Determining the Effects of Local Habitat Succession on Abundance and Species Diversity of Birds Captured at the Lesser Slave Lake Bird Observatory over 18 years of Standardized Mist-netting.

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Abstract

The Lesser Slave Lake Bird Observatory is a long-term avian migration monitoring station that began operation in 1994. One of the four core monitoring techniques employed is bird banding through passive mist-netting. Over the past 18 years the LSLBO has experienced falling capture rates. It was hypothesized that this was related to vegetation change through natural succession at the monitoring site.

To test this hypothesis, the vegetation's rate of change had to be determined. Unfortunately there was no existing vegetation assessment data. To rectify this, extensive field surveys were conducted at each netlane in the summer of 2011. Using this vegetation data in conjunction with historic photographs of the site, a dataset was created representative of vegetation conditions in 1999. Using these two time points, the rates of change in seven vegetation variables were calculated. Using factor analysis, these seven variables were then reduced to two factors (factors 1 and 2) that described 84% of the variation of the seven original variables.

Capture rates (birds caught per 100 net hours) were calculated for each netlane during both spring and fall migration seasons by year. This was done for all birds captured (both new and repeat bands) and for 21 select species. The resulting capture rates were analysed using linear OLS (ordinary least squares) regression for each species in each season at each netlane over time to determine how many more or fewer birds were being captured on average per 100 net hours annually since 1995.

To correlate the vegetation change to the changes in capture rates, the slope from each capture rate regression was used as the response variable and regressed on the change in vegetation per net between 2011 and 1999 using a mixed effects regression model in the program Stata. Analyses were performed for all vegetation variables, including factors 1 and 2, and for each of the 21 selected bird species as well as all bird species combined.

Factor 1 was the vegetation variable most significantly correlated to bird capture rates. It primarily described shrub density, green ground coverage and canopy openness. Netlanes with an increase in shrub cover and green total were positively correlated with factor 1 and netlanes with a decrease in shrub cover and green total were negatively correlated. Netlanes with an increase in canopy cover were negatively associated with factor 1, whereas netlanes with a decrease in canopy cover were positively associated. This demonstrated a negative correlation between canopy cover and shrub cover/green total.

Data for most bird species (17 of the 21) showed a positive, though not always significant, correlation between changes in capture rates and factor 1. The combined capture rate of all birds showed a significant positive correlation, meaning netlanes that showed an increase in canopy cover and decrease in shrub cover and green total experienced the greatest decrease in annual average capture rates for all birds and vice versa.

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1. Introduction

The Lesser Slave Lake Bird Observatory (LSLBO) is a long-term migration monitoring station located along the north-east shore of Lesser Slave Lake within the Lesser Slave Lake Provincial Park (LSLPP), approximately 20km north of the Town of Slave Lake. The monitoring site is situated within mixed boreal forest that was historically part of the old Freighter Highway; because of this, the vegetation at the site is younger than the adjacent areas to the east. The Freighter Highway was last cleared in the 1960s, and the habitat has remained relatively undisturbed since then. Initial test banding at the site began in 1993. In 1994, the first full monitoring season was undertaken, and standardized monitoring operations (see LSLBO field manual for protocol) have continued for the past 18 years. The LSLBO uses a variety of monitoring methods to estimate avian population trends, one of which is bird-banding using passive mist-netting. Over the course of the observatory's history it has been observed that the number of birds being captured through mist-netting during both the spring and the fall migration monitoring periods at the LSLBO have been decreasing. This observed decline in capture rates, however, has never been statistically demonstrated. In addition to this, the vegetation has undergone succession from riparian habitat to more mature woodland. It is hypothesized that the change in vegetative state directly affects the abundance and diversity of birds captured at the observatory.

The LSLBO has operated 12 standard netlanes since its establishment in 1994. These netlanes have remained in the same location since their initial establishment and are operated during both spring and fall migration (for net placement see Figure 1). The nets used by the LSLBO are 30mm mesh panel nets, 2.6 metres tall by 12 metres long; when set, the bottom of the net sits approximately 30cm off the ground. Spring migration monitoring typically begins in late April (weather permitting) and ends on June 10th. Fall migration monitoring begins July 12th and typically ends on September 30th. At the commencement of the fall 2010 monitoring period, two additional nets were erected at canopy height (when set, the bottom of the net is approximately 3 metres above the ground) to ascertain if they would significantly increase capture rates. It was hypothesized that the increase in net height would capture birds that use taller vegetation that was not previously present. These two aerial nets were set above nets 11 and 12 to sample the numbers and species composition of birds moving above the standard nets.

This study's goal is to establish if there has been significant change in the capture rates observed at the LSLBO and if they are correlated to vegetation growth over the last 18 years. Vegetation monitoring/ management plans will then be proposed based on the results.

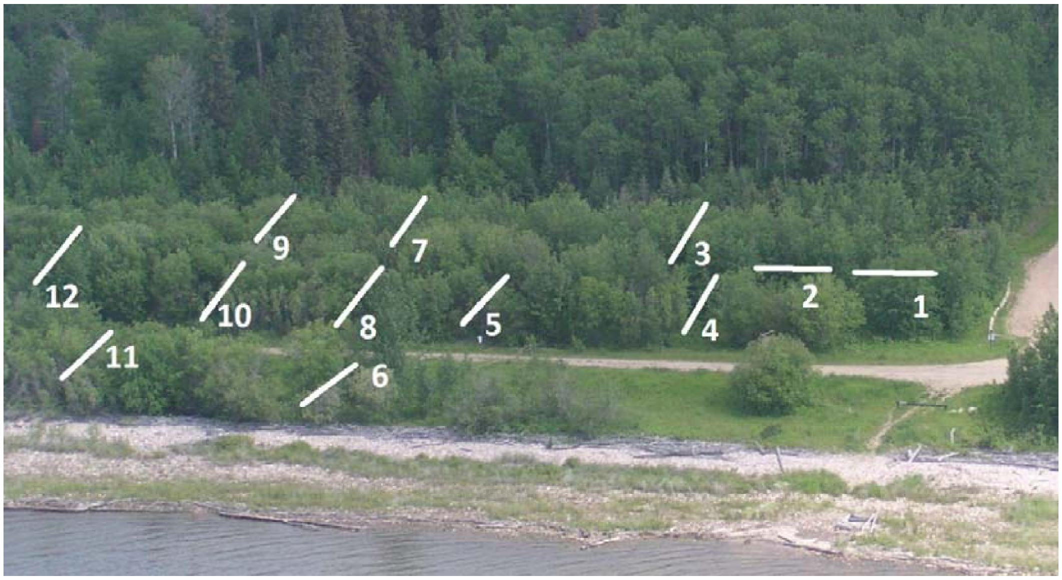

Figure 1 Approximate placement of netlanes at the Lesser Slave Lake Bird Observatory monitoring site. Aerial photograph taken between 1995 and 2000; exact date unknown.

2. Methods

2.1 Vegetation Survey

To determine the rate of vegetation change at the LSLBO, it was necessary to obtain at least two sets of vegetation data from different dates. However, since its establishment in 1994, the LSLBO study site has never conducted a comprehensive vegetation survey. To get the current vegetation state, surveys following the BBird protocol (Martin, 1997) were conducted at each of the existing netlanes during the summer of 2011. This data was the baseline for the creation of the second data set. Photographs were also taken of all the netlanes from various angles in the both the summer and fall of 2011 to serve as visual reference and comparison.

Because no vegetation surveys had been done prior to 2011, the second data set needed to be created from scratch based on other forms of documentation. The only historic documentation of the site prior to 2011 was a set of pictures taken of the netlanes in the spring of 1999, and another set taken during the summer sometime between 2000 and 2002. The photographs taken in 1999 include a good field-of-view of the majority of the netlane vegetation as well as a marked 8 metre measuring stick. Unfortunately, as they were taken in early spring before the plants had leafed-out, they provided little in the way of forb and shrub composition and density. The set of photographs taken mid-summer between 2000 and 2002, however, provided a good estimate of the forb and shrub ratio and density. To maintain the consistency necessary for comparing the two time periods, the data that was created to represent 1999 also adhered to the BBird protocol.

2.1.1 Data Collected

The BBird protocol (Martin 1997) collects data from two circles radiating from a central point, which in this study was the center of each netlane. The data fields collected in an 11.3m radius include a count of all trees with a diameter at breast height >8cm by species, size and, the canopy height and the canopy cover. The fields collected in the inner 5m radius circle included the organic litter depth, slope, composition of the ground cover (a proportion between green cover, bare ground, leaf litter, water and logs), dominant plant species, and numbers for all species of shrubs and sapling present (separated into two categories based on size, ones with stems having a dbh of <2.5cm and ones with a dbh of 2.5-8cm).

A variety of methods were used to fill each of the data fields for the 1999 data set. To obtain the number and size of trees, the 1999 pictures were compared to ones taken in 2011 that had the same field of view and perspective. The numbers of visible trees were counted in both photographs; the ratio of visible trees in the historic pictures compared to the current pictures was used to create an estimated tree count for the 1999 data. The canopy height was calculated using the measuring stick within the photograph to determine the average height of the surrounding vegetation. Canopy cover was expressed as an overall percentage and was a visual estimate based on comparison between the 2000-2002 summer photographs and the 2011 summer photographs. Organic litter was ignored since it was impossible to ascertain through photographs and likely irrelevant to the study. Slope was assumed to be the same. The composition of ground cover was expressed as a ratio of percentages and was obtained, again, by visual estimation of the summer photographs. The dominant species and numbers and species of shrubs were estimated visually as it was impossible to accurately count stems in the photographs. Table 1 summarizes the presumed degree of accuracy for each field sampled using the prescribed methods above.

Table 1. Summary of the degree of accuracy of each vegetation measurement between 1999 and 2011 with the BBird protocol (Martin et al. 1997). Measurements in 2011were made in the field while measurements from 1999 were derived from historic photographs.

	11.3m radius circle			5m radius circle				
Year	Trees	Canopy height	Canopy cover	Organic litter	Slope	Percent ground cover	Dominant species	Number of shrubs and saplings
1999	Fair	High	Fair	Low	High	Low	High	Fair
2011	High	High	High	High	High	High	High	High

2.1.2 Statistical Methods for Vegetation Change

The changes for seven vegetation variables were calculated. These variables were: tree height (change in metres), tree density (change in count), canopy cover (change in percentage), green total (a proportion of ground cover composition; change in percentage), shrub cover (a proportion of ground cover composition; change in percentage), small shrub density (change in count) and large shrub density (change in count). Change was defined as the difference between the 1999 and 2011 data, with a positive value being indicative of an increase in the given variable. All of the vegetation covariates were strongly correlated to one another so vegetation change was also described as a composite factor. To do this the vegetation variables were first standardized to zero mean and unit variance and then run through factor analysis to reduce the number of data variables to a series of uncorrelated factor scores that represented most of the variation in the data.

2.2 Capture Rate Analysis

Capture rates (expressed as no. of bird per 100 net hours) for all birds (both new bands and recaptures) during both seasons were calculated per netlane per day. They were then further broken down and calculated for each netlane per year per monitoring periods (spring and fall migration monitoring were kept separate). The capture rates for spring 1994 and 2011 and fall 1994 were omitted due to inconsistent effort in these years. It was also determined that there was not enough data on the aerial nets at this point to include them in this analysis. The capture rates were determined for all bird birds captured (new bands as well as recaptures) as well as for select species. Twenty one species were chosen to be analyzed to assess if there was a shift in species diversity using the habitat around the netlanes. These 21 species were of high monitoring priority at the LSLBO and exhibit a variety of foraging and nesting habits and have different habitat requirements. They were also species caught in high enough abundances to have sufficient data points to calculate trends (at least 400 records). The chosen species were: alder flycatcher, American redstart, black-and-white warbler, blackpoll warbler, Canada warbler, chipping sparrow, least flycatcher, Lincoln’s sparrow, magnolia warbler, mourning warbler, myrtle warbler, orange-crowned warbler, ovenbird, red-eyed vireo, ruby-crowned kinglet, sharp-shinned hawk, Swainson’s thrush, Tennessee warbler, white-throated sparrow, yellow-bellied sapsucker and yellow warbler.

2.2.1 Statistical Methods for Capture Rate Change

To calculate the trends in capture rates per netlane, linear OLS (ordinary least squares) regression was performed on the capture rates for each species at each netlane over time per season. A positive slope indicated that capture rates were increasing over time and a negative slope indicated that capture rates were decreasing. The rate of change was calculated for each bird species per netlane per season which showed how many birds more or less were caught at the LSLBO per 100 net hours annually since 1995.

2.3 Capture rate and Vegetation Correlation

The final analysis correlated the changes in capture rates at each of the LSLBO netlanes to the associated vegetation changes to determine if they were dependent. The slope of each capture rate regression was used as the response variable, while the change in vegetation was the predictor in a mixed effects regression model in the program Stata. The random effect in this mixed model was net identification, which accounted for the lack of independence in using the same net in different seasons and over time. Analyses were performed individually for all vegetation variables, including the significant factors identified through the factor analysis and each of the 21 selected bird species as well as all bird species combined.

3. Results

3.1 Vegetation Change by Net

Each of the 12 netlanes showed measurable changes, either positive or negative, in vegetation between the years of 1999 and 2011 (table 2). Changes were more prominent in some netlanes than in others. Overall, all netlanes showed positive change in tree height as well as tree density. Most netlanes showed an increase in the number of large shrubs (10 of the 12 netlanes) and number of small shrubs (8 out of the 12). Canopy cover also showed an increase in the majority of the netlanes, with the exception of three lanes. Canopy cover in netlanes 11 and 12 showed marked change in 2011 because of the clearing of trees necessary to erect the aerial nets above them. Percent green total decreased in all netlanes except one, where it showed no change; this is likely a result of increased canopy cover reducing sunlight to the forest floor thereby reducing forb density (forestencyclopedia, 2008). Overall density of shrubs also decreased in 7 of the 12 netlanes and showed no change in two.

Table 2. Change in vegetation variables at each of the 12 netlanes between the years 1999 and 2011.

Netlane	Tree height change (m)	Tree density change (count)	Canopy cover change (%)	Green total change (%)	Shrub cover change (%)	Small shrub change (count)	Large shrub change (count)
1	4.00	12.00	30.50	-22.50	-48.75	5.00	9.00
2	2.00	10.00	22.90	-43.75	-47.50	-16.00	17.00
3	4.50	5.00	12.40	-25.00	-27.50	20.00	-2.00
4	4.75	7.00	9.70	0.00	-7.50	-18.00	1.00
5	1.50	11.00	-0.10	-2.25	-15.00	13.00	19.00
6	3.25	3.00	1.40	-1.25	-5.00	-3.00	12.00
7	2.25	22.00	4.60	-7.50	1.25	29.00	9.00
8	1.50	24.00	2.10	-3.75	0.00	-1.00	9.00
9	2.00	24.00	14.50	-1.25	16.25	68.00	4.00
10	3.00	37.00	14.00	-11.25	0.00	18.00	3.00
11	1.50	7.00	-6.04	-2.50	8.75	27.00	-15.00
12	2.00	19.00	-0.20	-6.25	-6.25	26.00	5.00

The seven vegetation variables for each netlane were reduced to five factors using factor analysis. Of those five factors, the first two described 84% of the vegetation variance with the first one accounting for approximately 70%. Variables that were greater than or less than +/- 0.7 were considered to be strongly represented by the particular factor (Table 3). Factor 1 primarily described shrub density, green total and canopy openness. In general, netlanes with an increase in shrub cover and green total were positively correlated with factor 1 and netlanes with a decrease in shrub cover and green total were negatively correlated. The opposite is the case with canopy cover. Netlanes with an increase in canopy cover were negatively associated with factor 1 whereas netlanes with a decrease in canopy cover were positively associated. This demonstrated that canopy cover is negatively correlated to shrub cover and green total. In other words, as the canopy cover increases it is expected that the density of shrubs and percentage of green ground cover will decrease and vice versa.

Table 3. Loading of Factor Analysis of vegetation change variables.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness
Tree height	-0.4706	-0.4118	0.4838	0.2203	-0.0067	0.3264
Tree density	0.3369	0.6507	0.1463	0.1761	-0.0357	0.4093
Canopy cover	-0.7514	0.3694	0.384	0.1193	0.019	0.1368
Green total	0.8129	-0.2636	-0.0076	0.3223	0.0336	0.1646
Shrub cover	0.9638	0.0029	0.1334	0.0817	-0.0234	0.0460
sm shrub count	0.5568	0.3387	0.3079	-0.1939	0.047	0.4406
lg shrub count	-0.3671	0.3064	-0.4717	0.269	0.0211	1.4761

3.2 Summary of Capture Rate by Net

All netlanes, with the exception of netlane 6 in the spring, showed a decrease in the number of birds being caught annually in both the spring and the fall. Of these decreases, 10 of 12 in the fall and 5 of 12 in the spring were significant (Table 4). The largest decrease was observed in netlane 1 in the fall, which, on average, has captured 7.54 less birds/100 net hours each year since 1995. Conversely, the only netlane that showed increase (6 in the spring) averaged 1.36 more birds/100 net hours every year. These values were averages based on the slope of the regression derived from the capture rates of all birds per netlane per season per year. The fall season showed greater declines in capture rates than did the spring season (Figure 2).

Table 4. Coeffeicient and P-value for the average annual change in capture rate at each netlane in both spring and fall represented as number of birds caught per 100 net hours. Significant P-values are highlighted.

Netlane	Spring		Fall	
	Coeffiecient	P	Coeffiecient	P
1	-1.165	0.153	-7.539	**0.000**
2	-2.173	**0.000**	-5.543	**0.000**
3	-0.991	0.124	-2.691	**0.002**
4	-1.418	0.106	-3.076	**0.000**
5	-1.614	0.152	-5.760	**0.000**
6	1.360	0.623	-0.673	0.889
7	-0.827	**0.015**	-2.615	**0.009**
8	-1.056	**0.019**	-3.213	**0.000**
9	-0.620	0.200	-3.583	**0.000**
10	-2.063	**0.003**	-4.023	**0.000**
11	-1.242	0.688	-2.054	0.340
12	-2.964	**0.004**	-6.670	**0.000**

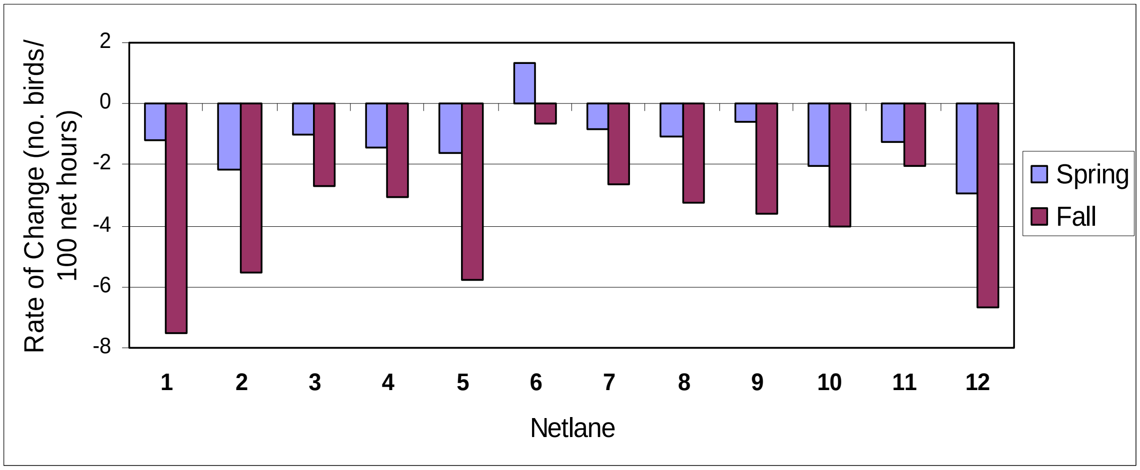

Figure 2. Average annual change in capture rate at each netlane in both spring and fall represented as number of birds caught per 100 net hours.

3.3 Summary of Capture Rate by Species

Changes in capture rates per species were investigated to ascertain if a shift in species composition being captured over time was present. Of the 21 bird species selected, 19 showed an average decrease in capture rates in both the spring and the fall. The bird species that showed the greatest decline in average capture rate was the American redstart in the fall. On average the LSLBO captured 0.88/100 net hours fewer American redstarts per year during fall. The species that showed the greatest increase was the Swainson's thrush in the spring, with an average increase of 0.16 birds/100 net hours per year. The only two species that showed an increase in capture rates in both the spring and the fall were the Swainson's thrush and the ovenbird. On average, fall showed greater decline than spring for all species. These values are based on averages of all 12 netlanes; for a complete breakdown of annual change in capture rates and associated p-values per species per net see Tables 7 and 8 in the appendix.

Table 5. Average annual change in capture rate and average p-value for all bird species and 21 individual species in both spring and fall represented as number of birds captured per 100 net hours. Significant P-values highlighted.

Season	Spring		Fall		Average change in capture rate
Species	Coefficient	P-value	Coefficient	P-value	
All birds	-1.2311	0.1739	-3.9533	0.1033	-2.5922
Alder flycatcher	-0.2042	0.0736	-0.1625	0.1000	-0.1833
American redstart	-0.2553	0.0723	-0.8853	0.0906	-0.5703
Black-and-white warbler	-0.0195	0.5080	-0.0368	0.1877	-0.0281
Blackpoll warbler	-0.0233	0.4278	-0.0363	0.1831	-0.0298
Canada warbler	-0.0546	0.4003	-0.2092	0.1244	-0.1319
Chipping sparrow	-0.1761	0.4733	-0.0106	0.4138	-0.0933
Least flycatcher	-0.2030	0.1495	-0.1356	**0.0465**	-0.1693
Lincoln's sparrow	-0.0039	0.3160	-0.0553	0.1795	-0.0296
Magnolia warbler	-0.0368	0.3487	-0.1261	0.0621	-0.0815
Mourning warbler	-0.0151	0.3027	-0.0740	0.0778	-0.0446
Myrtle warbler	-0.1231	0.4848	-0.7149	0.1027	-0.4190
Orange-crowned warbler	-0.0263	0.5123	-0.1250	0.1131	-0.0756
Ovenbird	0.0690	0.1894	0.1519	0.1504	0.1105
Ruby-crowned kinglet	0.0093	0.5523	-0.0658	0.3998	-0.0283
Red-eyed vireo	-0.0436	0.2172	-0.0959	0.1313	-0.0698
Sharp-shinned hawk	-0.0001	0.6139	0.0039	0.3429	0.0019
Swainson's thrush	0.1616	0.3634	0.0368	0.1621	0.0992
Tennessee warbler	-0.0004	0.6541	-0.3295	0.2398	-0.1649
White-throated sparrow	-0.0588	0.2694	-0.0928	0.2238	-0.0758
Yellow-bellied sapsucker	-0.0048	0.2937	-0.0010	0.3627	-0.0029
Yellow warbler	-0.1708	0.1173	-0.3262	0.1097	-0.2485

3.4 Vegetation and Capture Rate Correlation

The final analysis correlated vegetation change to capture rates at each netlane using a mixed effects regression model. For most species a positive slope was observed though it wasn't always significant. The coefficients and associated p value for each vegetation variable and bird species' relationship are shown below (Table 5). It is apparent that factor 1 was significantly correlated with the capture rates of all birds. This means that netlanes that had higher changes in factor 1 also showed a higher change in capture rates.

Table 6. coefficients and p-values for all bird species and vegetation variables analyzed using a mixed effect regression model. Significant P-values (any value below 0.05) are highlighted.

Veg. var. / Species	Factor 1		Factor 2		Green cover		lg shrub count		sm shrub count		Shrub cover		Canopy cover		Tree count		Tree height	
	Coeff.	P	Coeff.	P	Coeff.	P	Coeff.	P	Coeff.	P	Coeff.	P	Coeff.	P	Coeff.	P	Coeff.	P
allbirds	0.638	**0.002**	-0.630	0.119	0.012	0.180	-0.018	**0.020**	0.002	0.586	0.011	**0.000**	-0.014	0.238	0.000	0.991	0.167	0.517
ALFL	0.037	**0.012**	-0.032	0.198	0.002	0.472	-0.003	0.246	0.000	0.971	0.002	**0.042**	-0.003	0.095	-0.002	0.402	0.001	0.976
AMRE	0.214	**0.000**	-0.105	0.200	0.043	0.349	-0.041	0.195	0.002	0.914	0.034	**0.000**	-0.053	0.185	-0.036	0.437	0.021	0.828
BAWW	-0.005	0.826	-0.029	0.213	0.000	0.826	-0.001	0.740	-0.001	0.504	0.000	0.786	0.000	0.905	-0.004	**0.003**	0.013	0.522
BLPW	0.003	0.693	-0.001	0.918	0.000	0.973	0.000	0.620	0.000	0.800	0.000	0.616	0.000	0.740	0.000	0.694	-0.001	0.771
CAWA	0.032	0.138	-0.084	**0.000**	0.004	0.415	-0.004	0.451	-0.001	0.441	0.002	0.301	-0.005	0.066	-0.006	**0.020**	0.015	0.400
CHSP	-0.022	0.555	0.056	0.126	-0.002	0.467	0.001	0.815	0.001	0.669	-0.001	0.509	0.005	0.058	0.006	**0.022**	0.014	0.533
LEFL	0.016	0.636	-0.005	0.884	0.001	0.795	-0.001	0.803	0.000	0.865	0.001	0.385	0.001	0.764	0.000	0.882	0.026	0.129
LISP	0.012	0.471	-0.044	0.086	0.001	0.786	-0.001	0.813	-0.001	0.477	0.001	0.372	-0.003	0.122	-0.004	0.068	0.002	0.890
MAWA	0.061	**0.000**	-0.014	0.192	0.005	**0.000**	-0.002	0.501	0.001	0.337	0.003	**0.000**	-0.005	**0.000**	0.001	0.394	-0.019	0.271
MOWA	0.031	**0.022**	-0.014	0.454	0.002	0.210	0.001	0.658	0.000	0.899	0.001	**0.001**	-0.003	0.068	-0.001	0.730	-0.009	0.617
MYWA	-0.061	0.164	0.074	0.256	-0.005	0.214	0.003	0.650	0.000	0.883	-0.002	0.535	0.011	**0.013**	0.004	0.431	0.055	0.163
OCWA	0.030	0.052	0.016	0.263	0.003	0.149	0.001	0.781	0.000	0.406	0.002	0.078	-0.001	0.374	0.002	0.198	-0.017	0.279
OVEN	-0.046	0.123	-0.020	0.464	-0.004	0.184	-0.002	0.726	0.000	0.809	-0.002	0.172	0.003	0.056	-0.003	0.278	0.036	0.100
RCKI	0.026	0.162	0.014	0.483	0.002	0.290	0.000	0.950	0.000	0.622	0.001	0.162	-0.001	0.154	0.002	0.159	-0.019	0.282
REVI	0.008	0.608	-0.014	0.298	0.000	0.820	0.000	0.643	0.000	0.842	0.000	0.613	-0.001	0.132	-0.001	0.310	0.001	0.959
SSHA	0.000	0.964	-0.010	0.241	0.000	0.878	-0.001	0.247	0.000	0.857	0.000	0.919	-0.001	0.317	-0.001	0.191	0.001	0.917
SWTH	0.004	0.943	-0.125	**0.023**	0.004	0.555	-0.004	0.571	0.000	0.859	0.000	0.978	-0.005	0.392	-0.009	**0.001**	0.033	0.403
TEWA	0.056	0.272	-0.057	0.128	0.003	0.628	-0.004	0.233	0.000	0.968	0.003	0.117	-0.006	0.111	-0.006	0.196	-0.009	0.775
WTSP	0.073	**0.000**	-0.049	0.163	0.005	0.066	-0.005	0.299	0.001	0.458	0.003	**0.024**	-0.009	**0.000**	-0.001	0.610	-0.033	0.218
YBSA	0.012	0.229	0.006	0.513	0.000	0.860	-0.001	0.508	0.000	0.293	0.000	0.314	-0.001	0.058	0.000	0.596	-0.013	0.097
YWAR	0.056	0.355	-0.061	0.323	0.002	0.821	-0.004	0.471	-0.001	0.690	0.003	0.348	-0.005	0.444	-0.005	0.467	0.021	0.686

To better visualize these results it helps to look at Figures 3 and 4. Relationships that had a positive slope (coefficient) indicated that netlanes exhibiting a positive change in a given vegetation variable over time showed a positive change in a given bird's capture rate; netlanes with a negative change in a given vegetation variable over time showed a negative change in a given bird's capture rates. Conversely, relationships with a negative slope are ones in which netlanes that showed a positive change in vegetation had a decrease in bird capture rates and netlanes with a negative change in vegetation had an increase in capture rates. Figures 3 and 4 show the two most important vegetation variables related to capture rate changes; looking at them together helps to visualize the negative correlation between shrub cover and canopy cover as indicated by the factor analysis.

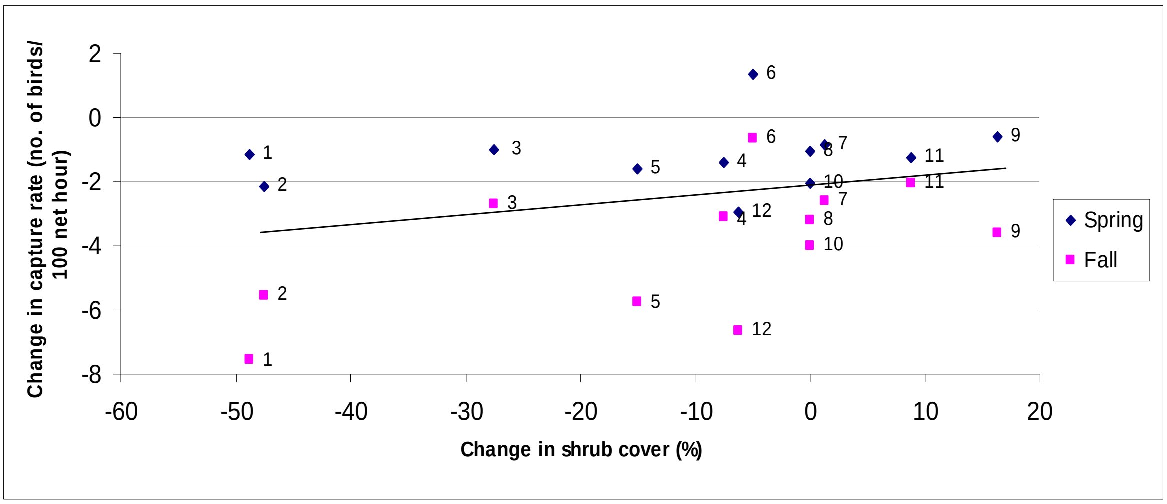

Figure 3. Relationship between rate of change in number of birds (all species) caught per 100 net hours annually over time (Y-axis) and the change in shrub cover (X-axis) for all netlanes in both the spring and fall. (coefficient: 0.011; P: 0.000)

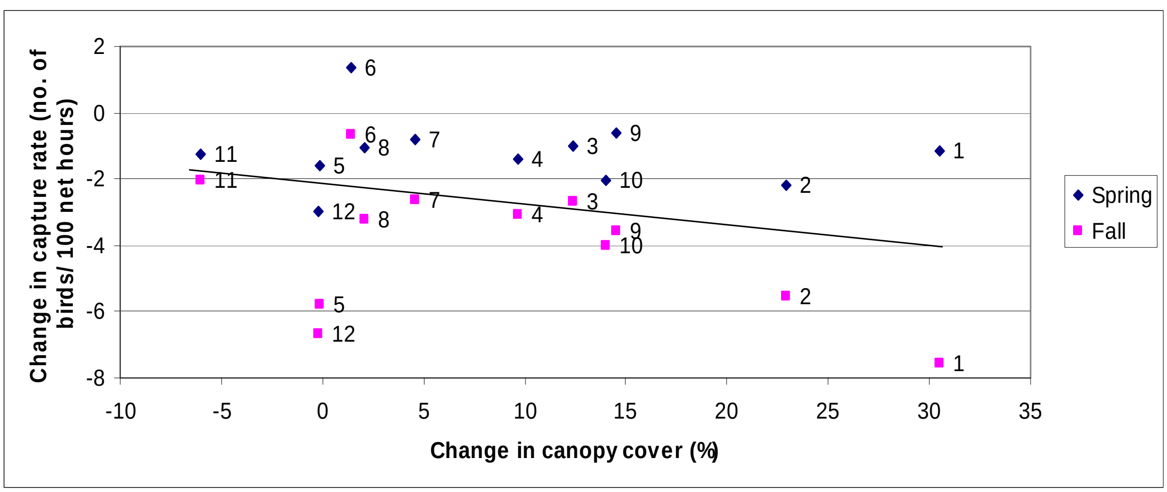

Figure 4. Relationship between rate of change in number of birds (all species) caught per 100 net hours annually over time (Y-axis) and the change in canopy cover (X-axis) for all netlanes in both the spring and fall. (coefficient: -0.014; P: 0.238)

4. Discussion

The main purpose of the Lesser Slave Lake Bird Observatory is long-term migration monitoring to determine population trends in birds. Bird banding through passive mist-netting is one of the four core monitoring methods. Although banding accounts for only about 5% of the total number of birds detected from 1994 to 2008 (Krikun, 2010), many species, which are discreet in their migration habits, are detected almost exclusively through banding. Twenty-one percent of the bird species that have been banded at the LSLBO attribute over half of their observation records to banding (Krikun, 2010). Of these species, many are considered to be of high monitoring priority and are among the 21 species that were singled out within this study. These species are: alder flycatcher, Swainson’s thrush, magnolia warbler, blackpoll warbler, ovenbird and Canada warbler. Knowing that banding is an effective way of detecting many species of birds and deriving population trends for them, it is crucial for the LSLBO to be able to determine if changes in capture rates are a result of changing variables in the monitoring process as opposed to actual changes in the populations.

Migrating birds are observed to use hierarchical decision making in regards to habitat selection when they migrate to and from their wintering and summering grounds (Moore et al, 1995). Migrants will follow corridors through habitats that have either intrinsic or extrinsic factors that are beneficial to them. Examples of intrinsic factors include resource availability, low competition and protection from predation. Extrinsic factors include a reduction in migration distance (such as flying over a lake as opposed to around it) and more favourable weather conditions (Moore et al, 1995). As there is no way to control extrinsic factors, this study looked at the intrinsic factors that affect whether or not a bird will use a particular habitat.

According to Schieck et al (1995), canopy heterogeneity (a ratio between covered and gaps with low being closed canopy and high being open canopy) changes in a bimodal pattern through natural succession. It is moderate in young forests (~25 years old), lowest in mature forests (~50 years old) and highest in old forests (>100 years old). Shrub density follows this pattern as it is dependent on availability of light on the forest floor. Young forests have moderate shrub density, mature forests have low shrub density and old forests have high shrub density. This is true of aspen dominated forests such as those at the LSLBO. Following Schieck et al.’s guidelines of age categories, the LSLBO’s forest (which is approximately 50 years old) is currently considered mature, and its vegetation change and characteristics follow the pattern they documented. In 1999, the forest (which then would have been classified as a young forest) had moderate canopy cover and moderate shrub cover. In 2011, it had high canopy cover and low shrub cover.

In a study by Moore et al (1995), it was found that the greatest species richness and abundance during fall migration were found in mixed-wood type habitats, closely followed by deciduous forest and scrub/shrub land. According to Schieck et al (1995), the abundance and species richness of breeding birds within mixed-wood aspen forests is dependent on successional stage. Of the 28 species with significant results in their study, 65% were most abundant in old forests, 25% in young forests and 10% in mature forests. Another study, done during the fall, by Rodewald and Brittingham (2004), found the abundances of migratory birds were positively correlated with an understory of shrubs with stems between 0-8cm dbh and negatively correlated with percentage of canopy cover. Essentially, abundance of migratory birds were highest in forests with lower canopy cover and higher shrub cover; i.e., old forests.

These findings are very supportive of our results. We found that the average capture rate for all bird species combined showed a significant positive correlation with shrub density and a negative correlation with canopy cover. Our factor analysis of the vegetation variables also linked canopy cover and shrub density as being two major determinants used by migrants when picking habitat. These two factors (which were combined, along with % green cover, as factor 1) are the main factors correlated with changes in capture rates of birds at the LSLBO. Knowing this, we can predict that netlanes that exhibit a decrease in shrub cover resulting from an increase in canopy cover will result in fewer birds being captured annually.

During migration, one of the most important intrinsic factors in habitat selection is food availability (Moore et al, 1995). This is one of the main reasons we looked at a variety of species: to identify if particular feeding guilds were more affected than others. Of the 21 species selected for individual analysis only, the Swainson's thrush and ovenbird in both the spring and fall, the ruby-crowned kinglet in the spring only, and the sharp-shinned hawk in the fall showed increases in annual change in capture rates. The two that showed increase in both seasons share very similar foraging habits. Both the ovenbird and Swainson's thrush feed mainly on arthropods that they glean from the forest floor (Schieck, 1995). This coincides with our vegetation results. With increased canopy cover and resulting decreased shrub density and green total it is expected within aspen-dominated forests that there will be an increase in leaf litter (forestencyclopedia, 2008), which creates ideal foraging habitat for ground species (Holmes & Scott, 1988).

Another important intrinsic factor of habitat is protection from predation (Moore et al, 1995). Sharp-shinned hawks showed increases in annual capture rates in the fall. Sharp-shinned hawks prefer mixed, aspen-dominated forests that have high canopy coverage and sparse understory (Reynolds, 1983), and their diets consist of over 90% avian prey (Joy et al, 1994). The forest around the LSLBO monitoring site showed gradual increase in canopy cover and decrease in shrub cover over time, potentially creating an ideal foraging habitat for sharp-shinned hawks. Knowing that sharp-shinned hawks are an important predator of migratory songbirds, their increase in the area potentially makes the habitat less suitable for songbirds because there is a greater chance of predation.

Of the species showing declines in annual change in capture rate, the five showing the largest declines (based on the average of spring and fall) are (from highest rate of decline to lowest) the following: American redstart, myrtle warbler, yellow warbler, alder flycatcher, and least flycatcher. Based on Schieck's classification of feeding styles (1995) all five of these birds feed mainly on arthropods, by either gleaning them from shrubs (American redstart, myrtle warbler, yellow warbler) or catching them in flight (American redstart, alder flycatcher, least flycatcher). Once again, this fits well with our data. The species showing strongest declines have a dependency on shrubs for obtaining food, and shrub density within the LSLBO netlanes is showing an overall decrease as a result of increasing canopy cover.

The data, from previous literature and our results, strongly supports the importance of canopy cover and shrub density as driving factors in habitat selection by migratory birds. Since shrubs are dependent on light reaching the forest floor to survive, shrub density is the dependent factor of the two vegetation variables (forestencyclopedia, 2008); therefore canopy cover is the important vegetation factor to focus on. The six netlanes showing the greatest change in canopy cover (in order of most change to least change) are as follows: 1, 2, 9, 10, 3 and 4. The actual canopy coverage score of these six netlanes are all currently above 90% coverage (unpublished LSLBO vegetation data). When we rank the netlanes based on the average change in capture rates for both the spring and fall, the six with the greatest decline in capture rates (in order of most decline to least decline) are as follows: 12, 1, 2, 5, 10 and 4. Netlanes 1, 2, 4 and 10 appear on both of these lists, which further supports the statistical correlation between canopy coverage and falling capture rates at the LSLBO.

Overall changes in capture rates appear to have a stronger correlation with vegetation change in the fall than they do in the spring. This could be a result of leaf-out timing during spring migration. During much of the spring migration monitoring period, the plants have not fully leafed-out; because of this, canopy coverage and shrub density are likely not relevant factors to migrating songbirds. Conversely, during the peak of fall migration the foliage is also at its peak, so vegetation characteristics would play a much greater role in habitat use determination by migrants. To statistically prove that fall capture rates have a stronger correlation to vegetation than spring capture rates, however, more analysis would have to be done.

A few other factors besides vegetation at the netlanes also need to be taken into consideration when looking at changing capture rates. One such factor is habitat adjacent to the study area being potentially more favourable and attracting the birds away from the netlanes. Looking at the historic pictures of the LSLBO, it is apparent that in 1999-2002 the shoreline was virtually devoid of vegetation, likely a result of heavy flooding that occurred in 1997. Presently, there is heavy growth of sandbar willow. The willow is very dense, extensive and is approximately 1 metre in height. Monitoring staff of the LSLBO have observed this area of riparian willow being heavily used by migrants during both the spring and fall. It is possible that the habitat around the netlanes is not necessarily of reduced quality for migrants, but rather that it is just poorer quality than the adjacent habitat. One way to potentially test this hypothesis would be to set additional nets directly alongside the existing netlanes that border the shoreline (netlanes 6 and 11). Capture rates for the existing nets that are just inside the forest along the shoreline could then be compared with capture rates for the net on the shoreline within the willow.

Another important factor to consider when looking at the changes in capture rates is if the particular species is showing an overall population decline. According to the 2011 Breeding Bird Surveys data, the populations of black-and-white warbler as well as ovenbirds are showing significant population growth in Alberta whereas the populations of the least flycatcher, chipping sparrow, alder flycatcher and red-eyed vireo are showing significant declines. Of these bird species showing significant changes in population, the alder flycatcher was the only one that we sampled that showed a decline in captures rates significantly correlated to vegetation. When looking at changes in our capture rates of these particular species, it is necessary to be cautious in interpretation since the change may result from an overall abundance change as opposed to a change in abundance within the local habitat.

5. Recommendations

Based on the results gathered through this study, five main recommendations to the Lesser Slave Lake Bird Observatory arise:

1. Implement a vegetation monitoring protocol.

One of the major problems encountered in this study was the lack of vegetation assessment. Long-term avian migration monitoring stations such as the LSLBO rely on annual consistency of monitoring methods in order to generate accurate population trends of birds. Changes to the monitoring site can cause changes in the number of birds being detected, which can positively or negatively skew the data. To be able to gauge the changes to the site so that they are taken into consideration when evaluating population trends, it is important to regularly survey the site. The Institute of Bird Populations (2001) recommends under their Monitoring Avian Productivity and Survivorship (MAPS) program that habitat should be surveyed at least every five years. In the Technical Manual for Vegetation Monitoring, written by Barker (2001), he also recommends a monitoring schedule of five year intervals. Given this, it is recommend that the LSLBO conduct complete vegetation surveys adhering to the BBird protocol every five years. These assessments should be supplemented by photographs taken of the site as a whole and of each of the netlanes. Habitat assessment should be done during the summer sometime between the end of spring migration and the beginning of fall migration. This time period is ideal since the vegetation is at its fullest and the lanes do not have the nets (which could be a hindrance to the survey) set within them. Photographs should be taken at the same time as the survey is conducted, and they should also be taken during either the spring or fall of the same year to show the vegetation without foliage. The photographs should be taken with the same field of view as the previous years' photographs and should include a marked measuring stick.

2. Implement a vegetation management plan.

Published findings and the results of this study both point to canopy cover and shrub density as being important vegetation variables in regards to species abundance and richness. Since shrub density is dependent on canopy cover, a vegetation management plan should focus on canopy cover. The netlanes that had the highest change in capture rates had canopy covers over 90%. In the 2011 vegetation data, 9 out of the 12 netlanes have a canopy cover over 90% with average canopy coverage of 92.2%; this is compared to 4 out of 12 with an average of 83.3% in the 1999 data (unpublished LSLBO data). With these percentages in mind, it is recommended that canopy cover over the netlanes be maintained between 80 and 90%, as close to 85% as possible. In order to achieve this a few mature trees would have to be selectively thinned from the site. Ideally, the opening of the canopy will stimulate shrub growth, which will, in turn, increase overall bird capture rates.

3. Continue work with the aerial nets.

Although there was not enough data from the aerial nets to include in this study, the nets should still be used, as there is lots of data to be potentially gained for future analysis. Both aerial nets demonstrated high capture rates in both the spring and fall (unpublished LSLBO data). After a few more years of operation, it should be possible to compare their capture rates with the capture rates of the standard nets below them and determine if the height of the net within the canopy has a statistical effect on capture rates.

4. Test the hypothesis about birds being drawn from the study site by adjacent shoreline habitat.

To test the hypothesis that the willow habitat along the shoreline is attracting birds away from the LSLBO's standard netlanes, it is recommended that a shoreline net be set directly alongside either netlane six or eleven; it should be set with the same orientation and height as the existing netlane. The capture rates of this net can then be compared to the capture rates of the standard net it is beside as well as the other standard nets to see if there is a significant difference in capture rates. Netlane six would likely be the better choice of the two since the willow is thicker beside it than it is at netlane eleven. When creating the new netlane, as few willows as possible should be cleared; keeping the willow cover heavy will help conceal the net and prevent net avoidance since it will be in a higher visibility area than the standard nets are.

5. Continue the research partnership with the Dr. Erin Bayne and the University of Alberta

As the results from this study are still very much preliminary, a continued partnership with Dr. Bayne, along with sharing of data, would be beneficial to the LSLBO in a number of ways. There are a lot more angles from which this data can be looked at to more conclusively determine the effects of habitat succession on capture rates. Different statistical method and correction factors can also be employed to further refine the results. Results gained would be useful not just to the LSLBO but to other long-term migration monitoring stations as well.

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Appendix

Table 7. Change in capture rate and associated P-value for all bird species and 21 individual species per net in the spring. Represented as number more or less of birds caught per 100 net hours per year. Significant P-values are highlighted.

Species		1	2	3	4	5	6	7	8	9	10	11	12	Average
All birds	Coeff.	-1.1652	-2.1733	-0.9910	-1.4178	-1.6137	1.3598	-0.8274	-1.0556	-0.6196	-2.0627	-1.2420	-2.9642	-0.2042
	P	0.1530	**0.0000**	0.1240	0.1060	0.1520	0.6230	**0.0150**	**0.0190**	0.2000	**0.0030**	0.6880	**0.0040**	0.1739
Alder flycatcher	Coeff.	-0.2336	-0.2166	-0.2192	-0.1857	-0.2688	0.0279	-0.2028	-0.1590	-0.1458	-0.2737	-0.1317	-0.4413	-1.2311
	P	**0.0220**	**0.0000**	**0.0010**	**0.0020**	**0.0180**	0.8180	**0.0000**	**0.0100**	**0.0110**	**0.0000**	**0.0000**	**0.0010**	0.0736
American redstart	Coeff.	-0.1352	-0.3317	-0.3296	-0.1775	-0.3744	-0.1285	-0.2590	-0.2119	-0.1757	-0.2115	-0.2676	-0.4609	-0.2553
	P	0.0970	**0.0010**	**0.0260**	**0.0090**	**0.0190**	0.6320	**0.0000**	**0.0050**	**0.0500**	**0.0070**	**0.0090**	**0.0120**	0.0723
Black-and-white warbler	Coeff.	0.0057	0.0092	-0.0005	-0.0429	-0.0472	-0.0300	-0.0332	-0.0249	-0.0369	-0.0715	-0.0023	0.0408	-0.0195
	P	0.8200	0.6800	0.9800	0.1780	0.3260	0.4480	0.4170	0.6310	0.2970	**0.0500**	0.9590	0.3100	0.5080
Blackpoll warbler	Coeff.	-0.0017	-0.0048	-0.0092	-0.0267	-0.0572	-0.0220	-0.0107	-0.0068	-0.0235	-0.0600	-0.0388	-0.0178	-0.0233
	P	0.9530	0.6230	0.4170	0.5150	0.0890	0.6870	0.3620	0.3580	0.2140	0.2300	0.5390	0.1460	0.4278
Canada warbler	Coeff.	-0.0180	-0.1718	-0.1482	-0.0063	-0.0852	0.0865	-0.0814	-0.0070	-0.0513	-0.1974	0.0256	-0.0014	-0.0546
	P	0.6890	**0.0280**	0.0570	0.9070	0.0890	0.2890	0.0560	0.8180	0.2090	**0.0030**	0.6890	0.9700	0.4003
Chipping sparrow	Coeff.	-0.1042	-0.1052	-0.0682	-0.1457	-0.3466	-0.5317	-0.0030	-0.0635	-0.0558	-0.1092	-0.4505	-0.1293	-0.1761
	P	0.4580	**0.0260**	0.4600	0.5610	0.4110	0.5820	0.9240	0.5320	0.3430	0.4390	0.6460	0.2970	0.4733
Least flycatcher	Coeff.	-0.1574	-0.2887	-0.0796	-0.0332	-0.3553	-0.1294	-0.1305	-0.0815	-0.1026	-0.2634	-0.3527	-0.4613	-0.2030
	P	**0.0340**	**0.0010**	0.0790	0.5540	**0.0350**	0.7260	**0.0170**	**0.0030**	**0.0370**	**0.0070**	0.2610	**0.0400**	0.1495
Lincoln's sparrow	Coeff.	-0.0535	-0.0413	-0.0063	-0.0312	-0.0232	0.2242	-0.0160	-0.0300	-0.0493	-0.0156	0.1522	-0.1564	-0.0039
	P	0.0980	**0.0500**	0.6900	0.3490	0.6990	**0.0010**	0.6160	0.3080	0.2300	0.6430	0.0920	**0.0160**	0.3160
Magnolia warbler	Coeff.	-0.0117	-0.1482	-0.1547	-0.0027	-0.0051	0.0253	-0.0204	-0.0256	-0.0144	-0.0559	0.0112	-0.0396	-0.0368
	P	0.7460	**0.0060**	0.0710	0.8020	0.6950	0.2980	0.3160	0.1120	0.5270	0.1020	0.3380	0.1710	0.3487
Mourning warbler	Coeff.	-0.0522	-0.0802	-0.0901	-0.0265	0.0161	0.1336	-0.0034	-0.0439	0.0093	-0.0085	-0.0177	-0.0178	-0.0151
	P	**0.0460**	**0.0000**	**0.0140**	0.1220	0.4920	**0.0220**	0.9050	**0.0030**	0.6480	0.5440	0.3360	0.5000	0.3027
Myrtle warbler	Coeff.	-0.0287	-0.0222	-0.0646	-0.2647	-0.2370	0.7538	-0.0430	-0.2041	0.0820	-0.1951	-0.4101	-0.8437	-0.1231
	P	0.8340	0.6970	0.2970	0.2020	0.4180	0.4520	0.6150	0.9960	0.4120	**0.0200**	0.7300	0.1450	0.4848
Orange-crowned warbler	Coeff.	0.0130	-0.0710	-0.0021	-0.0135	-0.0727	-0.0514	-0.0087	-0.0163	0.0281	-0.0264	-0.0559	-0.0383	-0.0263
	P	0.7720	**0.0400**	0.9580	0.7590	0.1060	0.4910	0.8690	0.6000	0.2000	0.3860	0.4730	0.4940	0.5123
Ovenbird	Coeff.	0.0153	0.0523	0.1058	0.0834	0.0674	0.0464	0.1342	-0.0147	0.0846	0.1380	0.0172	0.0984	0.0690
	P	0.3920	0.1500	0.2070	0.0570	**0.0220**	0.1110	**0.0030**	0.6880	0.0930	**0.0020**	0.5350	**0.0130**	0.1894
Ruby-crowned kinglet	Coeff.	0.0066	-0.0097	0.0358	0.0019	-0.0088	0.0169	0.0185	0.0158	0.0112	0.0110	0.0030	0.0097	0.0093
	P	0.8690	0.6490	0.4690	0.7570	0.7430	0.4730	0.1810	0.0940	0.5050	0.5720	0.8200	0.4960	0.5523
Red-eyed vireo	Coeff.	0.0134	-0.0271	0.0013	-0.0706	-0.0865	-0.0038	-0.0197	-0.0584	-0.0326	-0.0405	-0.1491	-0.0499	-0.0436
	P	0.4990	**0.0450**	0.8990	**0.0360**	**0.0150**	0.9140	**0.0390**	**0.0050**	0.0650	**0.0310**	**0.0130**	**0.0450**	0.2172
Sharp-shinned hawk	Coeff.		-0.0006	-0.0044	-0.0222	-0.0036	0.0316	-0.0062	-0.0089	-0.0041	0.0065	-0.0008	0.0110	-0.0001
	P		0.9530	0.8200	0.2730	0.8120	0.1430	0.7590	0.5240	0.8700	0.3630	0.9490	0.2870	0.6139
Swainson's thrush	Coeff.	0.2411	-0.0361	0.1979	0.1154	0.2694	0.3325	0.1337	0.1735	0.0745	0.0110	0.3423	0.0840	0.1616
	P	**0.0240**	0.6820	**0.0110**	0.6260	**0.0090**	0.2220	0.1970	0.1900	0.5030	0.8790	0.2710	0.7470	0.3634
Tennessee warbler	Coeff.	0.0311	-0.0233	0.0351	-0.0012	0.0133	-0.0734	0.0093	-0.0174	0.0573	-0.0707	0.0826	-0.0482	-0.0004
	P	0.7220	0.3380	0.6690	0.9940	0.8630	0.7580	0.8650	0.7600	0.3010	0.6100	0.5850	0.3840	0.6541
White-throated sparrow	Coeff.	-0.2038	-0.2440	-0.0464	-0.2233	0.0139	0.1191	-0.1289	-0.0793	-0.1082	-0.0849	0.1631	0.1177	-0.0588
	P	0.0630	**0.0440**	0.5730	**0.0410**	0.8960	0.3380	0.1680	0.2440	0.0650	0.1940	0.2900	0.3170	0.2694
Yellow-bellied sapsucker	Coeff.	-0.0352	0.0060	-0.0133	-0.0315	-0.0237	-0.0098		0.0108	0.0140	0.0134	0.0075	0.0091	-0.0048
	P	**0.0390**	0.5420	0.1920	**0.0230**	0.2230	0.7600		0.2040	**0.0330**	0.2960	0.6840	0.2350	0.2937
Yellow warbler	Coeff.	-0.3246	-0.1914	-0.0713	-0.1089	-0.2560	-0.0785	-0.0765	-0.1566	-0.1597	-0.1788	-0.2693	-0.1776	-0.1708
	P	**0.0150**	**0.0000**	**0.0440**	0.2740	**0.0050**	0.7620	0.0570	**0.0020**	**0.0010**	**0.0420**	0.1590	**0.0460**	0.1173

Table 8. Change in capture rate and associated P-value for all bird species and 21 individual species per net in the fall. Represented as number more or less of birds caught per 100 net hours per year. Significant P-values are highlighted.

Species		1	2	3	4	5	6	7	8	9	10	11	12	Average
All birds	Coeff.	-0.3541	-0.2302	-0.0850	-0.1873	-0.2564	-0.0164	-0.2032	-0.0663	-0.1344	-0.1507	-0.0725	-0.1935	-0.1625
	P	**0.0000**	**0.0000**	**0.0020**	**0.0000**	**0.0000**	0.8890	**0.0090**	**0.0000**	**0.0000**	**0.0000**	0.3400	**0.0000**	0.1033
Alder flycatcher	Coeff.	-7.5386	-5.5434	-2.6908	-3.0760	-5.7599	-0.6734	-2.6149	-3.2130	-3.5828	-4.0229	-2.0544	-6.6698	-3.9533
	P	**0.0000**	**0.0000**	**0.0410**	**0.0000**	**0.0000**	0.8780	**0.0000**	**0.0070**	**0.0040**	**0.0010**	0.2690	**0.0000**	0.1000
American redstart	Coeff.	-2.2154	-1.4420	-0.6648	-0.4765	-1.4385	-0.1622	-0.5405	-0.7583	-0.5489	-0.6185	-0.1952	-1.5625	-0.8853
	P	**0.0000**	**0.0000**	**0.0000**	**0.0010**	**0.0000**	0.6880	**0.0060**	**0.0040**	**0.0000**	**0.0010**	0.3870	**0.0000**	0.0906
Black-and-white warbler	Coeff.	-0.0390	-0.0225	-0.0133	-0.0414	-0.1803	0.2677	-0.0383	-0.0936	-0.0475	-0.0984	0.0510	-0.1856	-0.0368
	P	0.2700	0.2720	0.5870	0.2380	**0.0030**	0.0930	0.0740	0.0680	0.1150	**0.0320**	0.5000	**0.0000**	0.1877
Blackpoll warbler	Coeff.	-0.0950	-0.0265	-0.0521	-0.0077	-0.0612	-0.0330	-0.0170	-0.0138	-0.0184	-0.0446	-0.0084	-0.0579	-0.0363
	P	**0.0170**	**0.0380**	**0.0000**	0.4740	**0.0320**	0.5050	0.2260	0.2450	**0.0490**	**0.0370**	0.5610	**0.0130**	0.1831
Canada warbler	Coeff.	-0.2925	-0.3453	-0.1341	-0.1165	-0.2874	0.1022	-0.1706	-0.1439	-0.3460	-0.2825	-0.0008	-0.4935	-0.2092
	P	**0.0000**	**0.0000**	**0.0130**	**0.0420**	**0.0020**	0.4010	**0.0200**	**0.0010**	**0.0010**	**0.0240**	0.9890	**0.0000**	0.1244
Chipping sparrow	Coeff.	0.0027	-0.0038	-0.0013	-0.0093	-0.0201	0.0034	-0.0061	0.0000	-0.0197		-0.0481	-0.0142	-0.0106
	P	0.6820	0.3730	0.5570	0.1870	0.0950	0.9440	0.3280	1.0000	0.0590		0.2980	**0.0286**	0.4138
Least flycatcher	Coeff.	-0.2265	-0.1853	-0.1254	-0.1820	-0.2666	-0.0725	-0.0558	-0.0506	-0.0542	-0.1598	-0.1365	-0.1118	-0.1356
	P	**0.0000**	**0.0010**	**0.0010**	**0.0020**	**0.0010**	0.4750	**0.0140**	**0.0210**	**0.0020**	**0.0000**	**0.0400**	**0.0010**	**0.0465**
Lincoln's sparrow	Coeff.	-0.0650	-0.0635	-0.0644	-0.0334	0.0037	0.0643	-0.0641	-0.0499	-0.0930	-0.1402	-0.0243	-0.1343	-0.0553
	P	**0.0290**	**0.0060**	**0.0190**	0.1760	0.9070	0.1240	0.1240	**0.0480**	**0.0010**	**0.0010**	0.7130	**0.0060**	0.1795
Magnolia warbler	Coeff.	-0.3362	-0.2833	-0.1994	-0.0989	-0.0778	-0.0670	-0.1178	-0.0927	-0.0435	-0.0511	-0.0398	-0.1055	-0.1261
	P	**0.0020**	**0.0000**	**0.0020**	**0.0100**	**0.0090**	0.2400	**0.0210**	**0.0000**	0.1060	**0.0320**	0.3210	**0.0020**	0.0621
Mourning warbler	Coeff.	-0.1971	-0.0960	-0.0705	-0.1049	-0.0629	0.0779	-0.0137	-0.0288	-0.0593	-0.1030	-0.0763	-0.1538	-0.0740
	P	**0.0010**	**0.0130**	**0.0010**	**0.0020**	**0.0190**	0.0600	0.5460	0.0580	0.0510	**0.0180**	0.1500	**0.0140**	0.0778
Myrtle warbler	Coeff.	-0.5169	-0.5737	-0.6522	-0.2902	-0.9151	-1.9890	-0.3074	-0.5745	-0.6795	-0.5859	-0.8715	-0.6226	-0.7149
	P	0.0510	**0.0180**	**0.0140**	0.0840	**0.0110**	0.4670	**0.0040**	**0.0350**	**0.0060**	**0.0080**	0.3780	0.1560	0.1027
Orange-crowned warbler	Coeff.	-0.1643	-0.1873	-0.4233	-0.1456	-0.0688	0.0102	-0.1206	-0.0779	-0.0752	-0.0374	-0.0687	-0.1406	-0.1250
	P	**0.0350**	**0.0050**	**0.0440**	**0.0010**	0.2140	0.8110	**0.0350**	**0.0060**	**0.0280**	0.1100	0.0640	**0.0040**	0.1131
Ovenbird	Coeff.	0.2563	0.2850	0.5601	0.0824	0.0687	0.1165	0.0573	0.0419	0.0224	0.0721	0.1731	0.0877	0.1519
	P	**0.0070**	**0.0000**	**0.0000**	**0.0130**	0.2430	0.0790	0.2950	0.4850	0.3080	0.1350	**0.0370**	0.2030	0.1504
Ruby-crowned kinglet	Coeff.	-0.0875	-0.0784	-0.3780	-0.0499	-0.0988	0.0005	-0.0020	-0.0558	-0.0329	-0.0035	-0.0025	-0.0012	-0.0658
	P	**0.0080**	**0.0390**	0.0790	**0.0370**	**0.0090**	0.9940	0.9310	**0.0450**	0.1700	0.7470	0.8450	0.8940	0.3998
Red-eyed vireo	Coeff.	-0.2666	-0.1285	-0.0560	-0.1016	-0.0606	0.0000	-0.0733	-0.0487	-0.1232	-0.1632	-0.0249	-0.1043	-0.0959
	P	**0.0000**	**0.0000**	**0.0250**	**0.0140**	**0.0230**	0.9990	**0.0210**	**0.0060**	**0.0180**	**0.0020**	0.4560	**0.0110**	0.1313
Sharp-shinned hawk	Coeff.	-0.0087	0.0092	0.0320	0.0067	-0.0114	0.0164	-0.0538	-0.0257	-0.0208	-0.0015	0.0680	0.0362	0.0039
	P	0.4030	0.3790	**0.0310**	0.6300	0.6190	0.5440	**0.0050**	0.1770	0.1870	0.9130	0.1520	0.0750	0.3429
Swainson's thrush	Coeff.	0.2248	-0.2743	0.2261	-0.0272	0.1266	0.4361	-0.0667	-0.1256	-0.1606	-0.0667	0.2050	-0.0557	0.0368
	P	**0.0150**	**0.0160**	**0.0410**	0.0785	0.1330	**0.0020**	0.4970	0.0630	**0.0280**	0.2800	0.0840	0.7080	0.1621
Tennessee warbler	Coeff.	-0.7963	-0.3344	-0.1836	-0.2028	-0.4535	0.0334	-0.1904	-0.0875	-0.2314	-0.6594	-0.1162	-0.7311	-0.3295
	P	**0.0330**	**0.0010**	0.3380	0.0590	**0.0480**	0.9770	**0.0150**	0.4770	**0.0100**	0.0620	0.8400	**0.0170**	0.2398
White-throated sparrow	Coeff.	-0.3250	-0.2023	-0.0378	-0.1247	-0.0213	0.0053	-0.0742	-0.0748	-0.1120	-0.0428	0.0500	-0.1546	-0.0928
	P	**0.0000**	**0.0010**	0.3500	**0.0010**	0.6160	0.9200	0.0680	**0.0500**	**0.0000**	0.0600	0.5390	0.0810	0.2238
Yellow-bellied sapsucker	Coeff.		-0.0114		-0.0835	-0.0119	0.0511	0.0006	-0.0130	-0.0067	0.0011	0.0566	0.0067	-0.0010
	P		0.1590		**0.0400**	0.8580	0.1350	0.8460	0.2430	0.2340	0.8460	**0.0310**	0.2350	0.3627
Yellow warbler	Coeff.	-0.8903	-0.1899	-0.1501	-0.1678	-0.6247	0.1920	-0.2427	-0.2023	-0.2682	-0.3842	-0.1049	-0.8814	-0.3262
	P	**0.0010**	**0.0040**	**0.0000**	**0.0300**	**0.0000**	0.6190	**0.0220**	**0.0080**	**0.0010**	**0.0010**	0.6300	**0.0000**	0.1097