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Analysis of trends from woodcock singing ground surveys 1969-85

by B.T. Collins[1]

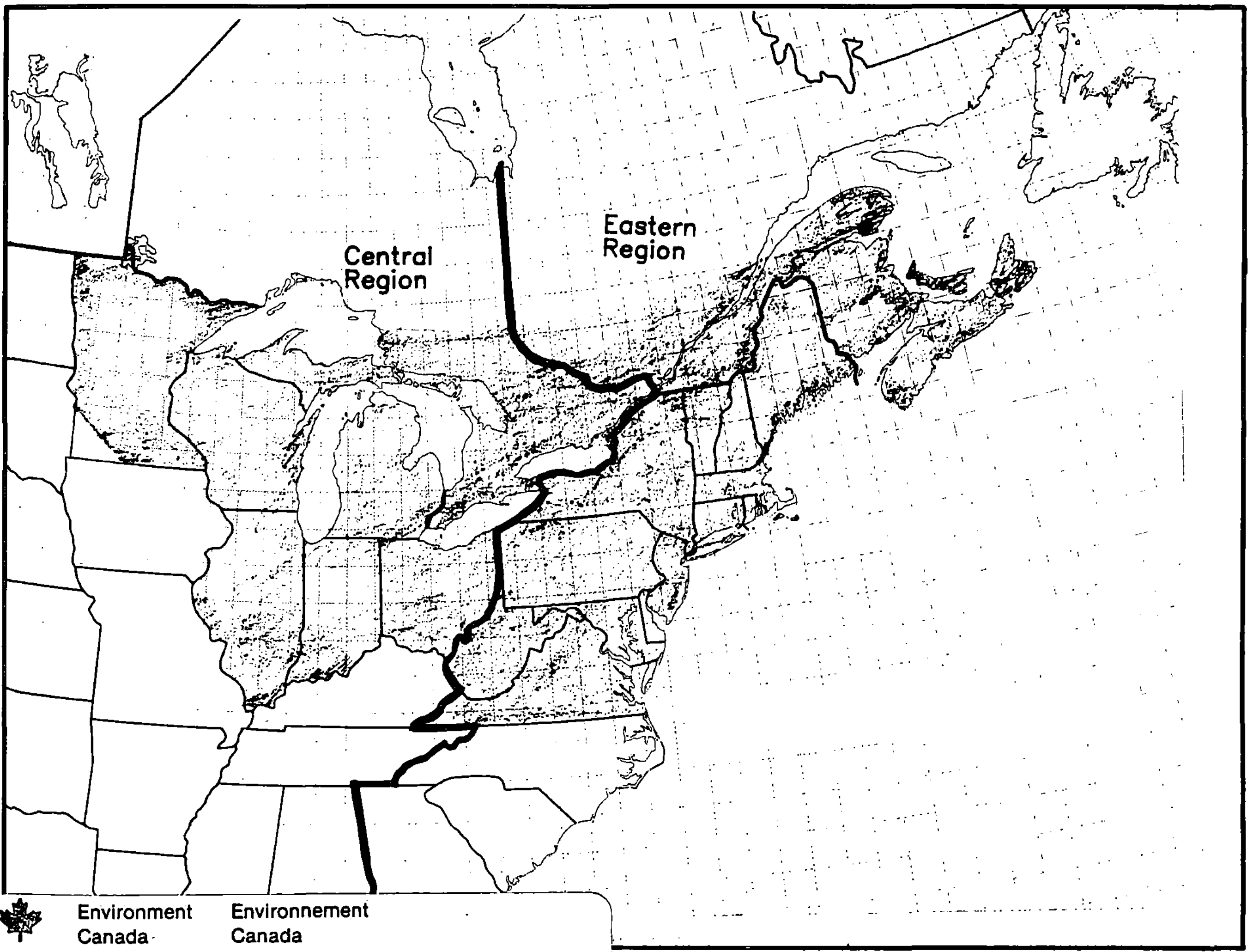
Introduction

The woodcock singing ground survey is conducted by the U.S. Fish and Wildlife Service in cooperation with the Canadian Wildlife Service. The survey takes place during the spring courtship displays of American Woodcock (*Scolopax minor*). A set of specified routes covering the breeding range of the woodcock has been selected (Fig. 1). Each year the observer assigned to a route conducts a count of the number of male woodcock seen or heard near dusk at 10 well-defined stops along the route. The survey is used to create an index to the breeding population. This index is calculated as a product of year-to-year change factors based on those routes that are comparable between each pair of adjacent years (Tautin 1985).

The year-to-year change factor procedure has been shown to give potentially false indications of trend even when none occurs; to avoid this and to make more efficient use of the data, Geissler and Noon (1981) proposed an alternative analysis procedure. A modification of this technique was used in an analysis of the Breeding Bird Survey in Canada (Collins and Wendt 1987), and an analysis of the woodcock singing ground survey data is presented here. A brief description of the technique is presented in Appendix 1.

The analysis was done separately for each state or province, and the state/province estimates were combined to provide estimates for each of the two management regions (eastern and central) and for each country (Canada

Figure 1
Area covered by singing ground survey



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and the United States). The model used in the analysis assumes a simple linear trend in the log scale over time. Because this model may not be valid for the entire time frame of the survey, the data were analysed over three time periods: (i) the entire survey period (1969–85); (ii) the last 10 years (1976–85); and (iii) the last 5 years (1981–85).

Results and discussion

The results of the analysis are shown in Table 1. The overall results by management region are similar to those produced by means of the year-to-year adjustment technique (Tautin 1985), i.e. a 34% decline in the index (significant at $p < 0.05$) from 2.40 in 1969 to 1.59 in 1985 for the eastern region and a 9% increase in the index (not significant at $p < 0.05$) from 3.30 in 1969 to 3.60 in 1985.

For the eastern region, the estimate of rate of decline corresponds to halving the population every 28 years, or a decline of 32% over the 17-year period of the survey. The trend was negative for all states and provinces for the 1969–85 period. The analysis of the shorter periods (1976–85 and 1981–85) also showed an overall significant ($p < 0.05$) decline. Most state and province estimates of trend were also negative. The lack of statistical significance for the shorter periods compared with that for the entire time period may be due to decreased power caused by a smaller sample size rather than to a reduction in the gradient of the trend.

In the central region, the picture is less clear. During the entire survey period (1969–85), significant ($p < 0.05$) increases were noted in Michigan and Minnesota, whereas a significant decline was noted in Ohio. These results tend to cancel each other out, resulting in an overall estimate of no trend. (The corresponding doubling-life for the population would be greater than 99 years.) This suggests that, even though there has been no net change in the population index for the central region, some areas of the region may need to be managed more carefully to preserve the distribution of the species. Some consideration should be given to partitioning the central region into smaller management areas. During 1976–85 there was a significant ($p < 0.05$) decline overall, and during 1981–85 there was a decline but it was not statistically significant. Most of the individual state and province trends were estimated to be negative for these two periods.

When the data for Canada are separated from those for the United States, the Canadian data indicate a significant downward trend for the two longer periods (1969–85 and 1976–85) and a downward, though not significant, trend for the shortest period (1981–85). All three estimates of the rate of decline are similar. Most of the trends in individual provinces are negative, but there was one estimated significant increase for Prince Edward Island (P.E.I.) for 1981–85.

The totals of the individual route weighting factors for each state/province are shown in Table 2. These show how influential each state/province was in the calculation of management region and country estimates. Because of a large number of observations or high counts, some states and provinces are given very high weighting factors: Michigan and Ontario have the two highest.

To allow a visual assessment of the magnitude of the trend, plots of the mean observed counts were made for Canada and for the two management regions (Figs. 2–4). Counts were not available for all routes in each year of the survey. To adjust for routes not run, the predicted value from the trend line was used in calculating the mean count. The mean predicted count was also plotted on the same figure. Because the mean observed data were adjusted for routes not run each year, the mean observed and predicted values will tend to be similar, and these plots should not be used as measures of the quality of fit to the trend line.

Figure 2 shows the plot of average woodcock counts adjusted for routes run each year and the fitted trend line for Canada. The magnitude of the trend indicates a substantial change in the population index over the 17-year period of the survey. The individual routes were weighted by the precision of the individual route trend estimates when the overall trend lines were calculated. Because this was not done for the observed mean counts, the trend line does not go through the apparent centre of the observations.

Figure 2
Mean observed woodcock counts adjusted for routes run each year and the fitted trend line for Canada

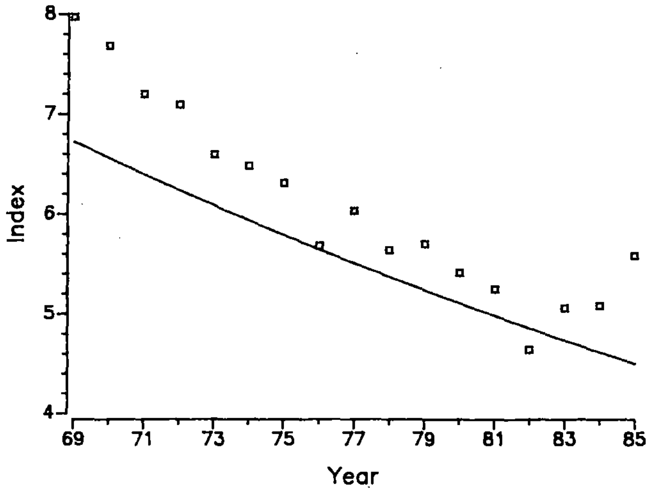

Figure 3, the fitted trend line for the eastern region, indicates a substantial decline in the population index.

The fitted trend line for the central region, which does not show a significant slope (Fig. 4), is at variance with the adjusted yearly averages. This may be due to the inability of a single trend line to describe a variety of changes in the index in different states and provinces during different periods of time for this region. Therefore, one should be skeptical of the negligible trend in the woodcock index for the central region.

Despite the misleading indication of the trend line for the central region, most of the data suggest that the woodcock index decreased over much of the breeding range

Table 1
Analysis of trends in woodcock singing ground counts†

	1981–85			1976–85			1969–85		
Strata	NR	Slope	(HDL)	NR	Slope	(HDL)	NR	Slope	(HDL)
Eastern region									
Canada									
P.E.I.	9	0.0598	(d5)*	11	−0.0147	(h21)	12	−0.0126	(h24)*
New Brunswick	53	−0.0384	(h8)	60	−0.0149	(h20)*	64	−0.0171	(h18)*
Nova Scotia	29	0.0040	(d76)	45	−0.0216	(h14)*	48	−0.0023	(hgn)
Quebec	39	−0.0110	(h27)	50	0.0033	(d92)	60	−0.0090	(h33)
United States									
Connecticut	4	−0.0394	(h8)	6	−0.0043	(h69)	10	−0.0269	(h11)*
Delaware	1	−1.1475	(h0.3)	2	0.0368	(d8)	3	−0.0278	(h11)
Maine	49	−0.0208	(h15)	60	−0.0167	(h18)*	62	−0.0084	(h36)*
Maryland	11	−0.1005	(h3)*	15	−0.0347	(h9)*	24	−0.0025	(hgn)
Massachusetts	12	−0.0512	(h6)	16	−0.0139	(h22)	19	−0.0125	(h24)
New Hampshire	14	−0.0177	(h17)	18	−0.0150	(h20)	18	−0.0218	(h14)*
New Jersey	9	−0.0022	(hgn)	13	−0.0001	(hgn)	14	−0.0131	(h23)
New York	67	−0.0121	(h25)	87	0.0013	(dgn)	101	−0.0020	(hgn)
Pennsylvania	32	−0.0090	(h33)	44	−0.0232	(h13)	58	−0.0249	(h12)*
Rhode Island	1	−0.0258	(h12)	2	−0.0164	(h18)	3	−0.0419	(h7)*
Vermont	15	0.0039	(d77)	21	−0.0263	(h11)*	22	−0.0153	(h20)*
Virginia	18	−0.1608	(h2)	31	−0.0014	(hgn)	64	−0.0050	(h60)
West Virginia	29	−0.0751	(h4)*	43	−0.0106	(h28)	45	−0.0141	(h21)*
Central region									
Canada									
Ontario	109	−0.0007	(hgn)	113	−0.0174	(h17)*	122	−0.0084	(h36)*
United States									
Illinois	8	−0.1015	(h3)*	24	−0.0158	(h19)	35	−0.0235	(h13)
Indiana	24	−0.0704	(h4)*	33	−0.0113	(h27)	43	−0.0013	(hgn)
Michigan	126	−0.0031	(h96)	129	−0.0110	(h27)*	136	0.0043	(d70)*
Minnesota	80	−0.0039	(h77)	89	0.0013	(dgn)	103	0.0155	(d19)*
Ohio	32	−0.0732	(h4)*	49	−0.0130	(h23)	67	−0.0129	(h23)*
Wisconsin	78	−0.0046	(h65)	92	−0.0217	(h14)*	102	0.0010	(dgn)
Eastern region		−0.0259	(h10)*		−0.0112	(h27)*		−0.0107	(h28)*
Central region		−0.0071	(h42)		−0.0121	(h25)*		0.0009	(dgn)
Canada		−0.0082	(h29)		−0.0153	(h19)*		−0.0104	(h29)*
United States		−0.0166	(h17)*		−0.0103	(h29)*		−0.0011	(hgn)
Combined		−0.0140	(h20)*		−0.0118	(h26)*		−0.0038	(h79)*

† NR, number of routes used in the analysis.
Slope, estimated slope of the linear regression on a log scale.
(HDL), slope expressed as the equivalent half-life (h) or doubling-life (d) (in years).
(hgn), half-life greater than 99 years.
(dgn), doubling-life greater than 99 years.
*, significant ($p < 0.05$) trend.

between 1969 and 1985, though with substantial differences in the rate of change between strata and between the early and more recent years.

Figure 3
Mean observed woodcock counts adjusted for routes run each year and the fitted trend line for the eastern region

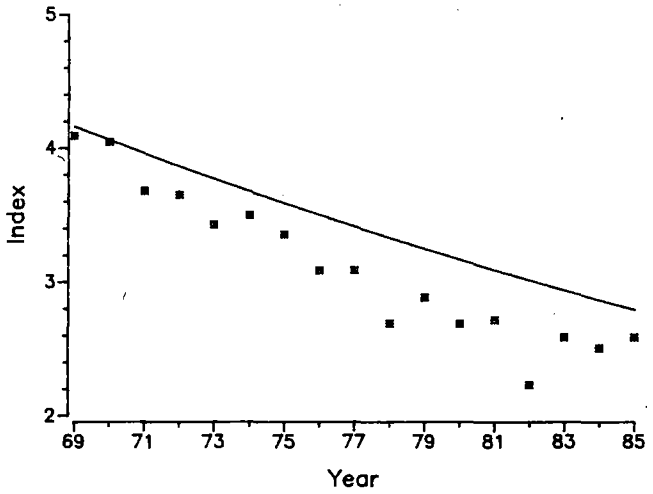

Figure 4
Mean observed woodcock counts adjusted for routes run each year and the fitted trend line for the central region

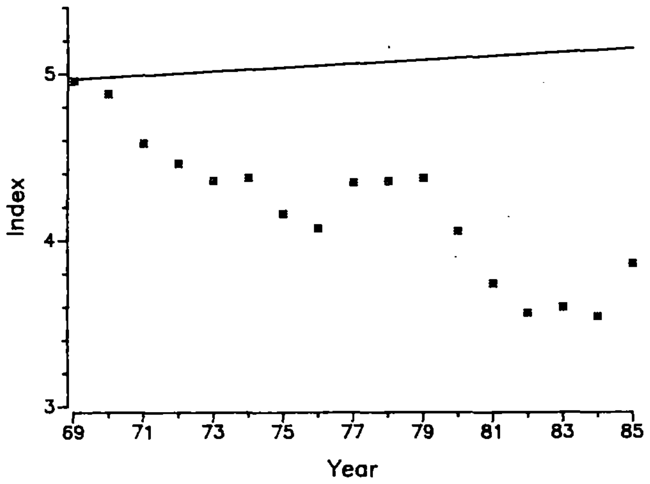

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Table 2
Totals of individual route weighting factors for each state and province

Strata	1981–85	1976–85	1969–85
Eastern region			
Canada			
P.E.I.	179.56	1 446.51	8 872.45
New Brunswick	1782.69	16 681.71	76 903.99
Nova Scotia	639.06	6 782.25	27 275.50
Quebec	703.89	5 367.84	15 135.06
United States			
Connecticut	76.26	619.56	4 215.94
Delaware	1.62	35.03	310.64
Maine	1570.23	12 394.96	64 087.49
Maryland	180.18	1 661.20	6 154.28
Massachusetts	218.66	1 935.57	9 032.29
New Hampshire	327.44	2 818.76	16 376.11
New Jersey	158.62	1 331.63	7 838.00
New York	2341.45	17 434.47	76 428.80
Pennsylvania	362.88	3 299.23	19 477.79
Rhode Island	7.08	55.00	595.82
Vermont	272.16	2 704.65	13 391.21
Virginia	334.64	2 010.42	10 416.26
West Virginia	345.11	2 976.92	12 847.77
Central region			
Canada			
Ontario	4682.80	32 116.49	136 224.60
United States			
Illinois	113.50	508.90	1 264.80
Indiana	239.18	2 025.26	9 108.95
Michigan	5107.18	43 666.02	205 526.50
Minnesota	3385.17	24 230.37	65 101.86
Ohio	642.94	4 727.86	22 953.26
Wisconsin	2231.24	21 467.00	95 941.55

Appendix 1

Estimating trend in fixed plot surveys

The procedures used in the analysis have been described in detail in various publications (Geissler and Noon 1981, Geissler 1984, Collins and Wendt 1987). This appendix gives only a brief description of the procedure used.

Let y_{ij} denote the *j*th observation taken on route *i*, and x_{ij} denote the year this observation was taken. The y_{ij} are transformed to:

$$z_{ij} = \log_{10} (y_{ij} + 0.23)$$

This transformation was used for the following reasons. First, it was recognized that the counts were only an index to the population and hence absolute changes in the index were not as interpretable as relative changes. In addition, trends probably affect a proportion of, rather than the entire, population (Geissler and Noon 1981). This suggests that a multiplicative model would be a suitable base for interpreting the data. A log transform converts a multiplicative model to a linear model, which is easier to manipulate as closed-form expressions for the solution are available. A constant number (0.23) was added to each value, as there were many observed values of zero which could not be log transformed. The value 0.23 was chosen because the bias introduced by it was less than 5% under a variety of simulated trends (Collins and Wendt 1987).

A simple linear regression of z_{ij} against time was done separately for each route to provide an estimate of trend over time (b_i) for each route. The individual route trends were aggregated to provide an overall estimate of trend for a stratum (province, state, management region or country) using a weighted average:

$$b = \frac{\sum_{i=1}^{n} w_i b_i}{\sum_{i=1}^{n} w_i}$$

where w_i denotes the weight given to route *i* and *n* denotes the number of routes in the stratum.

Weighting factors
The weighting factor is a product of two terms: (i) f_{1i}, a measure of the precision of the estimate of trend; and (ii) f_{2i}, a measure of the average index value on the route.

The precision of the estimate of trend is a function of the number of counts made on the route and the spacing in time of the counts. The first term in the weighting factor gives greater weight to those estimates which have more observations or are more spread out over the period of the survey. The factor f_{1i} used to weight for the precision of the estimate was:

$$f_{1i} = \sum_{j=1}^{n_i} (x_{ij} - \bar{x}_{i.})^2$$

where $\bar{x}_{i.}$ is the average of the n_i years route *i* was measured.

A given change in the population of woodcock along a route is of more concern in areas of high density than in areas of low density. The second term in the weighting factor, f_{2i}, is the predicted value for the index at the mid-range of the years of the survey and gives greater weight to those areas which have a larger population of woodcock.

In analyses of similar surveys (Geissler and Noon 1981, Collins and Wendt 1987), a third term, measuring the area of the sampling universe that each route represents, was included in the weight function. As measurements of the area represented by each route were not available, such a term in the weighting factor was not used in this analysis.

In the woodcock survey, some routes were run more than once in the same year by different observers to provide comparable routes for the year-to-year adjustment estimator. In the analysis used here, all observations on a route in one year were averaged. The analysis ignored the differences in number of observations taken on one route in one year.

Testing the hypothesis of no trend
The significance of the estimate of trend was assessed using a permutation test (Collins and Wendt 1987). In this procedure, the hypothesis that there had been no trend is tested by randomly rearranging the observations within each route. The proportion of times the randomized estimate is larger than the observed estimate is indicative of the probability that the observed trend could have arisen if the year-to-year differences in count had been due solely to random errors.