

TRENDS IN NUMBERS OF MIGRANT BIRDS AT LONG POINT BIRD OBSERVATORY (1961-2004) AND THUNDER CAPE BIRD OBSERVATORY (1995-2004)



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EXECUTIVE SUMMARY

In 2004, migration monitoring at Long Point Bird Observatory (LPBO) was carried out at three stations (Tip, Breakwater, Old Cut) for the 44th consecutive year (1961-2004) and at Thunder Cape Bird Observatory (TCBO) for the 10th consecutive year (1995-2004). Annual population indices, based on migration counts, were estimated using multiple regression to reduce the variance in daily counts associated with weather and season. Annual indices were then used to estimate population trends using polynomial regression, ranging from 1st order (linear) to 8th order for LPBO data and from 1st order to 2nd order for TCBO data.

Overall, the number of migrants that experienced declining trends increased in the past ten years (1994 to 2002-2004) at LPBO compared to overall long-term population trends from 1967-1969 to 2002-2004 and to the mean population change from 1961-1995 to 1995-2004. Upon comparison of average indices in the past five years to all previous five-year periods, it is also evident that in the past 10-15 years, there have been fewer significant increasing trends and a greater number of significant declining trends than at any previous five-year period since 1961. In the past ten years, trends of migrants passing through TCBO have also been predominantly negative, and this is true for both spring and fall migrants.

When trends were examined according to the Ministry of Natural Resources' Wildlife Population Program Monitoring Plan's habitat features, the same trend is evident, in that the majority of habitat feature guilds experienced a greater proportion of declining trends in the past ten years compared to all other time periods. However, because mean trends from 1961-1995 to 1995-2004 were primarily increasing, this suggests that current population levels of many species, although declining, are still above the mean annual indices over the long-term. Further years of migration monitoring data is required to determine if species experiencing population declines will continue to decline, and whether the number of species with declining trends will continue to rise.

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AND
THUNDER CAPE BIRD OBSERVATORY (1995-2004)**

by

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INTRODUCTION

Migration monitoring is a useful method to detect population trends over large geographic areas and those trends, defined as the geometric mean rate of population change over time (Francis and Hessel 1998), can be used as an early warning system to identify species of conservation concern. Counts of spring and fall migrants passing through three stations at Long Point Bird Observatory (LPBO) and one station at Thunder Cape Bird Observatory (TCBO) in Ontario have been collected since 1961 and 1995, respectively. The counts, or daily estimated totals (DETs), of birds passing through designated areas at each station were used to calculate annual population indices for spring and fall, and trends in annual indices were estimated for 64 species from LPBO and TCBO (although species differed between locations).

Many of the migrants passing through LPBO and TCBO were identified by the Ministry of Natural Resource's (MNR) Provincial Wildlife Population Program Monitoring Plan as representative species, i.e., they are expected to benefit from specific successional stages and/or habitat types and features that are created through forest management practices on Crown Land in Ontario (Ontario Ministry of Natural Resources 2004). In coordination with the Terrestrial Assessment Program (TAP; formerly Wildlife Assessment Program), Bird Studies Canada (BSC) examined whether the population trends of migrants that depend on specific habitat features (dead/downed wood, snags, riparian zones, mature/overmature forest stands, large areas of similar successional stage, and for habitat managed for Moose and Marten or Pileated Woodpecker and White-tailed Deer) were consistently increasing or declining, in an effort to facilitate understanding of why populations may be changing.

This document describes the field methods used to collect the data, the statistical methods used to obtain population indices from raw field data, and the results of trend analyses for LPBO and TCBO using polynomial regression.

METHODS

DAILY ESTIMATED TOTALS

Population indices are based on daily "estimated totals" (ETs), which are estimates of the number of each species of migrant present, or passing through a designated area, on a given day and during a standard count period. At LPBO, ETs were collected from three different stations (Old

Cut, Breakwater, Tip) and were derived from: a standardized daily census (in which all birds seen or heard on a specific route within the census area were counted over a one-hour period), banding totals (based on non-standardized banding), and general observations. However, not all stations were run every year, or on the same days each year. At TCBO, the procedure for determining ETs was standardized to include a fixed time for banding and observations (daybreak to 7 hours after sunrise). Details of the methods, and justifications for using ETs, are given in McCracken *et al.* (1993) and Wojnowski *et al.* (2000). The methods adopted at TCBO were consistent with the recommendations of Hussell and Ralph (1996).

ABUNDANCE INDICES

The number of birds detected in a census area on a given day reflects many different factors, including population level (the factor to be indexed), seasonal variation, weather conditions, phase of the moon and additional variation (error). Factors such as time in the season and certain weather variables (i.e., the passage of cold fronts in autumn) can affect the number of birds migrating on a given day, whereas factors such as cloud cover, rain, or phase of the moon can affect the number of birds that stop at a station.

By modelling variation in these additional factors, variation in the ETs can be reduced, which results in indices that more closely reflect true population changes for a species (see Hussell *et al.* 1992), and might result in increased sensitivity of the analyses for detecting population change. For the present analyses, we used multiple regression to estimate relationships between daily estimated totals and various external factors, such as weather and time of year, and then used those relationships to adjust the counts and produce annual population indices. Factors included in the equation were date (within a season), cloud cover, wind speed, wind direction, temperature and phase of the moon. Some of these variables were adjusted using linear terms, while others were adjusted using second or higher order polynomial terms. All variables were assumed to interact additively on a log scale (multiplicatively on the original scale), but to have independent effects at each of the three stations at LPBO.

For LPBO data, area effects were modelled using dummy variables so that data from all three stations could be included together (see Hussell *et al.* 1992, Francis and Hussell 1998 for further details). For LPBO and TCBO, indices were calculated separately for spring and fall data. Analyses were restricted to the migration window for each species, i.e., when most individuals of the species migrated. The migration window for each species was determined by excluding early or late records separated by more than 4 days from the next record, and by using only the middle 98% of occurrence days. In addition, if a small breeding population of a species occurred at a station, the late spring cut-off and the early fall cut-off were selected to exclude periods when more than half of individuals detected were probably resident in the area. This involved a judgement call in many cases, but additional analyses suggested that results were not strongly affected by the precise cut-off date used.

WEATHER DATA

Long Point Bird Observatory

For LPBO, complete hourly weather data from 1961-2004 were obtained from the U.S.

meteorological station for Erie, PA, for cloud cover, horizontal visibility, wind speed, wind direction, temperature, relative humidity, station pressure and ceiling height. Since 1961, a few changes occurred in the weather data for this station. In 1995, the weather station was automated and the wind measurement changed from a 1-minute mean to a 2-minute mean. Neither of these changes likely had an effect on the weather data, with the exception of Total Sky Cover (i.e. cloud cover). When the station became automated, opaque sky cover was no longer recorded, and sky cover was only recorded up to a height of 12000 ft (about 3600 m). Thus, after 1995, cloud cover above 12000 ft was recorded as clear sky. Although not critically evaluated, an analysis of ceiling height and cloud cover from earlier years suggested that total cloud cover above 12000 ft was not common, and this change likely had little effect on our analyses.

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For TCBO, hourly weather data from the Thunder Bay airport weather station were obtained for the months of April to November inclusive from 1991-2004 for cloud cover, horizontal visibility, wind speed, wind direction, temperature, relative humidity, station pressure and ceiling height. Relative humidity, station pressure and ceiling height have not been used in standard Canadian Migration Monitoring Network trend analyses, but should be tested for their usefulness in predicting bird abundance at TCBO and LPBO in the future.

POPULATION TRENDS

For the analysis of long-term population trends, polynomial regression often provides a better approximation to the true population trajectory than does linear regression. According to Tabachnik and Fidell (1989, in Hussell unpublished manuscript), a minimum of five cases (years) are recommended per independent variable for any multiple regression. Thus, because 44 years of data (1961-2004) were available for LPBO and 10 years of data (1995-2004) were available for TCBO, spring and fall polynomial models were fitted ranging from 1st order (linear) to 8th order on the log-transformed indices from LPBO and from 1st order to 2nd order on the log-transformed indices from TCBO (five years per polynomial term) (SAS 2001). An exception to this was the fall polynomial model for Snow Bunting at TCBO: the 1st order model was used to estimate trends because only nine annual indices were calculated for this species due to poor data coverage.

In addition to spring and fall trends, we also estimated a combined trend for spring and fall by allowing the population trajectories to differ when models were fit, but assuming that the overall trend did not differ between seasons. If combined trends were a significantly worse fit than the model that allowed trends to differ, the combined trend was not reported. In all cases, the most parsimonious model among the polynomial models tested (model with the lowest order that adequately fit the data) was selected using Akaike's Information Criterion (AIC; SAS 2001). Species were included in trend analyses if an average of at least 10 individuals were recorded per season per year on an average of at least 5 days, and at least one individual of a species was recorded in every year of coverage.

There were two components to testing the significance of population changes based on polynomial regression models. The first was to determine whether there was evidence for overall population change. If a 1st order (linear) model was selected by AIC, a slope significantly

different from zero provided evidence for overall population change. Alternatively, a non-linear model selected by AIC was also evidence for significant overall population change. To accomplish this first component, polynomial regression models were re-parameterized following the methods in Hussell (unpublished manuscript; see also Francis and Hussell 1998) to estimate and test the significance of overall population change between the average indices of the first three years and the average indices for the last three years (LPBO: 1967-1969 to 2002-2004; TCBO: 1995-1997 to 2002-2004). The mean of the first and last three years was used to estimate trends because the ends of a polynomial-fit curve are often strongly influenced by the first and last years of data. Therefore, basing the estimate on the mean reduced the sensitivity of the model to poor estimates of the shape of the curve at the endpoints. For LPBO, although all years (1961-2004) were used to fit the polynomial model, long-term trends were estimated using data from 1967 forward, as opposed to 1961 forward, because data were patchy and relatively unreliable when monitoring first began. Also, Breeding Bird Survey (BBS) data began in 1968, and this starting point will provide for easy comparisons with BBS in the future.

The second component to testing the significance of population change based on polynomial models involved testing whether the population levels in recent years were similar to those in the past. We tested this in three ways using LPBO data (again, by re-parameterizing the polynomial models following the methods of Hussell (unpublished manuscript): by examining recent population change (1994 to 2002-2004), by testing the average population change between the most recent ten years and all previous years (1961-1995 to 1995-2004), and by comparing the average population indices in the past five years to the average of all preceding five-year periods (2000-2004 to 1995-1999, 1990-1994, etc.). Because only 10 years of data were available for TCBO, the second component to the analysis of population trends was not applicable.

Population trends from LPBO and TCBO are discussed in the context of seasonal differences and according to the habitat features identified by the MNR's Provincial Wildlife Population Program Monitoring Plan (Appendix 1). Although combined seasonal trends are presented in the tables, combined trends should be interpreted with caution because while spring migrants generally follow a north-south migration axis, fall migrants at LPBO and TCBO can migrate from both north-western and north-eastern Canada (Dunn *et al.*, unpublished manuscript), and populations being sampled might therefore differ. Plots of annual indices and estimated population trajectories for each species analyzed are presented in Appendix 2 (LPBO) and Appendix 3 (TCBO).

CORRELATION OF LPBO AND TCBO SPECIES TRENDS

The similarity of species trends from LPBO to species trends at TCBO was examined by testing the correlation of LPBO species trends to TCBO species trends in both spring and fall. To do so, LPBO data were re-analyzed for the 1995-1997 to 2002-2004 time period, and the correlation of the obtained annual population indices was compared to the annual population indices at TCBO over the same time period. Polynomial regression (up to 2nd order for both LPBO and TCBO) was used to calculate trends, which were compared using Spearman Rank Correlation (Proc Corr; SAS 2001).

RESULTS

SEASONAL DIFFERENCES IN POPULATION TRENDS

Long Point Bird Observatory

Long-term Population Change (1967-1969 to 2002-2004). Of the 62 species that had data for both spring and fall migration at LPBO, long-term trends of 39 species (63%) did not differ significantly between seasons, and a combined trend was calculated (Table 1). The combined trend of the majority of those species was positive (67%). Of those species with trends that did differ significantly between seasons, 13 species experienced negative trends in spring and positive trends in fall (trends of Brown Creeper, Cape May Warbler, Dark-eyed Junco, Fox Sparrow and Winter Wren were significant in both seasons), and another seven species experienced positive trends in spring, but negative population trends in fall (trends of Gray-cheeked Thrush were significant in both seasons; Table 1).

Overall, 53% (34/64) of spring migrants showed increasing population trends from 1967-1969 to 2002-2004, of which 88% (30/34) increased significantly (Table 2). The remaining 30 spring migrants (47%) declined in population size, 15 significantly. Chipping Sparrow, Yellow Warbler, Warbling Vireo and Blue-gray Gnatcatcher showed the largest increases in long-term spring population indices (4.8%/year, 4.6%/year, 4.6%/year and 4.4%/year, respectively). Eastern Towhee, Red-headed Woodpecker and Brown Thrasher showed the largest average population declines (-5.2%/year, -3.4%/year and -3.1 %/year, respectively; Table 1).

In fall, a greater proportion of migrants experienced positive population trends than in spring. Sixty-eight percent (42/62) of fall migrants increased in population size, although only 64% of those species (27/42) increased significantly (Table 2). Of the remaining 20 fall migrants, 60% (12/20) declined significantly. Blue-gray Gnatcatcher, Eastern Phoebe and Warbling Vireo experienced the greatest population increases since 1967-1969 (5.9%/year, 3.8%/year and 3.7%/year, respectively). Red-headed Woodpecker, Savannah Sparrow and Brown Thrasher experienced the greatest long-term population declines (-2.1%/year, -2.1%/year and -1.9%/year, respectively; Table 1).

Mean Population Change (1961-1995 to 1995-2004). Population trends of 48% (30/62) of species that had data for both spring and fall did not differ significantly between seasons, and a combined trend was calculated (Table 3). Combined trends of 73% percent of those species were positive; the other 27% were negative. Of the remaining 32 species, 19 differed in the direction of trend between seasons: 11 species showed positive trends in spring and negative trends in fall (trends of Blackburnian Warbler and Ovenbird were significant in both seasons); the remaining eight species showed negative trends in spring and positive trends in fall (trends of Brown Creeper and Fow Sparrow were significant in both seasons; Table 3).

In spring, 67% (44/64) of migrants increased in population size from 1961-1995 to 1995-2004, 86% (38/44) of which increased significantly (Table 2). Of the 20 species that showed declining trends over this time period, 50% (10/20) were statistically significant. Yellow Warbler, Chipping Sparrow and Blue-gray Gnatcatcher showed the largest mean population increases

from 1961-1995 to 1995-2004 (6.9%/year, 6.6%/year and 5.8%/year, respectively). Eastern Towhee, Red-headed Woodpecker and Fox Sparrow showed the largest significant declines in population indices (-3.2%/year, -2.8%/year and -2.4%/year, respectively; Table 3).

Compared to spring migrants, fall migrants experienced a greater percentage of negative population trends (23/62, or 37%) from 1961-1995 to 1995-2004 (Table 2), although the occurrence of positive trends still outnumbered the occurrence of negative trends by a factor of 1.6 (38:23). Approximately 87% (33/38) of all positive fall trends and 57% (13/23) of all negative fall trends were statistically significant. Blue-gray Gnatcatcher, Eastern Phoebe and Chipping Sparrow experienced the greatest population increases (5.6%/year, 5.0%/year and 4.5%/year, respectively), while Bay-breasted Warbler, Tennessee Warbler and Red-headed Woodpecker experienced the greatest population declines (-3.7%/year, -2.6%/year and -2.2%/year, respectively; Table 3).

Recent Population Change (1994 to 2002-2004). For the analysis of recent population change at LPBO, 41 of the 62 species with spring and fall data did not differ significantly between seasons, and a combined trend was calculated. Sixty-eight percent of those individuals experienced negative combined trends, the remaining 32% experienced positive combined trends (Table 3). Of those species that experienced significantly different trends between seasons, five species showed positive trends in spring and negative trends in fall (trends of Gray-cheeked Thrush and Yellow Warbler were significant in both seasons) and another five species showed negative trends in spring and positive trends in fall (trends of Fox Sparrow and Northern Flicker were significant in both seasons).

From 1994 to 2002-2004, 41% (26/64) of the species analyzed experienced increasing population trends in spring, but only 35% (9/26) of trends increased significantly (14% of all spring migrants; Table 2). On the other hand, 59% (38/64) of spring migrants experienced population declines, 50% (19/38) of which were significant. Thus, in the past 10 years, 30% of all migrants passing through LPBO experienced statistically significant population declines in spring. Warbling Vireo, Gray Catbird and Yellow Warbler showed the greatest population increases (8.3%/year, 7.7%/year and 7.2%/year, respectively). Cape May Warbler, Tennessee Warbler, Winter Wren and Brown Creeper showed the greatest population declines (-10.9%/year, -10.1%/year and -9.4%/year, respectively; Table 3).

Compared to long-term and mean population trends, a greater number of migrants also experienced population declines in fall during the past 10 years. Sixty-three percent of fall migrants showed population declines, 52% (17/33) of which were statistically significant (Table 2). The other 47% of fall migrants experienced increasing population trends (29/62), of which 34% (10/29) were significant. Winter Wren, Hermit Thrush and Least Flycatcher experienced the greatest overall population declines (-9.4%/year, -5.7%/year and -2.4%/year, respectively). White-crowned Sparrow, Blue-headed Vireo and Fox Sparrow experienced the greatest population increases (12.3%/year, 7.7%/year and 6.6%/year, respectively; Table 3).

Recent Population Change Compared to All Previous 5-Year Periods.

Between the first four 5-year periods of migration monitoring (1961-1964, 1965-1969, 1970-

1975, 1975-1979) and the past 5 years (2000-2004) at LPBO, the number of species that showed significant positive population trends increased over time in both spring and fall, while the number of species that experienced significant negative trends did not show much variation (Figure 1). From 1980-1984 to 2000-2004, and all subsequent five-year comparisons, the number of species that experienced significant positive population trends began to decline (from 40 and 35 significant positive trends from 1975-1979 to 1995-2004 in spring and fall, respectively, to 7 and 10 significant positive population trends from 1995-1999 to 2000-2004 for spring and fall, respectively). Over the same time period, the number of species that showed significant negative trends in spring and fall increased, but at a slower rate than the decline of positive population trends. Since approximately 1990, the number of species with significant negative trends has outnumbered the number of species with significant positive trends in both spring and fall.

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Long-term Population Change (1995-1997 to 2002-2004). Sixty-four species of migrants were analyzed for population change using data gathered at TCBO. Of those, 43 species had spring and fall data, and trends of 38 species did not differ significantly between seasons and a combined trend was calculated (Table 4). Seventy-nine percent of species experienced a negative combined trend (30/38), 60% (18/30) of which were significant. Of the eight species that experienced positive combined trends, only one changed significantly (Ruby-throated Hummingbird: 4.2%/year). Trends of five species did differ significantly between seasons, but only the Red-eyed Vireo experienced a change in the direction of trend between spring and fall, with a positive trend in spring and negative trend in fall. Although the percent change in both seasons was greater than 4%/year for Red-eyed Vireo, neither trend differed significantly from zero.

In the past 10 years, 24% (10/42) of spring migrants experienced population increases (Table 5), but only Indigo Bunting and White-crowned Sparrow increased significantly (17.9%/year and 17.8%/year, respectively; Table 4). The remaining 76% (32/42) of spring migrants experienced population declines, 28% of which (9/32) declined significantly (Table 5). Cape May Warbler, Common Yellowthroat and Ruby-crowned Kinglet experienced the greatest spring population declines (-16.4%/year, -15.1%/year and -13.2%/year, respectively; Table 4).

As in spring, a greater number of fall migrants passing through TCBO experienced population declines than population increases in the past 10 years. In total, 68% (42/62) of fall migrants showed negative population trends, 33% (14/42) of which were significant (Table 5). The remaining 32% (20/62) of fall migrants increased in population size, but only 20% (2/20) increased significantly. Snow Bunting, Blackpoll Warbler and Blue-headed Vireo showed the greatest population increases in fall (9.2%/year, 7.5%/year and 7.3%/year respectively). Northern Saw-whet Owl, Cape May Warbler and Yellow-rumped Warbler experienced the greatest population declines (-22.0%/year, -13.4%/year and -11.6%/year, respectively; Table 4).

TREND ESTIMATES BY HABITAT FEATURE

Dead and Downed Wood

At LPBO, both species associated with dead and downed wood, Dark-eyed Junco and Winter Wren, experienced significant negative trends in spring and significant positive trends in fall from 1967-1969 to 2002-2004 (Tables 1,2). From 1961-1995 to 1995-2004, this pattern was also observed, but the observed population declines were small ($< -0.8\%/year$) and non-significant in spring (Table 3). In the most recent 10 years, however, both species declined significantly in spring ($p < 0.001$) and Winter Wren also declined significantly in fall ($-7.04\%/year$, $p < 0.01$; Table 3). The combined trend for Winter Wren, calculated using the most recent 10 years of data, was also negative and highly significant ($-8.1\%/year$, $p < 0.0001$). Dark-eyed Junco did not change from 1994 to 2002-2004.

At TCBO, trends were not calculated for Winter Wren and Dark-eyed Junco in spring (Table 4). However, fall trends in annual indices were negative but non-significant from 1995-1997 to 2002-2004 for both species (Tables 4,5).

Snags

From 1967-1969 to 2002-2004, two of four snag-dependent species (Brown Creeper and Northern Flicker) declined significantly in spring and one species, Yellow-bellied Sapsucker, increased significantly (Tables 2,3). In fall, only Brown Creeper showed a significant trend, at $1.2\%/year$ ($p < 0.05$). Mean population changes from 1961-1995 to 1995-2004 were positive and significant for two of four species in spring, Great Crested Flycatcher and Yellow-bellied Sapsucker, while Brown Creeper declined significantly in spring and increased significantly in fall, as observed over the long term. In the most recent 10 years, however, three of four species experienced relatively large, significant population declines in spring (minimum $-3.5\%/year$; Table 3). In particular, Brown Creeper declined by $-9.3\%/year$ ($p < 0.0001$) in the past 10 years. Yellow-bellied Sapsucker was the only species to increase significantly in spring and non-significantly in fall over all three time periods (Table 3).

At TCBO, data were not available for snag-dependent species in spring. In fall, two of four species declined in population size, the other two increased, all non-significantly, from 1995-1997 to 2002-2004 (Table 5). Northern Saw-whet Owl showed the largest population change, at $-22.0\%/year$ (Table 4), but large year-to-year variation likely decreased the precision of trend estimates (see Appendix 3).

Mature/Overmature

In spring, three of five species that passed through LPBO and required mature to over-mature forest habitat increased significantly in population size from 1967-1969 to 2002-2004 (Table 2). Four of the five species also showed a mean significant increase in population size from 1961-1995 to 1995-2004. In the past 10 years, however, only one species, Yellow-bellied Sapsucker, continued to increase significantly in population size in spring, while two species, Golden-crowned Kinglet and Ruby-crowned Kinglet, showed significant spring declines ($-8.1\%/year$, $p < 0.05$; $-3.7\%/year$, $p < 0.05$; Table 3).

In fall, only one species, Golden-crowned Kinglet, changed significantly from 1967-1969 to 2002-2004 (2.2%/year, $p < 0.05$; Table 1); two species, Golden-crowned Kinglet and Ruby-crowned Kinglet increased significantly from 1961-1995 to 1995-2004 (3.3%/year, $p < 0.001$; 1.9%/year, $p < 0.05$); and no species increased significantly in fall over the past 10 years (Tables 2,3). Least Flycatcher did, however, decline significantly in fall from 1994 to 2002-2004 (-6.2%/year, $p < 0.01$; Table 3).

Between 1995-1997 and 2002-2004 at TCBO, data for three species that depend on mature to overmature forest stands were available for analysis of spring trends. Two of these species, Ruby-crowned Kinglet and Least Flycatcher, declined in population size, while Red-eyed Vireo increased in population size, all non-significantly (Tables 4,5). In fall, five of six migrants at TCBO that are associated with mature/overmature habitat experienced population declines in the past 10 years, although only Least Flycatcher declined significantly (-7.0%/year, $p < 0.1$). Combined spring/fall trends for Ruby-crowned Kinglet and Least Flycatcher were negative and significant ($p < 0.1$; $p < 0.05$, respectively; Table 4).

Large Areas

In spring, six of the 12 species at LPBO that require large areas of habitat in a similar successional stage experienced significant increasing population trends from 1967-1969 to 2002-2004 (Table 2). For eight of 12 species, mean percent change in population size between 1961-1995 and 1995-2004 was also positive and significant, but no species that require large areas increased significantly in population size from 1994 to 2002-2004 (Table 2). Alternatively, Veery was the only species to show long-term, mean spring population declines (-0.6%/year, $p < 0.1$ for 1967-1969 to 2002-2004 and 1961-1995 to 1995-2004). In the past 10 years, Veery, Great Crested Flycatcher and Hermit Thrush declined significantly (-0.6%/year, $p < 0.1$; -3.5%/year, $p < 0.05$; -5.6%/year, $p < 0.001$; Tables 1,2).

Compared to spring, species associated with large areas experienced fewer significant increasing population trends and more significant declining population trends in fall during all three time periods examined (Table 2). From 1967-1969 to 2002-2004, two species increased significantly and three species decreased significantly in population size; from 1961-1995 to 1995-2004, four species increased significantly and four species decreased significantly in population size; and in the past 10 years, only Black-and-white Warbler increased significantly in population size (0.7%/year, $p < 0.05$), but five of 12 species showed significant population declines (Tables 2,3).

At TCBO, seven of eight area-dependent species with data in spring experienced population declines between 1995-1997 and 2002-2004 (Table 5). Two species, Black-and-white Warbler and American Redstart, declined significantly (-6.3%/year, $p < 0.1$; -5.5%/year, $p < 0.05$; Table 4). In fall, 10 species that depend on large areas of forested habitat passed through TCBO, and all 10 experienced population declines. Fall declines were significant for Chestnut-sided Warbler and Least Flycatcher ($p < 0.1$).

Riparian

One species that requires riparian habitat, Common Yellowthroat, was analyzed at LPBO. Long-term (1967-1969 to 2002-2004) and mean (1961-1995 to 1995-2004) population change for this species was positive and significant in spring, fall, and when seasons were combined (Table 2). In the most recent 10 years, population trends for Common Yellowthroat were also positive in both spring and fall, but only the fall trend was significant ($p < 0.0001$; Table 3).

Alternatively, at TCBO, both Common Yellowthroat and Alder Flycatcher experienced negative population trends in both spring and fall (Tables 4,5). Significant trends were observed for Common Yellowthroat in spring ($-15.1\%/year$, $p < 0.05$) and for Alder Flycatcher ($-7.4\%/year$, $p < 0.1$) in fall and spring/fall combined ($-6.6\%/year$, $p < 0.05$).

Early Successional

Only two species that are associated with early successional habitat, Mourning Warbler and White-throated Sparrow, were detected frequently enough for analysis at LPBO and TCBO. At LPBO, Mourning Warbler experienced long-term (1967-1969 to 2002-2004) and mean (1961-1995 to 1995-2004) significant increasing population trends in spring, but did not change significantly in fall (Tables 1,3). During the most recent 10 years, both spring and fall trends for this species were negative but non-significant at both LPBO and TCBO (Tables 3,4).

On the other hand, White-throated Sparrow experienced a significant declining population trend in spring from 1967-1969 to 2002-2004 at LPBO (Table 1), a significant increasing population trend in fall from 1961-1995 to 1995-2004, and a non-significant increasing trend from 1994 to 2002-2004 (Table 3). At TCBO, on the other hand, White-throated Sparrow declined non-significantly in both spring and fall from 1995-1997 to 2002-2004 (Table 4).

Moose and Marten Habitat Guidelines

Two species that are expected to benefit from habitat managed for moose and marten, Bay-breasted Warbler and Palm Warbler, were detected in spring and fall at LPBO and TCBO. Bay-breasted Warbler declined in population size during spring and fall for all time periods examined at LPBO and TCBO (declines were significant for all but spring at TCBO from 1995-1997 to 2002-2004; Tables 2,3,4). At LPBO, declines were greater and more highly significant in the most recent 10 years compared to the overall long-term population trend.

Palm Warbler, on the other hand, increased significantly in population size in spring from 1967-1969 to 2002-2004 and in spring and fall from 1961-1995 to 1995-2004 at LPBO (Tables 1,3). Recent changes, however, suggested Palm Warbler declined significantly in spring and fall at LPBO and in fall at TCBO (Tables 3,4).

Pileated Woodpecker and White-tailed Deer Habitat Guidelines

Three migrants that pass through LPBO and TCBO were expected to benefit from habitat managed for Pileated Woodpeckers and White-tailed Deer. Two of the three, Black-throated

Blue Warbler and Magnolia Warbler, showed significant positive population trends ($p < 0.001$) in spring and fall over the long term (1967-1969 to 2002-2004) and between 1961-1995 to 1995-2004 at LPBO (Tables 1,2,3). In the past 10 years, however, neither species experienced a significant trend at LPBO (Tables 2,3). Swainson's Thrush experienced a significant declining trend in fall at LPBO during all time periods.

At TCBO, Magnolia Warbler declined significantly in both spring and fall from 1995-1997 to 2002-2004, Black-throated Blue Warbler did not change significantly in either season, and Swainson's Thrush, declined significantly in fall during all time periods (Table 4).

CORRELATION OF LPBO AND TCBO SPECIES TRENDS

Both spring and fall trends from LPBO and TCBO for the period of 1995-1997 to 2002-2004 were significantly correlated (Spring: $n = 34$ species, Spearman Rank Correlation = 0.44, $p = 0.01$; Fall: $n = 46$ species, Spearman Rank Correlation = 0.43, $p = 0.003$), although trends at TCBO tended to be more negative than those at LPBO (Figure 2).

DISCUSSION

Overall, the number of declining trends has increased in the past 10 years at LPBO compared to overall population change from 1967-1969 to 2002-2004 and mean population change from 1961-1995 to 1995-2004. In the past 10 years, trends of migrants passing through TCBO have also been predominantly negative.

Although there has been a predominance of declining species trends in the most recent 10 years, mean indices at LPBO from 1995-2004 were on average greater than the mean indices from 1961-1995. This suggests that although many species are currently declining in population size, most populations remain above the long-term mean. Hermit Thrush, for example, experienced positive mean population change between 1961-1995 and 1995-2004 (based on combined spring/fall trend), but experienced a large population decline in the past 10 years ($-6.0\%/year$, $p < 0.0001$). Examination of the change in indices over time for this species suggests that despite the current decline, indices are not abnormally low (Appendix 2).

However, upon examination of average indices in the past five years at LPBO (2000-2004) compared to the average indices in all previous five-year periods, it is evident that over the past 15 years there have been fewer significant increasing population trends and more significant decreasing population trends in both spring and fall than at any time in the past (since 1961). Further years of migration monitoring are required to determine if the species experiencing population declines will continue to decline, and whether the number of species with declining trends will continue to rise. In either case, several species, including Black-throated Blue Warbler and Yellow Warbler, have persistently increased in population size during all time periods at LPBO and TCBO.

In general, a greater proportion of habitat feature indicator species showed declining population trends in spring and fall from 1994 to 2002-2004 at LPBO compared to the other time periods examined, with the exception of spring and fall trends of riparian species, spring trends of

species associated with early successional habitat and spring trends of species expected to benefit from habitat managed for Pileated Woodpeckers and White-tailed Deer, all of which experienced the same number of increasing and declining trends across all time periods. At TCBO, none of the MNR's habitat feature indicator species experienced significant increasing trends from 1995-1997 to 2002-2004, but significant declines were observed in spring, fall and when seasons were combined.

Although the cause behind population changes of migratory birds cannot be determined from migration monitoring alone, population trends of indicator species was examined in relation to their associated habitat features. Common Yellowthroat, for example, was the only riparian indicator species monitored at LPBO, and it experienced an increasing population trend in all seasons and time periods. This might suggest that the amount of riparian habitat available to this species is sufficient to maintain the current population level. At TCBO, however, both Common Yellowthroat and Alder Flycatcher, another riparian species, experienced spring and fall population declines between 1995-1997 and 2002-2004. According to Dunn *et al.* (unpublished manuscript), feather isotope analysis suggested that warblers migrating through TCBO in fall probably originated from northern Saskatchewan, Manitoba and northwestern Ontario, whereas LPBO is more of a transition zone, with migrants originating from the maritimes as well. Although isotope data were not available for Common Yellowthroat and Alder Flycatcher, it is possible that the two migration monitoring stations are sampling separate breeding populations of these species. Feather isotope analysis should continue, in particular for species that are experiencing both recent and long-term population declines, to determine where the birds are originating from, and whether habitat quality and quantity is sufficient to maintain breeding populations in those areas.

Compared to the other habitat feature species guilds, species associated with large areas of habitat in a similar successional stage and mature to overmature forest habitat experienced a particularly large proportion of population declines in spring and fall, especially during the most recent 10 years. At LPBO, seven of 12 species declined in spring and 11 of 12 species declined in fall between 1994 and 2002-2004. At TCBO, seven of eight area-dependent species monitored in spring, and all 10 species monitored in fall, experienced population declines between 1995-1997 and 2002-2004. These species are associated with a variety of habitat types, from hardwood, mixedwood, to red and white pine, in both the boreal and Great Lakes-St. Lawrence forest regions, and results suggest that large contiguous areas of these forest types might be in decline.

Similarly, species associated with mature to overmature forest habitat and habitat managed for moose and marten also experienced a greater proportion of negative spring and fall population trends in the past 10 years compared to the other time periods examined at both LPBO and TCBO. These results might suggest that the amount of mature to overmature forest and the amount of edge habitat (preferred by moose and marten) might also be in decline. However, long-term trends for several of these species were positive, and further years of data are necessary to determine whether the recent declines observed will continue. Research which examines the amount and quality of each habitat feature across breeding sites is also necessary to determine whether these trends are, in fact, correlated to changes in the amount and/or quality of the habitat features, or whether other factors, such as climate change or changes on the wintering

grounds, might be influencing the population status of migratory birds.

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Table 1 – Estimated annual percentage change in numbers of migrant landbirds passing through LPBO between 1967-1969 and 2002-2004 based on polynomial regressions (1st to 8th order as selected by A.I.C.) on indices derived from daily estimated totals. The combined spring/fall analysis is only present if the seasons were not significantly different. Species are listed according to the Habitat Features of interest to the OMNR's Terrestrial Assessment Program; species with an * are associated with more than one habitat feature.

Habitat Feature Species	Spring			Fall			Combined	
	Trend	p	Order	Trend	p	Order	Trend	p
Dead and Downed Wood								
Dark-eyed Junco	-2.16	**	(4)	1.02	+	(3)		
Winter Wren	-1.92	**	(8)	1.43	*	(6)		
Snags								
Brown Creeper	-1.38	*	(3)	1.17	*	(7)		
Great-crested Flycatcher*	-0.43		(8)	0.21		(6)	-0.07	
Northern Flicker	-2.38	****	(8)	0.3		(7)		
Yellow-bellied Sapsucker*	1.07	*	(2)	0.11		(1)	0.05	
Mature/Overmature								
Golden-crowned Kinglet	-1.74		(7)	2.2	*	(7)		
Least Flycatcher*	1.04	*	(3)	-0.54		(7)		
Red-eyed Vireo*	2.74	****	(3)	-0.17		(1)		
Ruby-crowned Kinglet	-0.5		(5)	0.91		(7)	0.26	
Yellow-bellied Sapsucker*	1.07	*	(2)	0.11		(1)	0.05	
Large Areas								
American Redstart	2.1	****	(3)	1.46	***	(3)	1.45	***
Black-and-White Warbler	1.35	**	(4)	0.74	*	(1)	0.95	***
Chestnut-sided Warbler	1.78	***	(6)	0.62		(3)		
Great-crested Flycatcher*	-0.43		(8)	0.21		(6)	-0.07	
Hermit Thrush	-0.31		(4)	0.01		(6)	-0.14	
Least Flycatcher*	1.04	*	(3)	-0.54		(7)		
Mourning Warbler*	0.78	+	(3)	0.72		(7)	0.88	*
Ovenbird	-0.37		(8)	-1.14	**	(1)	-0.93	**
Red-eyed Vireo*	2.74	****	(3)	-0.17		(1)		
Rose-breasted Grosbeak	0.01		(1)	-0.57		(7)	-0.18	
Scarlet Tanager	-0.8		(5)	-1.11	+	(1)	-1.01	*
Veery	-0.64	+	(1)	-0.89	+	(2)	-0.76	**
Riparian								
Common Yellowthroat	1.08	+	(8)	1.36	**	(2)	1.28	***
Early Successional								
Mourning Warbler*	0.78	+	(3)	0.72		(7)	0.88	*
White-throated Sparrow	-0.71	+	(2)	0.76		(6)		
Moose and Marten Habitat Guidelines								
Bay-breasted Warbler	-0.61	+	(2)	-1.25	*	(5)	-0.84	*
Palm Warbler	3.36	****	(5)	0.05		(5)		
Pileated Woodpecker and White-tailed Deer Habitat Guidelines								
Black-throated Blue Warbler	1.45	***	(8)	2	***	(4)	1.79	****
Magnolia Warbler	2.42	****	(3)	1.33	**	(3)	1.86	****
Swainson's Thrush	-0.35		(1)	-1.23	**	(3)		

+ p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001; **** p < 0.0001

Table 1 – Continued.

Habitat Feature	Spring			Fall			Combined	
Species	Trend	<i>p</i>	Order	Trend	<i>p</i>	Order	Trend	<i>p</i>
Other Species								
American Robin	2.18	**	(5)	3.68	****	(6)	2.99	****
Baltimore Oriole	1.19	*	(5)	-0.34		(8)	0.23	
Black-billed Cuckoo	-0.3		(3)	1.8	*	(3)		
Blackburnian Warbler	0.72		(8)	0.72		(4)	0.72	+
Blackpoll Warbler	2.52	***	(4)	2.04	***	(1)	2.2	****
Black-throated Green Warbler	1.46	**	(8)	1.12	*	(1)	1.34	**
Blue-gray Gnatcatcher	4.39	****	(8)	5.87	****	(5)	4.89	****
Blue-headed Vireo	0.78	*	(4)	3.05	****	(3)		
Brown Thrasher	-3.13	****	(8)	-1.87	*	(5)	-2.22	****
Canada Warbler	0.13		(1)	-0.74		(7)		
Cape May Warbler	-1.79	***	(3)	1.77	*	(8)		
Chipping Sparrow	4.79	****	(5)	3.61	****	(6)	4.16	****
Eastern Phoebe	2.72	**	(4)	3.82	****	(7)	3.33	****
Eastern Towhee	-5.18	****	(8)	0.75		(6)		
Eastern Wood-Pewee	1.44	**	(5)	1.85	****	(8)	1.87	****
Field Sparrow	-0.84		(5)	1.63	*	(5)		
Fox Sparrow	-2.35	***	(1)	1.54	**	(2)		
Gray Catbird	1.4	**	(8)	1.22	+	(4)	1.12	**
Gray-cheeked Thrush	1.18	**	(1)	-1.05	*	(3)		
House Wren	-0.44		(8)	0.51		(5)	0.12	
Indigo Bunting	1.49	+	(8)					
Lincoln's Sparrow	0.6	+	(1)	-0.03		(5)	0.38	
Nashville Warbler	-0.12		(8)	1.48	**	(7)		
Northern Waterthrush	-0.36		(8)	-0.94	+	(3)	-0.76	+
Philadelphia Vireo	1.38	**	(3)	-0.25		(1)		
Red-headed Woodpecker	-3.37	****	(5)	-2.09	*	(8)	-2.79	****
Savannah Sparrow	-0.4		(3)	-2.06	***	(1)		
Song Sparrow	-0.6		(5)	-1.61	**	(6)	-1.15	*
Swamp Sparrow	-2.69	***	(8)	-1.4		(6)	-1.81	**
Tennessee Warbler	-2.56	****	(7)	0.41		(8)		
Vesper Sparrow	-2.54	**	(5)	-1.74	*	(3)	-2.04	***
Warbling Vireo	4.57	****	(2)	3.71	****	(6)	4.27	****
White-crowned Sparrow	1.48	**	(2)	2.36	*	(8)	1.75	***
Wilson's Warbler	0.65		(8)	0.45		(3)	0.51	
Wood Thrush	-0.39		(1)					
Yellow Warbler	4.57	****	(8)	3.48	****	(8)	4.05	****
Yellow-bellied Flycatcher	1.68	*	(7)	0.7		(7)	1.19	**
Yellow-rumped Warbler	2.09	***	(8)	2.58	****	(3)	2.81	****

+ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

Table 2 – Summary of the number of increasing and decreasing species trends over various time periods (long-term trend = 1967-1969 to 2002-2004; mean change = 1961-1995 to 1995-2004; recent trend = 1994-2002-2004) and in relation to habitat features of interest to the MNR's Wildlife Population Monitoring Program Plan. Number of significant trends ($p < 0.1$) are in parentheses.

Habitat Feature	Time Period	Spring		Fall	
		Increase	Decrease	Increase	Decrease
Dead and Downed Wood					
	Long-term Trend	0 (0)	2 (2)	2 (2)	0 (0)
	Mean Change	0 (0)	2 (0)	2 (2)	0 (0)
	Recent Trend	0 (0)	2 (2)	1 (0)	1 (1)
Snags					
	Long-term Trend	1 (1)	3 (2)	4 (1)	0 (0)
	Mean Change	2 (2)	2 (1)	3 (1)	1 (0)
	Recent Trend	1 (1)	3 (3)	2 (1)	2 (0)
Mature/Overmature					
	Long-term Trend	3 (3)	2 (0)	3 (1)	2 (0)
	Mean Change	4 (4)	1 (0)	3 (2)	2 (0)
	Recent Trend	2 (1)	3 (2)	1 (0)	4 (1)
Large Areas					
	Long-term Trend	7 (6)	5 (1)	6 (2)	6 (3)
	Mean Change	11 (8)	1 (1)	4 (4)	7 (4)
	Recent Trend	5 (0)	7 (3)	1 (1)	11 (5)
Riparian					
	Long-term Trend	1 (1)	0 (0)	1 (1)	0 (0)
	Mean Change	1 (1)	0 (0)	1 (1)	0 (0)
	Recent Trend	1 (0)	0 (0)	1 (1)	0 (0)
Early Successional					
	Long-term Trend	1 (1)	1 (1)	2 (0)	0 (0)
	Mean Change	1 (1)	1 (0)	1 (1)	0 (0)
	Recent Trend	1 (0)	1 (0)	1 (0)	1 (0)
Moose and Marten Habitat Guidelines					
	Long-term Trend	1 (1)	1 (1)	1 (0)	1 (1)
	Mean Change	1 (1)	1 (1)	1 (1)	1 (1)
	Recent Trend	0 (0)	2 (1)	0 (0)	2 (1)
Pileated Woodpecker and White-tailed Deer Habitat Guidelines					
	Long-term Trend	2 (2)	1 (0)	2 (2)	1 (1)
	Mean Change	2 (2)	1 (0)	2 (2)	1 (1)
	Recent Trend	2 (0)	1 (0)	1 (0)	2 (1)
Other Species					
	Long-term Trend	22 (19)	15 (8)	24 (18)	12 (7)
	Mean Change	27 (24)	11 (7)	22 (19)	14 (7)
	Recent Trend	16 (8)	22 (9)	22 (7)	14 (9)
Grand Total					
	Long-term Trend	34 (30)	30 (15)	42 (27)	20 (12)
	Mean Change	44 (38)	20 (10)	38 (33)	23 (13)
	Recent Trend	26 (9)	38 (19)	29 (10)	33 (17)

Table 3 – Estimated percent change in mean population indices of migrant landbirds passing through LPBO in the past ten years (1994 vs. 2002-2004) and between 1961-1995 and 1995-2004. Estimates are derived from the polynomial models summarized in Appendix 1, and derived from daily estimated totals. The combined spring/fall analysis is presented if the spring and fall indices did not differ significantly. Species are listed according to the Habitat Features of interest to the OMNR's Terrestrial Assessment Program; species with an * are associated with more than one habitat feature.

	Recent Change (%/Year)						Mean % Change					
	1994 vs. 2002-2004						1961-1995 vs. 1995-2004					
	Spring Trend	<i>p</i>	Fall Trend	<i>p</i>	Combined Trend	<i>p</i>	Spring Trend	<i>p</i>	Fall Trend	<i>p</i>	Combined Trend	<i>p</i>
Dead and Downed Wood												
Dark-eyed Junco	-8.6	***	0.4				-0.8		1.5	**		
Winter Wren	-9.4	****	-7.0	**	-8.1	****	-0.5		1.6	**		
Snags												
Brown Creeper	-9.3	****	-2.1				-1.3	*	1.2	*		
Great-crested Flycatcher*	-3.5	*	-0.9		-2.1		1.0	**	-0.2		0.5	
Northern Flicker	-4.7	*	3.1	+			-0.1		0.5		0.2	
Yellow-bellied Sapsucker*	4.9	***	0.1				1.4	**	0.1		1.0	**
Mature/Overmature												
Golden-crowned Kinglet	-8.1	*	-3.0		-5.3	*	-0.7		3.3	***		
Least Flycatcher*	-2.4		-6.2	**			1.3	**	-0.6			
Red-eyed Vireo*	0.7		-0.2		-0.1		2.9	****	-0.2			
Ruby-crowned Kinglet	-3.7	*	-1.7		-2.3		0.9	+	1.9	**	1.4	***
Yellow-bellied Sapsucker*	4.9	***	0.1				1.4	**	0.1		1.0	**
Large Areas												
American Redstart	1.9		-0.3		-0.6		2.4	****	1.8	****	2.1	****
Black-and-White Warbler	-0.9		0.7	*	0.7	*	2.2	****	0.7	*		
Chestnut-sided Warbler	1.7		-2.6				2.1	****	0.8	+		
Great-crested Flycatcher*	-3.5	*	-0.9		-2.1		1.0	**	-0.2		0.5	
Hermit Thrush	-5.7	***	-6.3	**	-6.0	****	0.5		1.0	+	0.7	*
Least Flycatcher*	-2.4		-6.2	**			1.3	**	-0.6			
Mourning Warbler*	-1.4		-3.1		-1.6		1.0	*	0.0		0.4	
Ovenbird	-0.3		-1.1	**	-1.1	**	1.0	*	-1.1	**		
Red-eyed Vireo*	0.7		-0.2		-0.1		2.9	****	-0.2			
Rose-breasted Grosbeak	0.0		-1.9		-0.1		0.0		-2.1	***		
Scarlet Tanager	0.8		-1.1	+	-1.0	+	0.3		-1.1	+		
Veery	-0.6	+	-2.3	*	-0.7	*	-0.6	+	-1.0	*	-0.8	**
Riparian												
Common Yellowthroat	1.1		5.3	****	1.6		2.5	****	1.7	**	2.1	****
Early Successional												
Mourning Warbler*	-1.4		-3.1		-1.6		1.0	*	0.0		0.4	
White-throated Sparrow	0.4		2.2		0.9		-0.6		1.4	**		
Moose and Marten Habitat Guidelines												
Bay-breasted Warbler	-3.9	****	-5.2	*	-4.2	****	-0.9	*	-3.7	****		
Palm Warbler	-0.8		-2.4		-1.6		3.8	****	1.0	*		
Pileated Woodpecker and White-tailed Deer Habitat Guidelines												
Black-throated Blue Warbler	1.3		1.7		0.9		2.5	****	3.2	****	2.9	****
Magnolia Warbler	1.2		-2.1		-0.6		2.8	****	1.6	**		
Swainson's Thrush	-0.4		-5.0	**			-0.4		-1.1	**		

+ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

Table 3 – Continued.

Other												
American Robin	-0.9		2.2		0.8		3.0	****	4.4	****	3.7	****
Baltimore Oriole	3.7	*	3.8		3.7	*	2.5	****	1.6	*	2.2	****
Black-billed Cuckoo	2.6		2.7		2.7		0.4		2.8	***	.	
Blackburnian Warbler	-1.8		-0.5		-1.1		1.4	***	-1.0	+	.	
Blackpoll Warbler	3.9		2.0	***	2.1	****	4.0	****	2.0	***	.	
Black-throated Green Warbler	1.3		1.1	*	-0.2		1.7	****	1.1	*	1.3	****
Blue-gray Gnatcatcher	3.5		2.7		3.0	*	5.8	****	5.6	****	5.8	****
Blue-headed Vireo	2.6	*	7.7	***	.		1.5	****	3.0	****	.	
Brown Thrasher	-0.4		1.8		1.4		-1.6	***	-1.9	**	-1.7	****
Canada Warbler	0.1		-4.5	*	.		0.1		-1.6	***	.	
Cape May Warbler	-10.9	****	-3.1		.		-2.0	***	-1.4	*	-1.7	****
Chipping Sparrow	-0.2		1.9		0.8		6.6	****	4.5	****	.	
Eastern Phoebe	-3.2		1.2		-0.9		4.6	****	5.0	****	4.8	****
Eastern Towhee	-7.3	**	3.1		.		-3.2	****	0.6		.	
Eastern Wood-Pewee	-2.4		1.3		-0.5		1.4	**	2.2	****	1.7	****
Field Sparrow	-3.7	*	2.8		.		-0.2		2.0	**	.	
Fox Sparrow	-2.4	***	6.6	****	.		-2.4	***	2.0	***	.	
Gray Catbird	7.7	****	4.4	+	6.0	****	2.9	****	2.8	****	2.9	****
Gray-cheeked Thrush	1.2	**	-3.8	*	.		1.2	**	-0.6		.	
House Wren	-2.8		-5.9	+	-4.5	*	1.3	*	1.7	*	1.5	**
Indigo Bunting	0.1		.		.		4.2	****	.		.	
Lincoln's Sparrow	0.6	+	3.6		.		0.6	+	-0.7		.	
Nashville Warbler	-2.4		0.3		-1.1		1.4	**	1.1	**	1.3	****
Northern Waterthrush	-1.8		-5.8	**	.		1.9	***	-0.6		.	
Philadelphia Vireo	-1.9		-0.3		-0.3		1.5	**	-0.3		.	
Red-headed Woodpecker	0.2		2.4		1.3		-2.8	****	-2.2	**	-2.5	****
Savannah Sparrow	-3.1	+	-2.1	***	-2.1	****	-0.2		-2.1	***	.	
Song Sparrow	-4.4	+	-5.7	**	-5.2	**	0.1		-0.3		-0.1	
Swamp Sparrow	-6.6	**	-1.4		-3.3		-0.8		-0.4		-0.6	
Tennessee Warbler	-10.1	****	-2.8		.		-2.1	****	-2.6	****	-2.3	****
Vesper Sparrow	-3.2		1.3		-0.5		-2.2	**	-0.9		-1.5	**
Warbling Vireo	8.3	****	2.9	+	.		4.9	****	3.8	****	4.3	****
White-crowned Sparrow	5.0	****	12.3	***	.		1.8	***	2.0	**	1.9	****
Wilson's Warbler	2.5		-3.0	+	.		1.5	**	0.8		1.1	**
Wood Thrush	-0.4		.		.		-0.4		.		.	
Yellow Warbler	7.2	**	-4.9	*	.		6.9	****	2.3	****	.	
Yellow-bellied Flycatcher	-0.5		0.2		-0.2		1.4	*	0.2		.	
Yellow-rumped Warbler	-2.9	+	-3.4	+	-2.8	*	3.5	****	2.8	****	3.1	****

+ p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001; **** p < 0.0001

Table 4 – Estimated annual percentage change in numbers of migrant landbirds passing through TCBO between 1995-1997 and 2002-2004 based on polynomial regressions (1st to 2nd order as selected by A.I.C.) on indices derived from daily estimated totals. The combined spring/fall analysis is only present if the seasons were not significantly different. Species are listed according to the Habitat Features of interest to the OMNR's Terrestrial Assessment Program; species with an * are associated with more than one habitat feature.

	Spring			Fall			Spring/Fall	
	Trend	p	Order	Trend	p	Order	Trend	p
Dead and Downed Wood								
Dark-eyed Junco				-0.13		(1)		
Winter Wren				-1.52		(1)		
Snags								
Brown Creeper				3.44		(1)		
Northern Flicker				-0.77		(1)		
Northern Saw-whet Owl*				-21.98		(1)		
Yellow-bellied Sapsucker*				4.74		(1)		
Mature/Overmature								
Golden-crowned Kinglet				-5.81		(1)		
Least Flycatcher*	-7.90		(1)	-6.97 +		(1)	-7.4 *	
Northern Saw-whet Owl*				-21.98		(1)		
Red-eyed Vireo*	4.87		(1)	-4.16		(2)		
Ruby-crowned Kinglet	-13.22		(1)	-3.95		(2)	-8.7 +	
Yellow-bellied Sapsucker*				4.74		(1)		
Large Areas								
American Redstart	-5.54 *		(2)	-4.22		(1)	-4.9 +	
Black-and-White Warbler	-6.28 +		(1)	-2.69		(1)	-4.5 +	
Chestnut-sided Warbler	-0.22		(1)	-5.98 +		(2)		
Hermit Thrush				-6.78		(2)		
Least Flycatcher*	-7.90		(1)	-6.97 +		(1)	-7.4 *	
Mourning Warbler*	-8.03		(2)	-6.95		(1)	-7.4 *	
Ovenbird	-1.23		(1)	-4.02		(2)	-2.6	
Red-eyed Vireo*	4.87		(1)	-4.16		(2)		
Rose-breasted Grosbeak	-4.04		(2)	-2.68		(1)	-3.1	
Veery				-10.14		(2)		
Riparian								
Alder Flycatcher	-5.80		(2)	-7.45 +		(2)	-6.6 *	
Common Yellowthroat	-15.09 *		(1)	-0.24		(1)		
Early Successional								
Mourning Warbler*	-8.03		(2)	-6.95		(1)	-7.4 *	
White-throated Sparrow	-0.34		(1)	-2.69		(1)	-1.5	
Moose and Marten Habitat Guidelines								
Bay-breasted Warbler	-5.11		(1)	-9.69 *		(1)	-7.4 *	
Palm Warbler	-2.43		(2)	-6.59		(2)	-4.5	
Pileated Woodpecker and White-Tailed Deer Habitat Guidelines								
Black-throated Blue Warbler	-2.37		(2)	2.76		(2)	0.2	
Magnolia Warbler	-6.49 +		(1)	-7.17 **		(2)	-6.8 **	
Swainson's Thrush	-1.66		(1)	-9.89 *		(2)		

+ p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001; **** p < 0.0001

Table 4 – Continued.

Habitat Features	Spring			Fall			Spring/Fall	
Species	Trend	p	Order	Trend	p	Order	Trend	p
Other Species								
American Pipit				-1.80		(1)		
American Robin				1.22		(1)		
American Tree Sparrow				0.79		(2)		
Blackburnian Warbler	-7.93 +		(1)	-6.21		(1)	-7.1 *	
Blackpoll Warbler				7.48		(2)		
Black-throated Green Warbler	-2.54		(2)	0.30		(1)	-1.1	
Blue-headed (Solitary) Vire				7.31 +		(1)		
Canada Warbler	-8.39 +		(1)	-8.46 *		(2)	-8.4 **	
Cape May Warbler	-16.45 *		(2)	-13.45 **		(2)	-15.0 ***	
Chipping Sparrow	2.52		(2)	-8.74		(2)	-3.2	
Clay-colored Sparrow	4.16		(2)					
Common Grackle				-0.56		(1)		
Eastern Bluebird	-0.20		(1)	6.72		(2)	3.0	
Eastern Kingbird	-5.33		(1)	-9.91 *		(2)	-7.6 *	
Gray-cheeked Thrush				-6.11		(2)		
Horned Lark				2.68		(1)		
Indigo Bunting	17.90 +		(2)					
Lapland Longspur				3.56		(1)		
Lincoln's Sparrow	0.25		(1)	-1.53		(2)	-0.6	
Nashville Warbler	3.59		(2)	-0.64		(2)	1.5	
Northern Parula	-3.30		(1)	0.51		(1)	-1.4	
Northern Waterthrush	-1.81		(2)	-3.77 +		(1)	-2.8	
Olive-sided Flycatcher	-4.27		(1)	3.63		(1)	-0.5	
Orange-crowned Warbler	1.84		(2)	4.93		(2)	3.4	
Philadelphia Vireo	-7.21		(2)	-10.84 +		(2)	-8.9 +	
Red-winged Blackbird				-8.69 +		(1)		
Ruby-throated Hummingbird	2.27		(1)	6.13 +		(1)	4.2 +	
Rusty Blackbird				-2.41		(1)		
Savannah Sparrow				0.84		(1)		
Snow Bunting				9.23		(1)		
Song Sparrow	-1.90		(1)	-1.42		(2)	-1.7	
Swamp Sparrow	-1.81		(1)	-6.27		(1)	-4.1	
Tennessee Warbler	-12.85		(2)	-2.59		(2)	-7.9 +	
White-crowned Sparrow	17.83 +		(1)	2.47		(1)	10.0	
Wilson's Warbler	1.99		(1)	4.79		(1)	3.4	
Yellow Warbler	-2.47		(2)	4.80		(1)	1.1	
Yellow-bellied Flycatcher	-9.42 +		(1)	-8.40 *		(1)	-8.9 **	
Yellow-rumped Warbler	-10.89 +		(1)	-11.64 *		(2)	-11.3 **	

+ p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001; **** p < 0.0001

Table 5 – Summary of the number of increasing and decreasing species trends at TCBO from 1995-1997 to 2002-2004, in relation to habitat features of interest to the MNR's Wildlife Population Monitoring Program Plan. Number of significant trends ($p < 0.1$) are in parentheses.

Habitat Feature	Spring		Fall	
	Increase	Decrease	Increase	Decrease
<i>Dead and Downed Wood</i>	0 (0)	0 (0)	0 (0)	2 (0)
<i>Snags</i>	0 (0)	0 (0)	2 (0)	2 (0)
<i>Mature/Overmature</i>	1 (0)	2 (0)	1 (0)	5 (1)
<i>Large Areas</i>	1 (0)	7 (2)	0 (0)	10 (2)
<i>Riparian</i>	0 (0)	2 (1)	0 (0)	2 (1)
<i>Early Successional</i>	0 (0)	2 (0)	0 (0)	2 (0)
<i>Moose and Marten Habitat Guidelines</i>	0 (0)	2 (0)	0 (0)	2 (1)
<i>Pileated Woodpecker and White-tailed Deer Habitat Guidelines</i>	0 (0)	3 (1)	1 (0)	2 (2)
<i>Other Species</i>	9 (2)	16 (5)	17 (2)	19 (8)
<i>Grand Total</i>	10 (2)	32 (9)	20 (2)	42 (14)

Figure 1 – Total number of statistically significant ($p < 0.1$) increasing and decreasing species trends between 2000-2004 and all previous five-year intervals in a) spring and b) fall at LPBO.

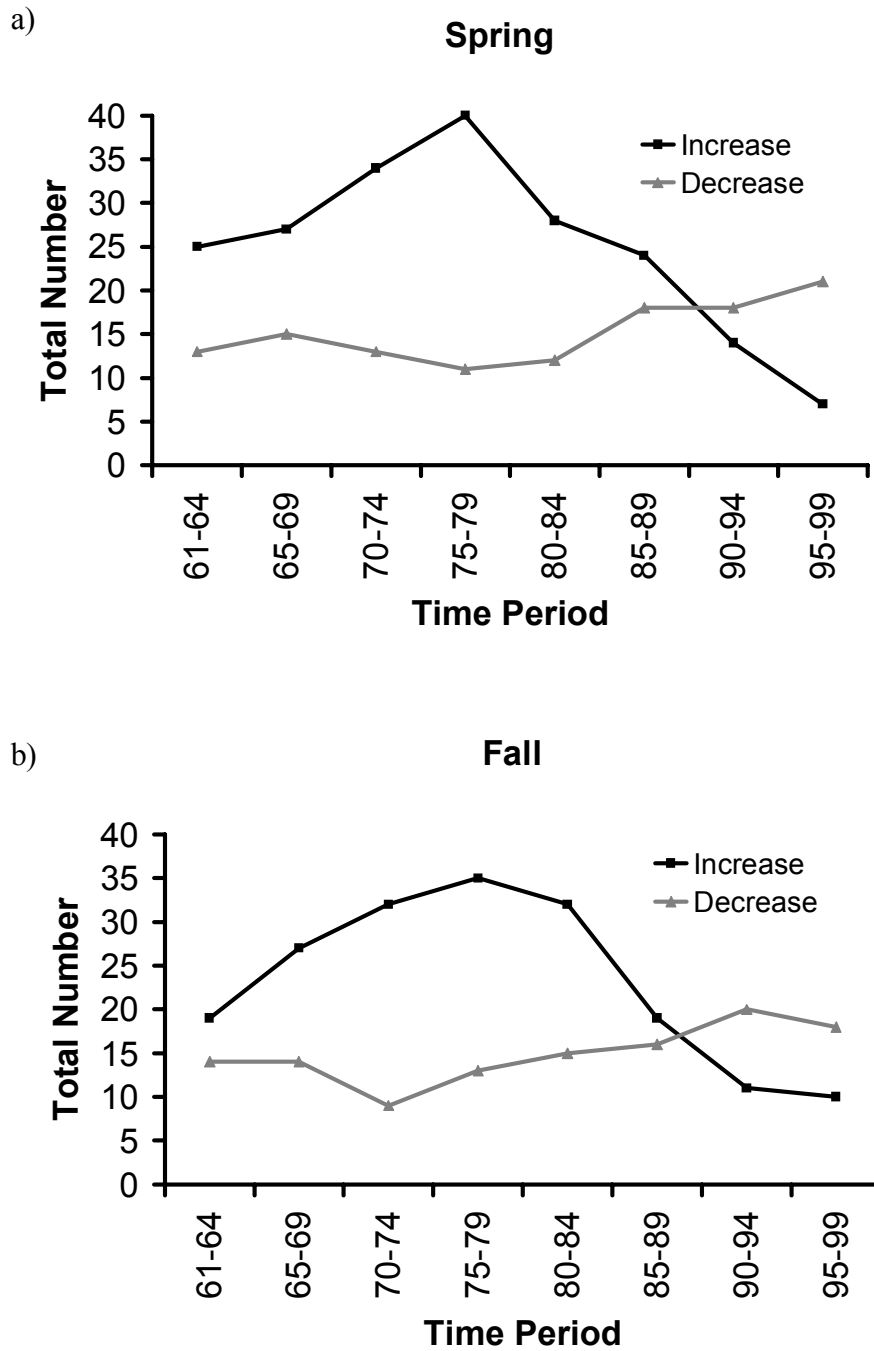
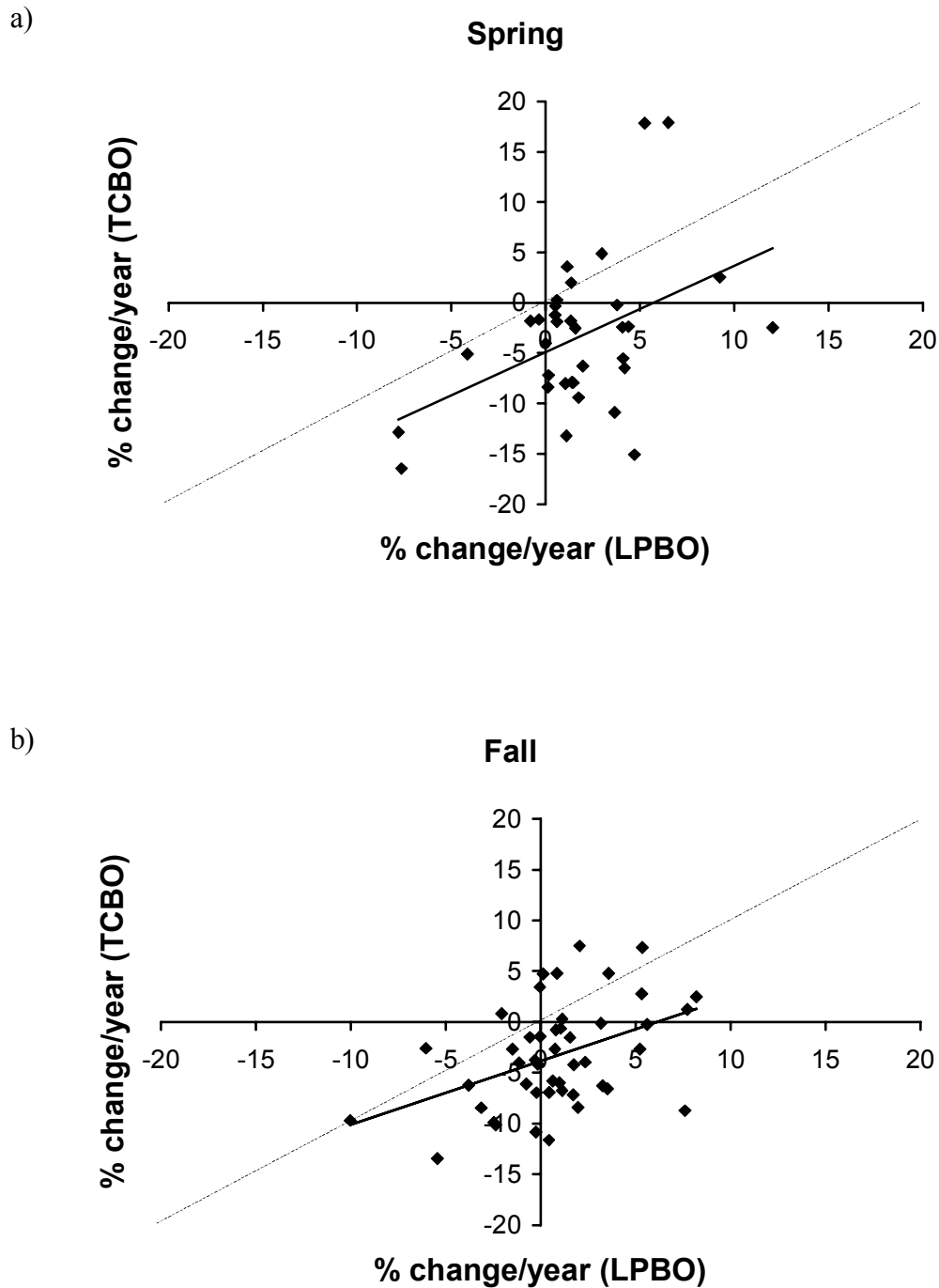


Figure 2 – Scatterplot showing the correlation of species trends at TCBO to species trends at LPBO (% change/year) in a) spring and b) fall. Dotted lines show expected one-to-one relationship for 100% correlation; solid lines show observed trend in the correlation among TCBO and LPBO species trends.

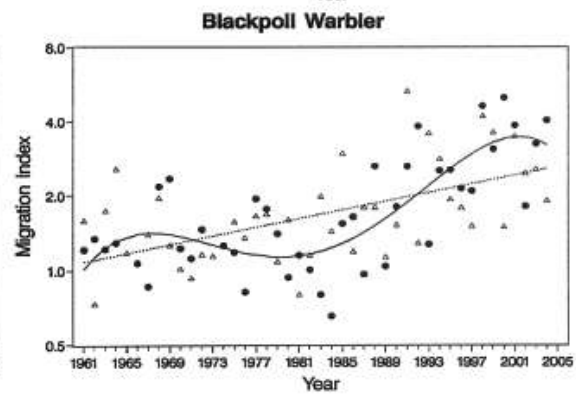
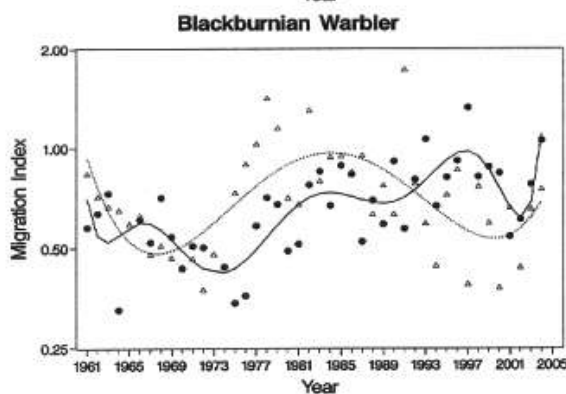
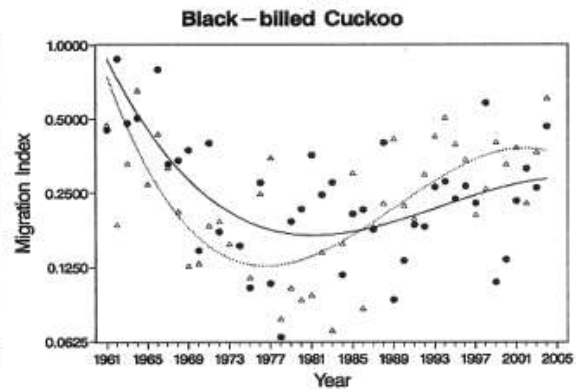
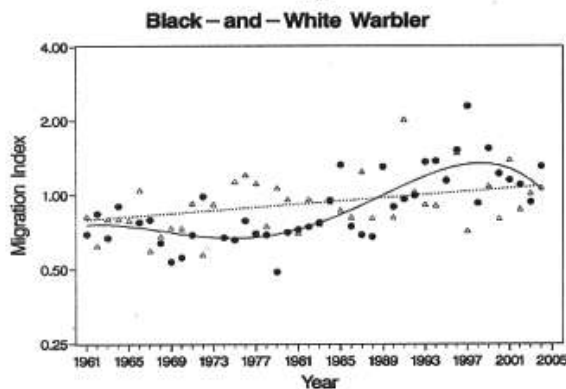
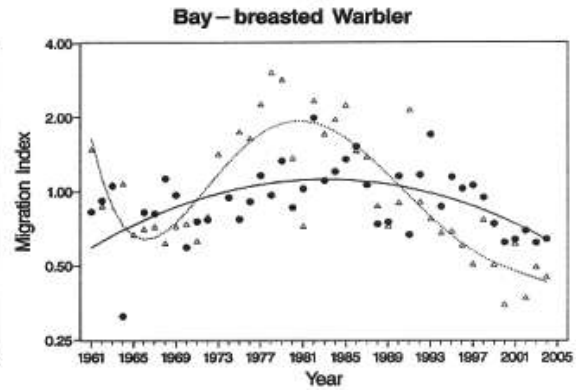
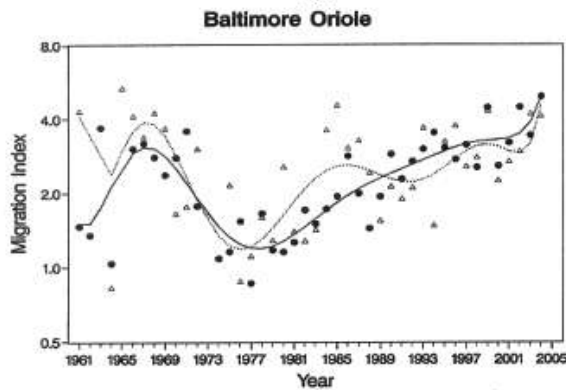
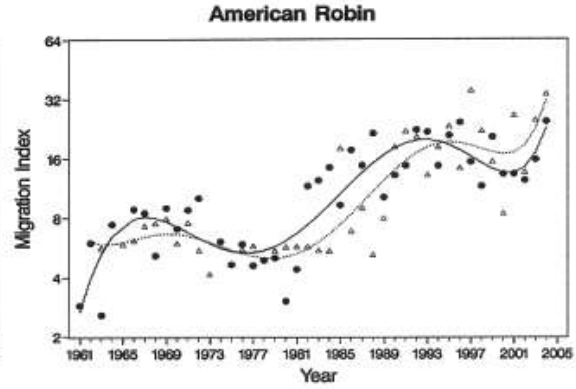
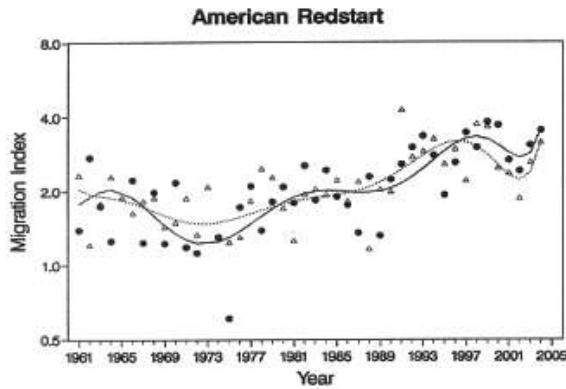


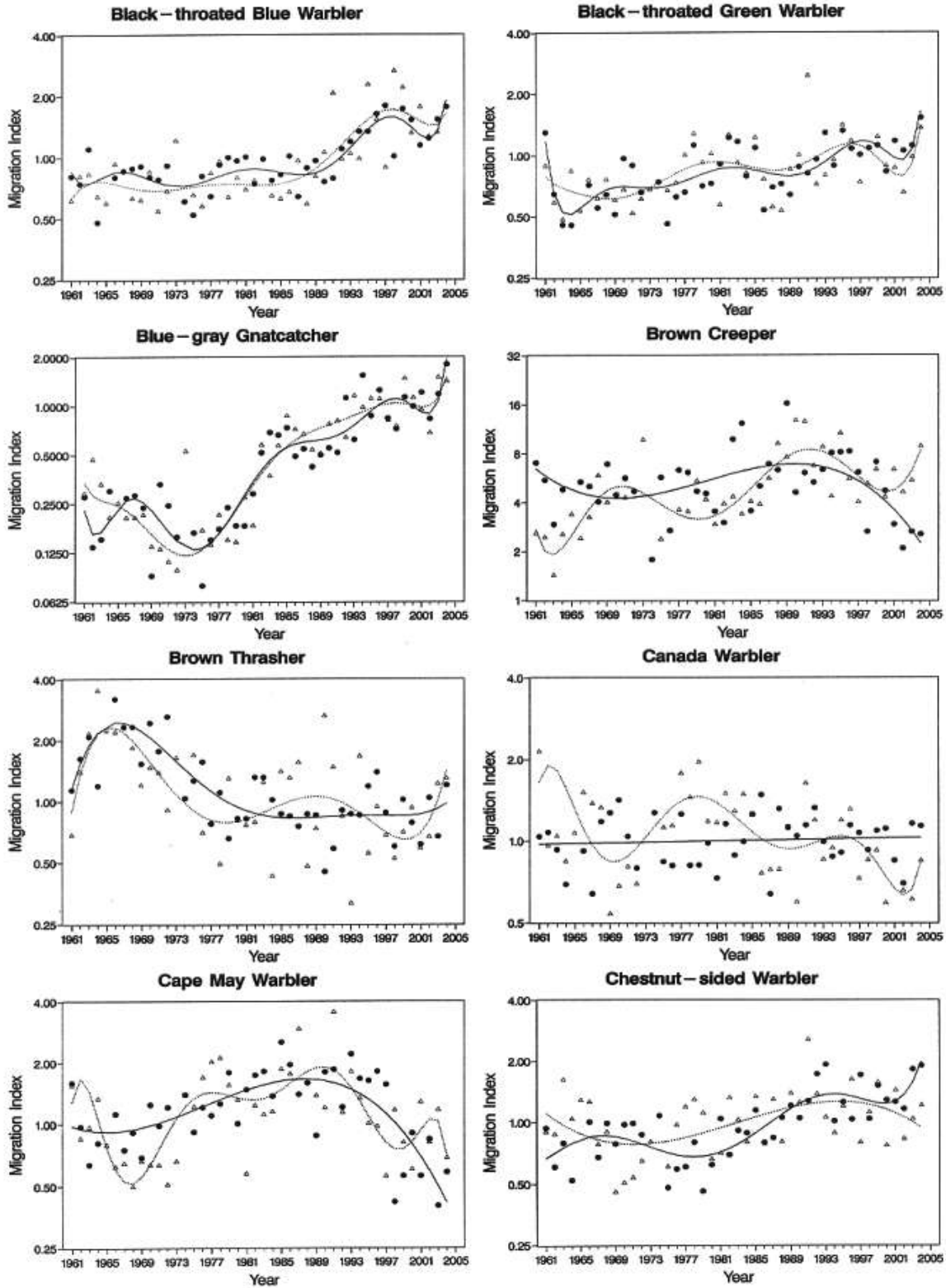
Appendix 1 - Migrant bird species to be monitored by the Provincial Wildlife Population Program Monitoring Plan, and for which population trends were calculated using daily Estimated Totals from Long Point Bird Observatory and/or Thunder Cape Bird Observatory. Habitat features and conditions that each species is expected to benefit from are shown.

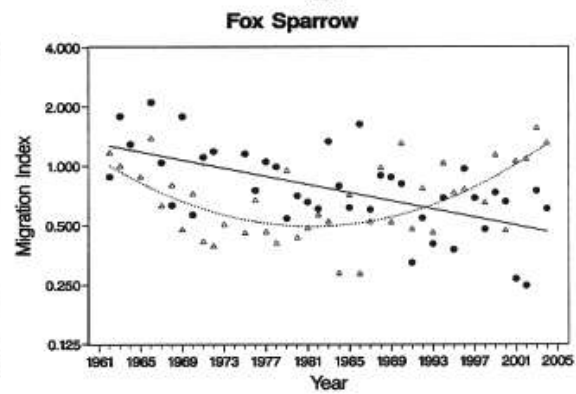
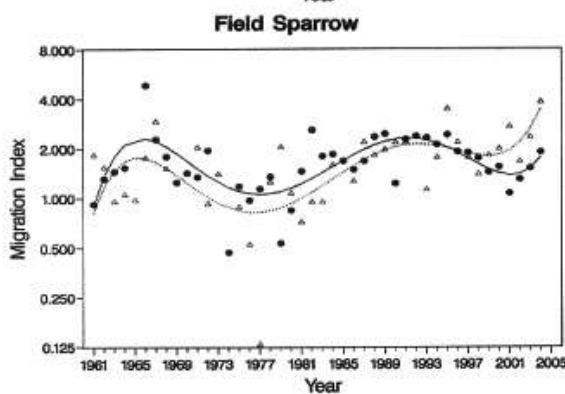
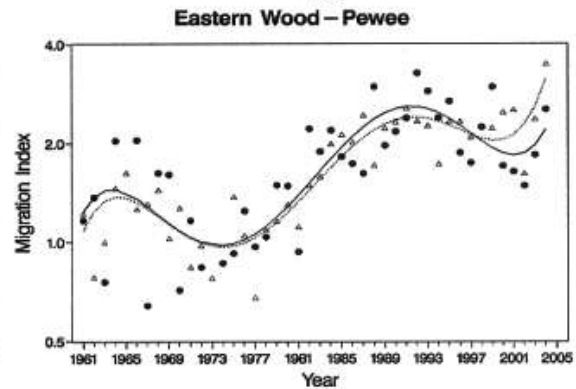
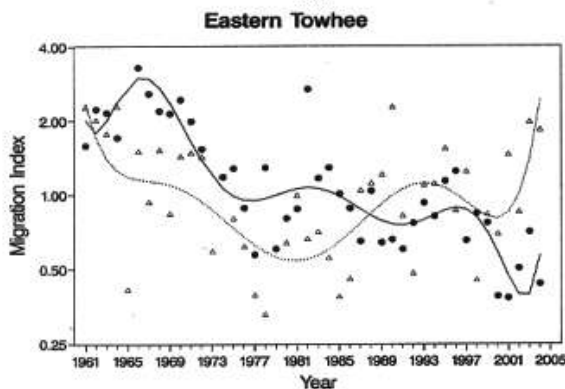
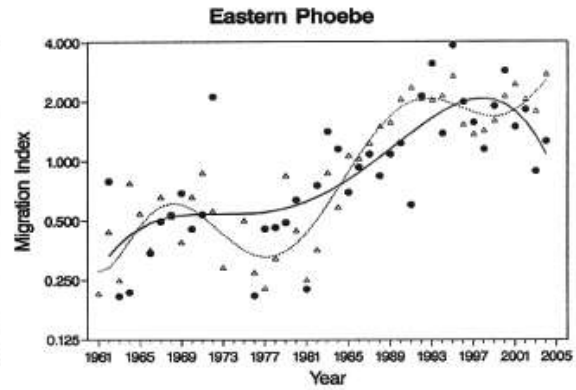
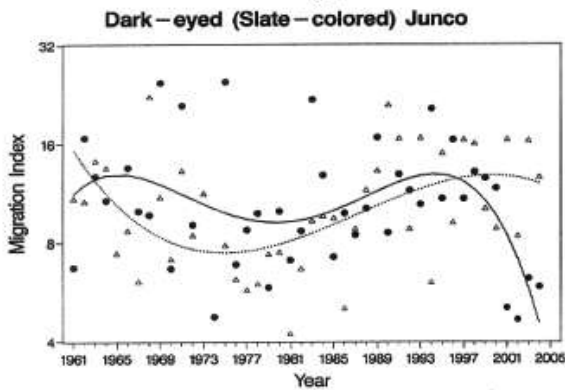
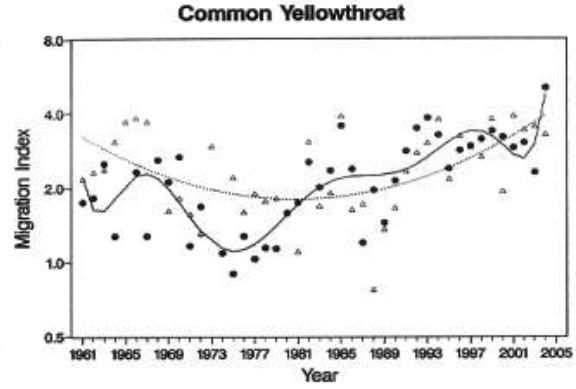
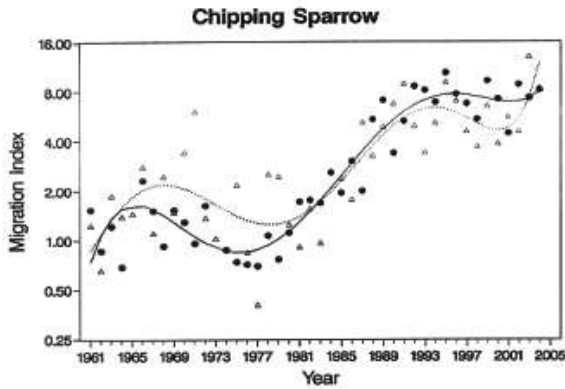
Species	LPBO	TCBO	Habitat Type/Feature		Habitat Condition
Alder Flycatcher	0	1	Riparian	Boreal	Lowland Conifer; Other Conifer; Mixedwood; Deciduous.
American Redstart	1	1	Large Areas	GLSL Boreal	Mixedwood; Tolerant Hardwood. Mixedwood; Deciduous.
Bay-breasted Warbler	1	1	Early Succession	Boreal	Other Conifer; Mixedwood.
Black-and-White Warbler	1	1	Large Areas	GLSL Boreal	Red/White Pine; Hemlock; Tolerant Hardwood. Mixedwood; Deciduous.
Black-throated Blue Warbler	1	1	Late Succession	GLSL	Tolerant Hardwood.
Brown Creeper	1	1	Snags	GLSL Boreal	Tolerant Hardwood. Other Conifer; Deciduous.
Chestnut-sided Warbler	1	1	Large Areas	GLSL Boreal	Red/White Pine; Mixedwood. Mixedwood.
Common Yellowthroat	1	1	Riparian	Boreal	Lowland Conifer; Other Conifer; Mixedwood; Deciduous.
Dark-eyed Junco	1	1	Downed/Dead Wood	GLSL	Boreal Conifer.
Golden-crowned Kinglet	1	1	Mature/Overmature	GLSL Boreal	Lowland Conifer; Boreal Conifer. Other Conifer; Mixedwood.
Great-crested Flycatcher	1	0	Snags, Large Areas	GLSL	Red/White Pine; Mixedwood; Tolerant Hardwood
Hermit Thrush	1	1	Large Areas	GLSL	Red/White Pine.
Least Flycatcher	1	1	Mature/Overmature; Large Areas	GLSL Boreal	Tolerant Hardwood Deciduous
Magnolia Warbler	1	1	Late Succession	GLSL	Mixedwood.
Mourning Warbler	1	1	Early succession; Large Areas	GLSL Boreal	Lowland Conifer; Mixedwood. Other Conifer; Mixedwood; Deciduous.
Northern Flicker	1	1	Snags	GLSL	Red/White Pine; Mixedwood; Tolerant Hardwood.
Northern Saw-Whet Owl	0	1	Snags; Mature	GLSL	Red/White Pine.
Ovenbird	1	1	Large Areas	GLSL Boreal	Red/White Pine; Mixedwood; Tolerant Hardwood. Mixedwood.
Palm Warbler	1	1	Early Succession	Boreal	Lowland Conifer.
Red-eyed Vireo	1	1	Mature; Large Areas	GLSL	Tolerant Hardwood
Rose-breasted Grosbeak	1	1	Large Areas	GLSL Boreal	Mixedwood; Tolerant Harwood Mixedwood.
Ruby-crowned Kinglet	1	1	Mature/Overmature	GLSL	Lowland Conifer
Scarlet Tanager	1	0	Large Areas	GLSL Boreal	Tolerant Hardwood. Deciduous.
Swainson's Thrush	1	1	Late Succession	GLSL	Lowland Conifer.
Veery	1	1	Large Areas	GLSL Boreal	Mixedwood. Mixedwood; Deciduous.
White-throated Sparrow	1	1	Early Succession	GLSL	Red/White Pine; Lowland Conifer; Boreal Conifer; Mixedwood.
Winter Wren	1	1	Downed/Dead Wood	GLSL	Hemlock; Lowland Conifer; Tolerant Hardwood.
Yellow-bellied Sapsucker	1	1	Snags; Mature/Overmature	GLSL	Red/White Pine; Mixedwood.

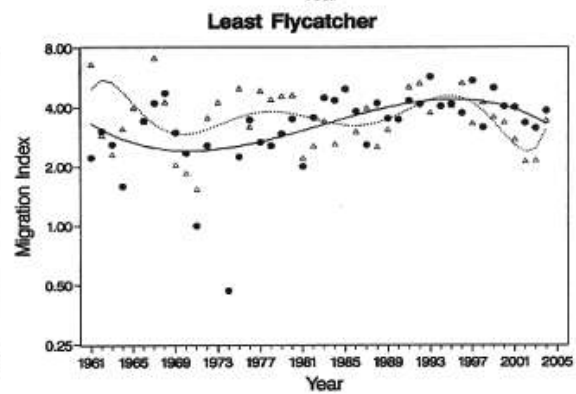
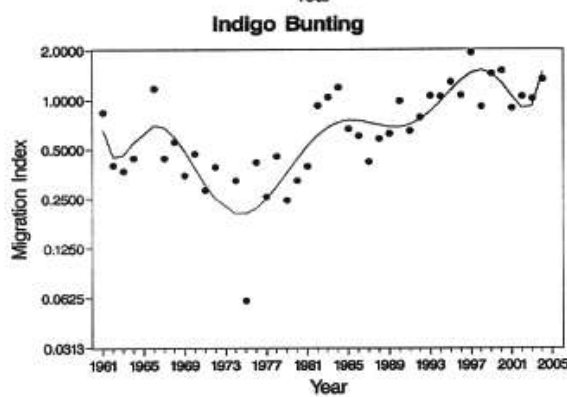
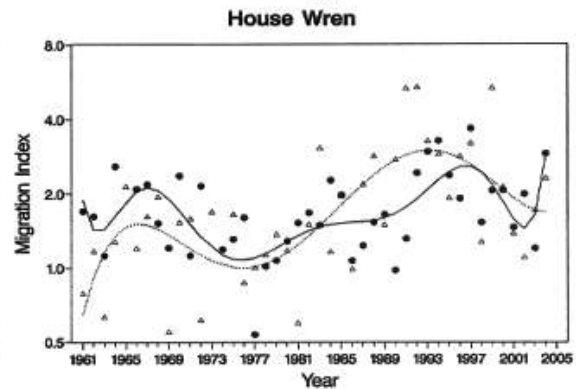
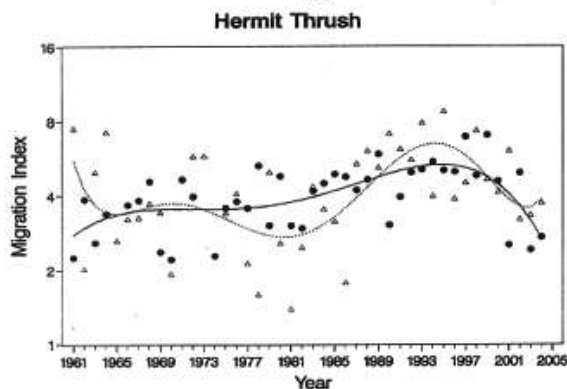
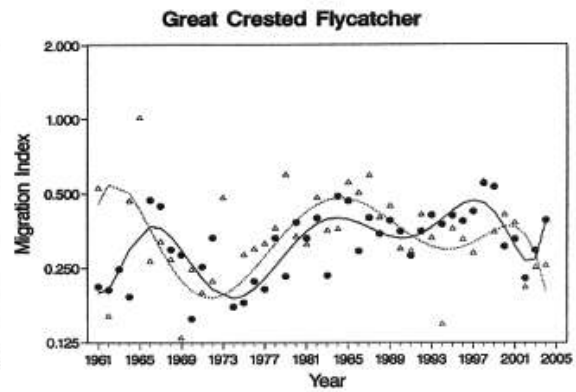
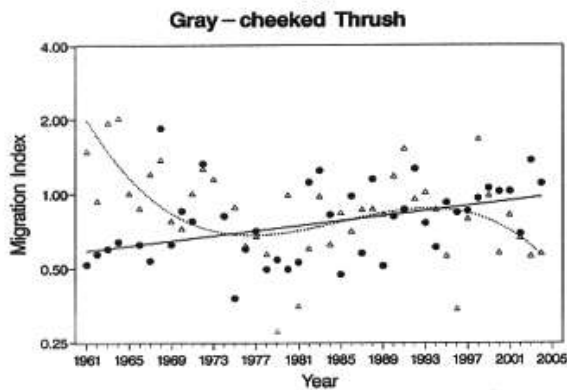
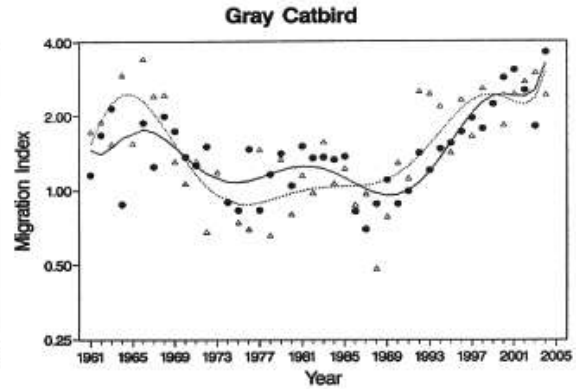
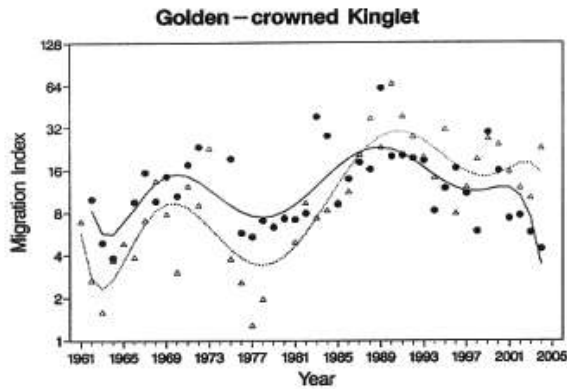
Appendix 2 - Graphs showing annual population indices for spring and fall, and estimated population trajectories for each species at LPBO from 1961-2004. Solid circles represent spring indices, while hollow triangles represent fall indices. Smaller symbols represent seasons with reduced coverage (less than 30 station days). Seasons in which there were fewer than 10 station-days during the migration window for a species were excluded from the analyses. Solid curves represent estimated population trajectories for spring indices, while dotted lines represent curves for fall indices. On the graphs, indices for spring and fall have been adjusted to the same mean value, thus it is not possible to tell from the graph whether a species was more abundant in spring or in fall. Some species, although recorded in adequate numbers in one season, were rarely detected in the other season and hence are graphed only for one season.

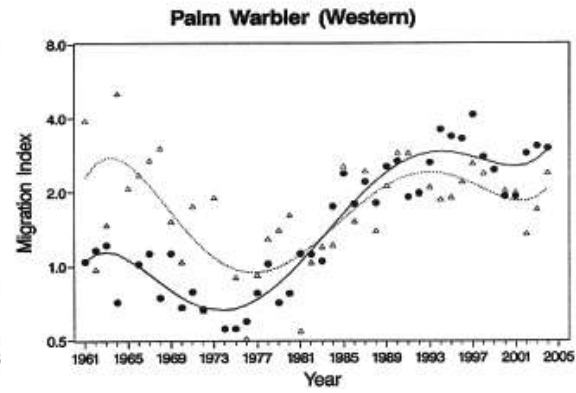
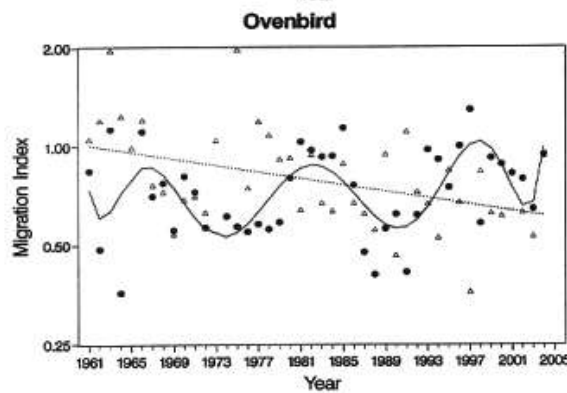
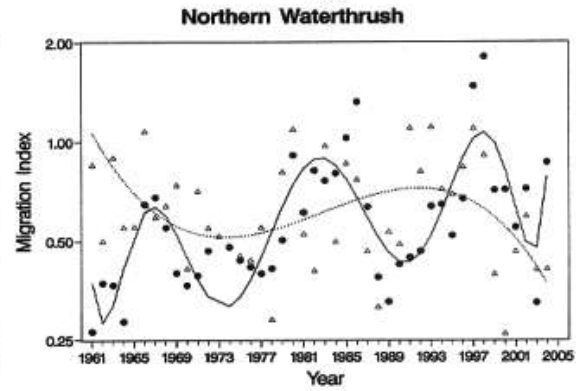
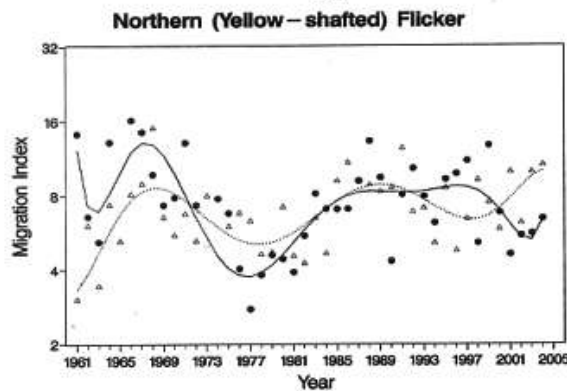
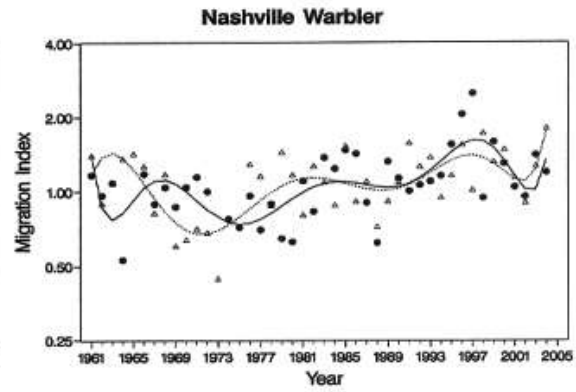
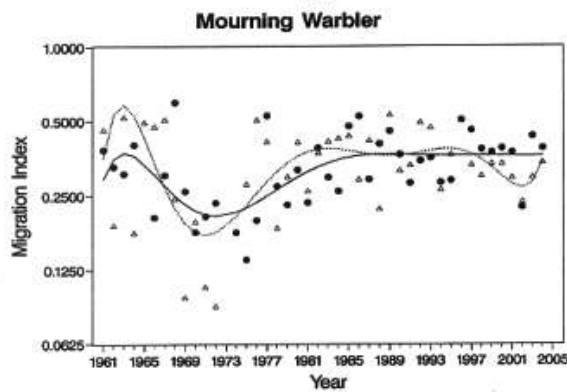
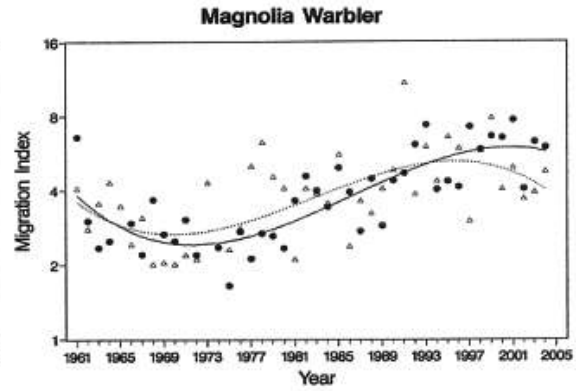
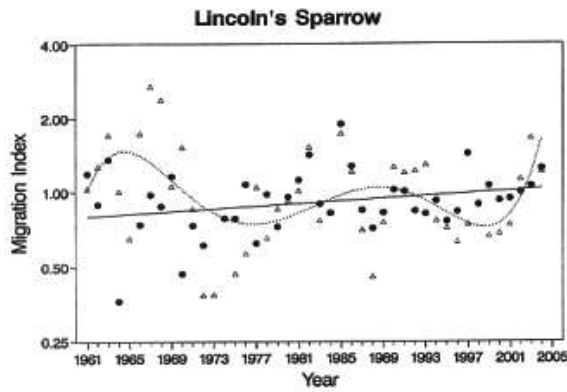
Population trajectories were estimated using the lowest order polynomial (maximum 8th order) that adequately fit the data based upon Akaike's Information Criterion. If there were no significant changes, then the linear curve was printed to show the general trend. All non-linear curves were significantly different from no population change. The significance of linear population change was determined from the significance levels in Table 1.

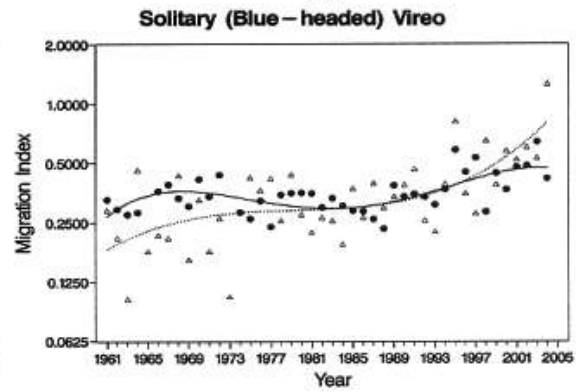
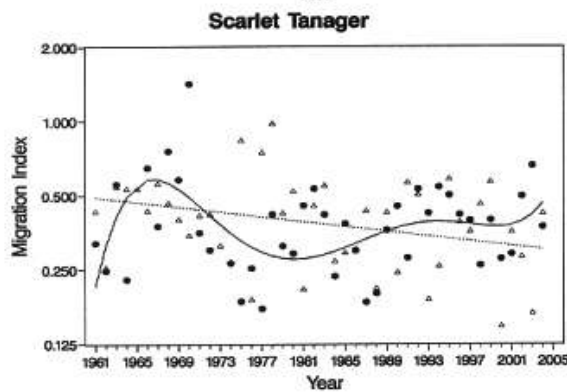
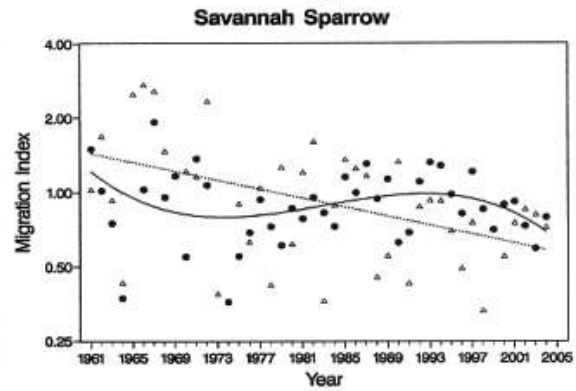
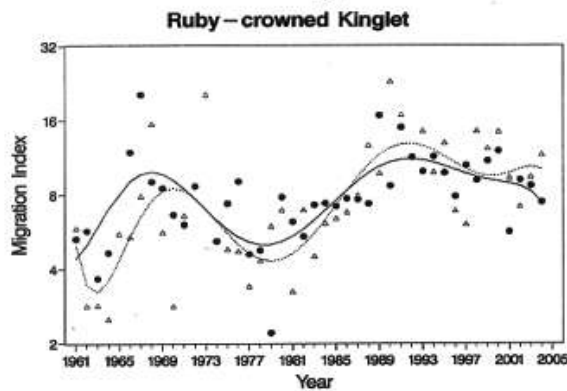
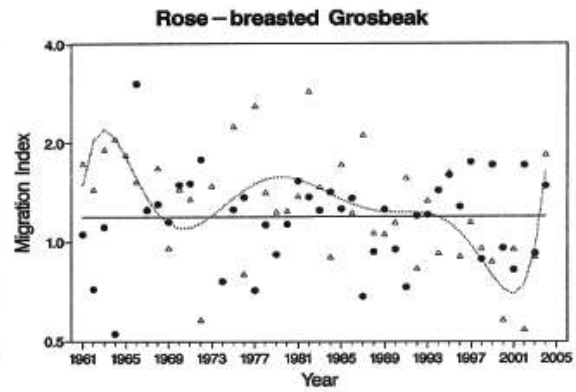
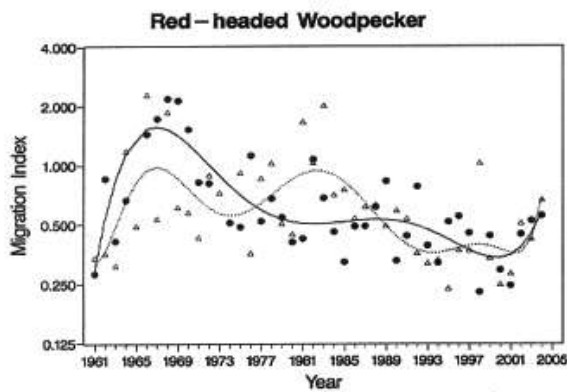
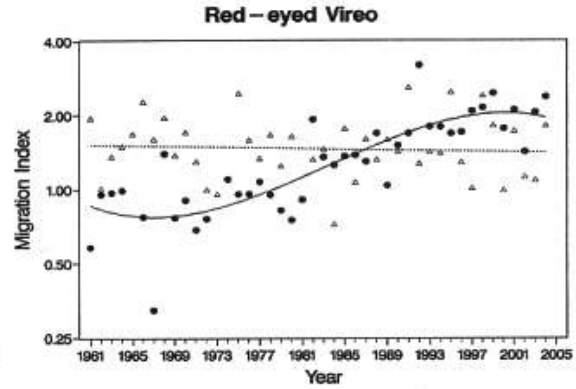
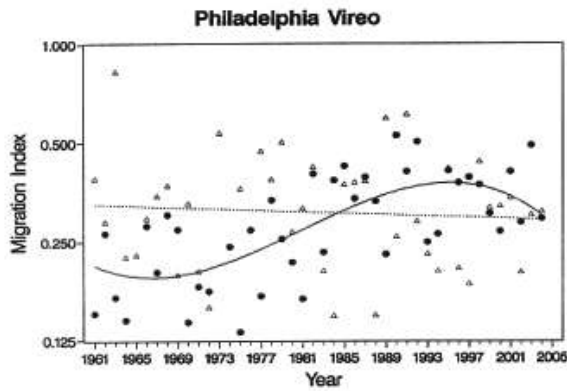


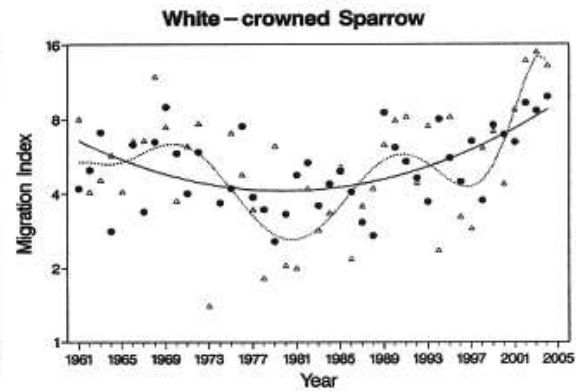
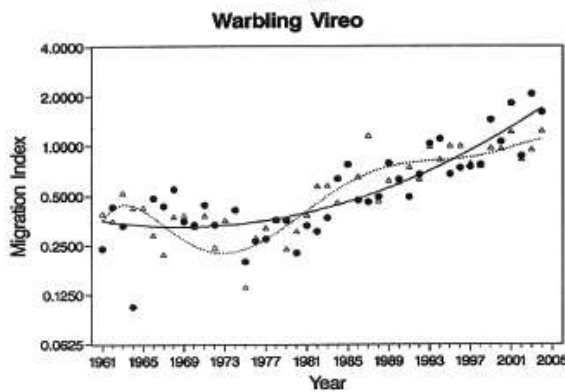
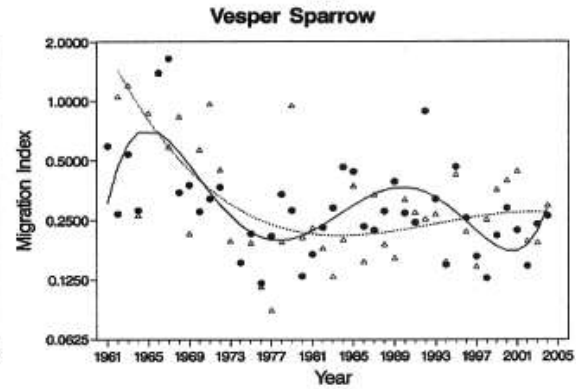
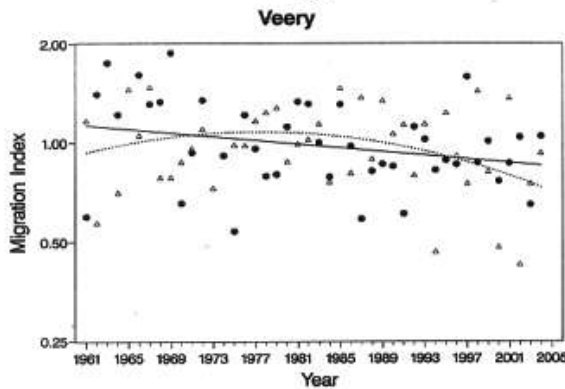
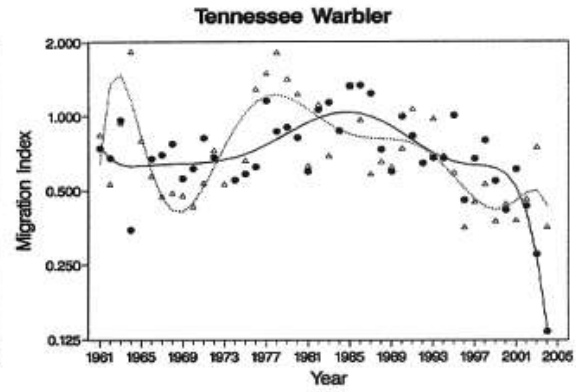
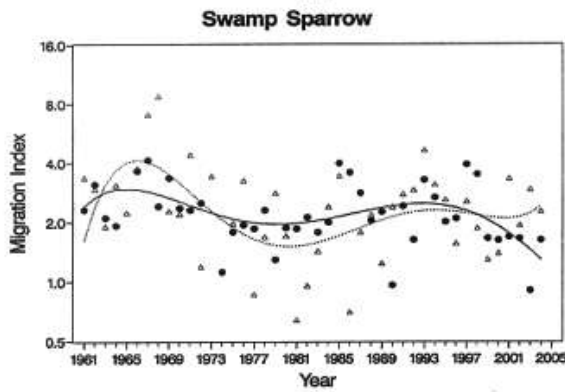
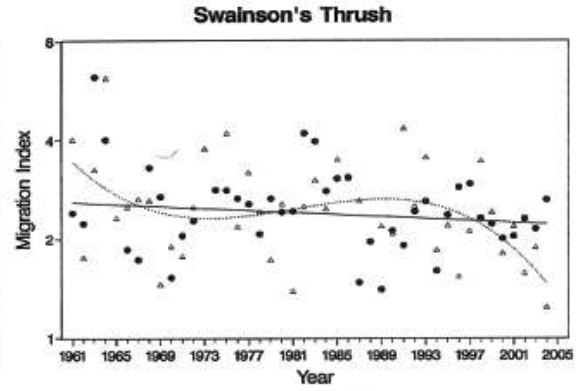
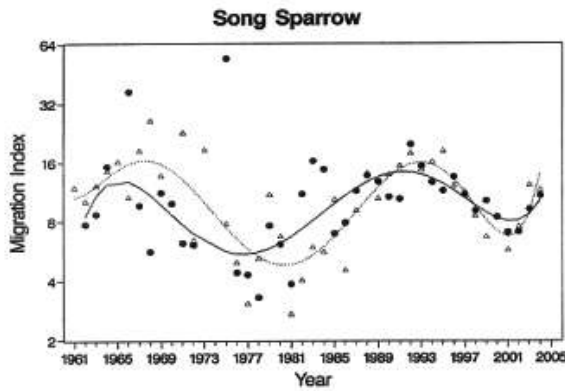


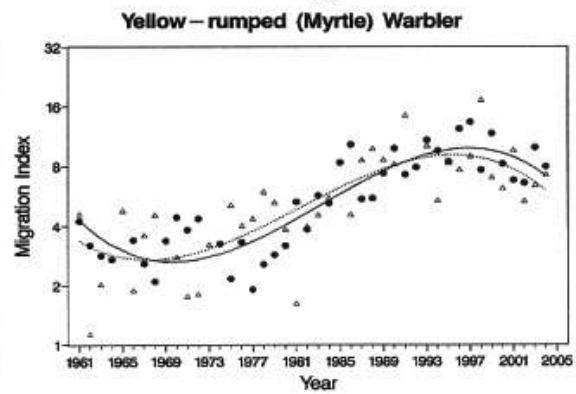
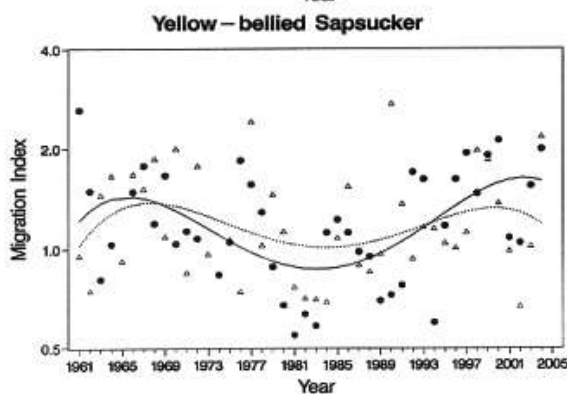
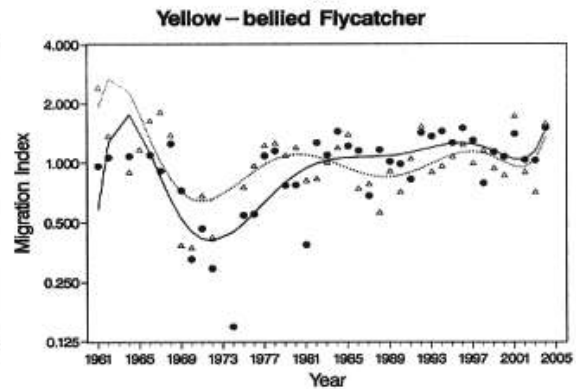
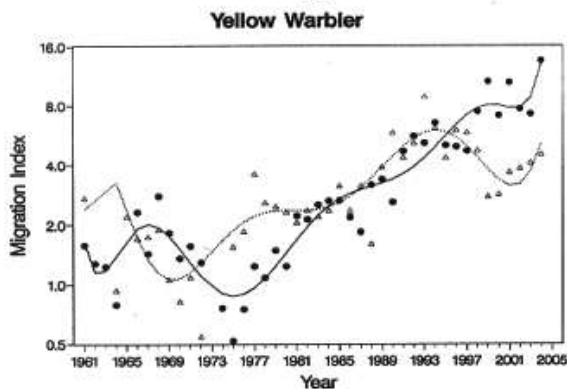
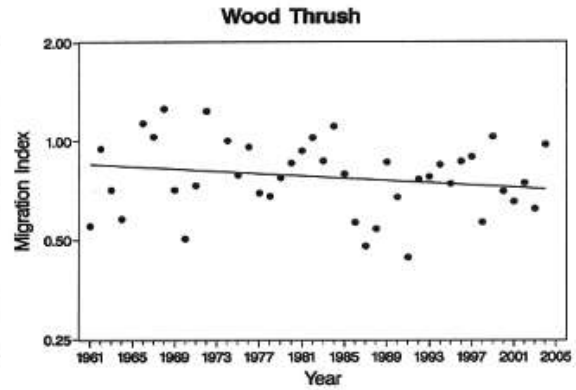
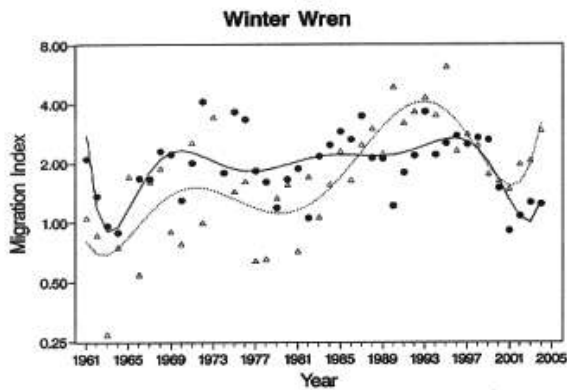
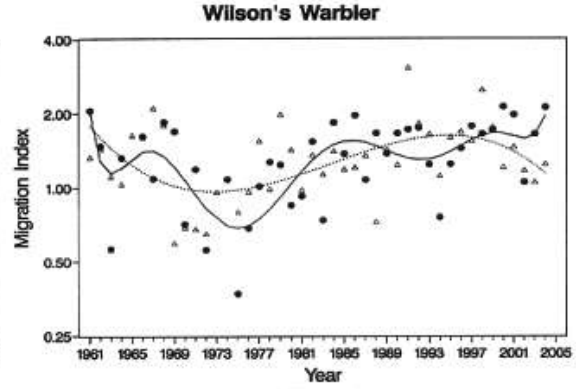
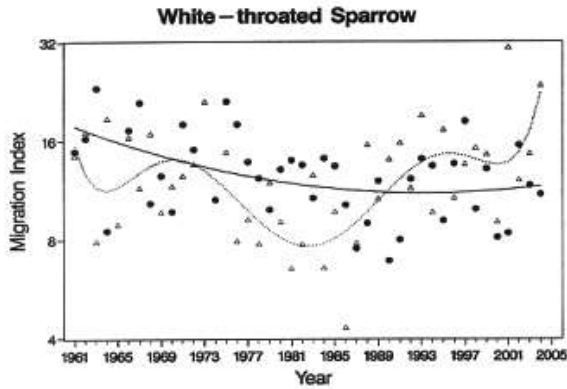












Appendix 3 - Graphs showing annual population indices for spring and fall, and estimated population trajectories for each species at TCBO from 1995-2004. Solid circles represent spring indices, while hollow triangles represent fall indices. Smaller symbols represent seasons with reduced coverage (less than 30 station days). Seasons in which there were fewer than 10 station-days during the migration window for a species were excluded from the analyses. Solid curves represent estimated population trajectories for spring indices, while dotted lines represent curves for fall indices. On the graphs, indices for spring and fall have been adjusted to the same mean value, thus it is not possible to tell from the graph whether a species was more abundant in spring or in fall. Some species, although recorded in adequate numbers in one season, were rarely detected in the other season and hence are graphed only for one season.

Population trajectories were estimated using the lowest order polynomial (maximum 2nd order) that adequately fit the data based upon Akaike's Information Criterion. If there were no significant changes, then the linear curve was printed to show the general trend. All non-linear curves were significantly different from no population change. The significance of linear population change was determined from the significance levels in Table 4.

