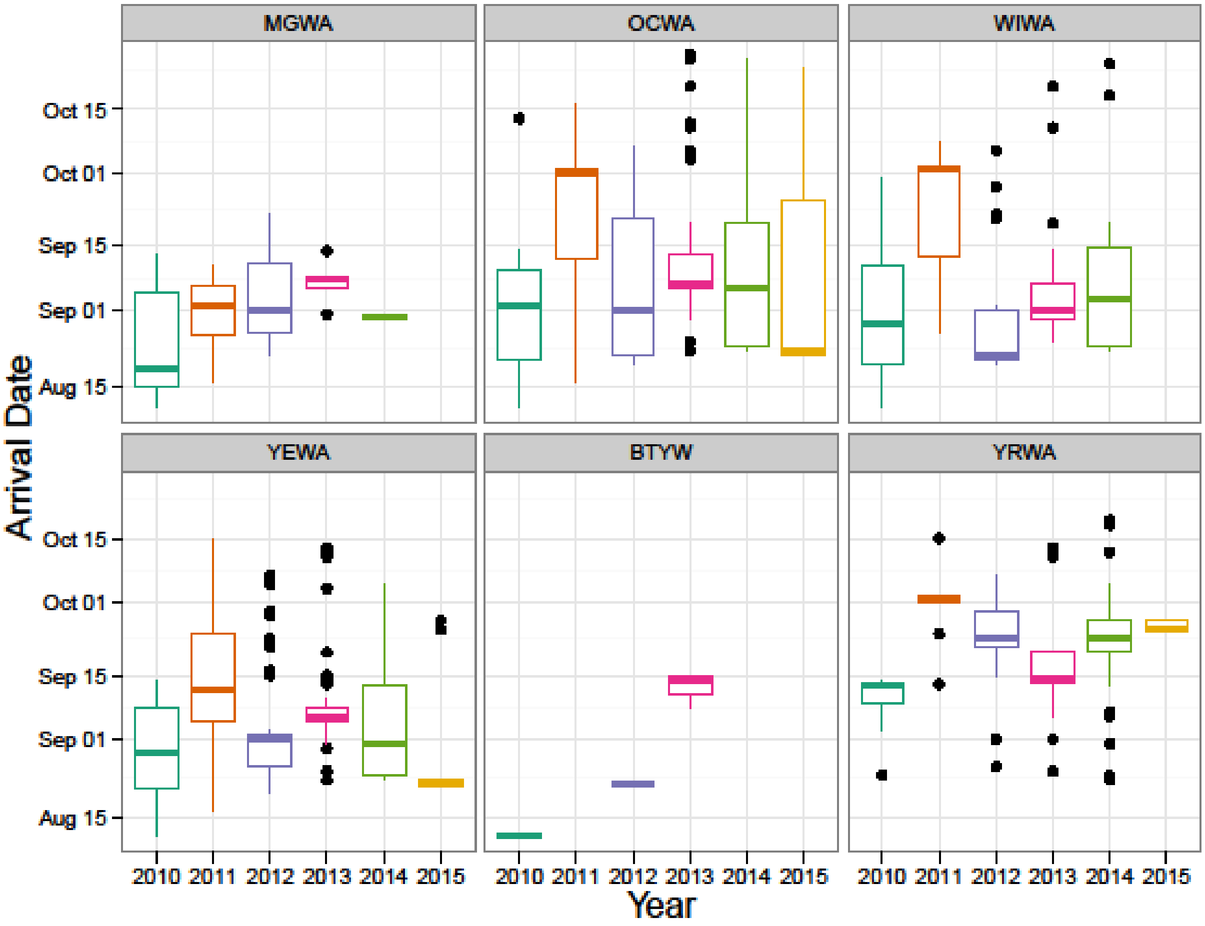


Figure 20. The arrival dates of different warbler species in the fall across six sampling years (2010-2015). The thick line of the boxplot indicates the median of the population. Colours depict different years. Species depicted by the four letter codes are as follows: MGWA – MacGillivray's warbler; OCWA – orange-crowned warbler; WIWA – Wilson's warbler; YEWA – yellow warbler; BTYW – black-throated gray warbler; YRWA – yellow-rumped warbler (including subspecies).

In the fall migration, the differences in arrival dates between sexes were similar to those seen in the spring. Males tended to arrive two and a half days before the females of their species (Figure 21). Once again, there were significant differences between species, which supports the data with several warbler species in Figure 20 (Table 12).

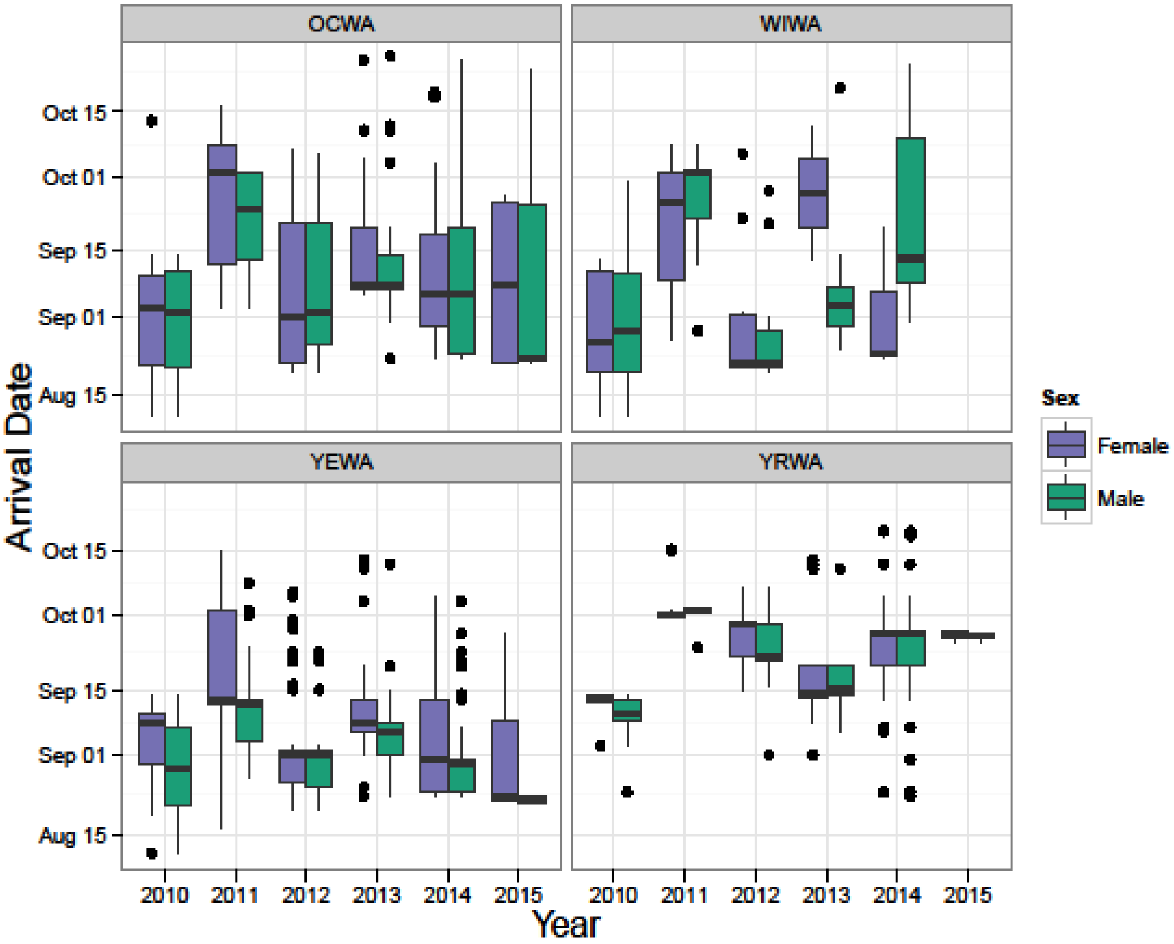


Figure 21. The arrival dates of four warbler species in the fall migration monitoring program across six years of sampling (2010-2015). Female birds are shown in purple and male birds are in green. Species depicted by the four letter codes are as follows: OCWA – orange-crowned warbler; WIWA – Wilson's warbler; YEWA – yellow warbler; YRWA – yellow-rumped warbler (including subspecies).

In the fall migration, hatch-year birds tended to be behind older birds of the same species. Birds aged as after hatch-year birds arrived at IIBO approximately four and a half days before younger birds (Figure 22, Table 12).

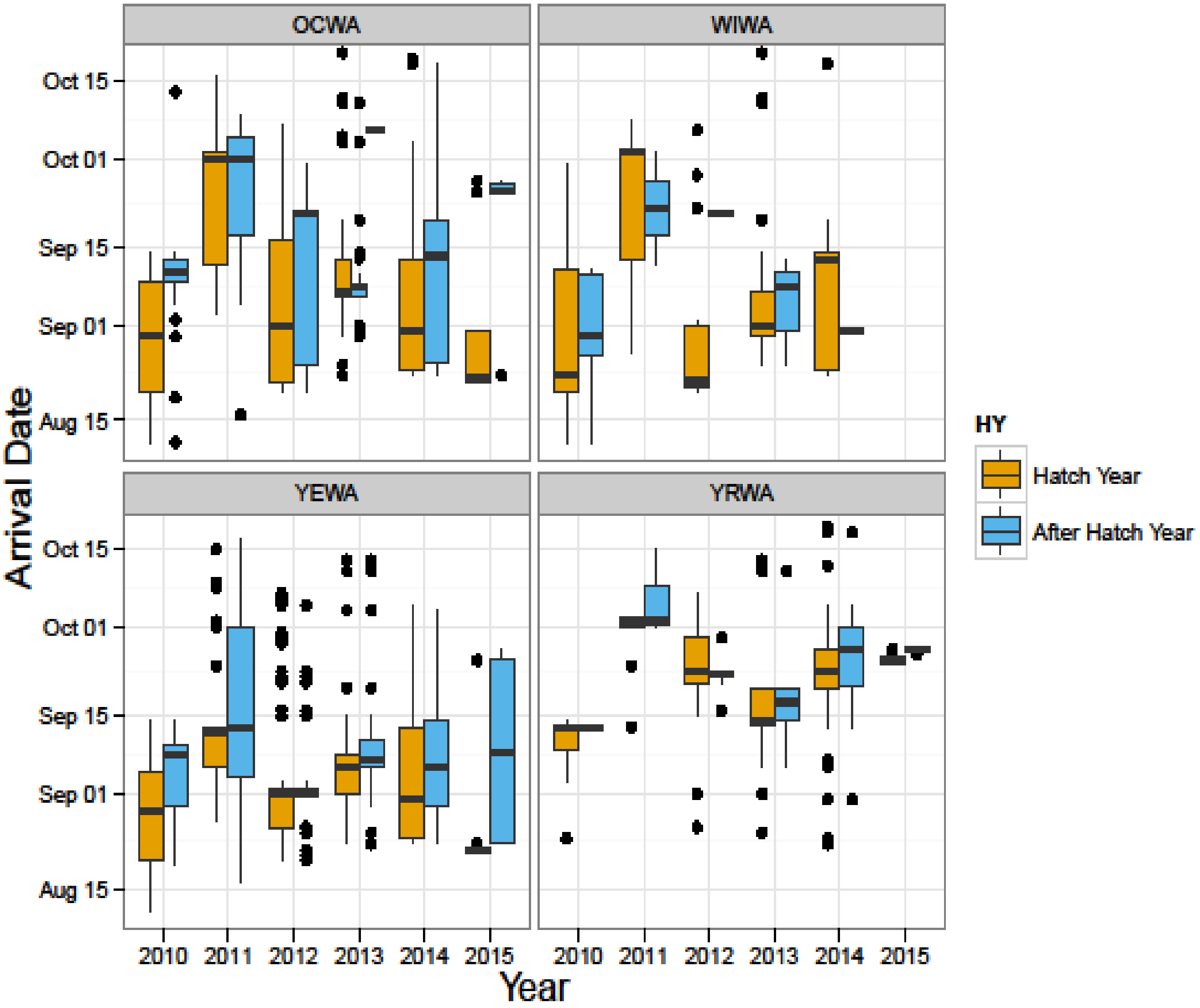


Figure 22. The four most abundant warbler species and their arrival dates in the fall, by age group, across the six years of sampling (2010-2015). Hatch-year birds are shown in orange and after hatch-year birds are in blue. Species depicted by the four letter codes are as follows: OCWA – orange-crowned warbler; WIWA – Wilson's warbler; YEWA – yellow warbler; YRWA – yellow-rumped warbler (including subspecies).

Table 12. Model results for the arrival dates of the four most abundant warbler species over six years of fall migration monitoring (2010-2015). Two models were conducted for analyses; one with sex and species as factors, and the second with age and species as factors. All terms in the model were significant.

	Model term	Estimate	Std. Error	t value	Pr(>|t|)	
model~sex+species	(Intercept)	251.791	0.5319	473.377	< 2e-16	***
	Sex	-2.6373	0.4237	-6.225	5.50E-10	***
	SpeciesWIWA	-5.1529	1.0839	-4.754	2.09E-06	***
	SpeciesYEWA	-4.5758	0.5688	-8.045	1.24E-15	***
	SpeciesYRWA	14.4936	0.6742	21.498	< 2e-16	***
	Adjusted R-squared: 0.3064					
model~age+species	(Intercept)	-1816.16	225.0361	-8.071	9.01E-16	***
	Age group	4.4913	0.4627	9.708	< 2e-16	***
	SpeciesWIWA	-4.1491	0.966	-4.295	1.78E-05	***
	SpeciesYEWA	-5.2436	0.4768	-10.997	< 2e-16	***
	SpeciesYRWA	13.1353	0.5878	22.348	< 2e-16	***
	Year	1.0266	0.1119	9.178	< 2e-16	***
	Adjusted R-squared: 0.3255					

**** indicates a significant effect (P<0.0001)*

3.2.2. Sparrows

Spring Migration Monitoring Program

The arrival dates of different sparrows in the spring did not show any consistent trends over the past six years of monitoring (Figure 21). Although there was considerable variation between years, there was no set direction of change in arrival dates, either between or within species. The earliest year of arrival for most species was 2011. Spotted towhees (SPTO) trend towards later arrival times with each year, but more data are needed to confirm this trend statistically.

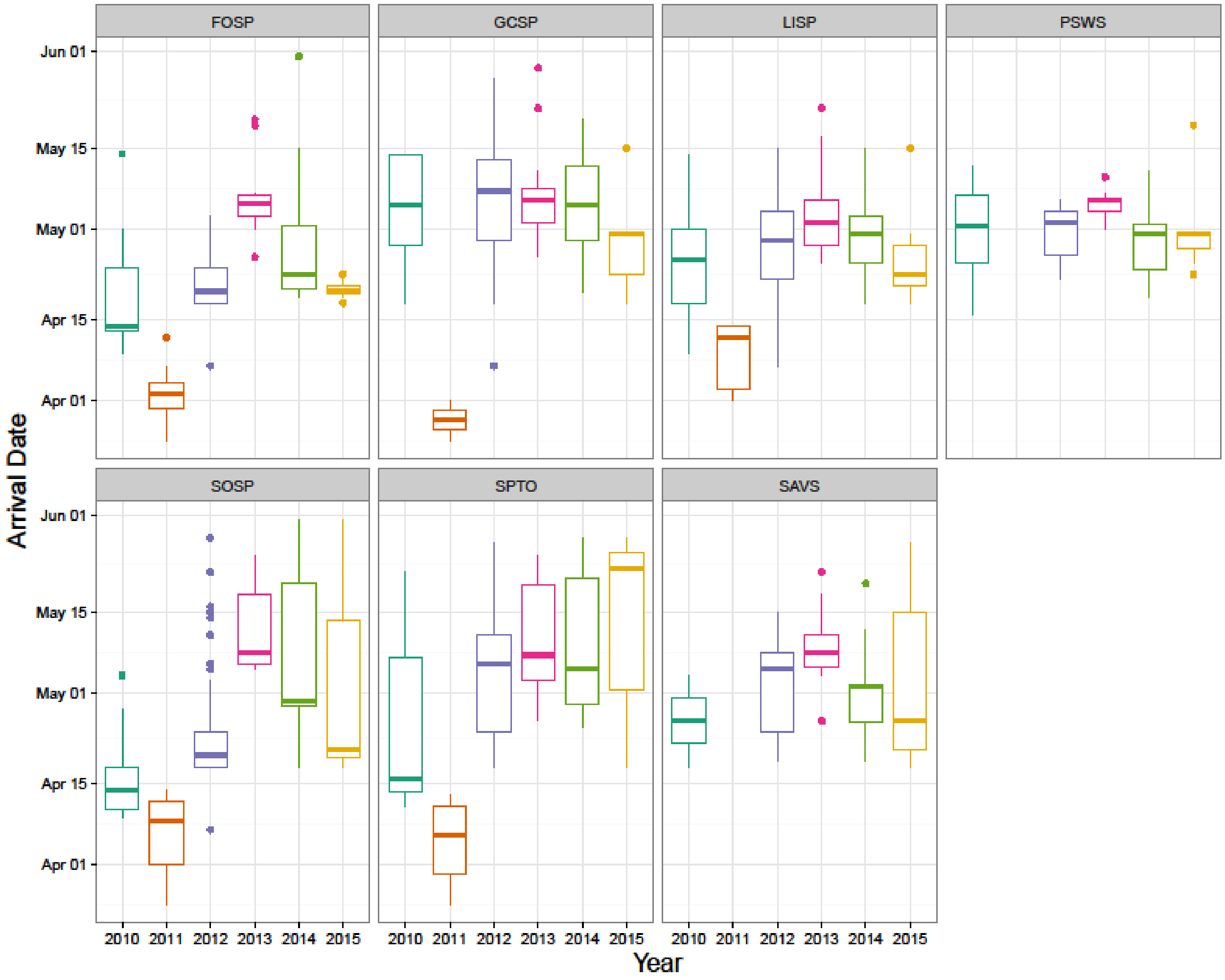


Figure 23. The arrival dates of seven species of sparrow in the spring migration monitoring program over the course of six years of monitoring (2010-2015). Overwintering individuals were removed from the dataset. The species shown are fox sparrows (FOSP), golden-crowned sparrows (GCSP), Lincoln's sparrows (LISP), white-crowned sparrows, Puget Sound subspecies, (PSWS),, song sparrows (SOSP), spotted towhees (SPTO), and savannah sparrows (SAVS).

Age group had a significant effect on arrival date across all seven sparrow species analyzed (Figure 24, Table 13). Older birds arrived just over two days before younger, second-year, birds. However, this effect varied across species with some species, such as song sparrows (SOSP), showing the opposite effect in some years, for example 2014 and 2015.

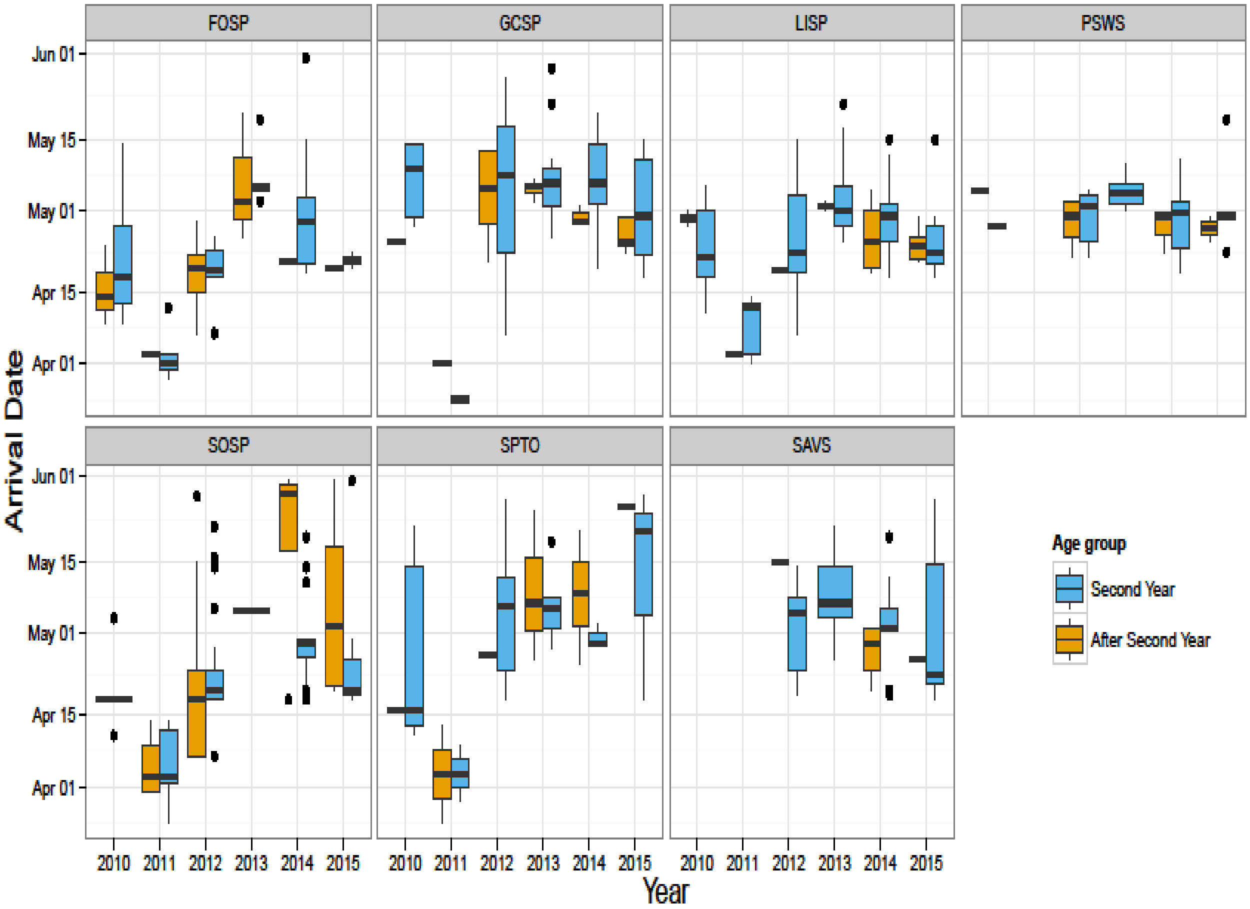


Figure 24. Boxplots showing the arrival dates of seven sparrow species in the spring season. The six years of sampling (2010-2015) are shown and each year has been split into second-year and after second-year, with younger birds in blue and older birds in orange. The species shown are fox sparrows (FOSP), golden-crowned sparrows (GCSP), Lincoln's sparrows (LISP), white-crowned sparrows, Puget Sound subspecies, (PSWS), song sparrows (SOSP), spotted towhees (SPTO), and savannah sparrows (SAVS).

Fall Migration Monitoring Program

The fall arrival date of migrating sparrows varied across years within a species; however no directional trends were evident from the data (Figure 25). There were differences between species, with savannah sparrows (SAVS) and Lincoln's sparrows (LISP) being fairly early arriving species, and fox sparrows (FOSP) tending to arrive last, of these seven species.

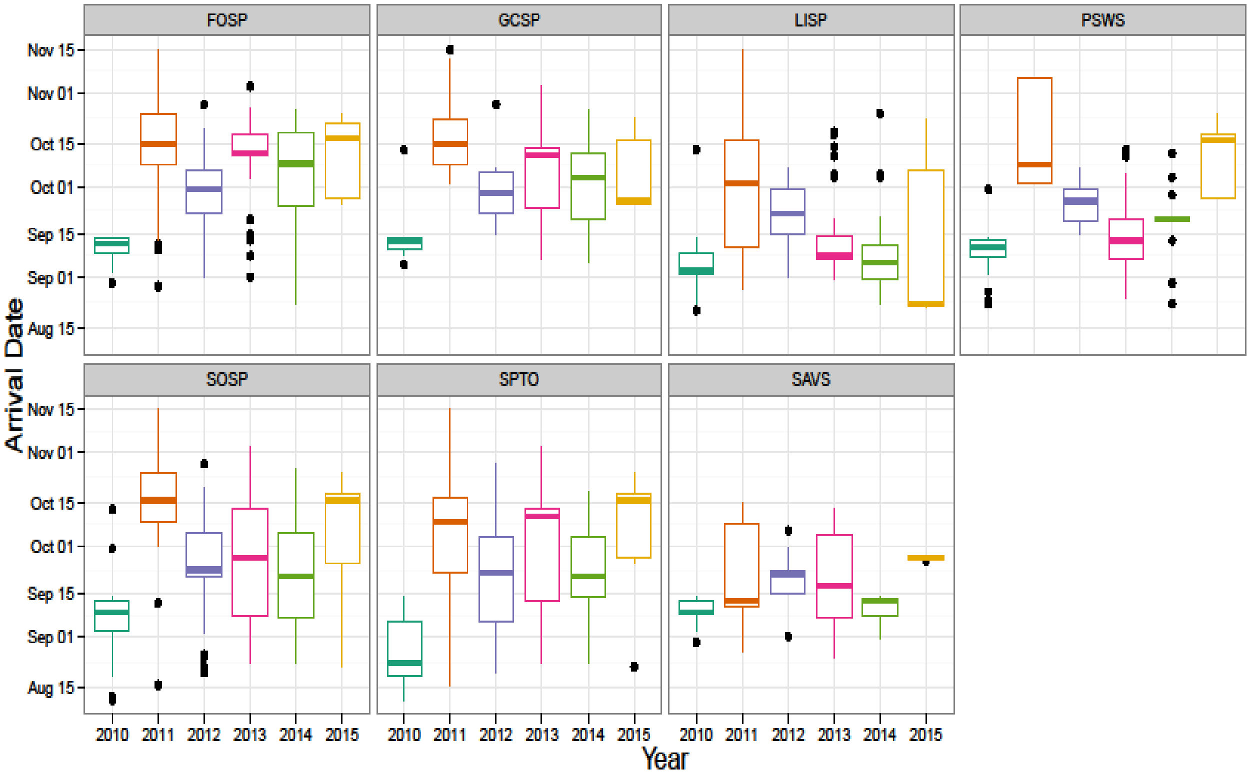


Figure 25. Boxplots showing the arrival dates of seven sparrow species in the fall season, over six years of sampling. Colours depict different years. The species shown are fox sparrows (FOSP), golden-crowned sparrows (GCSP), Lincoln's sparrows (LISP), white-crowned sparrows, Puget Sound subspecies, (PSWS), song sparrows (SOSP), spotted towhees (SPTO), and savannah sparrows (SAVS).

The arrival date of sparrows in the fall differed significantly by age group, with younger, hatch-year, birds arriving approximately three days later than after hatch-year birds (Figure 26, Table 13).

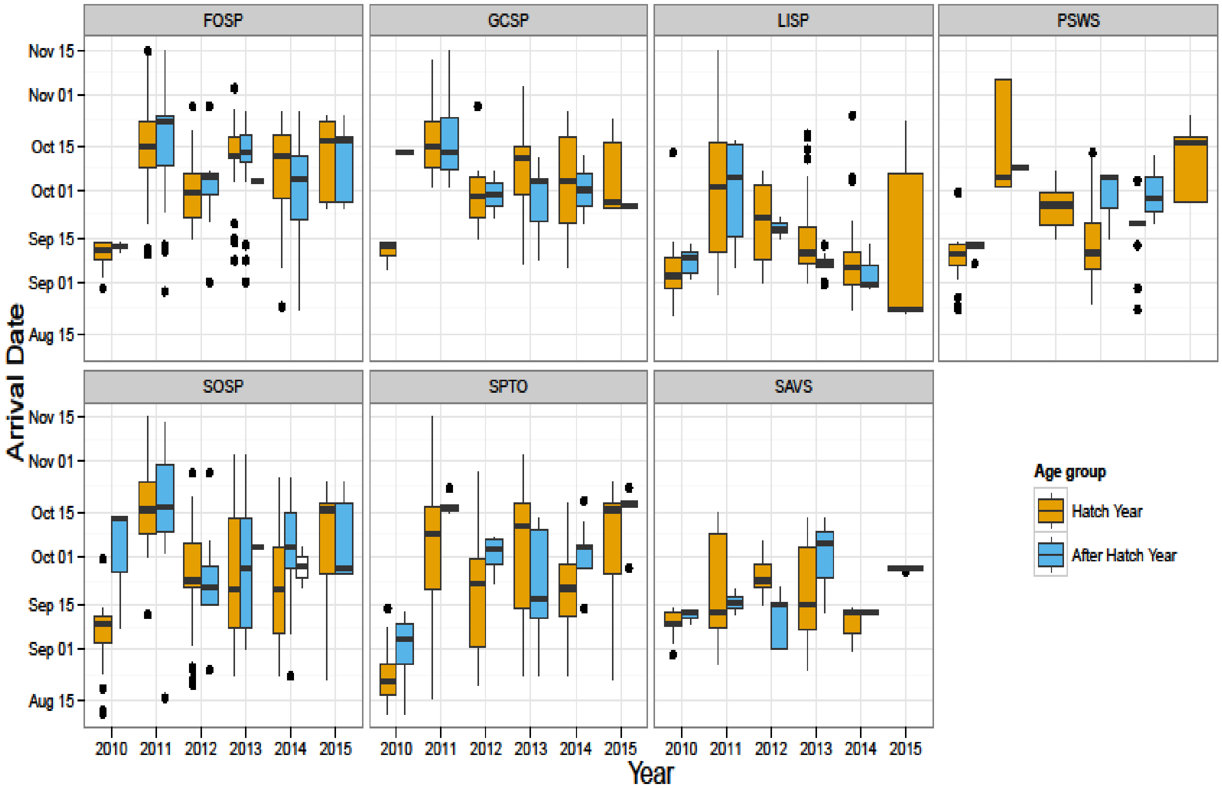


Figure 26. The arrival dates of seven sparrow species in fall, separated by age group. Hatch-year birds are in orange and after hatch-year birds are shown in blue. Birds whose age could not be determined were excluded from the dataset. The species shown are fox sparrows (FOSP), golden-crowned sparrows (GCSP), Lincoln's sparrow (LISP), white-crowned sparrows, Puget Sound subspecies, (PSWS), song sparrows (SOSP), spotted towhees (SPTO), and Savannah sparrows (SAVS).

Table 13. Model output from the linear model on the effect of age group on arrival time of seven sparrow species in the spring and fall season respectively. The adjusted R-squared value refers to the proportion of variation in the response (in this case, arrival date) that can be attributed to the terms in the model.

	Model terms	Estimate	Std. Error	t value	P value Pr(>|t|)	
model~age+species (Spring)	FOSP (intercept)	-4471.4437	632.6086	-7.068	4.28E-12	***
	Age group	2.8278	1.0531	2.685	0.00744	**
	SpeciesGCSP	10.8779	1.724	6.31	5.35E-10	***
	SpeciesLISP	3.1562	1.5743	2.005	0.045418	**
	SpeciesPSWS	6.7196	1.9593	3.43	0.000645	***
	SpeciesSOSP	-2.9287	1.6307	-1.796	0.072985	.
	SpeciesSPTO	9.471	2.219	4.268	2.28E-05	***
	SpeciesSAVS	8.4493	2.0443	4.133	4.08E-05	***
	Year	2.2762	0.3144	7.241	1.34E-12	***
	Adjusted R-squared: 0.2553					
model~age+species (Fall)	(Intercept)	282.3862	0.7462	378.456	< 2e-16	***
	Age group	3.0122	0.9837	3.062	0.00223	**
	SpeciesGCSP	-6.2247	1.5413	-4.039	5.57E-05	***
	SpeciesLISP	-25.6773	1.2958	-19.815	< 2e-16	***
	SpeciesPSWS	-19.0058	1.8454	-10.299	< 2e-16	***
	SpeciesSOSP	-10.4822	1.0037	-10.444	< 2e-16	***
	SpeciesSPTO	-16.0968	1.4139	-11.385	< 2e-16	***
	SpeciesSAVS	-23.8534	2.0679	-11.535	< 2e-16	***
	Adjusted R-squared: 0.2024					

**** indicates a significant effect (P<0.0001)*

***indicates a significant effect (P<0.01)*

4. DISCUSSION

4.1. Mark Recapture

We estimated monthly winter survival for five of the 39 species caught in the WSMP from 2010 through 2012, including: fox sparrow (FOSP), ruby-crowned kinglet (RCKI), song sparrow (SOSP), spotted towhee (SPTO) and black-capped chickadees (BCCH). For all species except for ruby-crowned kinglets (RCKI) and spotted towhees (SPTO) in 2011, there were enough captures to estimate survival separately for hatch-year (HY) and after hatch-year birds (AHY), although the standard error bars overlapped in all cases, suggesting that survival was not significantly different between the two age classes.

For all species assessed, survival was highest and most consistent in 2010, and lower in 2011 and 2012 with more variation from month to month. This may be an artifact of sample size in 2011 and 2012, as there were fewer capture occasions to estimate survival with, and survival was estimated over longer periods of time (two months rather than one) for some survival intervals.

In general, survival was higher for AHY birds, with the exception of two species in 2010, black-capped chickadees (BCCH) and song sparrows (SOSP), in which HY survival was higher. For SOSP, survival for both HY and AHY in 2010 was higher than in subsequent years, suggesting that it was a favorable year for the species. However, for BCCH in 2010, despite high survival for HY birds, survival of AHY birds was considerably lower in 2010 compared to subsequent years, with the exception of survival period from February to March in 2011 (Figure 13).

Overwintering survival for fox sparrows (FOSP) and song sparrows (SOSP) fell within the range of other published studies. For example, Whitaker et al (2008) found that overwintering survival for FOSP in the boreal forest of Newfoundland was 0.24. By multiplying the survival estimate for each overwintering period in our study, we can approximate total overwintering survival for FOSP, which was between 0.21 in 2012 and 0.41 in 2011 for AHY year birds. Annual survival for FOSP at IIBO was 0.52, which is higher than survival rates estimated in previously published studies; 0.229 (Whitaker et al. 2008) and 0.35 (Sandercock & Jaramillo 2002). SOSP annual survival ranged between 0.03 and 0.28, which was lower than 0.34, the lowest annual survival rate estimated by Sandercock & Jaramillo (2002). Arcese et al. (1992) estimated overwintering survival for a population of SOSP over the course of 15 years on Mandarte Island, British Columbia. They found that adult overwintering survival ranged between approximately 0.5 and 1.0, while juvenile survival ranged between 0.2 and 0.8. These are much higher than AHY survival estimates (0.12 and 0.29) and HY estimates (0.03-0.48) from IIBO.

Whitaker et al. (2008) estimated that overwintering survival for ruby-crowned kinglets RCKI was low (between 0.021 and 0.027 for females and males respectively), whereas survival at IIBO was extremely high comparatively (0.32 overall). In this study, annual survival for RCKI was 0.26, whereas Whitaker et al. (2008) estimated annual survival for RCKI to be between 0.02 and 0.026, a magnitude of order lower. There were very few published estimates of survival for spotted towhee (SPTO) that we are aware of, but Smith et al. (2016) estimated annual survival for SPTO at an urban park in Oregon, and found that survival ranged between 0.505 and 0.567. Survival at IIBO was lower, ranging between 0.19 and 0.34, however Smith et al. had high recapture rates, as all birds in their study returned every year, whereas at IIBO, survival may be confounded with emigration. Finally for BCCH, Brittingham and Temple (1988) estimated overwintering survival to be 0.37and survival during the breeding and post-breeding season (which they defined as May through September) to be 0.86. Overwintering survival for BCCH at IIBO was between 0.07 and 0.51 for AHY birds and between 0.12 and 0.47 (Table 9) for HY birds, and survival outside the overwintering period was 0.17 and 0.31 (Figure 14).

Overwintering survival estimates for the five species we presented in this report were rare (but see Smith et al. 2016, Whitaker et al. 2008, Sandercock & Jaramillo 2002, Brittingham and Temple 1988, and Arcese et al. 1992) and even fewer studies have considered whether temperature and precipitation influence survival (but see Brittingham and Temple 1988). Thus, WildResearch's WSMP had the potential to add valuable information to our understanding of overwintering songbirds and to track how survival changes over time. Although estimates are variable, demonstrated by the large standard errors, this variability does not appear to be uncommon for songbirds (Whitaker et al. 2008).

The survival analyses we conducted had several assumptions. The first was that there was no immigration or emigration (Υ'' and $1-\Upsilon'$ respectively in the models) during the study period, which may be unlikely given other studies have shown that immigration and emigration is common for bird populations. However, varying these parameters resulted in models that would not converge, and thus we fixed them equal to zero for this analysis. Additionally, given the current design of the WSMP, capture occasions may have occurred over time periods in which the closure assumption was violated. For example, there are often five or more days between capture occasions, over which death, immigration and emigration had the potential to occur. However, it is not uncommon to assume a closed system over such time periods (Schaub et al. 2002), and thus we feel this was a sound approach, given the data and the fact that the five species assessed are resident species, and are therefore less likely to emigrate over the course of the winter. Additionally, this approach was taken in preliminary mark recapture analyses of these data (WildResearch, unpublished data).

There is the potential for increasing precision of survival estimates and reducing the likelihood that assumptions are violated through modification of the WSMP study design in the future. Survival estimates may be improved by more closely following a Robust Design framework (Kendall et al. 1995), in which several capture occasions occur at the beginning and end of the period of interest but *not* in-between. This would allow a better assumption of closure between secondary capture occasions (see Methods), and may improve the ability to estimate temporary emigration and immigration. However, weather conditions may make this study design difficult to achieve.

4.2. Fat Content

The fat content analysis was conducted separately on two species groups: warblers and sparrows. This maximized the size of the dataset, however grouping several species together may mask species-specific differences in changes in fat content over the course of a given season. Unfortunately, not enough individual birds of any species were recaptured multiple times per season to allow for an analysis of change in fat content at the species level. As fat content is a relative measure however, combining data across species within a species group can occur without needing to control for species-specific differences.

Measuring fat content at IIBO was conducted to ascertain how migrating and overwintering birds may be using the park and as a measurable proxy for bird condition. For migrating birds, a stopover to refuel may be an essential aspect of a successful migration in both spring and fall (Environment Canada, 2012). Being unable to successfully migrate could negatively impact breeding success and territory acquisition, as well as overall survival. For overwintering species, a haven of resources may increase overwinter survival and allow for increased breeding success in the spring, particularly given the fragmented habitat that surrounds many urban centers (Tremblay et al. 2009).

In this analysis, warblers responded positively to stopover duration. In both spring and fall, warblers gained more fat the longer that they stayed at Iona Beach Regional Park. This indicates that the park is providing an important stop-over resource for migrating warblers on their southerly journey in the fall and their corresponding journey north the following spring.

Climate change is expected to have a negative effect on migrating species due to their reliance on detecting seasonal changes and shifts in timing of food availability (North American Bird Conservation Initiative Canada, 2012). This highlights the importance of parks and natural spaces that provide additional resources for migrants. As climate change progresses, combined with anthropogenic landscape changes along migrating corridors, the provision of resources to migrating species may become even more essential.

Migrating species occupy multiple ecological niches throughout the seasons, as they move from one habitat to the next. Conserving a variety of habitat niches may be essential to maintain functionality of many different habitats and ecosystems for different bird species that rely on stop-over habitat during migration. In addition, many migrating birds travel to developing countries where conservation programs are not in place and may therefore be faced with further stresses including environmental degradation and conflicting land use (Sandstrom et al. 2006)

Interestingly, none of the variables measured in the current study had a significant effect on sparrow fat content during the fall, spring or winter months. There are several other factors not measured here, including resource availability and predator presence, and observer bias, which may affect foraging and therefore fat content of overwintering songbirds. The method for measuring fat content is also subject to interpretation and therefore it may vary between observers, which could add further variably to the data.

Based on data collected at IIBO between 2010 and 2015, migrant bird species appear to be gaining valuable fat stores when they pass through Iona Beach Regional Park, which confirms the essential role that IIBO is playing in the conservation of these species.

4.3. Arrival Dates

Arrival dates of migrants were analyzed primarily to assess if there were trends appearing in the data over the six years of the study (2010-2015). With climate change, temporal changes are evident for some wildlife species and other organisms (Parmesan 2006) and therefore it would be important to understand if birds that pass through IIBO are detecting adjusting their migration habits. Furthermore, WildResearch's vision is to contribute to conservation science initiates, and therefore any early detection of downward population trends based on IIBO data is of utmost importance. Data collected at IIBO in 2010-2015 may also serve as baseline information for comparison with in future years, as the effects of climate change or other threats potentially influencing population trajectories increase, thus providing information to be utilized in decision making for conservation of neo-tropical migrant species.

Based on the two species groups examined in this analysis, there was no consistent trends observed across years of study in terms of shifting arrival dates. This should not be interpreted to mean that climate change is not, and will not, affect birds that migrate through IIBO. Many migrating birds have been shown to use day-length as a cue to migrate (Both & Visser, 2001) and therefore they may not be able to detect a seasonal shift due to climate change, since this shift is not affected by day length. The IIBO data for warblers and sparrows did not indicate a discernable trend in arrival date over time. Because IIBO is a stopover between overwintering and breeding grounds, climate patterns from the starting migration location are more likely to influence arrival dates than the conditions at IIBO, thus we did not explore the effects of any climate variables on arrival dates at IIBO given the lack of pattern in the data. However, long term datasets, such as this one, will play an essential role in providing baseline data with which to make comparisons in the future, and other studies have shown that birds may be migrating earlier in the spring (La Sorte et al. 2016).

Despite a lack of trend through time on arrival date, it is interesting to note that age group affected migration in warblers and sparrows. Older birds arrived before younger birds in the spring and fall seasons. This effect has been documented previously in a different warbler species, the American redstart (Smith & Moore 2005) and yellow warbler (Drake et al. 2013). Younger birds may not have the physiological ability to migrate as fast as older birds, and therefore arrive later (Smith & Moore, 2005). Another reason may be social structure within groups whereby older, dominant birds arrive first to secure superior breeding territories (Smith & Moore, 2005). Male warblers arrived before female warblers in both spring and fall migration, a result that is confirmed in the literature (Francis & Cooke, 1986; Quinlan, 2009). These studies suggest that that males arrive whenever resources at their final destination are available in order to defend the territory, whereas females arrive just before nesting.

As more years of data are contributed to this dataset, more in depth questions may be posed including looking at the arrival dates of specific individuals that are caught in multiple consecutive years, or adding other variables such as wing length (to look at physical flying ability of young compared with older birds), to the analysis to find other factors that may affect arrival or departure dates.

4.4. Conclusions

We leveraged data from the 6-year IIBO dataset (2010-2015) to analyze questions related to three main areas of interest to WildResearch; overwintering survival of resident species, changes in fat content for neo-tropical migrant species during stopover duration, and patterns in arrival dates for migrating species. Thousands of valuable volunteer contributions have made this data collection possible, and WildResearch is pleased to share results from the first six years of study in a report.

The mark recapture study examined overwinter survival of five songbird species: fox and song sparrows, spotted towhee, ruby-crowned kinglets and black-capped chickadees. In three of the five species, after hatch-year birds consistently had higher survival than hatch-year birds. As expected, survival varied across years, with 2010 generally being the best year of the three analyzed, in terms of survival. The biggest limitation in this analysis was the structure of the sampling design, and we recommend that WildResearch consider the time periods over which survival estimates are of interest (i.e. monthly overwintering, total overwinter, annual, etc.) and structure sampling occasions in a way that reflects these questions in a robust design framework (Cooch and White 2015; Kendall 1995). Altering sampling protocol will likely increase efficiency by ensuring that each sampling occasion adds valuable data to the dataset.

The fat content analysis focused on two species groups: warblers and sparrows. Warblers gained more fat the longer that they remained at IIBO indicating that this park is likely providing essential resources for these birds during their seasonal migrations. Duration between captures, temperature and precipitation did not significantly affect sparrows over the winter season.
Finally, there were no trends in arrival dates of migrating warblers or sparrows across the six years of data collection. However, sex and age group affect arrival with males arriving sooner than females, and older birds arriving before younger birds. It is possible that increasing the data set beyond a six year period may show additional population trends.

This report demonstrates the varied questions that can be addressed with a rich, long-term dataset. Capturing a diversity of bird species across three seasons provides Iona Island Regional Park with invaluable information, including the species frequently using the park and how they may be benefitting from the foraging opportunities provided at the park during migration. In addition, it has set a great example of how citizen science projects can be utilized to collect extensive data that can make excellent contributions to conservation initiatives (Plate 8).


Plate 8. Volunteer training on bird extraction through IIBO Citizen Science Program.

LITERATURE CITED

Arcese P, Smith JNM, Hochachka WM, Rogers CM, Ludwig D. 1992. Stability, regulation, and the determination of abundance in an insular song sparrow population. Ecology. 73:805-822

Bishop C.A. and T.J. Forrester. 2012. Spatial and Temporal Trends in Habitat Composition at WildResearch's Iona Island Bird Observatory, Iona Beach Regional Park, Richmond, BC.

Both, Christiaan, and Marcel E. Visser. 2001. Adjustment to climate change is constrained by arrival date in a long-distance migrant bird. Nature 411.6835: 296-298.

Boyd, M. 2012. Iona Island Bird Observatory. Prepared for WildResearch, unpublished report.

Brittingham MC, and Temple SA. 1988. Impacts of supplemental feeding on survival rates of the black-capped chickadees. Ecology. 69(3): 581-589.

Cooch E, White G. 2015. "Program MARK: a gentle introduction." http://www.phidot.org/software/mark/docs/book/.

Drake A, Rock C, Quinlan SP, Green DJ. 2013. Carry-over effects of winter habitat vary with age and sex In yellow warblers Setophaga petechial. Journal of Avian Biology. 44: 321–330

Francis, Charles M., and Fred Cooke. 1986. Differential timing of spring migration in wood warblers (Parulinae)." The Auk: 548-556.

Kendall WL, Pollock KH, Brownie C. A likelihood-based approach to capture-recapture estimation of demographic parameters under the robust design." Biometrics 1 (1995) 51(1): 293-308.

North American Bird Conservation Initiative Canada. 2012. The State of Canada's Birds, 2012. Environment Canada, Ottawa, Canada.

Parmesan C. 2006. Ecological and Evolutionary Responses to Recent Climate Change. Annual Review of Ecology, Evolution, and Systematic. 37: 637-669

Pyle P. 1997. Identification Guide to North American Birds, Part I: Columbidae to Ploceidae. Bolinas CA: Slate Creek Press. 732 p.
Pyle, P. 2008. Identification guide to North American birds. Part II. Anatidae to Alcidae. Slate Creek Press. Point Reyes, California, USA.

Sandercock BK, Jaramillo A. 2002. Annual survival rates of wintering sparrows: assessing demographic consequences of migration. The Auk. 119(1): 149-165.

Sandström, U. G., P. Angelstam, and G. Mikusiński. 2006. Ecological diversity of birds in relation to the structure of urban green space. Landscape and Urban Planning, 77(1): 39-53.

Schaub M, Pradel R, Jenni L, Lebreton JD. 2001. Migrating birds stop over longer than usually thought: an improved capture-recapture analysis. Ecology. 82(3): 852-859.

Sharrif, A. 2014. Spatial and Temporal Trends in Habitat Composition at WildResearch's Iona Island Bird Observatory, Iona Beach Regional Park, Richmond, BC.

Smith, Robert J. and Frank R. Moore. 2005. Arrival timing and seasonal reproductive performance in a long-distance migratory landbird". Behav. Ecol. Sociobiol. 57: 231-239.

Smith SB, McKay JE, Richardson JK, Shipley AA, Murphay MT. 2016. Demography of a ground nesting bird in an urban system: are populations self-sustaining? Urban Ecosystems:1-22.

Toochin, R. 2014. Checklist of the Birds of Iona Island, Richmond BC (GVRD). In: Klinkenberg, Brian. (Editor) 2015. E-Fauna BC. Electronic Atlas of the Fauna of British Columbia [www.efauna.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. [March 3, 2016].

Whitaker DM, Taylor PD, Warkentin IG. 2008. Survival of adult songbirds in boreal forest landscapes fragmented by clearcuts and natural openings. Avian conservation and Ecology. 3(1):5.

Quinlan, S.P. 2009. Habitat selection and migratory connectivity of a Neotropical songbird. – M.Sc. Thesis. Simon Fraser University, Burnaby, British Columbia.

5. APPENDICES

Appendix 1

Volunteer Contributors

2010	2011	2012	2013	2014	2015
Angie Hentze	Alexis Harrington	Aaron Gaffney	Agathe LeBeau	Aaron Gaffney	Aaron Ritchie
Anna Drake	Andrea Tha	Agathe LeBeau	Alan McKenzie	Agathe LeBeau	Alan McKenzie
Christine Rock	Andrew G	Alan McKenzie	Alison Porter	Alan McKenzie	Alex Dalton
Christopher Di Corrado	Anna Szeitz	Amos Chow	Alyssa Gerick	Alex Dalton	Ali Sulemanji
David Hodkinson	Candice S	Andrew Huang	Aman Kanwar	Alison Porter	Andrew Huang
Eric Palm	Catherine Jardine	Anna Szeitz	Andrew Huang	Alyssa Zucchet	Angela Bond
Jay Brogan	Christine Rock	Azim Shariff	Anna Szeitz	Andrew Huang	Anna Szeitz
Jeremiah Kennedy	Christopher Di Corrado	Bradley Fessenden	Avery Bartells	Andrew McCreery	Annegret Liederbach
Joeanne Barbeau	Claudia	Catherine Jardine	Azim Shariff	Anna Szeitz	Azim Shariff
Lindsay Davis	Courtney Albert	Christina Perkin	Bradley Fessenden	Annika Flores	Bill Plummer
Lisa Rockwell	David Hope	Christine Lion	Catherine Choi	Azim Shariff	Brandon Law
Micah Scholer	Donna McKenzie	Christine Rock	Catherine Jardine	Betsy Robertson	Britney Niedzielski
Mike Boyd	Ella Steczko	Christopher Di Corrado	Chelsea Enslow	Cadi Schiffer	Brynn Roach
Murray Lashmar	Elly Knight	Courtney Albert	Chris Ensing	Catherine Jardine	Cadi Schiffer
Nathan Hentze	Emily McAuley	Daniel Hudson	Christine Bishop	Cecilia Montauban	Cecilia Montauban
Pablo Jost	Erin Goodman	Danielle Daganais	Christine Rock	Christine Bishop	Celina Willis
Paul Levesque	Gregory Stuart	David Hodkinson	Courtney Lahue	Christine Rock	Chloe Boynton
Paul Preston	Hannah M	Donna McKenzie	Daniel Froehlich	Cindy Ederis	Christine Bishop
Rachel Gardiner	Jodie McCormick	Emily McAuley	Devin de Zwaan	Courtney Lahue	Christine Rock
Rian Dickson	Joe Soluri	Eric Demers	Donna McKenzie	David Carson	Cindy Ederis
Roy Teo	Johanna Anderson	Eric Warren	Elly Knight	David Wu	Colleen Murchison
Russell Cannings	Julian Heavyside	Erica Ross	Emily McAuley	Debbie Upton	Conny Bregman
Sam Quinlan	Kate LaPlante	Erin Goodman	Eric Demers	Devin de Zwaan	Courtney Lahue
Samantha Franks	Katherine Loewen	Grady Froese	Erica Ross	Donna McKenzie	Devin de Zwaan
Samantha James	Kavindra Pillay	Hannah Gehrels	Erin Goodman	Emily McAuley	Donna McKenzie
Sandro Jost	Kelsey B	Ian Thomas	Gwyn Thomas	Eugene Sit	Emily McAuley
Tom Plath	Kristin Aldous	Jay Brogan	Hana Hermanek	Florian Reurink	Eugene Sit
	Kristin Radatzke	Jen Gordon	Ian Thomas	Gerry Shaw	Faye d'Eon-Eggertson
	Kristy M	Jen Sibbald	Janice Kwo	Grady Froese	Florian Reurink
	Laurel Johnston	Jenny Bain	Jared Ellenor	Gwyn Thomas	Francisca Olaya Nieto
	Maddi O	Jeremiah Kennedy	Jason Currier	Hilary Lefort	Gary Clewley

2011

Meghan McKillop
Melanie Wilson
Michael Arbeider
Mike Boyd
Patches Flores
Paul Levesque
Paul Preston
Pieter van Veelen
Roy Teo
Sadia Ramirez
Samantha Franks
Sarah White
Seb Pardo
Simon Valdez
Sylvia Chow
Toby St. Clair
Tom Plath
Torin Heavyside
Tyler Farley
Tyler Farley
Ulla Steczko
Vinci Au
Wendy Easton
Willow English
Zach McElligott

2012

Julian Heavyside
Kala Harris
Kate England
Kristin Aldous
Kyle Tonnesen
Laurel Johnston
Louise Allen
Marinde Out
Mele Avery
Melyssa Desilles-Rubino
Merle Crombie
Michael Arbeider
Mike Boyd
Monique Constant
Pablo Jost
Paul Levesque
Paul Preston
Randy Walker
Rene McKibbin
Roy Teo
Sadia Ramirez
Samantha James
Stephanie Cavaghan
Tammy Sole
Teri Jones
Tom Plath
Torin Heavyside
Vanessa Sadler
Vinci Au
Willow English

2013

Jay Brogan
Jenny Auxier
Jeremiah Kennedy
Jeremy Watkins
Joanne Barbeau
Justin Leung
Katherine Loewen
Katy Gibb
Kavindra Pillay
Kim Dohms
Kim Gilbert
Kimberly House
Klair Phillipoff
Kristin Aldous
Lanaye Baxter
Leena Tirrul
Lindsay Knezevich
Louise Allen
Lydia Dickinson
Marc-Antoni Goulet
Marcia Baker
Margaret Eng
Marlene Wagner
Mehdi Khadraoui
Michael Arbeider
Mike Boyd
Murray Lashmar
Nahum Valdez
Paul Levesque
Pete Lypike
Peter Candido
Renae Mackas
Richard Johnston
Rob Knight
Roy Teo
Sadia Ramirez
Samantha Franks
Sarah Carncross
Sarah Nathan
Savannah Bishop

2014

Ian Thomas
Janice Kwo
Jared Ellenor
Jay Brogan
Jenny Auxier
Jeremiah Kennedy
Jessica Krippel
Jiling Wang
Joanne Barbeau
Jon Ruddy
Julian Heavyside
Justin Leung
Kate Gibson
Katelyn Crisp
Katie MacIntosh
Kavindra Pillay
Kaye Simard
Ken Flores
Kiirsti Owen
Kim Dohms
Kim Gilbert
Len Rasmussen
Leslie Bol
Lionel Lester
Liron Gertsman
Louise Allen
Maja Bjelic
Margaret Eng
Marleau Brown
Max Gotz
Medhi Khadraoui
Melanie Sora
Melissa Orobko
Merle Crombie
Michael Arbeider
Mike Boyd
Murray Lashmar
Nancy Chen
Olga Lansdorp
Pablo Jost

2015

Gwen Jongejan
Hilary Miller
Irene Mencke
Janice Kwo
Jared Ellenor
Jared Vanderveen
Jenna Cook
Jennifer Baici
Jesse Kemp
John Rawsthorne
Justin Leung
Katie MacIntosh
Katrina Fograscher
Kayi Chan
Ken Flores
Kiirsti Owen
Louise Allen
Louise Clewley
Matthew Strimas-Mackey
Maya Meron
Merle Crombie
Micah Scholer
Michael Arbeider
Murray Lashmar
Natasha Barlow
Peter Faught
Rebecca Tranmer
Renae Mackas
Sarah Carncross
Sarah Gutzmann
Sarah Nathan
Seth Bennett
Silu Wang
Tanya Seebacher
Toby St. Clair
Tyler Rogers
Tyler Rogers
Vanessa Isnardy
Vanessa Smith
Vinci Au

2013

Stefan Karanovic
Tara Matthews
Teddy Courtaux
Teri Jones
Toby St. Clair
Tom Plath
Vinci Au
Virginia Noble
Wallis Moore Reid
Willow English
Zachary Monteith

2014

Paul Levesque
Pauline O'Toole
Perry Browne
Peter Candido
Reed Lannan
Robyn Nitychoruk
Roy Teo
Sarah MacDonald
Sarah McArthur
Sarah McLaughlin
Sarah Nathan
Sarina Clay-Smith
Seth Bennett
Seweryn Pazckowski
Silu Wang
Sonya Zahedian
Stephen Sheppard
Teri Jones
Tim Forrester
Toby St. Clair
Torin Heavyside
Travis Scott
Vinci Au
Virginia Noble
Wendy Easton
Yoko
Zoe Long

2015

Virginia Noble

Appendix A

Code Lookup

Table A1. Alpha codes representing how to age banded birds.

Ageing Code	Alpha Translation	Description
P	Plumage	The plumage of a bird indicating a particular age, ie. primary cover shape/wear, molt limits, tail shape.
L	Molt Limit	The presence of a molt limit within a feather tract or between adjacent feather tracts. If used, the molt data section must be filled in.
J	Juvenile Plumage	The presence of juvenile body plumage.
S	Skull	The degree of skull pneumatisation.
E	Eye Colour	The colour of the iris.
I	Bill/Mouth Colour	The internal or external appearance of the bill, including the presence of a gape in extremely young birds.
M	Molt	Active molt, indicated by pin feathers or missing feathers in a symmetrical pattern.
C	Cloacal Protuberance	The presence of a cloacal protuberance in adults.
B	Brood Patch	The presence of a brood patch in adults.
W	Wing Length	The length of the wing.
O	Other	Any other ageing technique used.

Table A2. The species code and species name for the sparrows present at IIBO.

Species Code	Species
FOSP	Fox sparrow
GCSP	Golden-crowned sparrow
GRSP	Grasshopper sparrow
LISP	Lincoln's sparrow
PSWS	Puget Sound white-crowned sparrow
SOSP	Song sparrow
SPTO	Spotted towhee
WCSP	White-crowned sparrow
WTSP	White-throated sparrow
CHSP	Chipping sparrow
GWCS	Gambel's white-crowned sparrow
HOSP	House sparrow
SAVS	Savannah sparrow
SWSP	Swamp sparrow

Table A3. The species code and species name for the warblers present at IIBO.

Species Code	Species
MAWA	Magnolia warbler
MGWA	MacGillivray’s warbler
OCWA	Orange-crowned warbler
WIWA	Wilson’s warbler
YEWA	Yellow warbler
BTYW	Black-throated gray warbler
NAWA	Nashville warbler
TEWA	Tennessee warbler
TOWA	Townsend’s warbler
YRWA/UYRW/MYWA	Yellow-rumped warbler species complex

Appendix B

AIC tables for capture mark-recapture

Table B1. Fox sparrow 2010 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(~ HY)	10	324.82	0.00	0.09
ϕ(.) γ''(.) γ'(.)p(t + HY)c(~ HY)	14	325.05	0.23	0.08
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(~ HY)	15	325.26	0.44	0.07
ϕ(~ HY) γ''(.) γ'(.)p(t)c(~ HY)	14	325.54	0.72	0.06
ϕ(~HY + temp) γ''(.) γ'(.)p(t + HY)c(~ HY)	16	325.67	0.85	0.06
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(~ HY)	15	325.70	0.88	0.06
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(~ HY)	15	325.80	0.99	0.06
ϕ(.) γ''(.) γ'(.)p(t)c(~ HY)	13	326.90	2.08	0.03
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(.)	9	327.04	2.22	0.03
ϕ(.) γ''(.) γ'(.)p(t + HY)c(.)	13	327.13	2.31	0.03
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(.)	14	327.31	2.49	0.03
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(~ HY)	15	327.32	2.51	0.03
ϕ(~ HY) γ''(.) γ'(.)p(t)c(.)	13	327.62	2.80	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(t + HY)c(.)	15	327.68	2.86	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(.)	14	327.75	2.93	0.02
ϕ(.) γ''(.) γ'(.)p(~ HY)c(~ HY)	10	327.84	3.02	0.02
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(.)	14	327.85	3.03	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(~ HY)	15	327.97	3.15	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(~ HY)c(~ HY)	12	328.10	3.29	0.02
ϕ(temp) γ''(.) γ'(.)p(t)c(~ HY)	14	328.17	3.35	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(~ HY)	16	328.24	3.42	0.02

ϕ(t) γ''(.) γ'(.)p(~ HY)c(~ HY)	12	328.50	3.68	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(~ HY)	11	328.74	3.92	0.01
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(~ HY)	11	328.75	3.93	0.01
ϕ(t) γ''(.) γ'(.)p(t + HY)c(~ HY)	17	328.83	4.01	0.01
ϕ(~ HY) γ''(.) γ'(.)p(.)c(~ HY)	10	328.91	4.10	0.01
ϕ(.) γ''(.) γ'(.)p(t)c(.)	12	329.02	4.20	0.01
ϕ(precip) γ''(.) γ'(.)p(t)c(~ HY)	14	329.16	4.34	0.01
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(.)	14	329.37	4.55	0.01
ϕ(t + HY) γ''(.) γ'(.)p(t)c(~ HY)	17	329.41	4.59	0.01
ϕ(t + HY) γ''(.) γ'(.)p(t + HY)c(~ HY)	18	329.51	4.69	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(.)	14	330.02	5.20	0.01
ϕ(.) γ''(.) γ'(.)p(.)c(~ HY)	9	330.05	5.23	0.01
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(~ HY)	11	330.06	5.24	0.01
ϕ(.) γ''(.) γ'(.)p(~ HY)c(.)	9	330.06	5.24	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(.)	15	330.25	5.43	0.01
ϕ(temp) γ''(.) γ'(.)p(t)c(.)	13	330.26	5.44	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(~ HY)c(.)	11	330.26	5.44	0.01
ϕ(t) γ''(.) γ'(.)p(~ HY)c(.)	11	330.65	5.83	0.00
ϕ(temp) γ''(.) γ'(.)p(.)c(~ HY)	10	330.80	5.98	0.00
ϕ(t) γ''(.) γ'(.)p(t + HY)c(.)	16	330.81	5.99	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(.)	10	330.93	6.11	0.00
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(.)	10	330.94	6.12	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(~ HY)c(~ HY)	12	331.09	6.27	0.00
ϕ(~ HY) γ''(.) γ'(.)p(.)c(.)	9	331.13	6.31	0.00

Table B2. Fox sparrow 2011 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(.)	13	-7.32	0.00	0.09
ϕ(~HY + temp) γ''(.) γ'(.)p(~ HY)c(~ HY)	11	-7.26	0.06	0.09
ϕ(t + HY) γ''(.) γ'(.)p(~ HY)c(.)	10	-7.11	0.21	0.08
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(t + HY)	18	-7.07	0.25	0.08
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(.)	14	-6.99	0.33	0.08
ϕ(t) γ''(.) γ'(.)p(~ HY)c(.)	9	-6.88	0.44	0.07
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(t + HY)	17	-6.43	0.89	0.06
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(.)	13	-6.24	1.08	0.05
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(~ HY)	14	-6.03	1.29	0.05
ϕ(~HY + precip) γ''(.) γ'(.)p(~ HY)c(t + HY)	14	-5.68	1.64	0.04
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(t + HY)	13	-5.60	1.72	0.04

ϕ(.) γ''(.) γ'(.)p(~ HY)c(~ HY)	9	-5.42	1.90	0.03
ϕ(~HY + precip) γ''(.) γ'(.)p(~ HY)c(.)	10	-5.18	2.14	0.03
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(.)	9	-4.99	2.33	0.03
ϕ(t) γ''(.) γ'(.)p(t + HY)c(t)	16	-4.45	2.87	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(t + HY)c(t + HY)	18	-4.40	2.92	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(t + HY)c(.)	14	-4.32	3.00	0.02
ϕ(t + HY) γ''(.) γ'(.)p(t + HY)c(t)	17	-4.01	3.31	0.02
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(t + HY)	13	-3.60	3.72	0.01
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(~ HY)	10	-3.31	4.01	0.01
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(.)	9	-3.00	4.32	0.01
ϕ(.) γ''(.) γ'(.)p(t + HY)c(t + HY)	16	-2.84	4.48	0.01
ϕ(.) γ''(.) γ'(.)p(t + HY)c(.)	12	-2.54	4.78	0.01
ϕ(t + HY) γ''(.) γ'(.)p(~ HY)c(t)	13	-2.23	5.09	0.01
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(t)	16	-2.21	5.11	0.01
ϕ(t) γ''(.) γ'(.)p(~ HY)c(t)	12	-2.07	5.25	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(~ HY)c(t + HY)	14	-1.92	5.40	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(t)	17	-1.80	5.52	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(~ HY)c(.)	10	-1.42	5.90	0.00
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(t)	16	-1.13	6.19	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(t + HY)	17	-0.45	6.87	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(~ HY)c(t)	13	-0.30	7.02	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(.)	13	-0.26	7.06	0.00
ϕ(.) γ''(.) γ'(.)p(~ HY)c(t + HY)	12	-0.23	7.09	0.00
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(t)	12	-0.18	7.14	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(~ HY)	13	0.38	7.70	0.00
ϕ(.) γ''(.) γ'(.)p(~ HY)c(.)	8	0.47	7.79	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(t + HY)c(t)	17	0.88	8.20	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(~ HY)	14	1.33	8.65	0.00
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(t)	12	1.81	9.13	0.00
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(t + HY)	13	1.96	9.28	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(~ HY)	14	2.23	9.55	0.00
ϕ(.) γ''(.) γ'(.)p(t + HY)c(t)	15	2.49	9.81	0.00
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(.)	9	2.56	9.88	0.00
ϕ(t + HY) γ''(.) γ'(.)p(t)c(~ HY)	15	3.12	10.44	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(~ HY)c(t)	13	3.47	10.79	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(~ HY)	13	4.47	11.79	0.00
ϕ(t) γ''(.) γ'(.)p(.)c(~ HY)	9	4.76	12.08	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(t)	16	4.85	12.17	0.00

ϕ(.) γ''(.) γ'(.)p(~ HY)c(t)	11	5.21	12.53	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(t + HY)	16	5.88	13.20	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(.)	12	6.18	13.50	0.00
ϕ(t + HY) γ''(.) γ'(.)p(.)c(~ HY)	10	6.48	13.80	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(~ HY)	9	6.54	13.86	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(~ HY)	14	6.68	14.00	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(t + HY)	17	6.91	14.23	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(.)	13	7.10	14.42	0.00
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(t)	12	7.37	14.69	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(t + HY)	17	7.81	15.13	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(.)	13	8.00	15.32	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(~ HY)	10	8.39	15.71	0.00
ϕ(.) γ''(.) γ'(.)p(t)c(~ HY)	12	8.60	15.92	0.00
ϕ(t + HY) γ''(.) γ'(.)p(t)c(t + HY)	18	8.78	16.10	0.00
ϕ(t + HY) γ''(.) γ'(.)p(t)c(.)	14	8.87	16.19	0.00
ϕ(t) γ''(.) γ'(.)p(.)c(t + HY)	12	9.96	17.28	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(t + HY)	16	9.97	17.29	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t)c(~ HY)	13	10.00	17.32	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(.)	12	10.27	17.59	0.00
ϕ(t) γ''(.) γ'(.)p(.)c(.)	8	10.66	17.98	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(t)	15	11.22	18.54	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(t + HY)	12	11.73	19.05	0.00
ϕ(t + HY) γ''(.) γ'(.)p(.)c(t + HY)	13	11.75	19.07	0.00
ϕ(temp) γ''(.) γ'(.)p(.)c(~ HY)	9	11.90	19.22	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(t)	16	12.21	19.53	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(t + HY)	17	12.26	19.58	0.00
ϕ(t + HY) γ''(.) γ'(.)p(.)c(.)	9	12.35	19.67	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(.)	8	12.44	19.76	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(.)	13	12.45	19.77	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(t)	16	13.12	20.44	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(t + HY)	13	13.66	20.98	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(~ HY)	10	13.88	21.20	0.00
ϕ(.) γ''(.) γ'(.)p(t)c(t + HY)	15	14.02	21.34	0.00
ϕ(t + HY) γ''(.) γ'(.)p(t)c(t)	17	14.06	21.38	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(.)	9	14.26	21.58	0.00
ϕ(.) γ''(.) γ'(.)p(t)c(.)	11	14.42	21.74	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(t)	15	15.31	22.63	0.00
ϕ(t) γ''(.) γ'(.)p(.)c(t)	11	15.39	22.71	0.00

ϕ(~ HY) γ''(.) γ'(.)p(t)c(t + HY)	16	15.50	22.82	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t)c(.)	12	15.80	23.12	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(~ HY)	8	16.93	24.25	0.00
ϕ(temp) γ''(.) γ'(.)p(.)c(t + HY)	12	17.09	24.41	0.00
ϕ(t + HY) γ''(.) γ'(.)p(.)c(t)	12	17.16	24.48	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(t)	11	17.17	24.49	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(t)	16	17.57	24.89	0.00
ϕ(~ HY) γ''(.) γ'(.)p(.)c(~ HY)	9	17.70	25.02	0.00
ϕ(temp) γ''(.) γ'(.)p(.)c(.)	8	17.79	25.11	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(t)	12	19.07	26.39	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(t + HY)	13	19.15	26.47	0.00
ϕ(.) γ''(.) γ'(.)p(t)c(t)	14	19.38	26.70	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(.)	9	19.75	27.07	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t)c(t)	15	20.83	28.15	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(t + HY)	11	22.05	29.37	0.00
ϕ(temp) γ''(.) γ'(.)p(.)c(t)	11	22.53	29.85	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(.)	7	22.84	30.16	0.00
ϕ(~ HY) γ''(.) γ'(.)p(.)c(t + HY)	12	22.90	30.22	0.00
ϕ(~ HY) γ''(.) γ'(.)p(.)c(.)	8	23.60	30.92	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(t)	12	24.56	31.88	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(t)	10	27.51	34.83	0.00
ϕ(~ HY) γ''(.) γ'(.)p(.)c(t)	11	28.33	35.65	0.00

Table B3. Fox sparrow 2012 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(t + HY) γ''(.) γ'(.)p(.)c(~ HY)	11	73.24	0.00	0.07
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(t + HY)	14	73.28	0.04	0.07
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(t + HY)	12	73.32	0.08	0.07
ϕ(t + HY) γ''(.) γ'(.)p(.)c(t)	12	73.48	0.24	0.06
ϕ(t + HY) γ''(.) γ'(.)p(t + HY)c(.)	13	73.58	0.34	0.06
ϕ(t) γ''(.) γ'(.)p(.)c(t + HY)	12	73.79	0.55	0.05
ϕ(~ HY) γ''(.) γ'(.)p(t)c(t + HY)	13	74.26	1.02	0.04
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(~ HY)	12	74.36	1.12	0.04
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(.)	9	74.45	1.21	0.04
ϕ(t + HY) γ''(.) γ'(.)p(~ HY)c(.)	11	74.47	1.23	0.04
ϕ(t) γ''(.) γ'(.)p(~ HY)c(t + HY)	13	74.48	1.24	0.04
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(t)	13	74.62	1.38	0.04
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(~ HY)	13	75.34	2.10	0.02

ϕ(t) γ''(.) γ'(.)p(t + HY)c(t + HY)	15	75.38	2.14	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(t)	14	75.62	2.39	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(~ HY)	14	75.65	2.41	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(t + HY)	14	75.65	2.41	0.02
ϕ(t + HY) γ''(.) γ'(.)p(.)c(.)	10	75.93	2.69	0.02
ϕ(t + HY) γ''(.) γ'(.)p(t)c(t)	15	75.95	2.71	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(t)	15	75.96	2.72	0.02
ϕ(temp) γ''(.) γ'(.)p(.)c(~ HY)	9	76.60	3.36	0.01
ϕ(temp) γ''(.) γ'(.)p(.)c(t)	10	76.79	3.55	0.01
ϕ(t + HY) γ''(.) γ'(.)p(t)c(~ HY)	13	76.89	3.65	0.01
ϕ(~ HY) γ''(.) γ'(.)p(t + HY)c(.)	11	77.03	3.79	0.01
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(~ HY)	10	77.10	3.86	0.01
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(~ HY)	10	77.30	4.06	0.01
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(t)	11	77.32	4.08	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~ HY)c(~ HY)	11	77.43	4.19	0.01
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(t)	11	77.51	4.27	0.01
ϕ(~ HY) γ''(.) γ'(.)p(.)c(~ HY)	9	77.61	4.37	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~ HY)c(t)	12	77.67	4.43	0.01
ϕ(~ HY) γ''(.) γ'(.)p(.)c(t)	10	77.80	4.56	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(t + HY)c(.)	12	77.98	4.74	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(~ HY)	10	78.10	4.87	0.01
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(t)	13	78.22	4.98	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(t)c(.)	13	78.27	5.03	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(t)	11	78.32	5.08	0.01
ϕ(t) γ''(.) γ'(.)p(.)c(~ HY)	10	78.57	5.33	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(t + HY)	14	78.62	5.38	0.00
ϕ(t) γ''(.) γ'(.)p(.)c(t)	11	78.79	5.55	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t)c(~ HY)	11	78.99	5.75	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(t + HY)	14	79.03	5.79	0.00
ϕ(t) γ''(.) γ'(.)p(~ HY)c(~ HY)	11	79.21	5.97	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t)c(t)	12	79.23	5.99	0.00
ϕ(temp) γ''(.) γ'(.)p(.)c(.)	8	79.34	6.10	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(t + HY)	11	79.44	6.20	0.00
ϕ(t) γ''(.) γ'(.)p(~ HY)c(t)	12	79.45	6.21	0.00
ϕ(t + HY) γ''(.) γ'(.)p(t)c(.)	12	79.54	6.30	0.00
ϕ(temp) γ''(.) γ'(.)p(~ HY)c(.)	9	79.82	6.58	0.00
ϕ(~ HY) γ''(.) γ'(.)p(~ HY)c(.)	9	80.01	6.78	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(~ HY)c(.)	10	80.12	6.88	0.00

ϕ(temp) γ''(.) γ'(.)p(t + HY)c(~ HY)	13	80.24	7.01	0.00
ϕ(t) γ''(.) γ'(.)p(t + HY)c(t)	14	80.31	7.07	0.00
ϕ(~ HY) γ''(.) γ'(.)p(.)c(.)	8	80.35	7.11	0.00
ϕ(temp) γ''(.) γ'(.)p(t + HY)c(.)	11	80.63	7.39	0.00
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(t + HY)	12	80.68	7.44	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(.)	9	80.82	7.58	0.00
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(t + HY)	14	81.12	7.89	0.00
ϕ(t) γ''(.) γ'(.)p(.)c(.)	9	81.29	8.05	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(~ HY)	11	81.45	8.21	0.00
ϕ(~ HY) γ''(.) γ'(.)p(t)c(.)	10	81.68	8.44	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(t)	12	81.69	8.45	0.00
ϕ(t) γ''(.) γ'(.)p(~ HY)c(.)	10	81.90	8.66	0.00
ϕ(t) γ''(.) γ'(.)p(t + HY)c(.)	12	82.67	9.43	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(.)	11	83.00	9.76	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(t + HY)	10	83.30	10.06	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(~ HY)	12	83.31	10.07	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(~ HY)	14	83.42	10.18	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(t + HY)	13	83.46	10.22	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(t)	13	83.57	10.33	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(t)c(t)	15	83.74	10.50	0.00
ϕ(t) γ''(.) γ'(.)p(t + HY)c(~ HY)	15	84.06	10.82	0.00
ϕ(temp) γ''(.) γ'(.)p(t)c(.)	10	84.14	10.90	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(~ HY)	9	84.27	11.03	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(t)	10	84.46	11.23	0.00
ϕ(.) γ''(.) γ'(.)p(~ HY)c(t + HY)	11	85.15	11.91	0.00
ϕ(.) γ''(.) γ'(.)p(t + HY)c(t + HY)	13	85.23	11.99	0.00
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(~ HY)	10	85.46	12.22	0.00
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(t)	11	85.67	12.43	0.00
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(~ HY)	12	85.81	12.57	0.00
ϕ(t) γ''(.) γ'(.)p(t)c(.)	11	85.98	12.74	0.00
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(t)	13	86.07	12.83	0.00
ϕ(precip) γ''(.) γ'(.)p(.)c(.)	8	87.01	13.77	0.00
ϕ(precip) γ''(.) γ'(.)p(~ HY)c(.)	9	88.17	14.93	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(~ HY)	8	88.18	14.94	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(~ HY)	11	88.20	14.96	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(t)	9	88.35	15.11	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(t)	12	88.44	15.20	0.00
ϕ(precip) γ''(.) γ'(.)p(t + HY)c(.)	11	88.48	15.24	0.00

ϕ(.) γ''(.) γ'(.)p(t)c(t + HY)	13	88.74	15.50	0.00
ϕ(.) γ''(.) γ'(.)p(t + HY)c(~ HY)	11	89.96	16.72	0.00
ϕ(.) γ''(.) γ'(.)p(~ HY)c(~ HY)	9	89.98	16.74	0.00
ϕ(.) γ''(.) γ'(.)p(~ HY)c(t)	10	90.17	16.93	0.00
ϕ(.) γ''(.) γ'(.)p(t + HY)c(t)	12	90.20	16.96	0.00
ϕ(precip) γ''(.) γ'(.)p(t)c(.)	10	90.89	17.65	0.00
ϕ(.) γ''(.) γ'(.)p(.)c(.)	7	90.94	17.70	0.00
ϕ(.) γ''(.) γ'(.)p(t)c(~ HY)	10	91.24	18.00	0.00
ϕ(.) γ''(.) γ'(.)p(t)c(t)	11	91.45	18.21	0.00
ϕ(.) γ''(.) γ'(.)p(t + HY)c(.)	10	92.65	19.41	0.00
ϕ(.) γ''(.) γ'(.)p(~ HY)c(.)	8	92.72	19.48	0.00
ϕ(.) γ''(.) γ'(.)p(t)c(.)	9	93.95	20.72	0.00

Table B4. Song sparrow 2010 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(HY)γ''(.)γ'(.)p(.)c(.)	9	317.46	0.00	0.17
ϕ(t)γ''(.)γ'(.)p(.)c(.)	10	317.86	0.40	0.14
ϕ(.)γ''(.)γ'(.)p(.)c(.)	8	318.34	0.88	0.11
ϕ(t + HY)γ''(.)γ'(.)p(.)c(.)	11	318.64	1.18	0.09
ϕ(HY)γ''(.)γ'(.)p(HY)c(.)	10	319.37	1.91	0.06
ϕ(HY)γ''(.)γ'(.)p(.)c(HY)	10	319.88	2.42	0.05
ϕ(t)γ''(.)γ'(.)p(HY)c(.)	11	320.09	2.63	0.04
ϕ(t)γ''(.)γ'(.)p(.)c(HY)	11	320.33	2.87	0.04
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(.)	12	320.48	3.02	0.04
ϕ(t)γ''(.)γ'(.)p(t)c(.)	15	320.64	3.18	0.03
ϕ(.)γ''(.)γ'(.)p(HY)c(.)	9	320.71	3.25	0.03
ϕ(.)γ''(.)γ'(.)p(.)c(HY)	9	320.71	3.25	0.03
ϕ(t + HY)γ''(.)γ'(.)p(.)c(HY)	12	321.16	3.70	0.03
ϕ(t + HY)γ''(.)γ'(.)p(t)c(.)	16	321.77	4.31	0.02
ϕ(HY)γ''(.)γ'(.)p(HY)c(HY)	11	321.84	4.38	0.02
ϕ(HY)γ''(.)γ'(.)p(t)c(.)	14	322.37	4.91	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(HY)	12	322.62	5.16	0.01
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(HY)	13	323.05	5.59	0.01
ϕ(t)γ''(.)γ'(.)p(t + HY)c(.)	16	323.08	5.62	0.01
ϕ(.)γ''(.)γ'(.)p(HY)c(HY)	10	323.13	5.67	0.01
ϕ(.)γ''(.)γ'(.)p(t)c(.)	13	323.33	5.87	0.01
ϕ(t)γ''(.)γ'(.)p(t)c(HY)	16	323.38	5.92	0.01

ϕ(HY)γ''(.)γ'(.)p(.)c(t)	13	323.44	5.98	0.01
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(.)	17	323.88	6.42	0.01
ϕ(t)γ''(.)γ'(.)p(.)c(t)	14	324.04	6.58	0.01

Table B5. Song sparrow 2011 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(.)	12	108.36	0.00	0.08
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(.)	12	108.36	0.00	0.08
ϕ(HY + precip)γ''(.)γ'(.)p(t)c(t + HY)	15	108.73	0.38	0.06
ϕ(HY + temp)γ''(.)γ'(.)p(t)c(t + HY)	15	108.73	0.38	0.06
ϕ(t + HY)γ''(.)γ'(.)p(t)c(t + HY)	15	108.73	0.38	0.06
ϕ(HY)γ''(.)γ'(.)p(t + HY)c(t)	14	109.13	0.78	0.05
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(HY)	13	109.52	1.17	0.04
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(HY)	13	109.52	1.17	0.04
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(HY)	13	109.52	1.17	0.04
ϕ(precip)γ''(.)γ'(.)p(t + HY)c(t + HY)	15	109.54	1.19	0.04
ϕ(temp)γ''(.)γ'(.)p(t + HY)c(t + HY)	15	109.54	1.19	0.04
ϕ(t)γ''(.)γ'(.)p(t + HY)c(t + HY)	15	109.54	1.19	0.04
ϕ(HY + precip)γ''(.)γ'(.)p(t)c(t)	14	109.64	1.29	0.04
ϕ(HY + temp)γ''(.)γ'(.)p(t)c(t)	14	109.64	1.29	0.04
ϕ(t + HY)γ''(.)γ'(.)p(t)c(t)	14	109.64	1.29	0.04
ϕ(t)γ''(.)γ'(.)p(t + HY)c(t)	14	110.45	2.10	0.03
ϕ(precip)γ''(.)γ'(.)p(t + HY)c(t)	14	110.45	2.10	0.03
ϕ(temp)γ''(.)γ'(.)p(t + HY)c(t)	14	110.45	2.10	0.03
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(t + HY)	16	111.91	3.55	0.01
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(t + HY)	16	111.91	3.55	0.01
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(t + HY)	16	111.91	3.55	0.01
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(t)	15	112.64	4.29	0.01
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(t)	15	112.64	4.29	0.01
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(t)	15	112.64	4.29	0.01
ϕ(.)γ''(.)γ'(.)p(.)c(.)	6	113.04	4.69	0.01
ϕ(.)γ''(.)γ'(.)p(.)c(t + HY)	10	113.39	5.04	0.01
ϕ(.)γ''(.)γ'(.)p(.)c(HY)	7	113.48	5.13	0.01
ϕ(HY)γ''(.)γ'(.)p(.)c(.)	7	114.04	5.68	0.00
ϕ(HY)γ''(.)γ'(.)p(.)c(HY)	8	114.58	6.23	0.00
ϕ(HY)γ''(.)γ'(.)p(.)c(t + HY)	11	114.84	6.49	0.00
ϕ(.)γ''(.)γ'(.)p(.)c(t)	9	115.01	6.65	0.00
ϕ(.)γ''(.)γ'(.)p(HY)c(.)	7	115.12	6.76	0.00

ϕ(precip)γ''(.)γ'(.)p(.)c(.)	7	115.20	6.84	0.00
ϕ(temp)γ''(.)γ'(.)p(.)c(.)	7	115.20	6.84	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(.)	7	115.20	6.84	0.00
ϕ(.)γ''(.)γ'(.)p(HY)c(HY)	8	115.66	7.31	0.00
ϕ(precip)γ''(.)γ'(.)p(.)c(HY)	8	115.74	7.38	0.00
ϕ(temp)γ''(.)γ'(.)p(.)c(HY)	8	115.74	7.38	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(HY)	8	115.74	7.38	0.00
ϕ(HY)γ''(.)γ'(.)p(HY)c(.)	8	115.84	7.48	0.00
ϕ(.)γ''(.)γ'(.)p(HY)c(t + HY)	11	115.92	7.57	0.00
ϕ(precip)γ''(.)γ'(.)p(.)c(t + HY)	11	116.00	7.64	0.00
ϕ(temp)γ''(.)γ'(.)p(.)c(t + HY)	11	116.00	7.64	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(t + HY)	11	116.00	7.64	0.00
ϕ(HY)γ''(.)γ'(.)p(.)c(t)	10	116.34	7.98	0.00
ϕ(HY)γ''(.)γ'(.)p(HY)c(HY)	9	116.49	8.14	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(.)	8	116.72	8.36	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(.)	8	116.72	8.36	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(.)	8	116.72	8.36	0.00
ϕ(HY)γ''(.)γ'(.)p(HY)c(t + HY)	12	117.12	8.77	0.00
ϕ(precip)γ''(.)γ'(.)p(HY)c(.)	8	117.30	8.95	0.00
ϕ(temp)γ''(.)γ'(.)p(HY)c(.)	8	117.30	8.95	0.00
ϕ(t)γ''(.)γ'(.)p(HY)c(.)	8	117.30	8.95	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(HY)	9	117.37	9.02	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(HY)	9	117.37	9.02	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(HY)	9	117.37	9.02	0.00
ϕ(.)γ''(.)γ'(.)p(HY)c(t)	10	117.41	9.06	0.00
ϕ(precip)γ''(.)γ'(.)p(.)c(t)	10	117.49	9.14	0.00
ϕ(temp)γ''(.)γ'(.)p(.)c(t)	10	117.49	9.14	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(t)	10	117.49	9.14	0.00
ϕ(precip)γ''(.)γ'(.)p(HY)c(HY)	9	117.96	9.60	0.00
ϕ(temp)γ''(.)γ'(.)p(HY)c(HY)	9	117.96	9.60	0.00
ϕ(t)γ''(.)γ'(.)p(HY)c(HY)	9	117.96	9.60	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(t + HY)	12	118.00	9.65	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(t + HY)	12	118.00	9.65	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(t + HY)	12	118.00	9.65	0.00
ϕ(HY)γ''(.)γ'(.)p(HY)c(t)	11	118.48	10.13	0.00
ϕ(precip)γ''(.)γ'(.)p(HY)c(t + HY)	12	118.59	10.23	0.00
ϕ(temp)γ''(.)γ'(.)p(HY)c(t + HY)	12	118.59	10.23	0.00
ϕ(t)γ''(.)γ'(.)p(HY)c(t + HY)	12	118.59	10.23	0.00

ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(.)	9	118.62	10.27	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(.)	9	118.62	10.27	0.00
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(.)	9	118.62	10.27	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(t)	11	119.36	11.01	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(t)	11	119.36	11.01	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(t)	11	119.36	11.01	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(HY)	10	119.39	11.04	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(HY)	10	119.39	11.04	0.00
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(HY)	10	119.39	11.04	0.00
ϕ(precip)γ''(.)γ'(.)p(HY)c(t)	11	119.95	11.59	0.00
ϕ(temp)γ''(.)γ'(.)p(HY)c(t)	11	119.95	11.59	0.00
ϕ(t)γ''(.)γ'(.)p(HY)c(t)	11	119.95	11.59	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(t + HY)	13	120.42	12.06	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(t + HY)	13	120.42	12.06	0.00
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(t + HY)	13	120.42	12.06	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(t)	12	121.64	13.28	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(t)	12	121.64	13.28	0.00
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(t)	12	121.64	13.28	0.00

Table B6. Song sparrow 2012 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(HY)	13	220.97	0.00	0.05
ϕ(temp)γ''(.)γ'(.)p(t)c(HY)	11	220.98	0.01	0.05
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(.)	13	221.00	0.03	0.05
ϕ(HY)γ''(.)γ'(.)p(t)c(t)	12	221.01	0.04	0.05
ϕ(.)γ''(.)γ'(.)p(t)c(.)	9	221.10	0.14	0.05
ϕ(temp)γ''(.)γ'(.)p(HY)c(t)	11	221.24	0.27	0.04
ϕ(precip)γ''(.)γ'(.)p(HY)c(t + HY)	12	221.38	0.41	0.04
ϕ(HY + precip)γ''(.)γ'(.)p(t)c(t + HY)	14	221.61	0.64	0.04
ϕ(precip)γ''(.)γ'(.)p(t)c(t + HY)	14	221.65	0.68	0.03
ϕ(.)γ''(.)γ'(.)p(t)c(HY)	10	221.68	0.71	0.03
ϕ(HY)γ''(.)γ'(.)p(HY)c(t + HY)	12	221.74	0.77	0.03
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(HY)	14	221.76	0.79	0.03
ϕ(precip)γ''(.)γ'(.)p(HY)c(t)	11	222.15	1.18	0.03
ϕ(precip)γ''(.)γ'(.)p(t)c(.)	10	222.20	1.23	0.03
ϕ(t + HY)γ''(.)γ'(.)p(t)c(t + HY)	15	222.28	1.31	0.03
ϕ(HY + precip)γ''(.)γ'(.)p(t)c(t)	13	222.29	1.32	0.03
ϕ(HY)γ''(.)γ'(.)p(HY)c(t)	11	222.51	1.54	0.02

ϕ(HY + temp)γ''(.)γ'(.)p(t)c(.)	11	222.64	1.67	0.02
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(t + HY)	13	222.70	1.73	0.02
ϕ(.)γ''(.)γ'(.)p(HY)c(.)	8	222.70	1.74	0.02
ϕ(precip)γ''(.)γ'(.)p(t)c(HY)	11	222.82	1.85	0.02
ϕ(t)γ''(.)γ'(.)p(HY)c(t + HY)	13	222.89	1.92	0.02
ϕ(t + HY)γ''(.)γ'(.)p(t)c(t)	14	222.91	1.94	0.02
ϕ(.)γ''(.)γ'(.)p(HY)c(HY)	9	223.24	2.27	0.02
ϕ(HY + temp)γ''(.)γ'(.)p(t)c(HY)	12	223.31	2.34	0.02
ϕ(HY)γ''(.)γ'(.)p(t)c(.)	10	223.40	2.43	0.01
ϕ(t)γ''(.)γ'(.)p(t)c(HY)	12	223.42	2.45	0.01
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(t)	12	223.43	2.46	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(t)	12	223.62	2.65	0.01
ϕ(temp)γ''(.)γ'(.)p(HY)c(.)	9	223.73	2.76	0.01
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(t + HY)	13	223.76	2.80	0.01
ϕ(HY)γ''(.)γ'(.)p(t)c(HY)	11	224.02	3.05	0.01
ϕ(temp)γ''(.)γ'(.)p(HY)c(HY)	10	224.30	3.34	0.01
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(t)	12	224.49	3.52	0.01
ϕ(HY + precip)γ''(.)γ'(.)p(t)c(.)	11	224.59	3.62	0.01
ϕ(precip)γ''(.)γ'(.)p(HY)c(.)	9	224.64	3.67	0.01
ϕ(HY)γ''(.)γ'(.)p(HY)c(.)	9	224.99	4.03	0.01
ϕ(t + HY)γ''(.)γ'(.)p(t)c(.)	12	225.11	4.14	0.01
ϕ(temp)γ''(.)γ'(.)p(.)c(t + HY)	11	225.18	4.21	0.01
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(t + HY)	14	225.20	4.23	0.01
ϕ(precip)γ''(.)γ'(.)p(HY)c(HY)	10	225.21	4.25	0.01
ϕ(t)γ''(.)γ'(.)p(t)c(.)	12	225.23	4.26	0.01
ϕ(HY + precip)γ''(.)γ'(.)p(t)c(HY)	12	225.26	4.29	0.01
ϕ(HY)γ''(.)γ'(.)p(HY)c(HY)	10	225.57	4.60	0.00
ϕ(.)γ''(.)γ'(.)p(.)c(t + HY)	10	225.71	4.74	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(.)	10	225.82	4.85	0.00
ϕ(t + HY)γ''(.)γ'(.)p(t)c(HY)	13	225.83	4.86	0.00
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(t)	13	225.88	4.91	0.00
ϕ(temp)γ''(.)γ'(.)p(.)c(t)	10	226.00	5.03	0.00
ϕ(t)γ''(.)γ'(.)p(HY)c(.)	10	226.01	5.04	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(HY)c(HY)	11	226.44	5.47	0.00
ϕ(precip)γ''(.)γ'(.)p(.)c(t + HY)	11	226.51	5.54	0.00
ϕ(.)γ''(.)γ'(.)p(.)c(t)	9	226.57	5.61	0.00
ϕ(t)γ''(.)γ'(.)p(HY)c(HY)	11	226.63	5.66	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(.)	10	226.88	5.91	0.00

ϕ(precip)γ''(.)γ'(.)p(.)c(t)	10	227.33	6.36	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(HY)	11	227.51	6.54	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(t + HY)	12	227.65	6.68	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(t + HY)	12	227.65	6.68	0.00
ϕ(HY)γ''(.)γ'(.)p(.)c(t + HY)	11	227.83	6.87	0.00
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(.)	11	228.18	7.21	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(t)	11	228.42	7.45	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(t)	11	228.42	7.45	0.00
ϕ(temp)γ''(.)γ'(.)p(.)c(.)	8	228.57	7.60	0.00
ϕ(HY)γ''(.)γ'(.)p(.)c(t)	10	228.65	7.68	0.00
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(HY)	12	228.85	7.88	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(t + HY)	12	228.98	8.01	0.00
ϕ(temp)γ''(.)γ'(.)p(.)c(HY)	9	229.11	8.14	0.00
ϕ(.)γ''(.)γ'(.)p(.)c(.)	7	229.23	8.26	0.00
ϕ(.)γ''(.)γ'(.)p(.)c(HY)	8	229.72	8.75	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(t)	11	229.75	8.78	0.00
ϕ(precip)γ''(.)γ'(.)p(.)c(.)	8	229.90	8.93	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(t + HY)	13	230.17	9.20	0.00
ϕ(precip)γ''(.)γ'(.)p(.)c(HY)	9	230.43	9.47	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(t)	12	230.89	9.92	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(.)	9	230.90	9.93	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(.)	9	230.91	9.94	0.00
ϕ(HY)γ''(.)γ'(.)p(.)c(.)	8	231.22	10.26	0.00
ϕ(t)γ''(.)γ'(.)p(.)c(HY)	10	231.48	10.51	0.00
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(HY)	10	231.48	10.52	0.00
ϕ(HY)γ''(.)γ'(.)p(.)c(HY)	9	231.76	10.79	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(.)	9	232.23	11.26	0.00
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(HY)	10	232.81	11.84	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(.)	10	233.28	12.31	0.00
ϕ(t + HY)γ''(.)γ'(.)p(.)c(HY)	11	233.91	12.94	0.00

Table B7. Spotted towhee 2010 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(.)γ''(.)γ'(.)p(.)c(.)	8	264.88	0.00	0.14
ϕ(.)γ''(.)γ'(.)p(.)c(HY)	9	265.39	0.51	0.11
ϕ(HY)γ''(.)γ'(.)p(.)c(.)	9	266.04	1.16	0.08
ϕ(precip)γ''(.)γ'(.)p(.)c(.)	9	266.36	1.47	0.07

ϕ(HY)γ''(.)γ'(.)p(.)c(HY)	10	266.62	1.74	0.06
ϕ(t)γ''(.)γ'(.)p(.)c(.)	10	266.93	2.04	0.05
ϕ(precip)γ''(.)γ'(.)p(.)c(HY)	10	266.94	2.05	0.05
ϕ(.)γ''(.)γ'(.)p(HY)c(.)	9	267.30	2.42	0.04
ϕ(temp)γ''(.)γ'(.)p(.)c(.)	9	267.42	2.54	0.04
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(.)	10	267.54	2.66	0.04
ϕ(t)γ''(.)γ'(.)p(.)c(HY)	11	267.59	2.70	0.04
ϕ(.)γ''(.)γ'(.)p(HY)c(HY)	10	267.88	3.00	0.03
ϕ(temp)γ''(.)γ'(.)p(.)c(HY)	10	268.00	3.12	0.03
ϕ(t + HY)γ''(.)γ'(.)p(.)c(.)	11	268.05	3.17	0.03
ϕ(HY)γ''(.)γ'(.)p(HY)c(.)	10	268.16	3.27	0.03
ϕ(HY + precip)γ''(.)γ'(.)p(.)c(HY)	11	268.20	3.32	0.03
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(.)	10	268.64	3.76	0.02
ϕ(t + HY)γ''(.)γ'(.)p(.)c(HY)	12	268.79	3.91	0.02
ϕ(HY)γ''(.)γ'(.)p(HY)c(HY)	11	268.82	3.93	0.02
ϕ(precip)γ''(.)γ'(.)p(HY)c(.)	10	268.84	3.96	0.02
ϕ(HY + temp)γ''(.)γ'(.)p(.)c(HY)	11	269.30	4.42	0.02
ϕ(precip)γ''(.)γ'(.)p(HY)c(HY)	11	269.50	4.62	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(.)	11	269.53	4.64	0.01
ϕ(HY + precip)γ''(.)γ'(.)p(HY)c(.)	11	269.71	4.83	0.01
ϕ(temp)γ''(.)γ'(.)p(HY)c(.)	10	269.91	5.03	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(HY)	12	270.27	5.38	0.01
ϕ(t + HY)γ''(.)γ'(.)p(HY)c(.)	12	270.42	5.54	0.01

Table B8. Spotted towhee 2011 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(t)γ''(.)γ'(.)p(.)c(.)	7	90.49	0.00	0.46
ϕ(.)γ''(.)γ'(.)p(t)c(t)	9	91.01	0.52	0.35
ϕ(.)γ''(.)γ'(.)p(t)c(.)	9	93.63	3.14	0.10
ϕ(precip)γ''(.)γ'(.)p(t)c(t)	10	96.28	5.78	0.03
ϕ(temp)γ''(.)γ'(.)p(t)c(t)	10	96.28	5.78	0.03
ϕ(t)γ''(.)γ'(.)p(t)c(t)	10	96.28	5.78	0.03
ϕ(precip)γ''(.)γ'(.)p(t)c(.)	10	98.89	8.40	0.01
ϕ(temp)γ''(.)γ'(.)p(t)c(.)	10	98.89	8.40	0.01
ϕ(t)γ''(.)γ'(.)p(t)c(.)	10	98.89	8.40	0.01

Table B9. Spotted towhee 2012 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight

ϕ(t + HY)γ''(.)γ'(.)p(t)c(t)	6	52.92	0.00	0.07
ϕ(t + HY)γ''(.)γ'(.)p(t)c(t + HY)	6	52.92	0.00	0.07
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(HY)	7	54.51	1.59	0.03
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(t)	7	54.51	1.59	0.03
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(t)	7	54.51	1.59	0.03
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(t + HY)	7	54.51	1.59	0.03
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(.)	7	54.51	1.59	0.03
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(HY)	7	54.51	1.59	0.03
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(t)	7	54.51	1.59	0.03
ϕ(t + HY)γ''(.)γ'(.)p(t + HY)c(t + HY)	7	54.51	1.59	0.03
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(.)	7	54.51	1.59	0.03
ϕ(HY + precip)γ''(.)γ'(.)p(t + HY)c(t + HY)	7	54.51	1.59	0.03
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(.)	7	54.51	1.59	0.03
ϕ(HY + temp)γ''(.)γ'(.)p(t + HY)c(HY)	7	54.51	1.59	0.03
ϕ(.)γ''(.)γ'(.)p(HY)c(.)	3	54.52	1.60	0.03
ϕ(.)γ''(.)γ'(.)p(HY)c(HY)	3	54.52	1.60	0.03
ϕ(.)γ''(.)γ'(.)p(HY)c(t)	3	54.52	1.60	0.03
ϕ(.)γ''(.)γ'(.)p(HY)c(t + HY)	3	54.52	1.60	0.03
ϕ(.)γ''(.)γ'(.)p(.)c(.)	3	55.56	2.64	0.02
ϕ(.)γ''(.)γ'(.)p(.)c(t)	3	55.56	2.64	0.02
ϕ(.)γ''(.)γ'(.)p(.)c(HY)	3	55.56	2.64	0.02
ϕ(.)γ''(.)γ'(.)p(.)c(t + HY)	3	55.56	2.64	0.02
ϕ(precip)γ''(.)γ'(.)p(HY)c(.)	4	56.72	3.80	0.01
ϕ(precip)γ''(.)γ'(.)p(HY)c(HY)	4	56.72	3.80	0.01
ϕ(precip)γ''(.)γ'(.)p(HY)c(t)	4	56.72	3.80	0.01
ϕ(precip)γ''(.)γ'(.)p(HY)c(t + HY)	4	56.72	3.80	0.01
ϕ(temp)γ''(.)γ'(.)p(HY)c(t + HY)	4	56.72	3.80	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(.)	4	56.72	3.80	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(t + HY)	4	56.72	3.80	0.01
ϕ(temp)γ''(.)γ'(.)p(HY)c(.)	4	56.72	3.80	0.01
ϕ(temp)γ''(.)γ'(.)p(HY)c(HY)	4	56.72	3.80	0.01
ϕ(temp)γ''(.)γ'(.)p(HY)c(t)	4	56.72	3.80	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(HY)	4	56.72	3.80	0.01
ϕ(t)γ''(.)γ'(.)p(HY)c(t)	4	56.72	3.80	0.01
ϕ(.)γ''(.)γ'(.)p(t)c(.)	5	57.16	4.24	0.01
ϕ(.)γ''(.)γ'(.)p(t)c(HY)	5	57.16	4.24	0.01
ϕ(.)γ''(.)γ'(.)p(t)c(t)	5	57.16	4.24	0.01
ϕ(.)γ''(.)γ'(.)p(t)c(t + HY)	5	57.16	4.24	0.01

ϕ(precip)γ''(.)γ'(.)p(.)c(.)	4	57.93	5.01	0.01
ϕ(precip)γ''(.)γ'(.)p(.)c(HY)	4	57.93	5.01	0.01
ϕ(precip)γ''(.)γ'(.)p(.)c(t)	4	57.93	5.01	0.01
ϕ(precip)γ''(.)γ'(.)p(.)c(t + HY)	4	57.93	5.01	0.01
ϕ(temp)γ''(.)γ'(.)p(.)c(.)	4	57.93	5.01	0.01
ϕ(temp)γ''(.)γ'(.)p(.)c(HY)	4	57.93	5.01	0.01
ϕ(temp)γ''(.)γ'(.)p(.)c(t)	4	57.93	5.01	0.01
ϕ(temp)γ''(.)γ'(.)p(.)c(t + HY)	4	57.93	5.01	0.01
ϕ(t)γ''(.)γ'(.)p(.)c(.)	4	57.93	5.01	0.01
ϕ(t)γ''(.)γ'(.)p(.)c(HY)	4	57.93	5.01	0.01
ϕ(t)γ''(.)γ'(.)p(.)c(t)	4	57.93	5.01	0.01
ϕ(t)γ''(.)γ'(.)p(.)c(t + HY)	4	57.93	5.01	0.01
ϕ(.)γ''(.)γ'(.)p(t + HY)c(.)	6	58.54	5.62	0.00
ϕ(.)γ''(.)γ'(.)p(t + HY)c(HY)	6	58.54	5.62	0.00
ϕ(.)γ''(.)γ'(.)p(t + HY)c(t)	6	58.54	5.62	0.00
ϕ(.)γ''(.)γ'(.)p(t + HY)c(t + HY)	6	58.54	5.62	0.00
ϕ(precip)γ''(.)γ'(.)p(t)c(.)	6	60.28	7.36	0.00
ϕ(precip)γ''(.)γ'(.)p(t)c(HY)	6	60.28	7.36	0.00
ϕ(precip)γ''(.)γ'(.)p(t)c(t)	6	60.28	7.36	0.00
ϕ(precip)γ''(.)γ'(.)p(t)c(t + HY)	6	60.28	7.36	0.00
ϕ(temp)γ''(.)γ'(.)p(t)c(.)	6	60.28	7.36	0.00
ϕ(temp)γ''(.)γ'(.)p(t)c(HY)	6	60.28	7.36	0.00
ϕ(temp)γ''(.)γ'(.)p(t)c(t)	6	60.28	7.36	0.00
ϕ(temp)γ''(.)γ'(.)p(t)c(t + HY)	6	60.28	7.36	0.00
ϕ(t)γ''(.)γ'(.)p(t)c(.)	6	60.28	7.36	0.00
ϕ(t)γ''(.)γ'(.)p(t)c(HY)	6	60.28	7.36	0.00
ϕ(t)γ''(.)γ'(.)p(t)c(t)	6	60.28	7.36	0.00
ϕ(t)γ''(.)γ'(.)p(t)c(t + HY)	6	60.28	7.36	0.00
ϕ(precip)γ''(.)γ'(.)p(t + HY)c(.)	7	62.07	9.15	0.00
ϕ(precip)γ''(.)γ'(.)p(t + HY)c(HY)	7	62.07	9.15	0.00
ϕ(precip)γ''(.)γ'(.)p(t + HY)c(t)	7	62.07	9.15	0.00
ϕ(precip)γ''(.)γ'(.)p(t + HY)c(t + HY)	7	62.07	9.15	0.00
ϕ(temp)γ''(.)γ'(.)p(t + HY)c(.)	7	62.07	9.15	0.00
ϕ(temp)γ''(.)γ'(.)p(t + HY)c(HY)	7	62.07	9.15	0.00
ϕ(temp)γ''(.)γ'(.)p(t + HY)c(t)	7	62.07	9.15	0.00
ϕ(temp)γ''(.)γ'(.)p(t + HY)c(t + HY)	7	62.07	9.15	0.00
ϕ(t)γ''(.)γ'(.)p(t + HY)c(.)	7	62.07	9.15	0.00
ϕ(t)γ''(.)γ'(.)p(t + HY)c(HY)	7	62.07	9.15	0.00

ϕ(t)γ''(.)γ'(.)p(t + HY)c(t)	7	62.07	9.15	0.00
ϕ(t)γ''(.)γ'(.)p(t + HY)c(t + HY)	7	62.07	9.15	0.00

Table B10. Black-capped chickadee 2010 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(HY) γ''(.) γ'(.)p(~time)c(.)	6	179.22	0.00	0.13
ϕ(HY) γ''(.) γ'(.)p(.)c(.)	4	179.66	0.44	0.10
ϕ(HY) γ''(.) γ'(.)p(~time)c(HY)	7	181.11	1.89	0.05
ϕ(.) γ''(.) γ'(.)p(~time)c(.)	5	181.21	1.99	0.05
ϕ(HY) γ''(.) γ'(.)p(.)c(HY)	5	181.36	2.13	0.04
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(.)	7	181.69	2.47	0.04
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(.)	7	181.77	2.55	0.04
ϕ(~HY + temp) γ''(.) γ'(.)p(~time)c(.)	7	181.80	2.58	0.04
ϕ(.) γ''(.) γ'(.)p(.)c(.)	3	181.87	2.65	0.03
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(.)	5	181.92	2.70	0.03
ϕ(HY) γ''(.) γ'(.)p(HY)c(.)	5	181.97	2.75	0.03
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(.)	5	182.05	2.82	0.03
ϕ(temp) γ''(.) γ'(.)p(~time)c(.)	6	182.91	3.69	0.02
ϕ(.) γ''(.) γ'(.)p(~time)c(HY)	6	183.00	3.77	0.02
ϕ(temp) γ''(.) γ'(.)p(.)c(.)	4	183.36	4.13	0.02
ϕ(.) γ''(.) γ'(.)p(.)c(HY)	4	183.48	4.25	0.02
ϕ(precip) γ''(.) γ'(.)p(~time)c(.)	6	183.58	4.35	0.01
ϕ(.) γ''(.) γ'(.)p(~time +HY)c(.)	6	183.58	4.36	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(HY)	8	183.68	4.46	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(HY)	6	183.71	4.49	0.01
ϕ(HY) γ''(.) γ'(.)p(HY)c(HY)	6	183.76	4.54	0.01
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(HY)	8	183.76	4.54	0.01
ϕ(HY) γ''(.) γ'(.)p(.)c(~time)	7	183.78	4.55	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(~time)c(HY)	8	183.80	4.57	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(HY)	6	183.83	4.61	0.01
ϕ(HY) γ''(.) γ'(.)p(~time)c(~time)	9	183.95	4.73	0.01
ϕ(.) γ''(.) γ'(.)p(HY)c(.)	4	183.96	4.73	0.01
ϕ(precip) γ''(.) γ'(.)p(.)c(.)	4	184.03	4.81	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(.)	6	184.31	5.09	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(.)	8	184.34	5.11	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(.)	6	184.45	5.23	0.01

ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(.)	8	184.46	5.24	0.01
ϕ(temp) γ''(.) γ'(.)p(~time)c(HY)	7	184.80	5.58	0.01
ϕ(temp) γ''(.) γ'(.)p(.)c(HY)	5	185.05	5.83	0.01
ϕ(HY) γ''(.) γ'(.)p(.)c(~time +HY)	8	185.31	6.09	0.01
ϕ(temp) γ''(.) γ'(.)p(~time +HY)c(.)	7	185.39	6.17	0.01
ϕ(precip) γ''(.) γ'(.)p(~time)c(HY)	7	185.46	6.24	0.01
ϕ(.) γ''(.) γ'(.)p(~time +HY)c(HY)	7	185.47	6.25	0.01
ϕ(temp) γ''(.) γ'(.)p(HY)c(.)	5	185.55	6.33	0.01
ϕ(.) γ''(.) γ'(.)p(~time)c(~time)	8	185.62	6.40	0.01
ϕ(.) γ''(.) γ'(.)p(HY)c(HY)	5	185.65	6.43	0.01
ϕ(.) γ''(.) γ'(.)p(.)c(~time)	6	185.70	6.48	0.01
ϕ(precip) γ''(.) γ'(.)p(.)c(HY)	5	185.72	6.50	0.01
ϕ(HY) γ''(.) γ'(.)p(~time)c(~time +HY)	10	185.72	6.50	0.01
ϕ(precip) γ''(.) γ'(.)p(~time +HY)c(.)	7	186.03	6.80	0.00
ϕ(precip) γ''(.) γ'(.)p(HY)c(.)	5	186.16	6.94	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(HY)	7	186.20	6.98	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(~time)	8	186.34	7.11	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(HY)	7	186.34	7.12	0.00
ϕ(HY) γ''(.) γ'(.)p(HY)c(~time)	8	186.39	7.16	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(HY)	9	186.44	7.22	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(~time)	8	186.46	7.24	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(HY)	9	186.56	7.34	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(.)c(.)	7	186.75	7.53	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(~time)	10	186.76	7.54	0.00
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(~time)	10	186.84	7.62	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(~time)c(~time)	10	186.87	7.65	0.00

Table B11. Black-capped chickadee 2011 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(HY)	10	122.82	0.00	0.05
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(.)	10	122.86	0.03	0.05
ϕ(~time) γ''(.) γ'(.)p(.)c(HY)	7	123.08	0.26	0.05
ϕ(HY) γ''(.) γ'(.)p(~time)c(~time)	9	123.21	0.38	0.04
ϕ(temp) γ''(.) γ'(.)p(HY)c(~time)	8	123.43	0.61	0.04
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(HY)	9	123.51	0.69	0.04
ϕ(~time +HY) γ''(.) γ'(.)p(~time)c(HY)	10	123.55	0.72	0.04
ϕ(.) γ''(.) γ'(.)p(~time +HY)c(HY)	8	123.71	0.88	0.03

ϕ(~time) γ''(.) γ'(.)p(.)c(~time)	8	123.77	0.95	0.03
ϕ(precip) γ''(.) γ'(.)p(~time +HY)c(~time)	10	123.93	1.11	0.03
ϕ(~time) γ''(.) γ'(.)p(~time +HY)c(HY)	10	124.03	1.21	0.03
ϕ(.) γ''(.) γ'(.)p(.)c(HY)	5	124.20	1.37	0.03
ϕ(.) γ''(.) γ'(.)p(.)c(~time)	6	124.41	1.58	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(HY)	7	124.45	1.63	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(~time)	11	124.50	1.68	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(.)	7	124.57	1.75	0.02
ϕ(precip) γ''(.) γ'(.)p(HY)c(.)	7	124.66	1.84	0.02
ϕ(.) γ''(.) γ'(.)p(~time +HY)c(~time)	9	124.69	1.86	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(~time)	10	124.82	2.00	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(HY)	8	124.82	2.00	0.02
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(.)	8	124.85	2.03	0.02
ϕ(precip) γ''(.) γ'(.)p(~time)c(~time +HY)	10	124.85	2.03	0.02
ϕ(.) γ''(.) γ'(.)p(~time)c(~time +HY)	9	124.90	2.08	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(~time)c(~time +HY)	11	125.07	2.25	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(~time)	8	125.15	2.32	0.02
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(HY)	9	125.16	2.34	0.02
ϕ(~time +HY) γ''(.) γ'(.)p(~time)c(~time)	11	125.22	2.40	0.02
ϕ(HY) γ''(.) γ'(.)p(.)c(HY)	6	125.37	2.55	0.01
ϕ(~time +HY) γ''(.) γ'(.)p(.)c(HY)	8	125.46	2.63	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(HY)	10	125.56	2.73	0.01
ϕ(~time) γ''(.) γ'(.)p(~time +HY)c(~time)	11	125.71	2.89	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(~time)	9	125.80	2.98	0.01
ϕ(HY) γ''(.) γ'(.)p(.)c(~time)	7	125.81	2.98	0.01
ϕ(precip) γ''(.) γ'(.)p(.)c(~time +HY)	8	126.02	3.20	0.01
ϕ(~time) γ''(.) γ'(.)p(HY)c(HY)	8	126.06	3.24	0.01
ϕ(~time) γ''(.) γ'(.)p(~time)c(~time +HY)	11	126.21	3.39	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(.)c(~time +HY)	9	126.26	3.43	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(.)	8	126.35	3.53	0.01
ϕ(~time +HY) γ''(.) γ'(.)p(.)c(~time)	9	126.44	3.62	0.01
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(~time)	10	126.47	3.65	0.01
ϕ(temp) γ''(.) γ'(.)p(HY)c(~time +HY)	9	126.97	4.14	0.01
ϕ(.) γ''(.) γ'(.)p(HY)c(.)	6	127.00	4.17	0.01
ϕ(~time) γ''(.) γ'(.)p(HY)c(~time)	9	127.04	4.22	0.01
ϕ(HY) γ''(.) γ'(.)p(~time)c(~time +HY)	10	127.06	4.24	0.01
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(HY)	11	127.17	4.35	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(~time)	11	127.23	4.41	0.01

ϕ(~time) γ''(.) γ'(.)p(.)c(~time +HY)	9	127.31	4.48	0.01
ϕ(temp) γ''(.) γ'(.)p(.)c(~time +HY)	9	127.38	4.56	0.01
ϕ(.) γ''(.) γ'(.)p(.)c(~time +HY)	7	127.39	4.57	0.01
ϕ(precip) γ''(.) γ'(.)p(HY)c(HY)	8	128.00	5.18	0.00
ϕ(HY) γ''(.) γ'(.)p(HY)c(.)	7	128.04	5.22	0.00
ϕ(precip) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	11	128.16	5.33	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(HY)	9	128.47	5.65	0.00
ϕ(.) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	10	128.54	5.72	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(.)c(~time +HY)	9	128.68	5.86	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(~time +HY)	11	129.05	6.22	0.00
ϕ(HY) γ''(.) γ'(.)p(.)c(~time +HY)	8	129.05	6.23	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	12	129.15	6.32	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(~time)	12	129.27	6.45	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(~time +HY)	10	129.66	6.84	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(~time)	10	129.78	6.96	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(~time)c(~time +HY)	12	129.87	7.05	0.00
ϕ(.) γ''(.) γ'(.)p(HY)c(HY)	7	130.08	7.25	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(.)c(~time +HY)	10	130.29	7.47	0.00
ϕ(~time) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	12	130.36	7.54	0.00
ϕ(temp) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	12	130.59	7.77	0.00
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	11	130.70	7.87	0.00
ϕ(.) γ''(.) γ'(.)p(HY)c(~time)	8	130.77	7.95	0.00
ϕ(~time) γ''(.) γ'(.)p(HY)c(~time +HY)	10	130.90	8.07	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(~time)	10	131.28	8.46	0.00
ϕ(HY) γ''(.) γ'(.)p(HY)c(HY)	8	131.38	8.55	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	12	131.88	9.06	0.00
ϕ(HY) γ''(.) γ'(.)p(HY)c(~time)	9	132.36	9.54	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(~time +HY)	11	134.01	11.18	0.00
ϕ(.) γ''(.) γ'(.)p(HY)c(~time +HY)	9	134.30	11.48	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	13	134.40	11.58	0.00
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(~time +HY)	11	135.51	12.68	0.00
ϕ(HY) γ''(.) γ'(.)p(HY)c(~time +HY)	10	136.22	13.39	0.00

Table B12. Black-capped chickadee 2012 winter survival AIC table for models included in model averaging estimates

Model	npar	AICc	DeltaAICc	weight
ϕ(~time) γ''(.) γ'(.)p(~time +HY)c(HY)	8	112.76	0.00	0.06
ϕ(HY) γ''(.) γ'(.)p(HY)c(~time)	7	113.18	0.41	0.05

ϕ(HY) γ''(.) γ'(.)p(HY)c(~time +HY)	8	113.33	0.57	0.04
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(.)	7	113.53	0.76	0.04
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(~time)	9	113.72	0.96	0.04
ϕ(~HY + temp) γ''(.) γ'(.)p(~time)c(~time)	9	113.72	0.96	0.04
ϕ(~time +HY) γ''(.) γ'(.)p(~time)c(~time)	9	113.72	0.96	0.04
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(HY)	8	113.73	0.97	0.04
ϕ(precip) γ''(.) γ'(.)p(~time +HY)c(~time)	9	113.73	0.97	0.04
ϕ(temp) γ''(.) γ'(.)p(~time +HY)c(~time)	9	113.73	0.97	0.04
ϕ(~time) γ''(.) γ'(.)p(~time +HY)c(~time)	9	113.73	0.97	0.04
ϕ(~HY + precip) γ''(.) γ'(.)p(~time)c(~time +HY)	10	114.30	1.53	0.03
ϕ(~HY + temp) γ''(.) γ'(.)p(~time)c(~time +HY)	10	114.30	1.53	0.03
ϕ(~time +HY) γ''(.) γ'(.)p(~time)c(~time +HY)	10	114.30	1.53	0.03
ϕ(precip) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	10	114.31	1.55	0.03
ϕ(temp) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	10	114.31	1.55	0.03
ϕ(~time) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	10	114.31	1.55	0.03
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(.)	6	114.35	1.59	0.03
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(.)	6	114.35	1.59	0.03
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(.)	6	114.35	1.59	0.03
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(HY)	7	114.37	1.61	0.03
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(HY)	7	114.37	1.61	0.03
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(HY)	7	114.37	1.61	0.03
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(~time)	9	114.70	1.94	0.02
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(~time)	8	115.15	2.38	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(~time)	8	115.15	2.38	0.02
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(~time)	8	115.15	2.38	0.02
ϕ(HY) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	10	115.27	2.51	0.02
ϕ(~HY + temp) γ''(.) γ'(.)p(HY)c(~time +HY)	9	115.50	2.74	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(HY)c(~time +HY)	9	115.50	2.74	0.01
ϕ(~time +HY) γ''(.) γ'(.)p(HY)c(~time +HY)	9	115.50	2.74	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(.)	8	115.62	2.86	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(.)	8	115.62	2.86	0.01
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(.)	8	115.62	2.86	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(HY)	9	116.03	3.26	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(HY)	9	116.03	3.26	0.01
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(HY)	9	116.03	3.26	0.01
ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(~time)	10	117.22	4.46	0.01
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(~time)	10	117.22	4.46	0.01
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(~time)	10	117.22	4.46	0.01

ϕ(~HY + precip) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	11	118.04	5.27	0.00
ϕ(~HY + temp) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	11	118.04	5.27	0.00
ϕ(~time +HY) γ''(.) γ'(.)p(~time +HY)c(~time +HY)	11	118.04	5.27	0.00