The first ten years of the co-operative Breeding Bird Survey in Canada

by Anthony J. Erskine

Major regions of Canada
For legend, see back cover

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The author

Anthony J. (Tony) Erskine has been employed by the Canadian Wildlife Service (CWS) as an ornithologist since 1960. Born in England, he came to Canada in 1936. His university career included the degrees of B.Sc. from Acadia University, and M.A. and Ph.D. from Queen's University, all in chemistry, followed by M.A. in zoology from the University of British Columbia. After joining CWS he worked on waterfowl, particularly the life history of the Bufflehead and population studies on mergansers. In 1966 he undertook to organize the co-operative Breeding Bird Survey (BBS) in the Maritime Provinces, which led to his appointment as research scientist in Populations and Surveys Division, Migratory Birds Branch, CWS, in Ottawa, with responsibilities covering non-game birds across Canada. He has recently been appointed Chief, Migratory Birds Division, Atlantic Region, CWS, with headquarters in Sackville, New Brunswick.

Acknowledgements

The Breeding Bird Survey is a co-operative project which over 10 years has involved several hundred bird enthusiasts across Canada. Although the effort put forth has varied, some persons having done several surveys in each year that surveys were operational in their region whereas others took part only once, it would be invidious to single out a few of the many persons deserving recognition. The BBS, in Canada as in the United States, is one of the most extensive surveys of bird numbers attempted anywhere by volunteers, and its success encourages us to hope for continued co-operation in the future. Without the co-operation of most of the keener bird watchers in all provinces, we could not have attempted this project, and we thank you, all of you, for your efforts in the first 10 years.

I must risk favouritism, however, by extending special thanks to our long-term regional co-ordinators — David Christie (Maritimes), Martin Edwards and Murray

Speirs (Ontario), Herbert Copland (Manitoba), Jack Park (Alberta), and Wayne Neily (Cape Breton Island, later Yukon Territory). These enthusiastic and dedicated people have themselves regularly surveyed from one to seven routes each year, and in addition, year after year, they have recruited others to help fill the gaps in the coverage of their respective areas.

This work has also been encouraged throughout by Chandler S. Robbins of the United States Fish and Wildlife Service (USFWS), who originated the BBS in Maryland in 1965, and by Hugh Boyd and F. Graham Cooch of CWS, Ottawa, who supervised my work on it since the first analyses in 1967. They and many others contributed to discussions leading to the conclusions expressed here, and I thank them all for their help.

Abstract

The co-operative Breeding Bird Survey (BBS) has been active in Canada since 1966. This report discusses the first 10 years (1966–75). The main objectives of the BBS are to detect and measure year-to-year and long-term changes in populations of birds, particularly the smaller land birds. The surveys, carried out by volunteer observers, are based on random sampling and a standardized roadside point-count method, as in parallel surveys in the United States. Analyses are carried out for six major regions — the Maritime Provinces, agricultural southern Ontario and Quebec, forested central Ontario and Quebec, agricultural southern Prairie Provinces, forested central Prairie Provinces, and British Columbia west of the Rocky Mountains. No attempt is made to combine the results for nation-wide indices, because few if any environmental factors act uniformly and concurrently all across an area as large as Canada.

The methods of data collection and their biases are discussed critically, and the data are believed to be sufficiently reliable for the purposes of the BBS. There is no better method which can make use of the individual efforts of many volunteers. All alternative methods require far more expenditure of time, effort, and money.

The BBS results document the effects of severely cold springs in reducing numbers of small insectivorous birds in the Maritimes in 1967 and 1974 and in central Ontario and Quebec in 1974. They also agree with other sources on the year-to-year fluctuations in the numbers of various seed-eating birds that occur, apparently in response to changes in the crops of tree seeds. Some changes in the Maritimes are well correlated with variations in the regime of forest spraying against spruce budworm; species known to increase in response to increasing budworm densities generally showed upward trends, while a number of other insectivorous species showed upward trends which may be correlated with the decline of DDT, last used in spraying in New Brunswick in 1967, in the environment. Greatly increased spraying in 1975, including use of highly toxic phosphamidon, resulted in a substantial decrease in several species.

There are few sustained downward trends shown by the BBS, and none is clearly correlated with obvious environmental changes. Some declines in the Maritimes might reflect forest succession in the wake of abandonment of unproductive agricultural lands, while a few elsewhere may be connected with more intensive use of land for farming. On the other hand, Red-winged Blackbirds show upward trends in all regions except British Columbia, roughly paralleling increases in areas planted to corn; other blackbird species show no upward trends.

No clear agreement, other than general increases from 1973 to 1974, could be demonstrated between the BBS indices for waterfowl in the Prairie Provinces and the results of aerial surveys by the United States Fish and Wildlife Service (USFWS) and co-operating agencies. The dates of these surveys differ by about 3 weeks on average, but this seems insufficient to explain the lack of agreement.

The results of the BBS, particularly in the Maritimes, where surveys have been operational longer and with larger samples than elsewhere, indicate the desirability of continuing these surveys in the same fashion in the future. The results would be improved by somewhat larger samples in most regions, and coverage should not be allowed to decline below present levels. One threat to continuation of the BBS lies in the increasing price of gasoline. A method less dependent on cars should be investigated. The BBS stands as a fine example of productive co-operation between government agencies and concerned members of the public.

Résumé

L'Étude collective des populations d'oiseaux nicheurs au Canada dure depuis 1966. Le présent rapport fait le point sur les dix premières années de cette étude, qui a pour principal objectif de déceler et mesurer les variations, tant annuelles qu'à long terme, des populations d'oiseaux, surtout chez les petits oiseaux terrestres. La collecte des données, confiée à des bénévoles, se fait, comme pour les relevés homologues aux États-Unis, au moyen de l'échantillonnage au pur hasard et plus précisément du point normalisé au hasard, à partir du bord des chemins. Six grandes régions sont visées: les provinces maritimes, les régions agricoles du sud de l'Ontario et du Québec, les régions boisées du centre de l'Ontario et du Québec, les régions agricoles du sud des provinces des prairies, les régions boisées du centre de ces mêmes provinces, et la partie de la Colombie-Britannique située à l'ouest des Rocheuses. Vu qu'il n'y a guère de facteur ambiant qui agisse uniformément et simultanément sur un territoire de l'échelle du Canada, on n'essaie pas de tirer des résultats obtenus des indices qui fussent valables à l'échelle du pays entier.

On fait en outre une étude critique des méthodes de collecte des données et des erreurs systématiques qui en découlent. On postule que les données sont assez

The boreal forest is the largest single region of Canada, but our surveys sample it rather poorly owing to a lack of roads

fidèles quant aux fins de l'Étude. Il n'y a pas de méthode qui permette de tirer meilleur parti du travail personnel de nombreux bénévoles. Toutes les autres méthodes connues exigent bien davantage de temps, d'énergie et d'argent.

Les résultats de l'Étude documentent la baisse d'effectifs chez les petits oiseaux insectivores du fait de printemps très froids en 1967 et 1974 dans les provinces maritimes et en 1974 dans le centre de l'Ontario et du Québec. Ils concordent en outre avec ceux d'autres travaux sur les fluctuations annuelles de l'effectif de diverses populations d'oiseaux granivores en fonction, à ce qu'il semble, de changements aux moissons de graines d'arbres. Il y a corrélation positive de certains changements enregistrés dans les provinces maritimes aux variations du régime des pulvérisations d'insecticide sur les forêts pour combattre la tordeuse de bourgeons; dans l'ensemble, c'est l'effectif des espèces qui prolifèrent lorsque la densité en tordeuses est forte qui a connu une augmentation; par ailleurs, on pourrait établir une corrélation avec l'accroissement des effectifs de bon nombre d'autres espèces insectivores.

Introduction

The BBS was developed in the United States (US) in 1964–65 (Robbins and Van Velzen 1967) by extending to all birds the basic methods already used for conducting a census of game birds that can be detected by sound. The drumming of grouse, crowing of pheasants, peenting of woodcock, and cooing of doves have all been sampled for many years by stopping at regular intervals along roads for standardized times, and counting these sounds (review by Overton 1971). By a similar method, with counts distributed according to a statistical sampling plan, it was hoped to monitor trends in numbers of most song birds. Both the amount and kind of effort required were such that volunteers could be expected to take part effectively and willingly. Even the most optimistic forecasts of the coverage possible fell short of what was accomplished in areas where the method was pushed with enthusiasm, but there are still many misconceptions of what can be expected from this project. This report is a broad-scale review of the project as it relates to Canada, with material from the US brought in only where necessary to supplement our own.

The success of a pilot project carried out in Maryland and Delaware in 1965 led to expansion of coverage across the US and Canada during 1966–68 (Robbins and Van Velzen 1967, 1969). Surveys began in the Maritime Provinces and Quebec in 1966, in Ontario and Manitoba in 1967, and in Saskatchewan, Alberta, and British Columbia in 1968. Coverage has since expanded in all these provinces, and a few surveys have been made in Newfoundland and in Yukon Territory. Co-ordination of the Canadian effort was undertaken by CWS Ottawa with my appointment there in December 1968. I had co-ordinated the surveys in the Maritimes only in 1966–68. Since then, the CWS has published a series of reports on the year-by-year progress of the BBS in Canada (Erskine 1970, 1971*a*, 1972–77). The administrative operations of the surveys, particularly the supplying and distribution of survey materials and the assembly of completed forms, has remained with the USFWS at the Patuxent Wildlife Research Center, Laurel, Maryland, under the direction of Chandler S. Robbins.

The Canadian data have thus been collected as part of a program covering most settled areas of North America north of Mexico. As birds do not recognize political boundaries this is a reasonable approach, but we believe that a separate Canadian analysis not only is more interesting to most Canadians but also recognizes the ecological differences between Canada and the US. Few birds are confined to Canada, but many of our common species cease to be common beyond the northernmost states, and many birds widespread in the US have only small peripheral populations in Canada. From the start of the BBS, we have carried out our own evaluation and analysis of Canadian data independent of any uses made of the same data at Patuxent.

Methods

The basic methods (standard instructions are given in Appendix 1) have been reviewed fully by Robbins and Van Velzen (1967, 1969) and only a few aspects are discussed here. The sampling unit is the degree-block of latitude and longitude, an area 111.1 km N–S, with E–W width narrowing from about 78.8 km at latitude 45°N to about 47.4 km at 65°N. The use of blocks two degrees by two degrees, as in the western states, was abandoned in western Canada after 1968 in favour of one-degree blocks, to help minimize travel to starting points. The sampling intensity in Canada has been one survey route per degree-block except in the Maritimes and southern parts of Quebec, Ontario, and British Columbia, where two and occasionally even three or four routes per degree-block were surveyed. The sampling intensity is governed primarily by the availability and distribution of qualified observers and of all-weather roads. Each survey is made up of 50 sampling stations (stops) spaced at 0.5 mile (0.8 km) intervals along a road. Each route is covered on one day in June (extremes allowable: 28 May – 7 July) under acceptable weather conditions (light winds, little or no precipitation), starting 30 minutes before local sunrise and spending 3 minutes at each of 50 stops. All birds heard, regardless of distance, and all seen within 0.25 mile (0.4 km), are recorded on standard forms, together with the weather conditions at the start and end of the survey. The instructions provide for minor variations from the standard procedure in case of unforeseen circumstances, but individual observers have adopted many other variations, some of minor significance but others affecting results to the point of excluding surveys from comparisons.

Co-operators were recruited by appeals through naturalists' newsletters and particularly by individual letters or personal contacts. Some willing observers at first lacked experience in identifying birds by song; many of those who persisted were able to achieve useful results after two or three surveys. As yet we have not found

a way to help observers with the costs of these surveys. In the US, observers can deduct these costs as "business expenses" on their income tax returns.

Routes for most Canadian surveys were selected in Canada, using the sometimes obsolete maps of the National Topographic Series, usually in 1:250 000 and 1:50 000 scales. Provincial road maps were sometimes more helpful in determining which were all-weather roads. The instructions (App. 1) prescribed procedures for realigning routes in case of need. Observers changed a number of routes, often with no explanation; some of these changes probably involved routes that were virtually impassable as drawn, but others were obviously dictated by the whim or convenience of the individual observer.

The methods of analysis were modified several times, as experience and better advice became available. All previous analyses have been brought up to date, using the method adapted by G.E. John Smith (Appendix 2; repeated from Erskine 1973). Because the samples were drawn at random from each degree-block, the analysis makes use of strata, each stratum including one or more degree-blocks as required to include two or more comparable surveys. The comparability of surveys was assessed more or less objectively by assigning scores from 0 to 3 in each of four main fields — observer, date, conditions, adherence to instructions, as follows:

1. Observer

3, same observer in successive years;
1, twin brother of previous observer (special case);
0, different observers in successive years.

2. Date

3, 0–4 days difference in dates between years;
2,* 5–9 days difference;
1, 10–19 days difference;
0, 20 or more days difference.

*This may be reduced to 1 if one date was after 1 July.

3. Weather

3, comparable without qualifications;
2, less favourable in one year, e.g. maximum wind force 3, compared to force 1 or 0 in the other year;
1, moderately unfavourable in one year, e.g. showers or drizzle, wind of force 4 or more;
0, decidedly unfavourable in one year, e.g. rain, strong winds
(Note: results are obviously affected under these conditions, less obviously so with score "1", and may not be detectably different with score "2".)

4. Adherence to instructions

3, no obvious departure from rules;
2, start 10–15 minutes early or 10–20 minutes late, or end more than 4½ hours after start, or minor departure (1 or 2 stops) from route used previously;
1, start 15–20 minutes early or 20–40 minutes late, or end more than 5 hours after start, or moderate departure (3 to 6 stops) from route used
0, previously; start more than 20 minutes early or more than 40 minutes late, or end more than 6 hours after start, or route changed by more than 6 stops, or other obvious departures from prescribed procedures.

To be considered comparable, coverage in the 2 years being compared must score at least 8 out of a possible 12 points, with no zero scores.

Analyses were carried out for up to six regions of Canada, as sufficient comparable coverage was achieved in the various areas. The regions were chosen partly on geographic and partly on political bases, thus: (1) the Maritime Provinces (east of the Appalachians); Ontario and Quebec, subdivided into (2) southern (agricultural) and (3) central (forested) regions; the Prairie Provinces plus northeastern British Columbia, subdivided into (4) southern (prairies) and (5) central (parklands, forest, and foothills) regions; and (6) British Columbia (west of the Rockies). The boundary between the southern and central Prairie Province regions has been changed since the 1975 report (Erskine 1976), and all analyses for these regions have been recalculated. As now defined, the boundary between regions (4) and (5) roughly coincides with the southern limit of White-throated Sparrows* and, in Alberta only, with the northern limit of Chestnut-collared Longspurs; Horned Larks and Western Meadowlarks also become much scarcer north of this line. The boundary between regions (2) and (3) is more arbitrary inasmuch as the southern region here was artificially cleared rather than being naturally open, thus retaining a number of relict woodlands; north of this line, open-country species such as Starling, Eastern Meadowlark, and Red-winged Blackbird become scarce, while forest birds such as Veery, Chestnut-sided Warbler, Ovenbird, and White-throated Sparrow become common. No attempt has been made to compare data from the scattered surveys in Newfoundland, Labrador, Yukon Territory, and northern British Columbia. Samples there seem likely to remain too small for helpful analysis, and to combine these with other regions would make the latter more heterogeneous.

Previous analyses included about 40 species in each region. For this report, data were analysed for about 20 more species in each region. Almost all species for which adequate samples were available in all years with enough comparable surveys to permit useful analysis are now included. Criteria used in determining whether a species would be included were the number of birds detected on comparable surveys, the proportion of surveys on which a species was detected, whether the same species was included in analyses in other regions, and whether particular interest attached to a species.

* Scientific names are given in Appendix 4. These follow the A.O.U. Checklist and supplements, as do English names, except that Northern Junco is used in preference to Dark-eyed Junco.

Plate 1

Prairie Provinces. Farms with shelterbelts provide variety in the vast sweep of grainlands and prairie grassland, but farther north new roads extend deep into the boreal forest. (a) At least half of the land birds of the prairies are associated with shrubbery and shelterbelts, Delisle, Sask. (b) Even in the villages, open land is the dominant landform in the west, Myrnam, Alta. (c) Many roads in this region of fine, silty soils are quite unusable for Breeding Bird Surveys after rain, Fairview, Alta. (d) The scarcity of birds along the forest roads of the northern frontier, which lacks open lands, settlements, and extensive marshes, is a marked contrast to more southern areas, Atikameg, Alta.

Plate 1

a

b

c

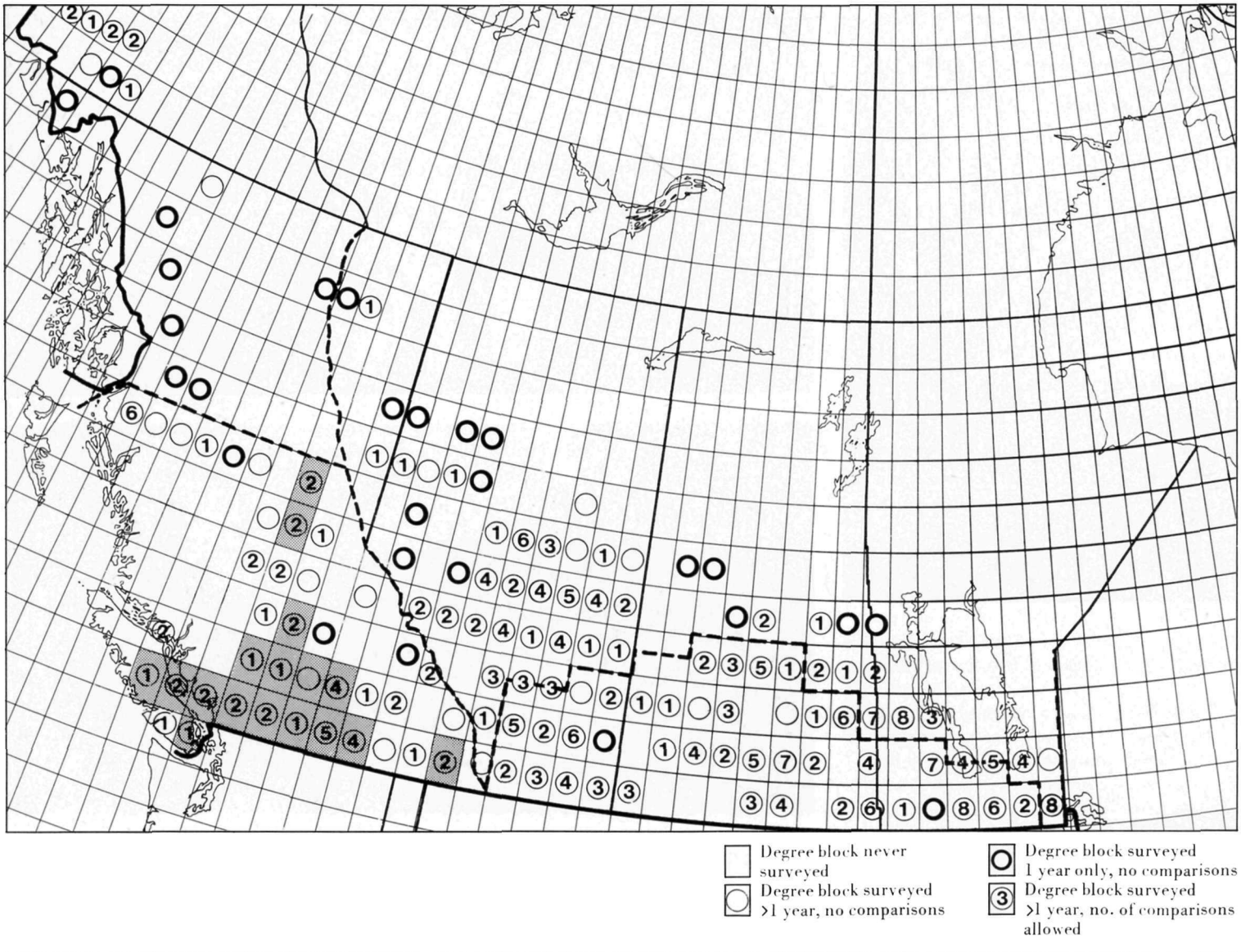
d

Results

Figure 1a
Frequency of comparable coverage, Breeding Bird Survey, western Canada, 1966–75

Figure 1b
Frequency of comparable coverage, Breeding Bird Survey, eastern Canada, 1966–75

Figure 1a

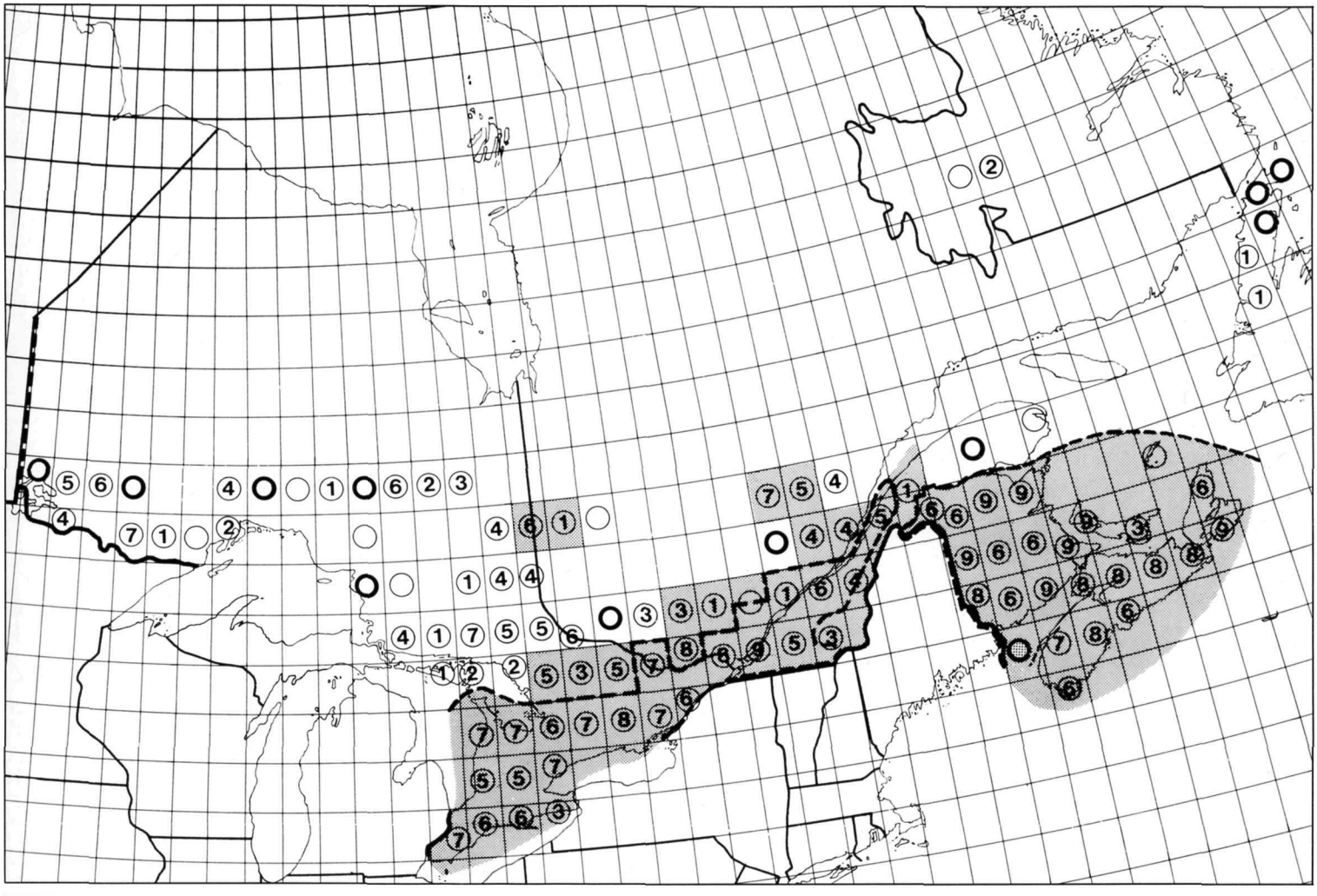


1. Coverage

By 1975, coverage included most of the accessible area (Fig. 1), although many northern routes and a few closer to urban centres had sporadic surveys only. Table 1 gives the proportion of degree-blocks with roads in which surveys have been made at least once in 1966–75, and Figure 1 shows the frequency of comparable coverage, by degree-block, in various areas. The potential number of comparisons falls from east to west and from south to north, following the extension of surveys to new areas. Nine comparisons is the maximum number possible in the Maritimes, compared to seven or eight in southern Ontario and Quebec, six or eight in the Prairie Provinces, and only two in most of British Columbia and the peripheral areas along the northern fringes of settlement.

Table 2 gives a breakdown of the coverage by regions. In brief, there are two small regions — the Maritimes, and southern Ontario and Quebec — which have

Figure 1b



2 (or more) routes/degree block (no. given is composite from all routes in block)

Boundaries between regions

been sampled generally by two routes per degree-block with fairly complete coverage, and four large regions, sampled generally by only one route per degree-block with many blocks unsampled in all or most years. Even weighting the data from areas with incomplete coverage, by allowing a single route to represent up to 2½ degree-blocks, has never enabled all accessible areas in the four large regions to be represented in the analyses.

2. Year-to-year changes and long-run trends

Changes between each successive pair of years were published for each region as sufficient data became available (Erskine 1970, 1971*a*, 1972–77). Not all previously published results are fully comparable, owing to changes in the species included, in the methods of analysis, and in the boundaries between regions, although most of the differences have been small. Summaries of year-to-year changes for each

Figure 2
Examples of inadequacy of year-to-year changes in weighted mean numbers per route for graphing long-term changes in populations. Small size and varying comparability of the samples are responsible for the discontinuities between years. Data are from the Maritime Provinces, 1966–76

region, presented as annual indices compared to 1973 values (set at 100), are given in Tables 3 to 8. The weighted mean numbers per route on comparable surveys in 1975 are given as a rough index to sample size for each species. The scarcer species generally show much more variable indices and fewer statistically significant changes.

We recognize that indices are not an ideal mode of presentation but unfortunately no other method allows easy graphing of trends. In the US, where samples are much larger and less variable, the actual weighted means can be presented, which is obviously preferable. In our analyses, the samples of routes comparable from (say) 1970 to 1971 almost never coincide exactly with those comparable from (say) 1971 to 1972. Unless the weighted mean number of a species on the routes included only in the latter comparison was identical with those included only in the former comparison, we would be left with two weighted means, differing to a greater or less extent, for 1971 (or any other year within the series), as shown in Figure 2. American Robin in the Maritime Provinces, a common non-flocking species, shows less variation in numbers than do many less common species with different habits (*cf.* Red-winged Blackbird, Fig. 2), but even here weighted mean numbers are less satisfactory than the indices. Many kinds of statistical analysis of trends are thus less easy, though probably not impossible. Without greatly increased numbers of comparable routes or the combining of several regions for such analysis it seems unlikely that we can solve this problem at present. Our analysis is therefore restricted to tabular and graphical presentation of indices, and discussion of trends where these were obvious without statistical verification.

Figure 2

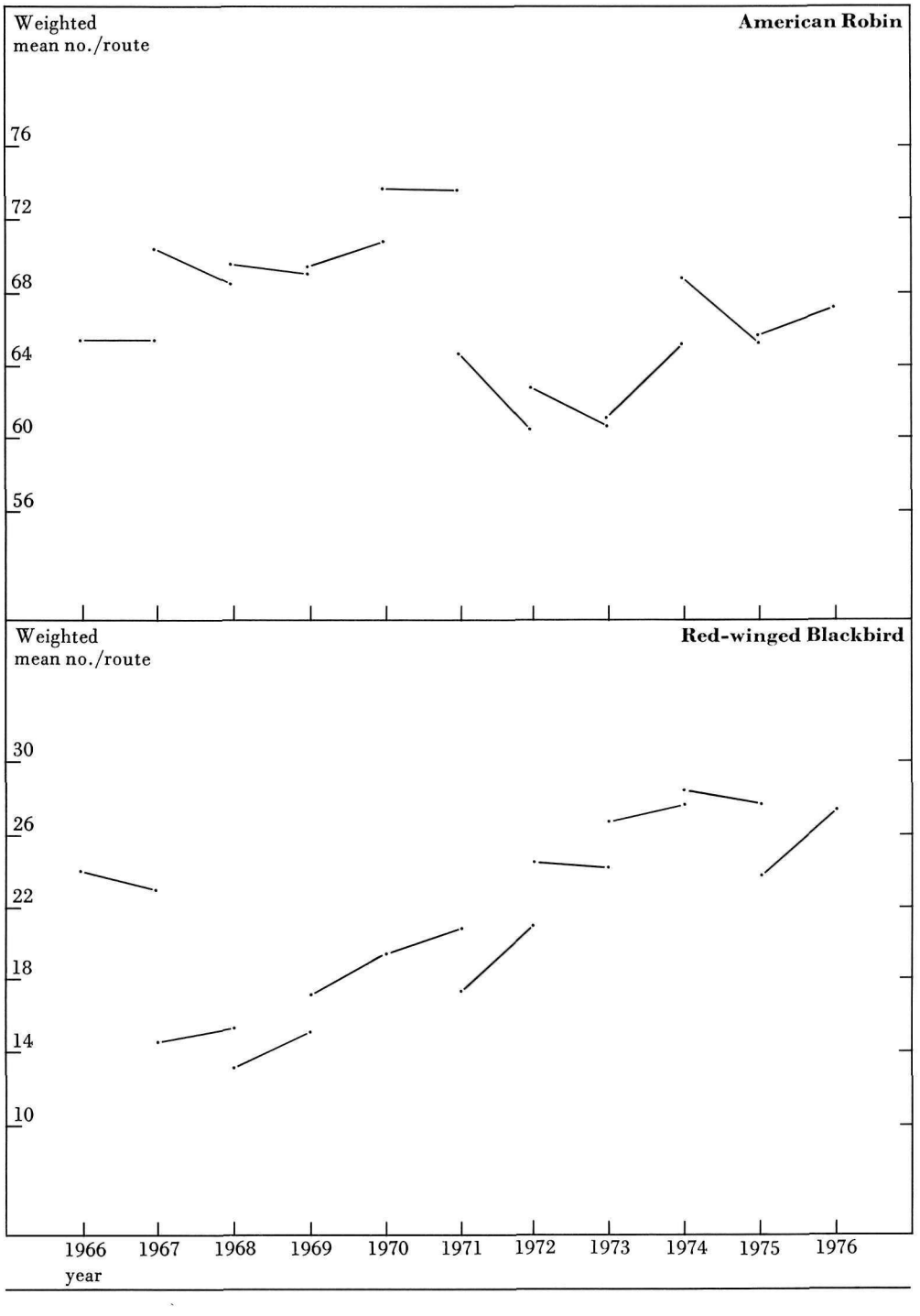


Table 1
The proportion of degree-blocks sampled by the Breeding Bird Survey, 1966–75

Province	No. of degree-blocks with surveys in 1 or more years	No. of degree-blocks with roads on which surveys are possible	%
Newfoundland (island)	5*	18	28
Prince Edward Island†	1	1	100
Nova Scotia†	10	10	100
New Brunswick†	11	11	100
Quebec (S of 49°N)	28	34	82
Ontario (S of 50°N)	50	61	82
Manitoba (S of 55°N)	16	24	67
Saskatchewan (S of 55°N)	30	48	63
Alberta (S of 57°N)	45	54	83
British Columbia (S of 56°N)	43‡	63	68
Yukon Territory	7	19	37

* Also 2 in Labrador.
† Coastal degree-blocks combined into roughly equal sampling units.
‡ Also 10 farther north in B.C.

Note:
The northern portions of all provinces other than the Maritimes were excluded, owing to the few roads in any of these areas.

Table 2
Extent of coverage in Breeding Bird Survey, by region

Region	Maximum extent (°E–W × °N–S)	No. of sampling units (strata) accessible	No. of comparable routes/year (range) †	No. of strata actually sampled* (range) †
1. Maritime Provinces	9 × 4½	22	(18–)25–41	(14–)17–20
2. Central Ontario and Quebec	31 × 5	55½	(14–)21–29	(13/26–)20/34–26/41½
3. Southern Ontario and Quebec	14 × 3	19	23–30	15–16
4. Southern Prairie Provinces	19 × 4	51	(16–)23–28	(16/31½–)23/45½–28/49½
5. Central Prairie Provinces	30 × 10	76½	(13–)23–25	(13/23½–)23/41½–25/43½
6. British Columbia (W of Rockies)	15 × 6	51½	26–27	17½/28½–18/24½

* The numbers in the form of fractions (e.g. 20/34) given for all except the smallest regions indicate the actual number of degree-blocks sampled over the number of degree-blocks these represent in the analysis.
† The figures in parentheses represent the limit, including samples smaller than considered satisfactory; these occurred only in the first year (regions 1 and 2) or first and second years (regions 4 and 5) of analyses.

Table 3
Index numbers for bird populations, Maritime Provinces, from Breeding Bird Survey, based on 1973 index of 100

Species	Annual indices (based on 1973 set at 100)[a]										Weighted mean for 1975[b]
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	
Common Loon	(40)	292	225	144	85	99	132	100	151	95	1.02
Great Blue Heron	(39)	(47)	(41)	129	97 *	64	71	100	78	74	2.35
Black Duck	311 *	127	270 *	189	344	347	250 *	100	171 *	349	2.38
Killdeer	53	48	63	92	111	109	99	100	157	165	1.87
Common Snipe	(48)	87	97 *	71	90	112	103	100 *	169 *	103	5.33
Herring Gull	154	168	133	132	331 *	149	238 *	100	91	82	28.43
Chimney Swift	126	78	105	160	198 *	103	102	100 *	71 *	50	1.82
Belted Kingfisher	49	56	85	67	93 *	51	74	100 *	44	50	0.77
Common Flicker	225	194	196	176	194	167 *	82	100	99	78	2.89
Yellow-bellied Sapsucker	120	134	125 *	168 *	131	196 *	133	100	125	140	8.44
Alder Flycatcher	90	102	125 *	149 *	103 *	127	123 *	100 *	149 *	103	14.92
Least Flycatcher	119 *	80	66	95 *	73	93	90	100	87	71	4.13
Eastern Wood Pewee	103	107	153	136	125	116	106	100	105 *	52	1.18
Tree Swallow	142	125	105	117	108 *	141	127	100	79 *	56	12.27
Bank Swallow	86	106	88	78	69	111	81	100	96 *	42	9.03
Barn Swallow	80	94	80	92	96	80	88	100 *	74 *	53	15.85
Cliff Swallow	139	100 *	56	131	106	108	93	100	79	82	4.04
Blue Jay	79	83 *	197 *	122	115	131	102	100	136	116	3.71
Common Raven	170 *	104	93	80	92	111	110	100	111	91	8.89
Common Crow	124 *	97	103	117	101	102	114	100	108 *	95	33.58
Black-capped Chickadee	97	125	134	147	125	144	143 *	100 *	228	189	3.30
Winter Wren	78	97	93	85	76	94	97	100 *	165 *	101	4.70
Gray Catbird	134	126	91	113	117	140	108	100 *	161	151	3.83
American Robin	112	112	110	109	111	111	104	100	107	102	65.29
Hermit Thrush	82	101	98	87 *	112	115	116	100	121	120	9.69
Swainson's Thrush	81	83	91	105	92	89	106	100	90	88	21.49
Veery	106	86	73	83	80	94	105	100	93	77	7.03
Ruby-crowned Kinglet	122 *	99	83	86	85	98 *	114	100	110	109	17.60
Cedar Waxwing	533	368	364	328	259	313	222 *	100	263 *	124	1.41
Starling	111	87	98	93	99	95	94	100	96	103	50.08
Solitary Vireo	105	64	50	43	59	56	79	100	76 *	121	2.97
Red-eyed Vireo	77 *	61	71	90	78	85 *	105	100 *	137	115	12.57
Black-and-white Warbler	139 *	71	58	76	62	73	80	100 *	71	63	3.43
Tennessee Warbler	50	38 *	53	64 *	42	52 *	76	100	110 *	85	9.88
Nashville Warbler	87	75	63 *	102	114	128	133 *	100	76	69	4.58
Northern Parula Warbler	75 *	52	50	64	66 *	89	93	100 *	54	71	5.00
Yellow Warbler	83	69	71	82	71	74	86	100 *	79	72	13.12
Magnolia Warbler	69 *	55	60	60 *	76	81	83	100 *	75	77	13.23
Yellow-rumped Warbler	77	100	103	87 *	127 *	84	106	100	109	123	5.88
Black-throated Green Warbler	91 *	64	78	83	90 *	69 *	83	100	70	65	7.17

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Table 3 *cont'd*

Species	Annual indices (based on 1973 set at 100)[a]										Weighted mean for 1975[b]
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	
Blackburnian Warbler	83	80	57	76	93	78	91	100	123	116	1.18
Chestnut-sided Warbler	77	56	58	78	88	96	116	100	81	75	5.41
Bay-breasted Warbler	41	42	41	47	55	47	86	100	* 64	79	3.21
Ovenbird	52	56	54	65 *	84	76 *	101	100	119	* 89	12.31
Northern Waterthrush	52	77 *	49	56 *	79	83	73	100	* 161	* 108	2.74
Mourning Warbler	54	51	63	52	65	70	83	100	99	79	2.33
Common Yellowthroat	94	97	93	89	95	97	97	100	* 85	78	25.03
Canada Warbler	66	80	82	76	92	98	105	100	116	98	2.44
American Redstart	66	55	60	65	76	86	86	100	108	104	19.57
House Sparrow	95	105	99	119	140	108	98	100	113	* 89	12.58
Bobolink	74	83 *	100	108 *	84	87 *	111	100	* 124	* 104	16.08
Red-winged Blackbird	62	59	63	71	79	85 *	101	100	104	103	27.94
Common Grackle	134	106	108	103	92	81	88	100	* 79	71	26.74
Brown-headed Cowbird	112	140	155	209	157	129	119	100	123	109	7.49
Rose-breasted Grosbeak	30	44	46	56	68 *	98	130	100	155	183	5.35
Evening Grosbeak	(14)	(19)	(22)	(33) *	92	166	151	100	66	* 103	15.66
Purple Finch	56 *	116	122 *	99	116	164	141	100	102	106	9.01
Pine Siskin	306	254	328 *	154	196	165 *	33	100	61	* 249	7.28
American Goldfinch	150	222	162	144	125	141	128 *	100	110	107	11.92
Savannah Sparrow	103	111	120	104	116	103	104	100	93	95	12.23
Northern Junco	156	164 *	130	121	122	101	105	100	102	101	13.64
Chipping Sparrow	109	128	120	119	113	120	124	100	83	84	7.71
White-throated Sparrow	(86)	102 *	94	100	105 *	96	103	100	* 106	100	56.37
Lincoln's Sparrow	(24)	(28)	(30) *	(46)	(57)	(49) *	88	100	108	95	3.08
Song Sparrow	(140) *	91	97	101	94	94 *	81 *	100	92	88	36.19
No. of routes included in comparison	18	28	33	33	32	41	32	30	28		

[a]Figures in parentheses considered unrepresentative owing to discontinuities in data compared. Asterisks mark statistically significant changes.

[b]Weighted mean for 1975 is of no. of individuals per route.

Table 4
Index numbers for bird populations, central Ontario and Quebec, from Breeding Bird Survey, based on 1973 index of 100

Species	Annual indices (based on 1973 set at 100)[a]							Weighted mean for 1975[b]
	1969	1970	1971	1972	1973	1974	1975	
Common Loon	109 *	38	78	116	110	88	108	1.63
Great Blue Heron	102	63 *	152	102	100	88	93	0.82
American Kestrel	47	92	68	92	100 *	61	66	0.80
Killdeer	104	81	80	98	100	89	115	3.80
Common Snipe	94	90	76 *	51 *	100	134 *	75	1.66
Herring Gull	182	197	303 *	100	100	130 *	62	4.36
Black-billed Cuckoo	119	113	195	80	100	189 *	387	2.99
Belted Kingfisher	140	182 *	109	182 *	100	76	88	0.89
Common Flicker	112	87	84	103	100	93	99	3.74
Yellow-bellied Sapsucker	90	124	124 *	67	100	77	98	2.97
Hairy Woodpecker	94	138	152	67	100	115	161	0.93
Eastern Kingbird	66	130	159	154	100 *	158	155	1.39
Eastern Phoebe	142 *	68	94	93	100	86	101	1.54
Alder Flycatcher	151	142 *	182 *	115	100	128	116	8.73
Least Flycatcher	97	110	102	100	100	83	86	8.55
Tree Swallow	86	103	115	116	100	82 *	126	12.80
Bank Swallow	131 *	92	122	213	100	156 *	75	1.81
Barn Swallow	110	89	77	83	100	76 *	101	11.00
Cliff Swallow	71	77	74	124	100	154	130	5.72
Blue Jay	200	162	177 *	110	100	77	82	2.56
Common Raven	150 *	102 *	140	101	100	103	106	5.49
Common Crow	108	99	90	105	100	96 *	71	16.01
Black-capped Chickadee	159	89	109	132	100	135 *	72	1.22
Red-breasted Nuthatch	119	99	210 *	103	100	157	177	2.23
Winter Wren	61	81	87	78	100	122 *	167	10.34
American Robin	104	101	96	106	100	107	104	27.52
Hermit Thrush	103	98	135	116	100	94	143	13.83
Swainson's Thrush	91	96	118	113	100 *	86 *	115	20.47
Veery	96	92	116	125 *	100	92	109	17.96
Ruby-crowned Kinglet	81	76	91	118	100	121	118	11.37
Cedar Waxwing	180	169	220 *	130	100	95	105	4.74
Starling	111	98	92	110	100	86	112	37.05
Red-eyed Vireo	92	94 *	125	101	100	88 *	107	29.17
Black-and-white Warbler	105	149	113	135	100	75	98	2.25
Tennessee Warbler	89	134	134	133	100	158	182	6.67
Nashville Warbler	113	90	131	97	100	101	81	9.39
Yellow Warbler	47	57	86	61	100	66	94	3.92
Magnolia Warbler	81	112	119 *	93	100	100	115	6.89
Yellow-rumped Warbler	93	130	103	92	100	85	122	7.94
Chestnut-sided Warbler	94	94	113	89	100	91	101	16.58

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Table 4 *cont'd*

Species	Annual indices (based on 1973 set at 100)[a]							Weighted mean for 1975[b]
	1969	1970	1971	1972	1973	1974	1975	
Ovenbird	87	83 *	104	100	100	96	92	19.31
Mourning Warbler	113	105	112	115	100	106 *	142	13.49
Common Yellowthroat	80	100	111	100	100	98	112	18.09
Canada Warbler	183	132	205 *	127	100	94	94	1.77
American Redstart	78	98	106	89	100	111	122	7.45
House Sparrow	123	85	78 *	118	100	63	115	1.78
Bobolink	81	77	92	89	100 *	88	100	10.96
Red-winged Blackbird	87	80	89	94	100	100	106	15.87
Common Grackle	133	104	110	109	100 *	72	84	7.23
Brown-headed Cowbird	109	96	124	115	100	86	94	4.53
Rose-breasted Grosbeak	46	44 *	60	69 *	100	84	97	6.18
Evening Grosbeak	28	31 *	102 *	50	100 *	44	50	6.78
Purple Finch	90	68	68	74	100	92	80	2.79
Pine Siskin	(40 600)	* (7 730)	(12 900) *	130	100	176	340	3.65
American Goldfinch	152 *	91 *	196 *	110	100	84	95	5.49
Savannah Sparrow	82	82	91 *	121 *	100	85	105	11.54
Northern Junco	130	86	82	119	100	77	96	6.42
Chipping Sparrow	73	88	96	119 *	100	112	109	10.47
White-throated Sparrow	100	94 *	107	111 *	100	107	108	60.65
Lincoln's Sparrow	95	63 *	89	135 *	100	123	114	4.95
Swamp Sparrow	53	60	60	88	100	75	94	3.66
Song Sparrow	85	100	105	111	100	92	101	15.82
No. of routes included in comparison	14	29	21	28	28	28		

[a] Figures in parentheses considered unrepresentative owing to discontinuities in data compared. Asterisks mark statistically significant changes.

[b] Weighted mean for 1975 is of no. of individuals per route.

Table 5
Index numbers for bird populations, southern Ontario and Quebec, from Breeding Bird Survey, based on 1973 index of 100

Species	Annual indices (based on 1973 set at 100)[a]								Weighted mean for 1975[b]
	1968	1969	1970	1971	1972	1973	1974	1975	
Great Blue Heron	59	48	92	69	60	100	95	141	2.46
Mallard	(2.5)	(4)	(9)	148 *	71	100	101	72	1.92
Killdeer	89	81	87	91	97	100	89	107	22.08
Common Snipe	76	57	54	69	90	100	* 146	111	3.49
Rock Dove	180	141	116	130	135	* 100	115	128	19.41
Mourning Dove	61	58	66	71	79	100	91	91	16.39
Chimney Swift	162	105	116	158	101	100	76	106	2.86
Belted Kingfisher	73	89	90	* 45	67	100	61	80	0.80
Common Flicker	124	92	94	98	103	100	101	98	4.94
Eastern Kingbird	91	88	93	86	91	100	96	79	7.41
Great Crested Flycatcher	62	60	68	69	68	* 100	* 69	63	3.80
Eastern Phoebe	66	95	97	121	92	100	77	56	1.15
Traill's Flycatcher	74	88	106	107	114	100	173	145	2.36
Least Flycatcher	99	98	* 151	* 95	124	100	85	105	2.15
Eastern Wood Pewee	111	98	118	103	108	100	89	* 62	2.57
Horned Lark	130	141	124	124	110	100	89	138	7.17
Tree Swallow	105	91	96	85	114	100	* 148	129	10.25
Bank Swallow	58	102	100	127	93	100	* 47	46	21.98
Barn Swallow	80	90	112	104	103	100	111	121	36.18
Cliff Swallow	276 *	141	155	150	238	* 100	132	* 421	4.22
Purple Martin	119	100	108	157 *	99	100	110	108	4.92
Blue Jay	99 *	134	93 *	142 *	98	100	82	84	4.58
Common Crow	89	91	91	104	97	100	98	88	41.46
Black-capped Chickadee	111 *	59	47	74	83	100	145	261	2.06
House Wren	69	51 *	82	78	94	100	* 120	146	6.14
Gray Catbird	118	143	170	158	137	* 100	* 132	130	3.58
Brown Thrasher	60	65	80	108	78	* 100	89	72	4.02
American Robin	99	98	96	107	113	* 100	105	106	49.76
Wood Thrush	85	107 *	72	86	103	100	131	111	3.17
Veery	123	114	135 *	108	98	100	107	139	5.26
Cedar Waxwing	(41)	82	86	140 *	83	100	119	102	3.78
Starling	70	73	72	74	83	100	104	101	170.82
Red-eyed Vireo	103	121	137	136	125	* 100	110	* 147	6.15
Warbling Vireo	76	83	110	157	151	* 100	132	143	3.53
Yellow Warbler	109 *	130	118	121 *	86	100	109	89	6.33

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Table 5 *cont'd*

Species	Annual indices (based on 1973 set at 100)[a]								Weighted mean for 1975[b]
	1968	1969	1970	1971	1972	1973	1974	1975	
Ovenbird	160	181	152	131	88	100	125	110	1.89
Common Yellowthroat	91	74 *	110	89	89	100	90	100	9.93
American Redstart	49	77	89	110	75	100	85 *	42	0.92
House Sparrow	95 *	110 *	88	85	94	100	97	87	70.04
Bobolink	89	103	107 *	128	123	100	118	113	47.35
Eastern Meadowlark	85	91	79	85	93	100	97 *	80	24.06
Red-winged Blackbird	59 *	69	71	79	110	100	107 *	138	183.85
Northern Oriole	94	92	98	113 *	92	100	110	102	8.52
Common Grackle	87	113 *	81	94	86	100	93	108	84.61
Brown-headed Cowbird	114	112	124	131	122 *	100 *	140	115	21.16
Rose-breasted Grosbeak	78	70	71	80	92	100	107	144	5.72
Indigo Bunting	52	51	67	82	86	100 *	69	86	3.03
American Goldfinch	202 *	115	117	125	109	100	102	122	19.84
Savannah Sparrow	88	100	94	99 *	120 *	100	88	104	57.68
Vesper Sparrow	154	166	183 *	145	147 *	100	91	90	6.61
Chipping Sparrow	127 *	97	118	111 *	141 *	100	108	118	11.78
Field Sparrow	49	41	56	67	81	100	82	101	2.49
White-throated Sparrow	75	71 *	92	96 *	122	100 *	151	211	6.91
Song Sparrow	98	92	94	101	90	100	103 *	91	34.38
No. of routes included in comparison	27	29	23	25	30	26	23		

[a] Figures in parentheses considered unrepresentative owing to discontinuities in data compared. Asterisks mark statistically significant changes.

[b] Weighted mean for 1975 is of no. of individuals per route.

Table 6
Index numbers for bird populations, southern Prairie Provinces, from Breeding Bird Survey, based on 1973 index of 100

Species	Annual indices (based on 1973 set at 100)[a]						Weighted mean for 1975[b]
	1970	1971	1972	1973	1974	1975	
American Bittern	115	254	167	100	* 322	* 167	1.51
Mallard	117	96	91	100	100	116	41.18
Gadwall	43	75	87	100	122	134	6.76
Pintail	196 *	118	80	100	163	233	26.75
Blue-winged Teal	145	139 *	96	100	148	171	13.90
Northern Shoveler	146 *	54	137 *	100	116	* 182	11.24
American Wigeon	87	119	145	100	111	143	7.59
Canvasback	131	144	125	100	273	207	4.13
Lesser Scaup	44	127	118 *	100	244	176	8.68
Swainson's Hawk	53	57	66 *	100	* 64	77	2.15
Marsh Hawk	116 *	80	115	100	70	91	1.99
Sora	114	126	154	100	164	218	4.44
American Coot	219	339 *	156	100	200	206	10.22
Killdeer	127	116	104	100	114	124	14.27
Common Snipe	59	128	109	100	180	223	2.01
Willet	77	104	81	100	148	135	4.35
Marbled Godwit	128	185	141	100	123	103	4.71
Wilson's Phalarope	175	112	90	100	95	98	4.71
Ring-billed Gull	122 *	66	63	100	* 42	47	17.10
Franklin's Gull	21	96	385 *	100	178	94	13.35
Black Tern	104	109	101	100	77	102	10.27
Rock Dove	277 *	144	115	100	* 67	80	5.92
Mourning Dove	95	123	114	100	103	112	11.94
Common Flicker	137	125	125	100	87	112	2.30
Eastern Kingbird	93	80	84	100	91	81	6.54
Western Kingbird	132	120	85	100	86	100	3.71
Least Flycatcher	141	195 *	111	100	129	186	2.77
Horned Lark	130	96	88	100	113	120	98.13
Tree Swallow	70	40 *	110	100	102	112	2.04
Barn Swallow	113 *	80 *	125 *	100	89	98	15.35
Cliff Swallow	152	167	222 *	100	140	153	26.00
Black-billed Magpie	113	121	124	100	90	82	7.45
Common Crow	89 *	118 *	96	100	89	80	29.13
House Wren	87 *	126	110	100	91	92	8.83
Gray Catbird	73	134	122	100	103	105	1.67
Brown Thrasher	66	66	43	100	57	102	1.28
American Robin	54	80	87	100	96	96	5.32
Sprague's Pipit	26	203	167	100	111	74	1.49
Starling	89	264 *	111	100	129	144	19.74
Red-eyed Vireo	241	195	156	100	121	162	1.28

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Table 6 *cont'd*

Species	Annual indices (based on 1973 set at 100)[a]												Weighted mean for 1975[b]
	1970		1971		1972		1973		1974		1975		
Warbling Vireo	68	*	115		116		100		105		102		2.42
Yellow Warbler	109		139	*	118		100		97		75		4.38
Common Yellowthroat	43		88		98		100		103		114		2.18
House Sparrow	57		60	*	86		100		82		116		95.29
Bobolink	82		103		81		100	*	67		79		3.64
Western Meadowlark	101		110		104		100		106		95		53.82
Yellow-headed Blackbird	57	*	105		103		100		144		155		24.62
Red-winged Blackbird	66		76	*	91	*	100		96		107		110.74
Northern Oriole	60		71		75		100		100		104		2.73
Brewer's Blackbird	96		97		109		100		113		121		29.51
Common Grackle	27		48		64		100	*	55		86		6.64
Brown-headed Cowbird	101		93		92		100		120		116		31.11
American Goldfinch	83		83		110		100		89		85		3.59
Lark Bunting	62		39	*	244	*	100		110	*	32		6.04
Savannah Sparrow	55	*	82	*	110		100		118		111		20.90
Vesper Sparrow	82		102		93		100		109		110		16.80
Clay-coloured Sparrow	56	*	78		92		100		93		82		22.85
Song Sparrow	132		107		105		100		124		98		8.53
Chestnut-collared Longspur	103	*	64	*	92		100		90		102		22.82
No. of routes included in comparison	17		16		26		28		23				

[a] Asterisks mark statistically significant changes.
[b] Weighted mean for 1975 is of no. of individuals per route.

Table 7
Index numbers for bird populations, central Prairie Provinces, from Breeding Bird Survey, based on 1973 index of 100

Species	Annual indices (based on 1973 set at 100)[a]					Weighted mean for 1975[b]
	1971	1972	1973	1974	1975	
American Bittern	136	67	100	276	273	5.34
Mallard	59	43	100	88	79	23.99
Pintail	76 *	29	100	258	178	6.69
Blue-winged Teal	42	54 *	100	166	139	8.65
Northern Shoveler	120	73	100	207	* 134	3.57
American Wigeon	53	35	100	98	90	2.73
Lesser Scaup	133	69	100	91	83	8.08
American Kestrel	77	54	100	* 55	64	1.11
Ruffed Grouse	77	58	100	254	358	2.50
Sora	62	99	100	113	125	5.88
American Coot	71	74	100	134	183	12.08
Killdeer	104	118	100	116	107	8.07
Common Snipe	(23)	(34) *	100	108	117	9.10
Franklin's Gull	136	263 *	100	139	89	19.20
Black Tern	154	159 *	100	97	101	10.73
Rock Dove	212	222 *	100	119	102	2.52
Mourning Dove	64	82	100	70	* 111	4.70
Common Flicker	160	141 *	100	97	143	3.80
Eastern Kingbird	87	85	100	125	103	3.18
Eastern Phoebe	61	84	100	93	74	2.25
Alder Flycatcher	161	122	100	139	157	9.66
Least Flycatcher	83	91	100	92	99	10.85
Western Wood Pewee	160 *	85	100	76	103	1.98
Horned Lark	93	111	100	* 84	64	4.54
Tree Swallow	114	159 *	100	103	116	5.21
Barn Swallow	72	86	100	101	109	13.18
Cliff Swallow	77	108	100	143	* 273	17.45
Black-billed Magpie	84	115	100	80	74	11.39
Common Raven	125	100	100	182	* 124	1.49
Common Crow	93	88	100	82	82	35.00
Black-capped Chickadee	144	105	100	71	* 192	2.53
House Wren	101	121	100	92	99	11.69
Gray Catbird	58	85	100	62	85	2.28
American Robin	97	122 *	100	99	101	19.89
Swainson's Thrush	81	127	100	177	* 83	3.84
Ruby-crowned Kinglet	(0)	132	100	(2480)	(3940)	3.52
Starling	81	80	100	* 70	71	21.72
Red-eyed Vireo	81	104	100	* 50	66	7.56
Warbling Vireo	141	100	100	92	* 63	3.13
Tennessee Warbler	88	122	100	214	257	1.93

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Table 7 *cont'd*

Species	Annual indices (based on 1973 set at 100)[a] 1971		1972		1973		1974		1975	Weighted mean for 1975[b]
Yellow Warbler	76		70		100		116		115	11.19
Ovenbird	181		109		100		117	*	76	1.20
Common Yellowthroat	158	*	128		100		115		116	5.03
House Sparrow	100		75	*	100	*	73		88	20.76
Western Meadowlark	92		90		100		101		87	9.03
Yellow-headed Blackbird	62		49		100		101		143	13.53
Red-winged Blackbird	80		90		100		96		102	59.39
Northern Oriole	72		63	*	100		134		110	4.58
Brewer's Blackbird	76		74		100		137		123	22.74
Common Grackle	122		141		100		104		156	3.95
Brown-headed Cowbird	88		74		100	*	145		129	15.31
Rose-breasted Grosbeak	117		109		100		87		86	1.55
Pine Siskin	0		34		100		146	*	38	2.51
American Goldfinch	164		121		100		73		65	3.17
Savannah Sparrow	64	*	98		100		100		91	16.02
LeConte's Sparrow	64		114		100		154		159	3.63
Vesper Sparrow	82		99		100		95		100	11.77
Northern Junco	123		170		100		106		133	5.92
Chipping Sparrow	94		121		100		137	*	95	6.75
Clay-coloured Sparrow	104		111		100		103		112	33.61
White-throated Sparrow	79		135		100		115		108	8.75
Song Sparrow	92		105		100		95		93	22.98
No. of routes included in comparison	13		18		23		25			

[a] Figures in parentheses considered unrepresentative owing to discontinuities in data compared. Asterisks mark statistically significant changes.

[b] Weighted mean for 1975 is of no. of individuals per route.

Table 8
Index numbers for bird populations, British Columbia west of Rocky Mountains, from Breeding Bird Survey, based on 1973 index of 100

Species	Annual indices (based on 1973 set at 100)[a] 1973		1974		1975	Weighted mean for 1975[b]
Common Loon	100		76		107	0.62
Great Blue Heron	100	*	50		48	0.67
Mallard	100		56		95	3.64
American Kestrel	100	*	53		92	0.74
Ring-necked Pheasant	100		122		141	3.46
Killdeer	100	*	64	*	100	3.92
Common Snipe	100	*	64	*	97	2.78
Glaucous-winged Gull	100	*	168		410	6.81
Band-tailed Pigeon	100		289	*	49	1.20
Rock Dove	100		66		70	2.63
Rufous Hummingbird	100		143		123	2.62
Belted Kingfisher	100		154	*	89	0.75
Common Flicker	100	*	78		98	6.13
Yellow-bellied Sapsucker	100		149		125	2.21
Hairy Woodpecker	100		91		128	1.19
Eastern Kingbird	100		67		84	1.92
Willow Flycatcher	100		94		100	5.55
Least Flycatcher	100		70	*	45	1.78
Western Wood Pewee	100		84		50	3.97
Olive-sided Flycatcher	100		54		83	2.14
Violet-green Swallow	100		127		76	5.44
Tree Swallow	100		96		78	7.02
Bank Swallow	100		71		46	4.51
Rough-winged Swallow	100		205	*	96	3.49
Barn Swallow	100		101		141	19.80
Cliff Swallow	100		75		63	7.52
Common Raven	100		99		144	6.31
Crows[c]	100		89		103	32.74
Black-capped Chickadee	100	*	51		60	9.16
Chestnut-backed Chickadee	100		64		54	3.61
Red-breasted Nuthatch	100		62		61	1.96
Winter Wren	100		113		82	2.64
American Robin	100	*	83		80	58.63
Varied Thrush	100		98		146	3.45
Swainson's Thrush	100		98		92	29.37
Veery	100	*	62	*	100	8.08
Golden-crowned Kinglet	100		85		72	3.58
Ruby-crowned Kinglet	100		87		130	5.29
Cedar Waxwing	100		79		69	3.76
Starling	100		81		103	70.13

cont'd next page

Table 8 *cont'd*

Species	Annual indices (based on 1973 set at 100)[a] 1973		1974		1975	Weighted mean for 1975[b]
Solitary Vireo	100		128		138	4.13
Red-eyed Vireo	100		84		75	10.27
Warbling Vireo	100		104		92	5.65
Orange-crowned Warbler	100		100		85	5.99
Yellow Warbler	100		111	*	88	10.56
Yellow-rumped Warbler	100		117		122	8.88
Townsend's Warbler	100		103		137	4.28
Northern Waterthrush	100		59		51	1.11
MacGillivray's Warbler	100	*	66		57	6.48
Common Yellowthroat	100		122		113	2.75
Wilson's Warbler	100		177	*	81	1.64
House Sparrow	100		114		118	5.01
Western Meadowlark	100		87	*	129	12.51
Red-winged Blackbird	100		82		137	16.78
Brewer's Blackbird	100		79		66	15.50
Brown-headed Cowbird	100		116		124	9.63
Western Tanager	100		104		110	7.66
Pine Siskin	100		95		151	38.89
American Goldfinch	100		120		99	5.47
Rufous-sided Towhee	100		89		71	4.30
Savannah Sparrow	100	*	66		71	5.25
Vesper Sparrow	100		140		188	1.94
Northern Junco	100		120		114	11.23
Chipping Sparrow	100		91	*	123	23.31
White-crowned Sparrow	100		77		68	6.04
Song Sparrow	100		114		107	11.99
No. of routes included in comparison		27		26		

[a] Asterisks mark statistically significant changes.
[b] Weighted mean for 1975 is of no. of individuals per route.
[c] Common Crow and Northwestern Crow combined.

Discussion

At this point we must re-emphasize the objective of the BBS — to detect and measure changes in population levels of birds, in a statistically and biologically acceptable way, across North America, or for our purposes across Canada. This is important, for the BBS — like so many other undertakings — is often criticized for failing to do (or for doing poorly) things which it never set out to do. We recognize that many other suggested objectives are laudable, but to insist on them being combined with the BBS would probably mean that none of the objectives would be met with the resources now available. We now consider the advantages and disadvantages of the methods adopted.

1. Methodology

In order to survey the enormous areas of Canada and the US at reasonable cost, it was necessary to draw heavily on volunteer effort. This had been tried before (review by Robbins, in press) with a different method and a significant lack of success, at least in North America. The mapping census method then attempted has been used effectively for monitoring bird numbers in parts of Europe, notably Great Britain, e.g. Batten and Williamson (1974). The roadside count method, already used for certain game birds, had much in common with the regular habits of bird watchers, combining as it did the use of cars for transport and frequent short stops to note birds, with no need for repeated visits to the same area. All that was needed was to employ random sampling to fix the places where the method would be employed, and to standardize as much as possible the procedures for selecting routes and collecting data. No other method yet devised has been able to make use of many, individually small, contributions by volunteers. Demanding relatively greater efforts or using paid workers gives better results, but is impracticably costly on the continental scale required.

A roadside method is not ideal. Many areas and habitats are not served by roads, which introduce an edge effect and preclude a strictly natural habitat. But since many of the factors likely to influence bird numbers result directly or indirectly from man's actions, it is reasonable that areas affected by man should be included in the areas sampled. The vast roadless hinterlands of Canada cannot be surveyed by the BBS either in its present form or in variants using other mechanized transport such as off-road vehicles or trail bikes. Use of power canoes along rivers or lakeshores would limit the sample to riparian habitats, and might complicate statistical treatment by methods based on random sampling. Also, water craft would probably be too slow to permit coverage of 50 stops in one morning, as would walking or the use of horses or bicycles for surveys on land, even if we could find enough observers willing to use such methods. However, volunteers are willing to use cars and a roadside method, so — "if you can't lick 'em, you join 'em."

An obvious advantage of the BBS method is that the small demand on the individual means that observers are willing to travel farther to a survey, so the coverage possible is greatly enlarged. A person who would think twice before agreeing to travel 25 km to a study area that required 8 to 10 visits during a season may cheerfully undertake a single trip to a BBS route 150 km from home. This is helpful, since most of the qualified observers live in the larger cities and towns, whereas the survey routes are more uniformly distributed.

Each BBS sample is spread across more than 30 km of often varied habitats, and thus more bird species are detected than would be found on a small study area. Individual surveys detect from 35 species in Newfoundland and Yukon Territory to twice this number in New Brunswick, with most regions averaging about 55 species per survey. A more informative comparison is between the number of species detected by the BBS and the total number known to breed in a region. Our regions do not coincide with the political divisions for which such species lists are usually compiled, but we have made a few comparisons. In 1969, 47 BBS routes surveyed in the Maritimes detected 143 bird species, not counting five species believed not to have been breeding where they were found. Through 1975, the Maritimes Nest Records Scheme had assembled records for 171 species, excluding eight known from one record only, which were surely casual breeders. Thus, the BBS recorded 143 of 171 regularly breeding species, or about 84%. Similarly, in 1975 the BBS recorded 184 species (excluding 11 rejected as not breeding where noted) for British Columbia west of the Rockies, compared to a total of 237 species in the provincial nest records scheme (not counting species known only from east of the Rockies and excluding 11 known from one record only), giving about 78% of the possible total. With less complete sampling, fewer species are detected; in 1966 with only 33 BBS routes covered in the Maritimes, only 125 species were recorded.

Not all species are equally well sampled, of course. The BBS is not well suited to sampling scarce birds, e.g. raptors. The sampling intensity — one or two routes per degree-block — is low; an average of less than one individual per survey is detected for over half the species reported. Such numbers, given the limited coverage in any region, are wholly inadequate for monitoring trends. Colonial water birds, including many species vulnerable to toxic chemicals, are poorly sampled, not only because their habitats are badly served by roads, but also because their gregarious habits make them unsuited to sampling by random methods (unless with a vastly greater sampling intensity). Waterfowl and other water birds are also poorly sampled. However, ducks, raptors, and colonial water birds are all subjects of special surveys more suited to their habits and habitats, so their poor sampling by the BBS is less important. Species which for various reasons are poorly sampled by the BBS are summarized in Appendix 3. Most of the species for which the BBS is well suited are

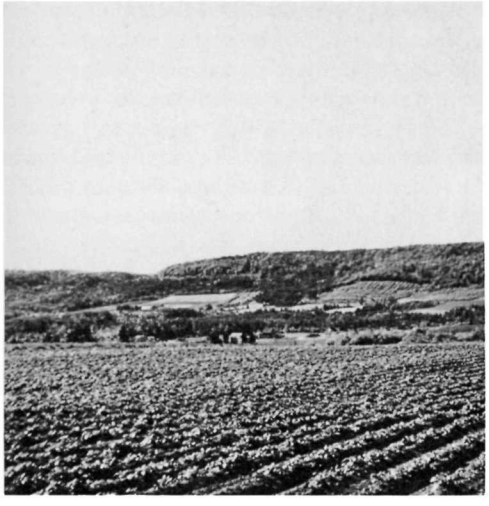
Plate 2
Maritime Provinces. This region is characterized by varied habitats within short distances, resulting in generally higher numbers of bird species per route than in other regions. (a) Roadside fields with mixed forest beyond, Carleton Co., N.B. (b) Pasture and hayfields, with riverside trees and shrubbery, Kings Co., N.B. (c) Monoculture crops with varied fields, shrubbery, and woods, Kings Co., N.S.

Plate 2

a

b

c



not monitored at all by other means, and our efforts have been concentrated on these birds. Species and groups reasonably well sampled include: Killdeer, doves, woodpeckers, flycatchers, Horned Lark, jays, Black-billed Magpie, crows, chickadees, Red-breasted Nuthatch, House and Winter Wrens, mimids, thrushes, Ruby-crowned Kinglet, vireos, warblers, House Sparrow, Bobolink, meadowlarks, orioles, Western Tanager, Rose-breasted Grosbeak, Indigo Bunting, sparrows, juncos.

Not least among the advantages of the BBS method is that it samples larger numbers of individual birds relative to the time spent than almost any other type of ground survey (aerial surveys may be still more time-effective for species that can be detected from the air). This stems from the short time spent at each of many stops, in effect sampling a new population every 5 minutes. Fewer, longer stops, as have been urged by many people, would give more complete counts at each stop, and these would probably be individually less variable. But as most birds are detected in the first few minutes at a stop (*ca.* 60% in the first 3 minutes of the total detected in 15 minutes in forest (unpublished data); at least 90% in the first 5 minutes in farmland (Jørgensen 1974)), a reduction in the number of stops made in a certain time would reduce the samples obtained from a route, a reduction not offset by the more complete counts at each stop. The statistical reliability would thus be reduced for the more common species, and still fewer of the less common species would be detected in numbers sufficient for analysis. The overall effect of using fewer, longer stops seems unlikely to be an improvement on the present method.

Inexperienced observers might benefit from longer stops, since more time would be available to confirm the identity of species of which they were unsure. Some workers are sceptical that identification of many species can be accurate under the conditions of the BBS. Mistakes are certainly made, and in some cases the observers themselves have expressed doubts. Nevertheless, misidentifications are unlikely to invalidate most of the comparisons, for the following reasons: (*i*) analyses were largely restricted to the more common species, with which observers are most familiar; (*ii*) many of the more improbable results were reported on surveys which for various reasons were excluded as not comparable; (*iii*) independent observers surveying the same route obtained quite similar results for most species. On different dates during June 1967, for example, four observers separately surveyed one route in Nova Scotia (Table 9). Survey 4 had moderately adverse weather, and surveys 3 and 4 were late in finishing and starting respectively, so the results are not fully comparable. The low overall count on survey 4 is attributed to poor weather, and other differences are probably due to the different dates and to some mis-identifications of less common species. However, many observers obtain results differing much more than did these four.

Inexperienced observers have had difficulties in separating species with similar songs, especially:

"*Robin-like songs*"—American Robin, Rose-breasted and Black-headed Grosbeaks, Western and Scarlet Tanagers, most vireos;
vireos — Red-eyed, Philadelphia, Solitary, and Yellow-throated Vireos (but not Warbling Vireo);
thrushes — Swainson's, Hermit, and Wood Thrushes (Veery and Gray-cheeked Thrush are different from the others);
flycatchers — Least vs. Yellow-bellied Flycatchers; Alder Flycatcher vs. Eastern Phoebe, Dusky vs. Hammond's Flycatchers;
"*grassland sparrows*" — Savannah, Grasshopper, LeConte's, Baird's, and Sharp-tailed Sparrows (Vesper and Henslow's Sparrows are quite different).

Table 9
Comparison of surveys on one route (N.S. 026) by various observers, June 1967

Survey number / Date	1 (7th)	2 (11th)	3 (25th)	4 (30th)
Total no. of species	55	59	59	53
Total no. of birds	517	624	526	400
No. of birds of 35 species noted on all surveys	451	541	454	354
Percent of total	87	87	86	88
No. of species noted on only one survey	3	7	3	6
No. of birds of species noted on only one survey	8	17	4	15
Percent of total	2	3	1	4

Most birds reported in the BBS, even in open habitats, are first detected by sound. Many birdwatchers had never deliberately set out to identify birds by song before they first undertook a BBS route, although they recognized songs of many common birds. Most beginners who persisted with their surveys obtained results, after two or three attempts, comparable to those of more experienced observers. The general uniformity of results obtained by different observers throughout each region supports our belief that few serious mistakes are incorporated into the analyses. Berthold (1976) has emphasized that in all strictly observational surveys there is no proof that birds detected are actually breeding. For scarce species, and particularly for those that do not breed as yearlings, this is a valid warning, but for common species I believe there is no important error in making the assumption that singing birds are breeding.

There are some difficulties with the actual counting of birds, on the BBS as elsewhere. Aside from the fact that some observers can hear birds at greater distances than others, nearer birds may drown out the sounds of more distant ones of the same or different species. In such cases, a low density population may allow detection of the same number of individuals of a species at a given stop as a high density population where the more distant sounds had been drowned out. The obvious reduction in background noise may not enable the human ear to discriminate more individuals. Only about six or seven different birds of a species can be differentiated by sound during the 3 minutes spent at any one stop. During the dawn chorus a great number of individuals will be singing within earshot, and the extraordinarily high counts occasionally reported suggest that some observers have attempted to overcome this difficulty by some unstandardized method. A related problem is "first-time jitters". When most or all observers in a region had made their first surveys in the same year, they fairly consistently recorded more birds, on otherwise comparable surveys, in the second year than the first, the increase being about 10% (Maritimes 1966–67, 10.9%; southern Ontario and southern Quebec 1968–69, 9.4%; British Columbia 1973–74, 3.4% — but 1974 was unprecedentedly cold). It is understandable that an observer making a survey for the first time, concerned about following the rules and the route and about finishing in time, might record only three or four birds of a species per stop, whereas with increasing confidence in a succeeding year five or six would be recorded, particularly during the dawn chorus. There is no evidence of such increases beyond the second year for most observers.

Some other difficulties are associated with the use of a relative rather than an absolute method. The BBS is not a census, only a standardized count. The birds detected at each stop are drawn from an area which differs among species (depending on the distance at which they can be identified by sound or sight), among observers, and with weather conditions, so no attempt should be made to use the BBS counts to give estimates of bird densities in a region. Similarly, comparisons of the relative abundance of different species should not be based on BBS counts, except in a very general way and among species with similar detectability. Comparisons among BBS counts should be valid within a species insofar as the data were collected in comparable fashion.

2. Comparability

In the first year, we were preoccupied with achieving adequate coverage, and we naïvely assumed that prescribing a definite procedure would be sufficient to ensure comparability. In the United States there are far more surveys, so discrepancies have much less influence on the overall sample size for a given species than in Canada. Although the inclusion of all data from all surveys will increase the sample size, and thus theoretically the statistical validity of results, we think that this will not material-

ly improve the conclusions to be drawn, since some data will not be biologically comparable. The comparability scoring system (see Methods section) was devised in 1967 for treating the Maritimes data, and subsequently modified slightly. Comments on the main factors follow.

2.1. Observer

Observers have different abilities to hear or see various species. Originally we thought that all but extremely divergent results from different observers could be accommodated by varying the scores under this heading, but later we concluded that it was preferable to eliminate from comparison all routes with observer changes between years (except for one case of twin brothers). Although an observer working alone must use part of each 3-minute stop for recording data and noting time, thus either reducing the observing time or delaying the finish of the survey, this is probably no worse than the auditory distraction of calling out the birds to a separate person acting as recorder. The presence or absence of an assistant made no obvious difference to results obtained by most observers. A few older or inexperienced observers did report more birds when assisted by someone entering data and timing the stops, but most such variations, when checked, proved to involve observations of a team, rather than of a single observer as specified in the instructions. Since the sampling plan is based on the assumption that all samples taken are equivalent, although the number of samples may not be the same in all degree-blocks, collaboration of two or more observers is clearly undesirable. We suspect that more cases of this exist than have come to our attention, and we hope that the practice will cease.

2.2. Date

Birds breed at different times through the season, so an early survey may miss late arrivals and a late one may count flying young. After a cold spring all schedules will be later than after a warm one, but such differences decrease in importance towards the end of June. Observers who can do their surveys only at weekends find that the date gets earlier each year until they must shift to a later weekend, if this has not already been forced on them by bad weather or other factors. However, only changes of 20 days or more will exclude the survey from comparison if other factors are comparable.

2.3. Weather

Wind, rain and fog all tend to reduce the number of birds recorded. Observers often do not start a survey under poor conditions unless they have made a long trip and see little prospect of trying again. Wind is often a disturbing factor, especially in poplar forests where the leaves rattle constantly. On the prairies, winds are often stronger than force 3 after 08:00, so the maximum acceptable wind for surveys had to be increased there. Heavy rain rapidly stops birdsong, but birds will continue to sing through drizzle or light showers; often it is possible to wait out brief, heavy showers and resume the count after 15–20 minutes, but long breaks are undesirable. Originally we had hoped to take traffic into account in assessing conditions, but this was seldom recorded. If traffic was heavy enough to interfere seriously with hearing birdsong, we usually re-routed the survey or omitted a section and resumed counting on the next side road, as explained in the instructions.

2.4. Other variables

Departures from the rules should not have to be considered, but our co-operators are human like the rest of us. Although the starting times are specified for each route, some observers oversleep or find the road to the start rougher than they expected, so are late starting. Occasionally people have not understood that the time stated in the instructions is the starting time, not sunrise, and have started half an hour early, or in cases of the wrong time zone even an hour early. Fortunately, such errors in starting time are seldom repeated. In mountainous areas, a route in the shadow of a ridge or mountain will remain dark and cold long after official sunrise, and starts delayed by up to 20 minutes for this reason may be appropriate in a few cases; this should not be accepted unless a large part of the route would otherwise be traversed in shadow.

Delayed finishes are still more prevalent, and for more reasons. Rough roads that cannot be driven rapidly, detours for road or bridge repairs, and flat tires are acceptable excuses, and brief coffee breaks can be tolerated where energy or concentration wane before the survey is finished. Few delayed finishes are explained, and we surmise that common reasons include delays to search out unidentified songs or to re-assemble too large a party at each stop, or difficulties in recording data.

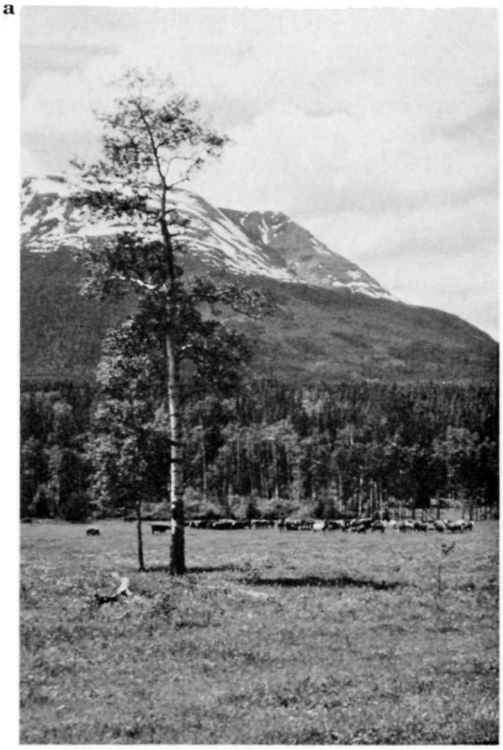
If habitats were uniform, the location of each stop would make little difference, but in most areas the same stops should be used each year. Brief descriptions for each or at least for most stops would help ensure uniformity of coverage. Speedometers vary, and worn tires can affect the distance recorded by as much as 10%. Occasionally roads are altered; where old routes cannot be continued changes, however slight, should be reported, as the analyses are based on the assumption that the routes remain constant. We disapprove of the practice (fortunately uncommon) of reversing the direction of routes, usually done in order to start at the end nearer home or to avoid driving into the rising sun all the way. There can be considerable differences in results if a species which sings only at dawn is found at only one end of the route; a survey in the reverse direction will not detect it (*cf.* Weber and Theberge, unpublished ms.). The statistical analysis is based on a random sampling plan; if many observers alter the routes to suit their convenience, the statistical results could then be called in question in any management situation by opponents of recommendations

Plate 3

British Columbia. The westernmost region is a succession of mountain ranges, between which the few roads pick their ways with little claim to represent all habitats to be found there. (a) Cattle ranching in the aspen parklands features the more fertile sites in a largely coniferous region, Nadina Mt., B.C. (b) Some of the finer valleys of the west have been drowned in the name of electricity or flood control, thus losing the rich bird community of riverside shrubbery, Bighorn Reservoir, Alta. (c) At higher elevations where rock and ice are dominant, birds are virtually lacking, Bear Pass, B.C.

Plate 3

a



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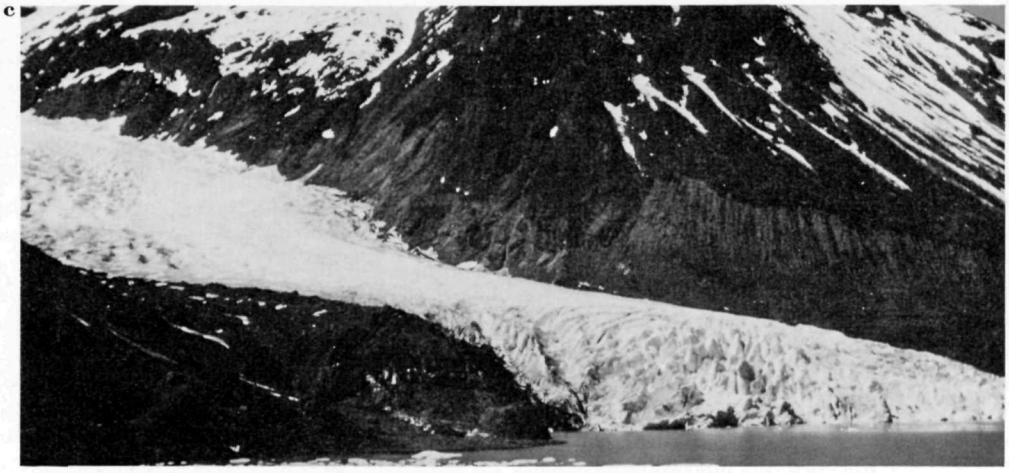


based on BBS findings. However, we believe that most observers follow the instructions carefully, recognizing that these surveys are designed to provide useful data.

For our co-operators, we must again emphasize that coverage which is not fully comparable with that of the previous year is always preferable to no coverage. Without a survey there is no possibility of a comparison in the following year. A non-standard survey may mean one comparison missed, but a survey omitted means missed comparisons both with the year before and the year ahead.

3. Analysis

The survey method is based on stratified random sampling, in order to cope with the immense area under study, and the analysis takes this into account. Most difficulties are the result of the relatively few and small samples that are available and comparable between years, since small samples are more variable and thus statistically less reliable than larger ones. We have not attempted regional comparisons using fewer than 13 comparable surveys, and have long considered that 25 such surveys was a useful level to be aimed for in each region. We have made more effective comparisons within the Maritime Provinces region largely because we have equalled or exceeded 30 comparable surveys in six of the nine comparisons there, compared to only one comparison involving 30 or more surveys in all other regions combined. The longer period during which the BBS has existed in the Maritimes has also contributed to the more convincing identification of trends there.

As yet, we have not attempted to weight the data according to varying areas of the sampling units, but this could be done quite easily. Only the British Columbia and central Prairie Provinces regions extend so far north that the degree-blocks become appreciably narrower. Possibly more serious are the fragmented degree-blocks along both coasts and around the Great Lakes. For example, in the Maritimes,

even after combining adjacent blocks with small land areas, the total area of 129 500 km² is treated as 22 sampling units rather than the 15 to be expected if the same area were a simple rectangle. The areas within the sampling units are somewhat smaller, on average, in Nova Scotia and much smaller in Prince Edward Island than in New Brunswick, which presumably tends to underemphasize the effects of changes in the last-named province. A trial calculation using approximate weighting for the area of land in each sampling unit suggested that few discrepancies as large as 5% would be occasioned by omitting this adjustment, so this cannot be considered a major stumbling block.

The detection and measurement of continuing trends is probably the most interesting objective of the BBS. Our analysis, however, is built on comparisons between successive years only, thus: year 1 with year 2, year 2 with year 3, and so on. We can illustrate long-run trends only by setting a base year and calculating forward and back from this, using the percentage changes between years. Any discontinuity in the data, i.e. a major change in one or other direction that is not reversed in the following year, affects all the indices in succeeding years (and similarly when calculating backward). As not all surveys comparable between year 1 and year 2 will be comparable between year 2 and year 3, and vice versa, we can anticipate some discontinuities in the indices because of this, and because of non-random distribution of birds. Flocking birds are particularly likely to give rise to such difficulties, and many of these might better be excluded from comparisons by this method. Unfortunately, there is no firm separation between flocking and non-flocking birds, but rather a continuum from highly gregarious species which are flocked at all times, through birds that flock only at certain seasons or that are only found in rather small groups, to solitary forms that come together only as breeding units. Exclusion of flocking birds is not a simple answer, the more so as some flocking birds, such as blackbirds, are of interest as agricultural pests and are no better (if as well) sampled by other methods than the BBS. The methods used are clearly most satisfactory for birds that are non-flocking and fairly common; for other species we must examine all trends very carefully and check them against other sources.

Table 10
Frequencies with which the 20 species most frequently recorded in each region were noted, and the proportion these birds made up of all birds observed there, Breeding Bird Survey, 1975

Region	No. of top 20 species noted on: 100% of routes	90–99% of routes	80–89% of routes	70–79% of routes	60–69% of routes	less than 60% of routes	Sum of top 20 species as % of total for all species
Maritime Provinces	6	8	5			1	63
Central Ontario and Quebec	3	8	7		1	1	62
Southern Ontario and Quebec	13	4	2	1			83
Southern Prairie Provinces	10	5		1	1	3	71
Central Prairie Provinces	1	1	11	3	1	3	60
British Columbia (W of Rockies)		5	6	3	4	2	61

Note:
Data are updated from Tables 2 to 7 in Erskine (1976).

We might expect that our data would show upward trends over a long period of years, owing to the improvement in effectiveness of observers in their second years not being offset by a decrease in their performance just before they ceased to take part in the BBS. As yet we have no evidence of the latter and since only four of the 33 routes surveyed in the Maritimes in 1966 were covered by the same observer in each of the first 10 years, it seems unlikely that many observers will remain with us long enough to show such deterioration. More species show sustained upward than downward trends in the Maritimes, but the most common pattern is oscillation around some intermediate value rather than a sustained trend.

4. Changes and trends

Among the many factors which affect our ability to detect and measure changes and trends are the available sample size and the time span of the surveys, already discussed, and also the variations within each region and how well these are sampled. The southern Ontario and Quebec region is by far the most homogeneous of the six, being not only the smallest in area but also made up largely of level, agricultural lands with little forest, and little climatic variation. The other regions are much more heterogeneous, but the small size and consequent high sampling intensity possible in the Maritimes partly offsets its inherent variability. As an example of the comparative uniformity of birds in the various regions, Table 10 summarizes the relative importance of the 20 major species in each region; in the southern Ontario and Quebec region, which is very uniform, the same species are important throughout, occurring on most or all routes and collectively making up over 80% of the total birds recorded. The others are progressively less uniform, although in all regions the top

Plate 4

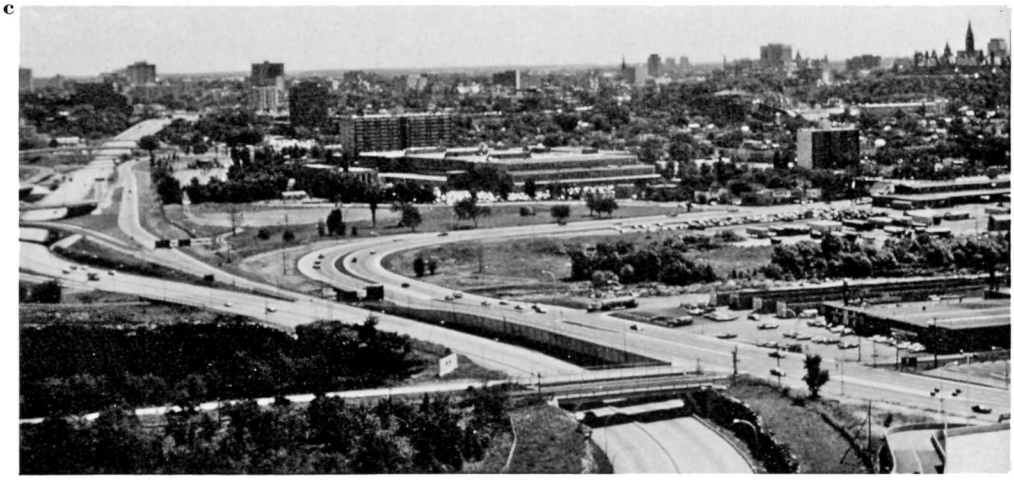
Southern Ontario and Quebec. This region is basically an agricultural area with only scattered woods and trees, leading to low bird diversity but often large numbers of birds. (a) Pastures with "umbrella elms" with woodlots beyond, Carleton Co., Ont. (b) Farm buildings and feedlots add a few birds to the farmland community, Carleton Co., Ont. (c) Urban areas make up larger parts of this region than elsewhere in Canada, but heavy traffic precludes effective surveys in most cities, Cté. Gatineau, Qué.

Plate 4

a

b

c



20 species make up at least 60% of all birds recorded on these surveys. In British Columbia, where the topography, climate, and vegetation are extremely variable, there are many common birds which are not found in all areas sampled.

As shown in Table 2, only the two smaller regions — Maritimes and southern Ontario and Quebec — have been well sampled throughout, and even there a few gaps occurred frequently. In the other regions, the coverage has often been discontinuous (see Fig. 1), and the sampling has been quite uneven. The fact that not all the same routes in a given area are comparable each year may not be a handicap from a sampling viewpoint (A. R. Sen, pers. comm.), but some areas within a region may not be sampled at all in some years. This must be a serious drawback for sampling species which are restricted in range, but need not interfere with the study of generally distributed birds, and most of those considered in our analyses are widespread.

Year-to-year changes in numbers may result from short-term environmental changes such as adverse weather, locally deficient food supplies, or acute poisons, or they may reflect part of a long-term trend resulting from a continuing environmental stress or relaxation of a limiting factor. Equally, short-term changes may be superimposed on long-term trends, and the return to normal may be spread over several years, effectively concealing a continuing trend. The BBS data have already permitted recognition of both short-term and continuing changes in a number of species.

4.1. Spring weather

First of all, we shall consider changes correlated with adverse weather in late spring, at the time when migratory insectivorous birds are just arriving in their breeding areas and while earlier-nesting species may already have eggs or young in the nest. In the second year of the BBS in the Maritimes, 1967, the spring was exceptionally cold and wet (Fig. 3), which gave us a good opportunity to learn whether the method could demonstrate the effects of such a natural, adverse stress, just as the severe winter of 1962–63 gave an immediate test of the efficacy of the Common Birds Census in Britain. A similarly cold but dry May in 1974 suggests that low temperatures are more critical than the

Figure 3
Mean monthly temperature and total precipitation for the month of May, 1966–75, at Moncton (airport), New Brunswick (from the Monthly Record of Meteorological Observations in Canada; Canada, Atmospheric Environment Service)

Figure 3

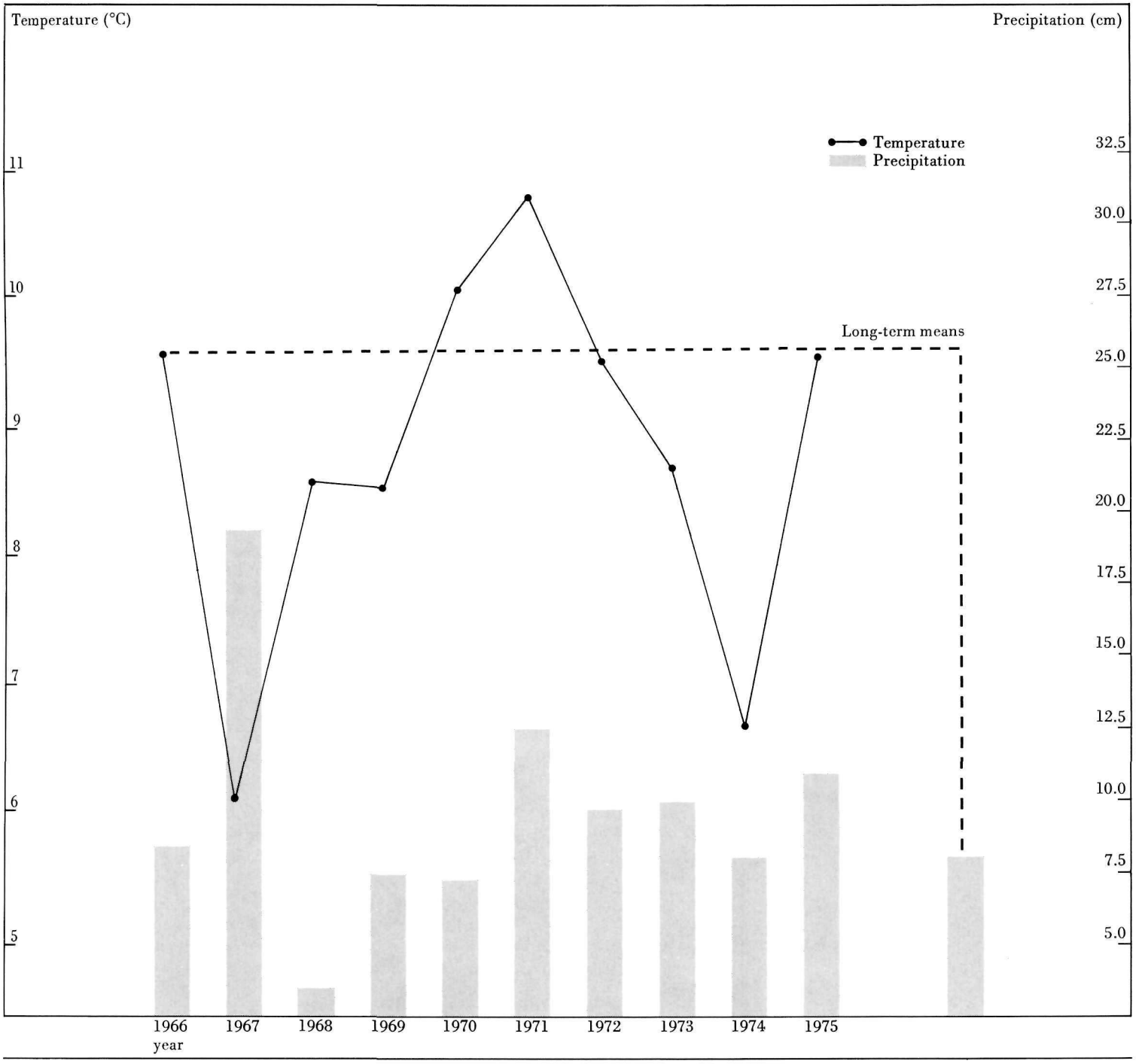


Figure 4a
Trends in index numbers for bird populations, Maritime Provinces, 1966–75 (from Table 3). Warblers, (Parulidae) affected by May cold snaps Black-and-white Warbler, Parula Warbler, Magnolia Warbler, Yellow Warbler, Common Yellowthroat, plus a late-arriving species (unaffected) — Alder Flycatcher. Heavy line indicates statistically significant trend

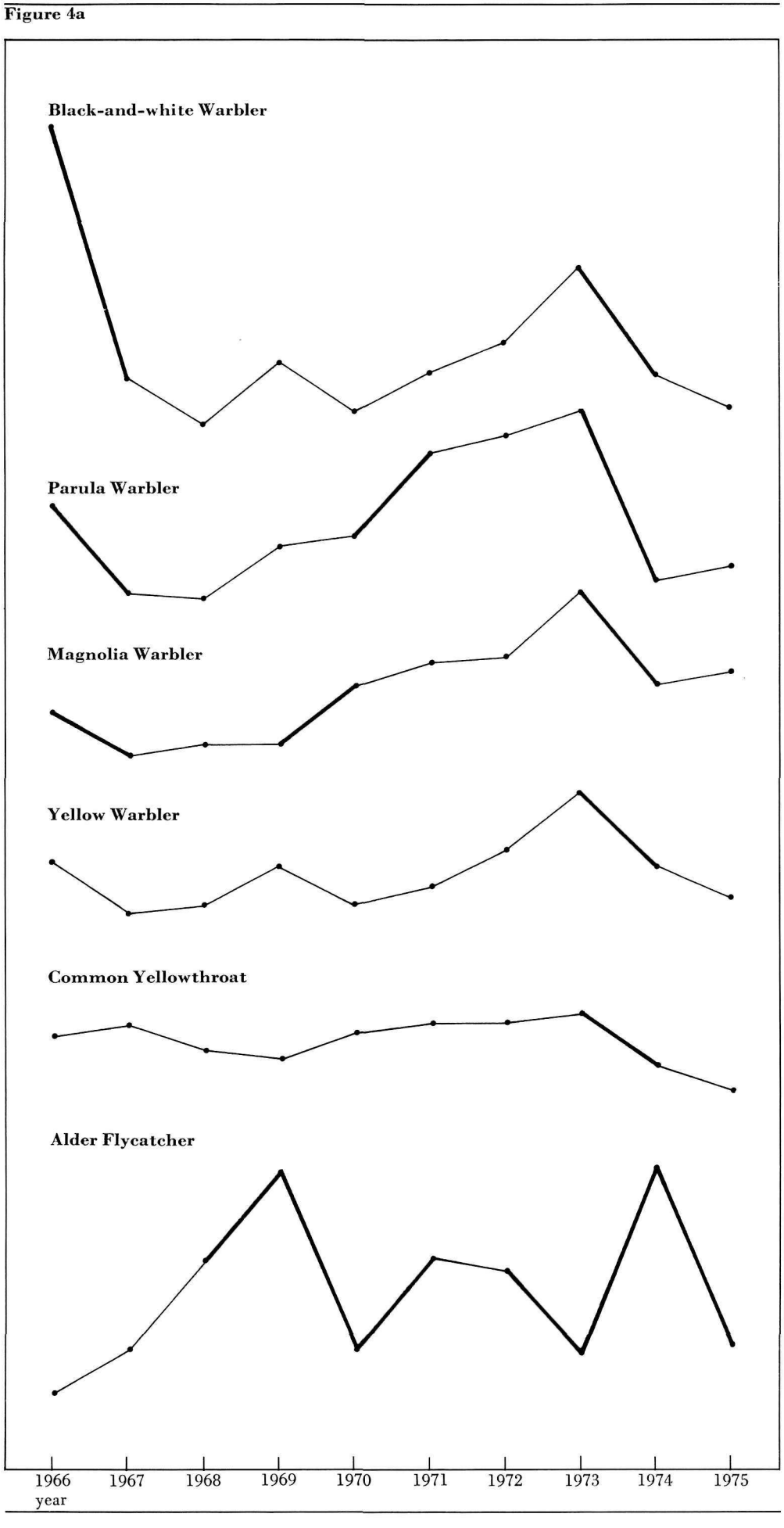
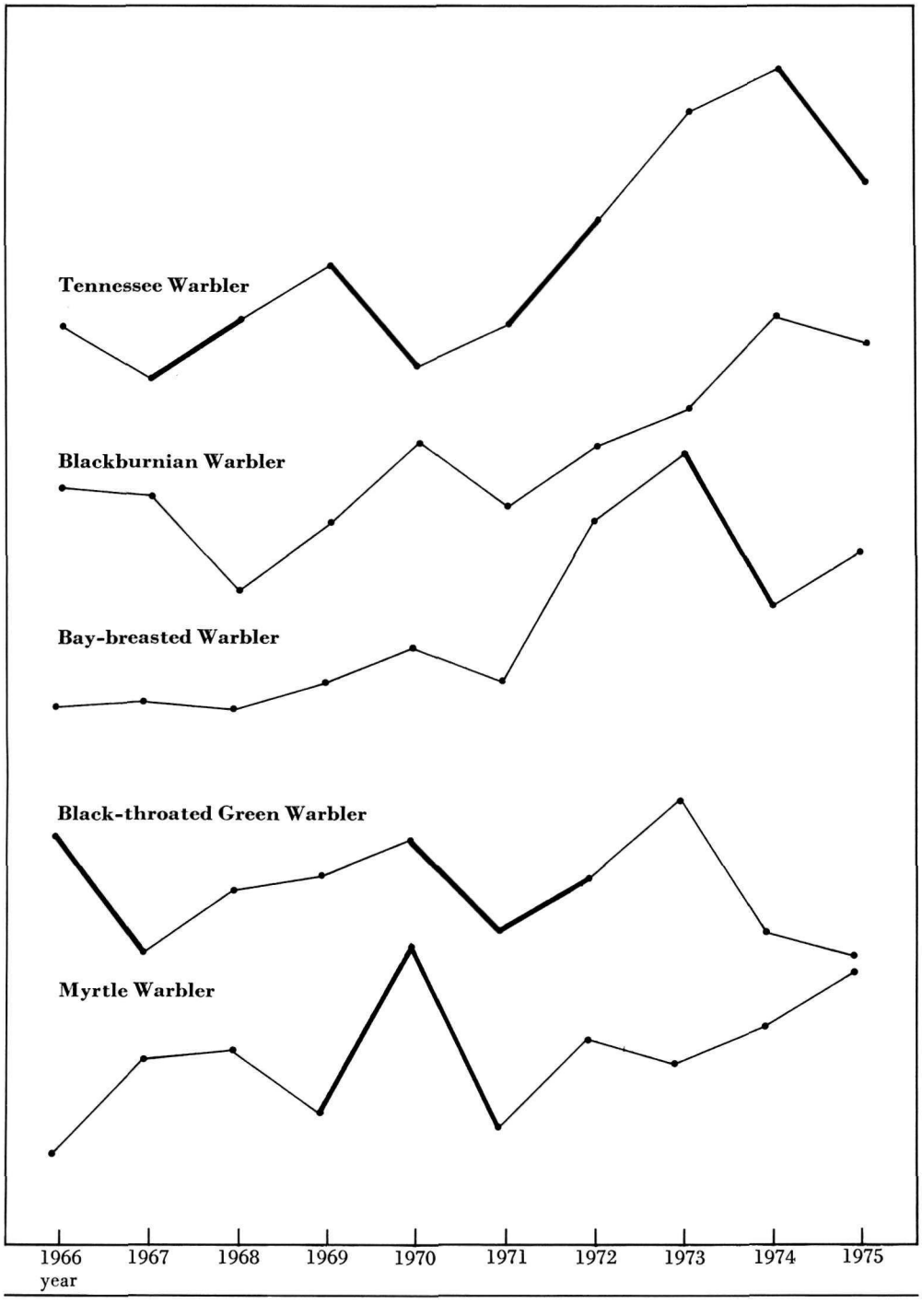


Figure 4b
Trends in index numbers for bird populations, Maritime Provinces, 1966–75 (from Table 3). Warblers, including those responding to spruce budworm, showing upward trends (mainly conifer birds) — Tennessee Warbler, Blackburnian Warbler, Bay-breasted Warbler, Black-throated Green Warbler, Myrtle Warbler. Heavy line indicates statistically significant trend



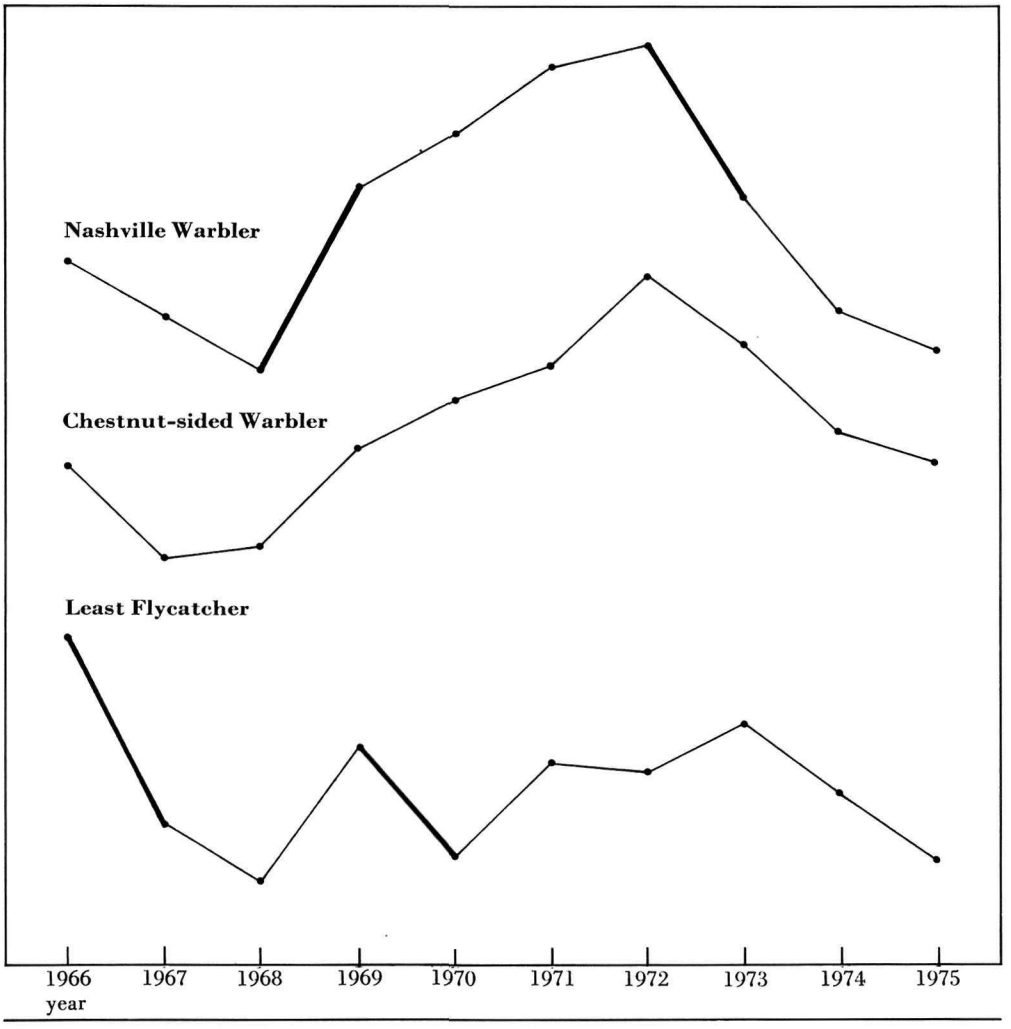
excessive precipitation also experienced in 1967. A number of small insectivores in the Maritimes, especially warblers (Fig. 4, a–c), showed marked decreases from 1966 to 1967, followed by a gradual recovery for several years, with a second pronounced decrease from 1973 to 1974. Many of these decreases were statistically significant. May 1974 was cold all across southern Canada, with temperature deficits averaging 1.5–4°C at representative stations in all regions. Nevertheless, only in the central Ontario and Quebec region was there any other suggestion that insectivorous birds and early-nesting species might have decreased appreciably in 1974 (Fig. 5). This suggests that low temperatures, at least on the basis of monthly means, only have an adverse effect below about 7°C, as in the other regions the low mean temperatures of May 1974 were generally above this level. My experience tends to confirm this as a threshold both for increased activity by biting insects (mosquitoes and blackflies) and for the start of laying by early-nesting birds, e.g. Common Grackle (Erskine 1971*b*).

4.2. Seed crops

Changes in numbers of seed-eating birds have recently been correlated with the crops of tree seeds available to them (e.g. Bock and Lepthien 1976). In view of the flocking habits of many of these birds (Newton 1972), it is unlikely that the BBS is a very satisfactory means of sampling such changes. Of the eight northeastern US species mainly discussed by Bock and Lepthien, Pine Grosbeak and the two crossbills were detected on the BBS in numbers insufficient for analysis in any region, while Common Redpoll, a subarctic species, was found only in Yukon Territory and Labrador where no analyses have been done. Comparisons are possible for the other species, but the series used by Bock and Lepthien ended with the winter of 1971–72 so that only our data for the Maritimes and central Ontario and Quebec cover (part of) the same period. The BBS

Figure 4c
Trends in index numbers for bird populations, Maritime Provinces, 1966–75 (from Table 3). Some broad-leafed forest insectivores showing decreases in cold snap years and also in other years—Nashville Warbler, Chestnut-sided Warbler, Least Fly-catcher. Heavy line indicates statistically significant trend

Figure 4c



data do not show the regular alternation of high and low years found in the data on winter eruptions. If one looks only at the eruption data for the northeastern US, however, these correlate fairly well with the BBS data from the central Ontario and Quebec region, unfortunately available only for the last 3 years of the period, and less well with those from the Maritimes (Table 11). Of the 18 comparisons involving three species in the Maritimes, only 12 are in the expected direction, i.e. with increases in the years preceding eruptions, while the numbers were building up, and decreases in the years following eruptions, in which much of the population had moved away (south) and not returned. In central Ontario and Quebec, of 12 comparisons involving four species, nine are in the expected direction and two more are inconclusive, showing no change when one might have been expected. Populations in the Maritimes are more likely to be sedentary than those in western areas, which have harsher winters, whence the birds would move south when crops failed.

Figure 5

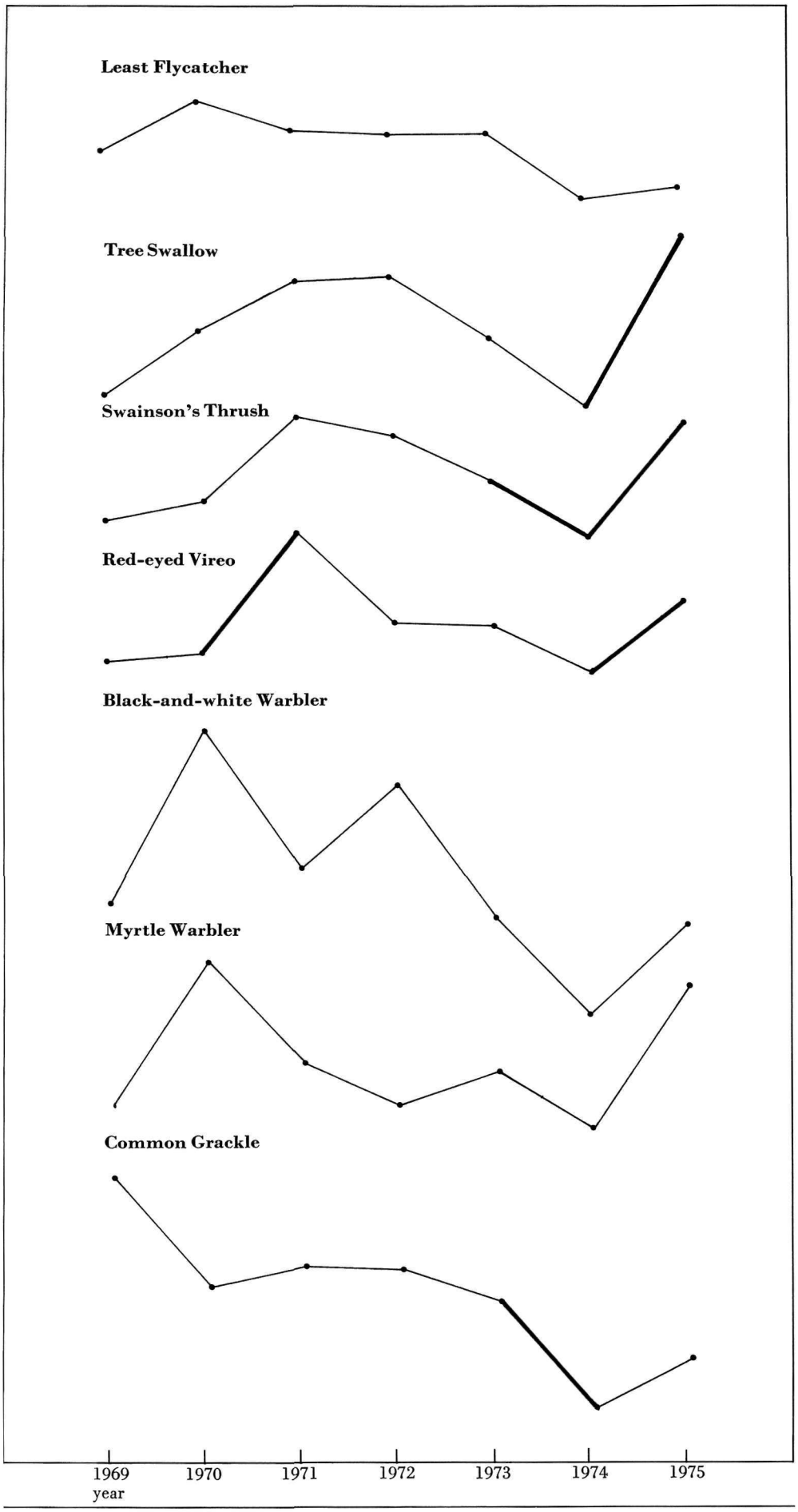


Figure 5
Trends in index numbers for bird populations, central Ontario and Quebec, 1969–75 (from Table 4), showing parallel trends and, especially, decreases in 1974—Least Flycatcher, Tree Swallow, Swainson's Thrush, Red-eyed Vireo, Black-and-white Warbler, Myrtle Warbler, Common Grackle. Heavy line indicates statistically significant trend

4.3. Spruce budworm outbreaks

We might also expect that numbers of some birds found on the BBS, particularly Evening Grosbeaks, would fluctuate wildly in response to the varying populations of spruce budworms, which have been epidemic through these same regions in recent years, and with whose distribution Evening Grosbeaks are well correlated in summer.

Under natural conditions, spruce budworms exist at low, endemic levels for many years until, in the presence of extensive areas of mature or near-mature spruce or fir forests, a series of warm dry springs provide favourable conditions for the buildup of populations to epidemic levels. Left to itself, such an epidemic runs its course in a few years, killing much of the mature stand in the areas exposed to it, but seldom extending over more than a few hundred square kilometres. Since 1945, the widespread use of chemical insecticides has made it possible to prevent completion of the budworm cycle by cutting their numbers down to a level such that the forest stand is not destroyed. Eradication of budworm populations has not proved possible without also destroying most other forms of animal life in the same area. The reduced budworm populations are held in the most rapid growth phase of the cycle, ready to break out every subsequent year unless the spring is unusually cold and wet. The result of this is that birds which feed on spruce budworms are able to maintain relatively high populations, which vary locally depending on the pattern of forest spraying in the preceding year and on the suitability of spring weather for budworm breeding.

Although spruce budworm has been at epidemic levels in Algonquin Park, Ontario, and through much of southwestern Quebec during the period of the BBS, very few surveys there have sampled high budworm areas. Spraying against budworm in these areas began in 1970 and was extensive from 1971, but most of the sprayed areas are remote and accessible

Table 11
Comparison of winter eruptions detected in northeastern US (after Bock and Lepthien 1976) with changes in breeding season numbers from Breeding Bird Survey in eastern Canada, 1966–71

	Eruptions		Change in BBS index next year in	
Species	Year	Scale	Maritimes	Centr. Ont and Que.
Red-breasted Nuthatch	1969	major	not analysed	decrease
	1970	none	not analysed	increase
	1971	minor	not analysed	decrease
Evening Grosbeak	1966	none	increase	no data
	1967	none	increase	no data
	1968	major	increase	no data
	1969	major	increase	no change
	1970	none	increase	increase
	1971	major	decrease	decrease
Purple Finch	1966	none	increase	no data
	1967	minor	no change	no data
	1968	moderate	decrease	no data
	1969	major	increase	decrease
	1970	none	increase	no change
	1971	major	decrease	increase
Pine Siskin	1966	none	decrease	no data
	1967	none	increase	no data
	1968	moderate	decrease	no data
	1969	major	increase	decrease
	1970	none	decrease	increase
	1971	major	decrease	decrease

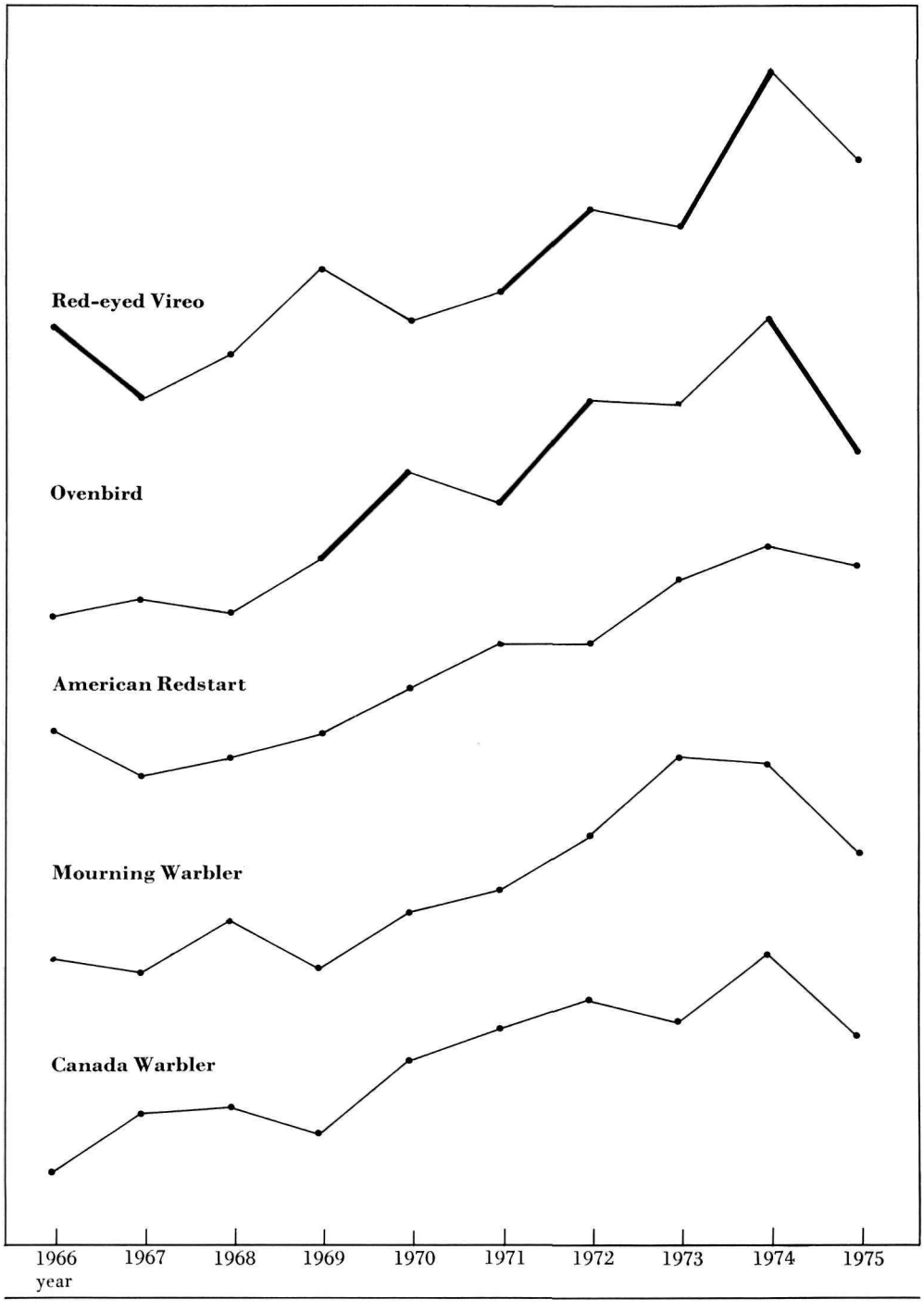
(if at all) only by private logging roads. A poorly-executed spraying near Maniwaki, Quebec, in 1973 caused substantial bird kill (M. Gilbertson, pers. comm.), but it showed no detectable effect on total bird numbers reported on the one BBS route in the area affected, although the observer noted that there were small areas totally devoid of bird song. Some characteristic "budworm birds", such as Evening Grosbeak and Yellow-bellied Sapsucker, were already prominent in these budworm areas by 1971, but the warblers usually associated with budworm only built up to expected levels later.

In New Brunswick, where budworms have been at epidemic levels since the late 1940's, with annual spraying since 1952 (except in 1959), the BBS coverage of affected areas has been more extensive, but still far from comprehensive. Of the warblers typically considered to show a positive response to increases in budworm densities (Morris *et al.* 1958), Cape May Warblers were too seldom reported for analysis, but Tennessee, Blackburnian, and Bay-breasted Warblers showed pronounced upward trends (Fig. 4b), particularly since 1971 when budworm numbers began their recent upward turn. Before 1968 the spray program used DDT as the main insecticide; more recently, fenitrothion, a non-persistent organophosphate chemical, has been used instead, but attempts have been made, in 1964–65 and 1975–76, to employ phosphamidon, a more effective budworm killer that is highly toxic to birds (Fowle 1972).

In the Maritimes, many of the small insectivorous forest birds have shown

Figure 6
Trends in index numbers for bird populations, Maritime Provinces, 1966–75 (from Table 3) showing sustained upward trends—after cessation of spraying with DDT?—Red-eyed Vireo, Ovenbird, American Redstart, Mourning Warbler, Canada Warbler. Heavy line indicates statistically significant trend

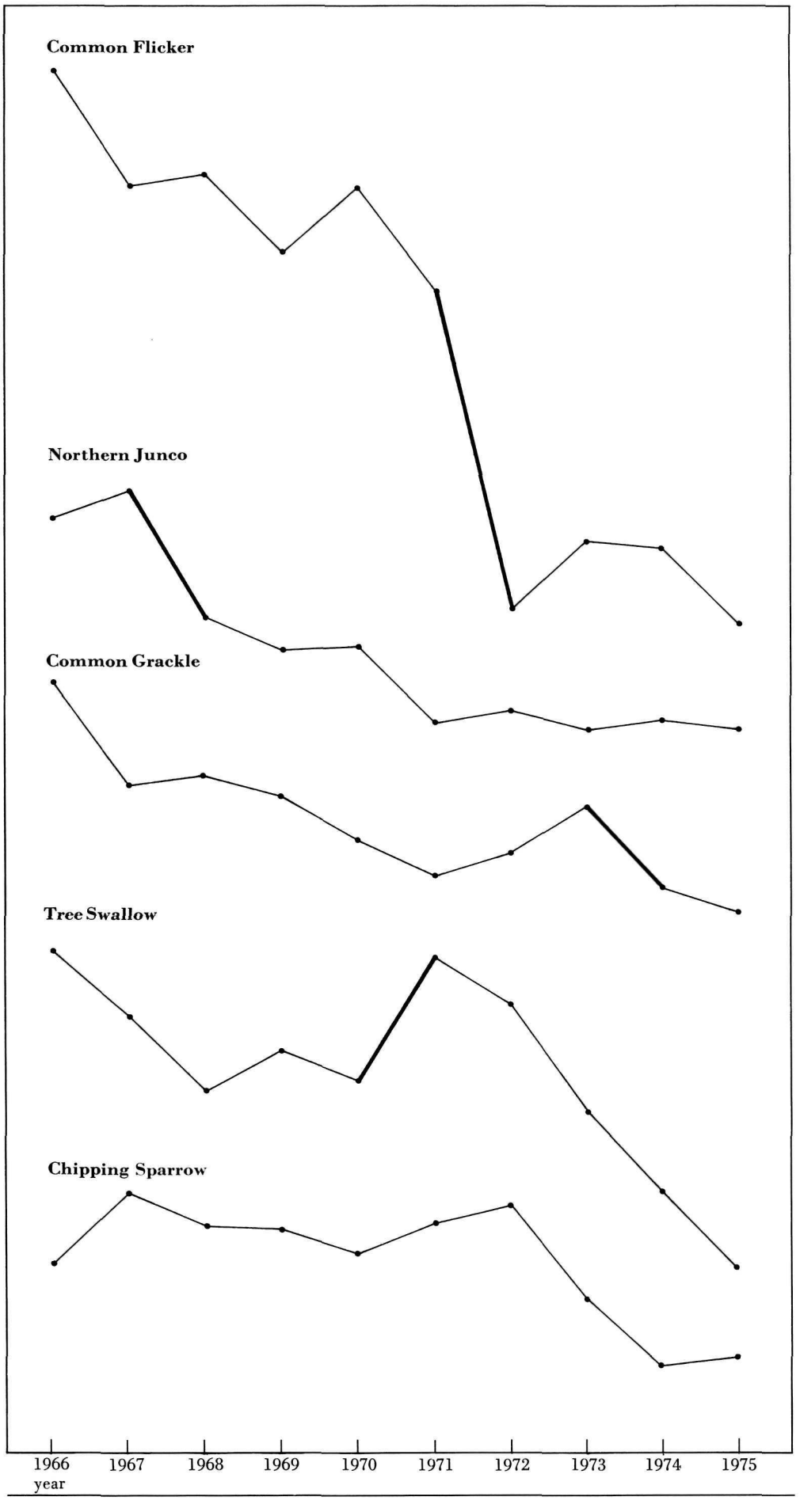
Figure 6



sustained and striking increases in their BBS indices between 1967 and 1974 (Fig. 6). These increases, particularly for Red-eyed Vireo, Ovenbird, and American Redstart, may be correlated with the gradual decrease of DDT in the environment, after its use for forest spraying in New Brunswick ended in 1967 (Robbins and Erskine 1975). Johnston (1974, 1975) noted that DDT residues in specimens of these and several other passerines, picked up dead around a television tower in north Florida, had decreased markedly over the period 1964–73. This is plausible both because of the absolute decrease and because of the decline in availability of DDT and its metabolites in the arboreal and surface environment after its use was terminated. Upward trends for a number of species (Fig. 4) are obscured by the decreases correlated with adverse spring weather in 1967 and 1974. Three of the species discussed by Johnston (1974) were not recorded here in numbers sufficient for analysis, while three — Gray Catbird, Yellow-rumped (Myrtle) Warbler, and Common Yellowthroat — showed no overall change, although there were frequent and pronounced year-to-year variations within the period. All of these trends are based on the data for all comparable BBS routes in the Maritimes; they are unlikely to be altered though they might be accentuated by restricting consideration to New Brunswick where the spraying was done. The data for New Brunswick have been recalculated separately for 10 species, but these showed no obvious or consistent differences compared with those for the whole Maritimes region.

In 1975, mortality resulting from spraying against spruce budworm was evident in New Brunswick (Pearce *et al.* 1976), and separation of the BBS data on sprayed and unsprayed areas supported the other evidence of the kill. It seems unlikely that similar correlations will be feasible for earlier years; in some years the areas sprayed were much smaller, and

Figure 7
Trends in index numbers for bird populations, Maritime Provinces, 1966–75 (from Table 3), showing sustained downward trends—*Common Flicker*, Northern Junco, Common Grackle, Tree Swallow, Chipping Sparrow. Heavy line indicates statistically significant trend



when larger areas were sprayed the coverage of BBS routes within the sprayed area was not always comparable from year to year. Nevertheless, the evidence of the BBS over the past 10 years gives no suggestion of a "silent spring", although it does not exclude the possibility of bird losses during the earlier (DDT and phosphamidon) years of the New Brunswick spray program.

4.4. Early warning of declines

Sustained downward trends in BBS indices are unusual compared to single-year decreases, but they are of particular interest to CWS and other conservation organizations concerned with the continued survival of species. Obviously the BBS is in no position to help monitor numbers of truly rare birds such as the Whooping Crane or the Peregrine Falcon, but it may provide an early warning of species that are dwindling gradually though still not really scarce, and for which there is still time for research into remedial measures. Only three species in the Maritimes (Fig. 7, which also includes two less convincing examples) give any convincing evidence of sustained declines during the BBS period, and comparisons of the mean numbers per route of these species bear out the indices. We have no convincing explanation for these declines, but one possibility is the abandonment of former agricultural land in the Maritimes (D. Erskine, in Warkentin 1968), particularly since World War II. These birds are associated with woodland edges and early stages of succession towards forest, but by the 1970's much former shrubland had reverted back to closed forest unsuitable for them. Increased exploitation of forests during the same period may have given rise to extensive new areas of early succession, but these are less likely to be served by all-weather roads than were the long-settled agricultural lands, and without such roads the new areas would not be sampled by the BBS. Increased forest exploitation and management would also tend to reduce

the availability of dead trees and stubs in which Common Flickers excavate their nests (*cf.* Haapanen 1965, on reduction of hole-nesting birds in managed forests in Finland), consequently reducing the numbers of birds which nest in flicker holes (Erskine and McLaren 1976).

Downward trends in the other regions are also few, and generally less convincing than those in the Maritimes. Species with possible declines include Blue Jay and Cedar Waxwing in central Ontario and Quebec, and Warbling Vireo, Rose-breasted Grosbeak, and American Goldfinch in the central Prairie Provinces. Few possible explanations come to mind, and some of these might be only chance variations. A decline in Vesper Sparrows, and until 1974 in Horned Larks, in southern Ontario and Quebec might reflect a loss of extensive, grazed grassland, as cattle are now increasingly raised in feed lots. Rock Dove and Common Flicker in the Prairies might also be victims of changing agricultural practices, the former losing access to the interiors of the better-sealed modern grain elevators both for nesting and for survival in harsh winters, while the clearing and filling-in of former brush-rimmed wetlands would reduce nesting opportunities for flickers. We should watch all suspected cases of continued decreases, as they become more convincing and more serious over longer periods. It is to be hoped that research will be undertaken on species which the BBS suggests are declining in numbers.

4.5. Waterfowl in the Prairie Provinces

A special case of birds studied for decades because of fears for their decreasing numbers is that of prairie waterfowl. In addition to many special studies, usually local in scope, extensive aerial surveys by the USFWS and co-operating agencies have been used for monitoring duck numbers in western Canada since the late 1940's. Although the BBS data only extend back to 1970 in the south and to 1971 in the central prairies, it was desirable to see if variations in duck numbers detected in the same years by the BBS and the USFWS surveys showed correlations. The BBS indices for eight duck species in the southern Prairie Provinces, six of them also for the central Prairie Provinces, are plotted in Figure 8. Inasmuch as the BBS results reflect only what can be seen from roads, the lack of uniformity is not surprising, but there are a few common tendencies. Numbers of Mallard, Pintail, Blue-winged Teal, and Northern Shoveler all fell from 1970 to 1972 or 1973 and rose again in 1975. The two diving ducks both decreased slightly from 1971 to 1973, rose abruptly in 1974, and fell again in 1975, but the high water levels of 1974 would have made these open water species much more visible in that year. The lack of agreement between the BBS trends for a species in the southern and in the central Prairie Provinces might be expected, since in dry years ducks move northward to summer and perhaps breed in the parklands and forested areas, whose water regime is less variable though they are never as productive as are the prairies in good (wet) years.

We also compared the BBS indices for other water birds in the Prairie Provinces (Fig. 9), since these might help to reflect the general availability of water, which is so important to duck production in these areas. These birds generally showed the same pattern as the diving ducks, increasing from 1970 to 1971, falling slightly or appreciably to 1973, rising sharply in 1974, with no consistent pattern from 1974 to 1975; however, in the central Prairie Provinces, nearly all these species showed upward trends.

The comparisons with the USFWS data, however, proved discouraging. Not one of the nine waterfowl species (including American Coot) compared in the southern region or of the seven compared in the central region showed a close parallel even in the direction of year-to-year changes (*cf.* Figs. 8 and 10). In the southern region, the six years' data give

Figure 8a
Trends in index numbers for waterfowl populations, southern and central Prairie Provinces, 1970–75 (from Tables 6 and 7)—Mallard, Pintail, Blue-winged Teal, Northern Shoveler. Heavy line indicates statistically significant trend. Solid line indicates the southern area, dotted line the central area

Figure 8a

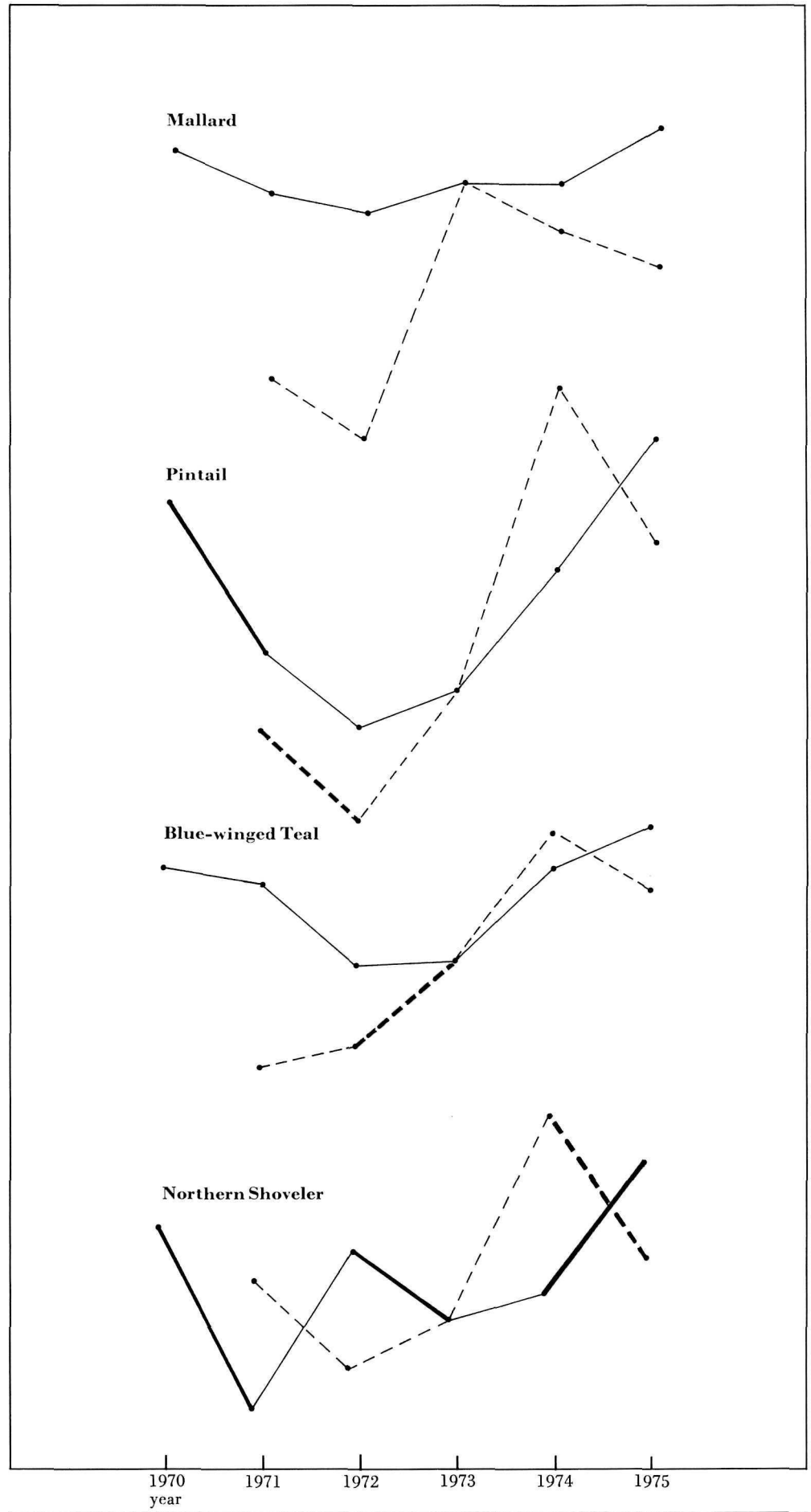


Figure 8b

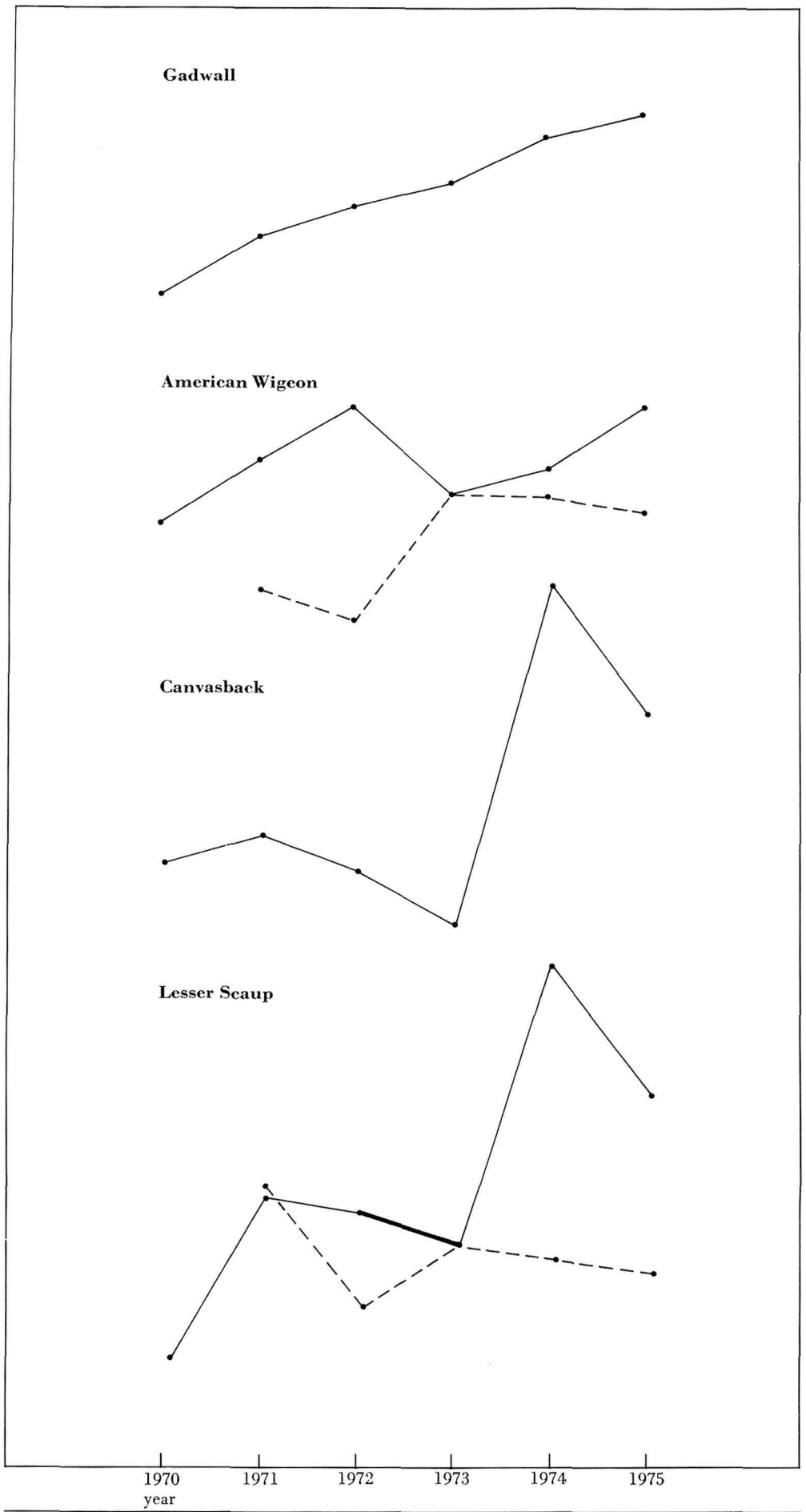


Figure 8b
Trends in index numbers for waterfowl populations, southern and central Prairie Provinces, 1970–75 (from Tables 6 and 7)—American Wigeon, Lesser Scaup, Gadwall, Canvasback. Heavy line indicates statistically significant trend. Solid line indicates the southern area, dotted line the central area

Figure 9a
Trends in index numbers for populations of some water birds not included in Figure 8, southern and central Prairie Provinces, 1970–75 (from Tables 6 and 7)—American Bittern, Sora, American Coot, Common Snipe. Solid line indicates the southern area, dotted line the central area

Figure 9a

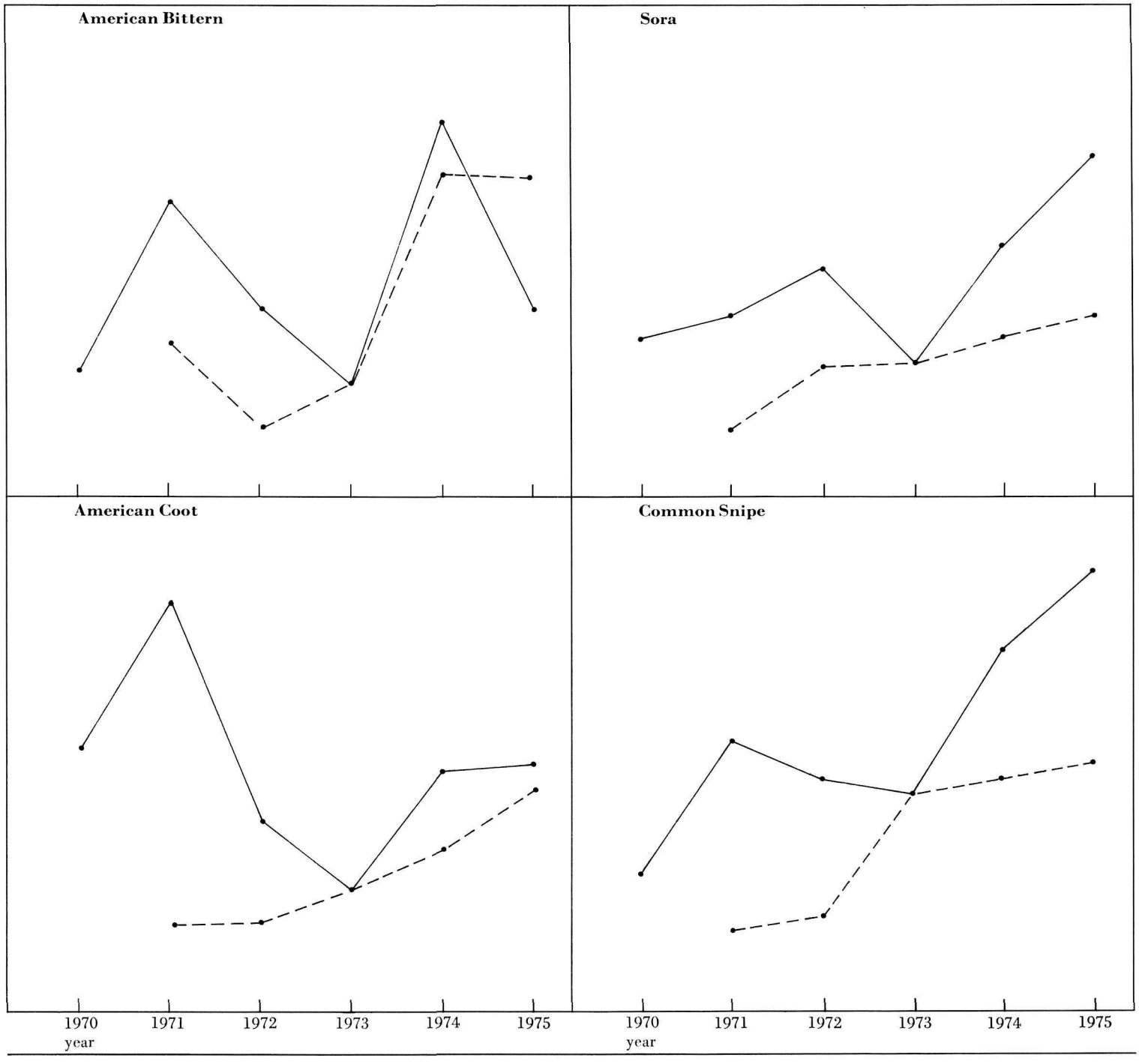


Figure 9b
Trends in index numbers for populations of some water birds not included in Figure 8, southern and central Prairie Provinces, 1970–75 (from Tables 6 and 7)—Willet, Marbled Godwit, Wilson's Phalarope, Black Tern, Yellow-headed Blackbird, LeConte's Sparrow. Solid line indicates the southern area, dotted line the central area

Figure 9b

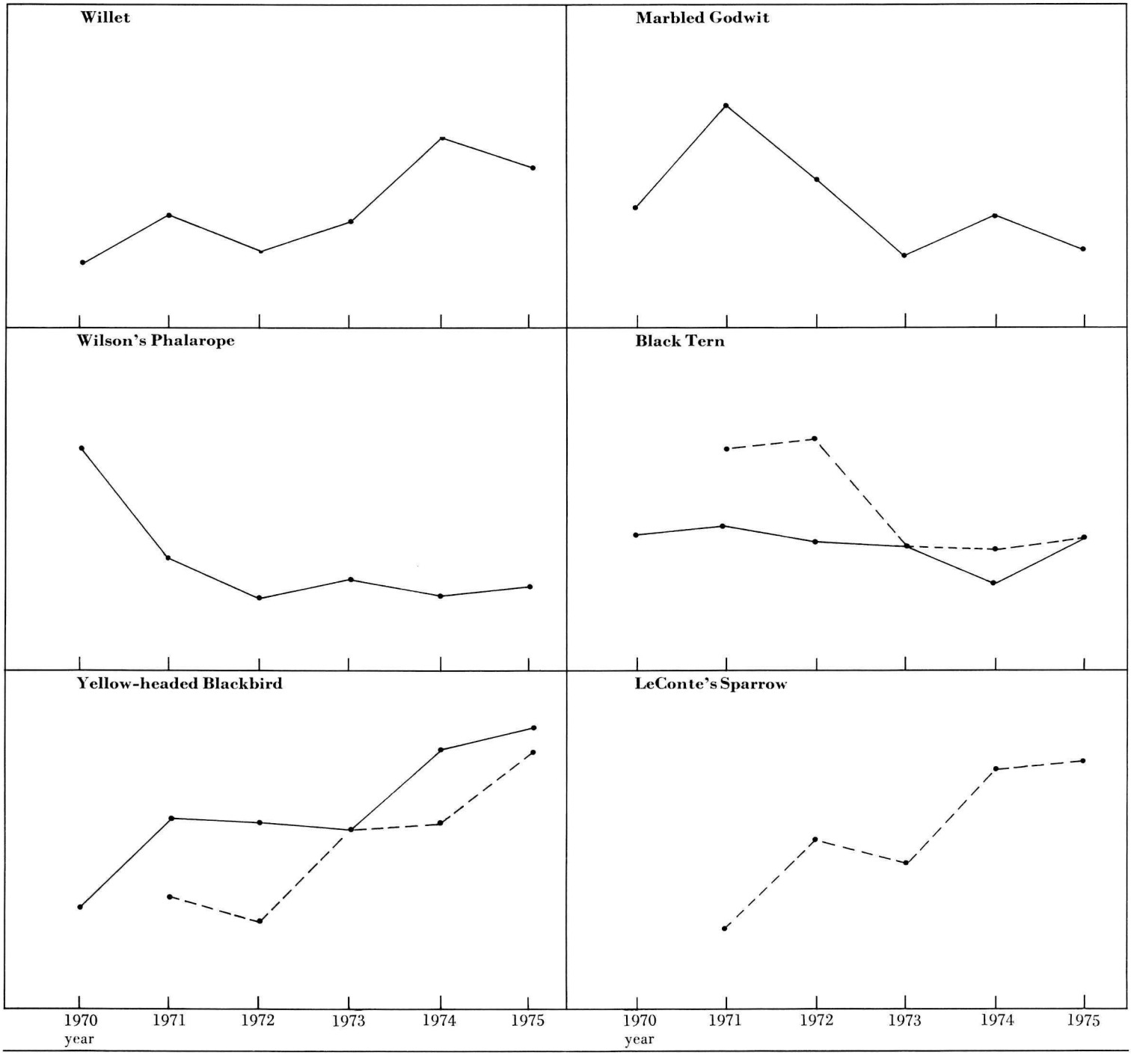


Figure 10a
Trends in index numbers for waterfowl populations from USFWS aerial surveys, southern and central Prairie Provinces, 1970–75—Mallard, Pintail, Blue-winged Teal, Northern Shoveler. Solid line indicates the southern area, dotted line the central area

Figure 10a

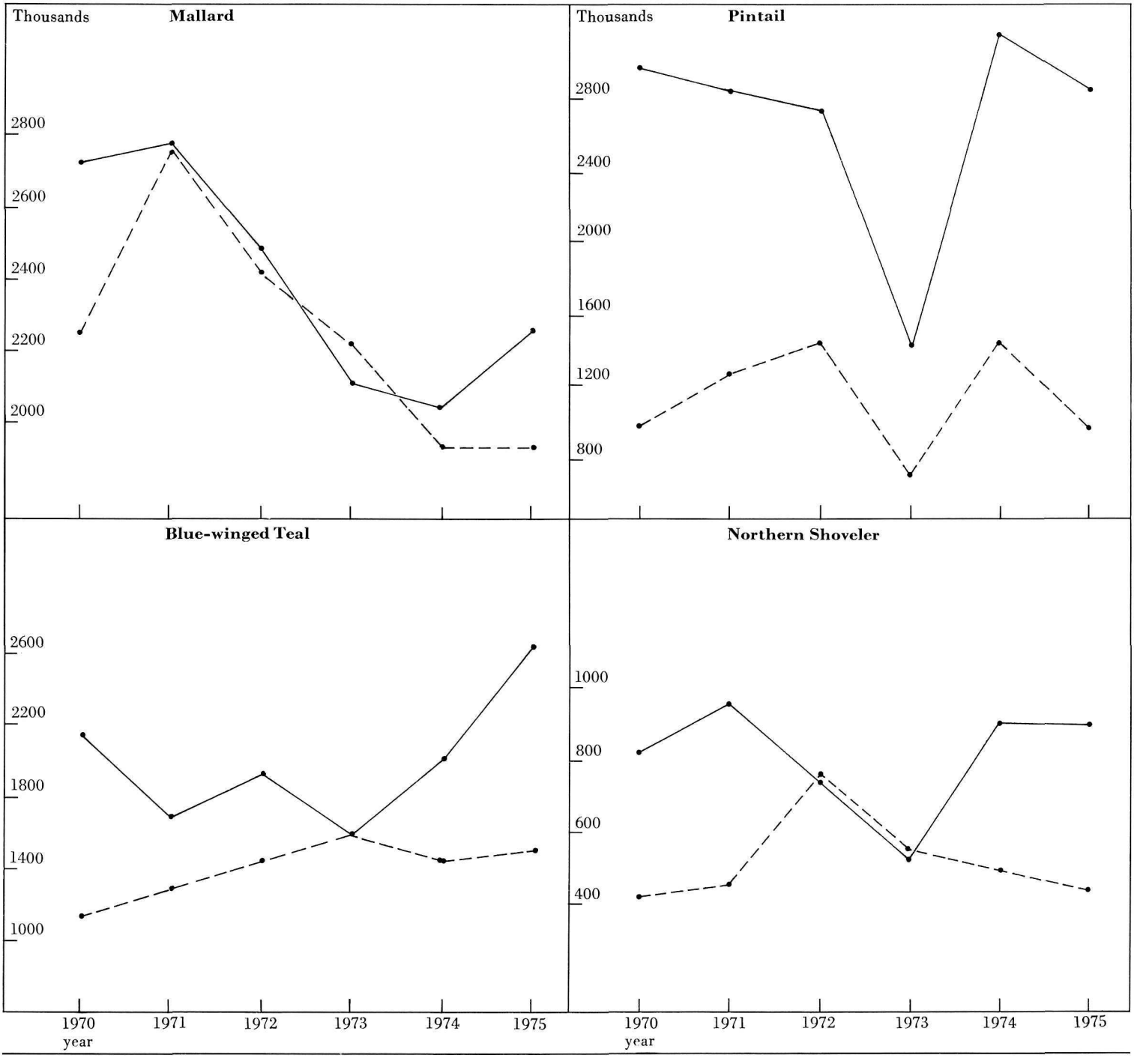


Figure 10b
Trends in index numbers for waterfowl populations from USFWS aerial surveys, southern and central Prairie Provinces, 1970–75—Gadwall, American Wigeon, Canvasback, Lesser Scaup, American Coot. Solid line indicates the southern area, dotted line the central area

Figure 10b

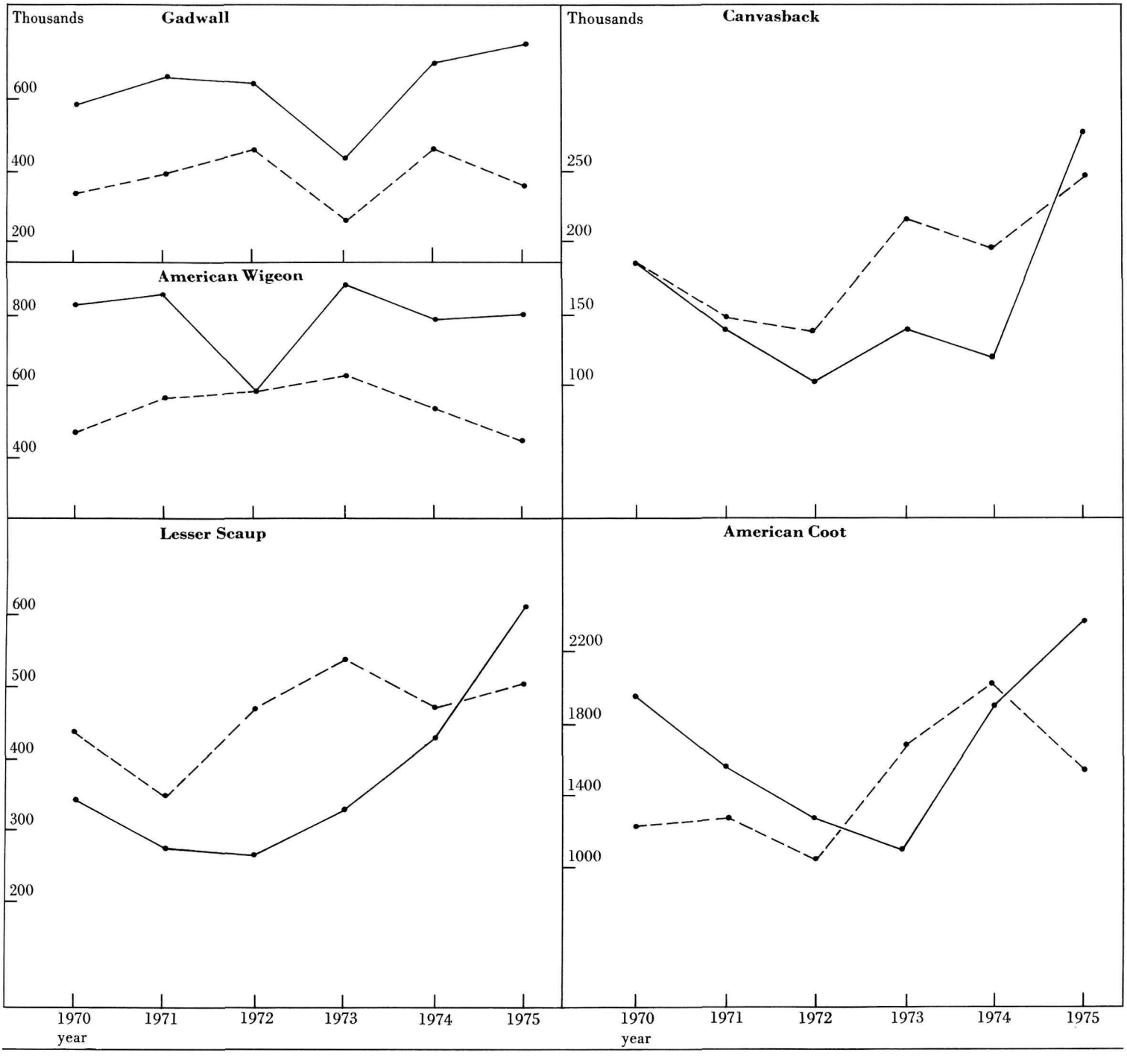


Plate 5
Red-winged Blackbirds still nest only in marshes in frontier areas, as here at Glendyer, N.S.; but in agricultural areas they are now a dominant species of farmlands as well

five sets of year-to-year comparisons for each of nine waterfowl species, thus 45 comparisons in all. The USFWS data showed changes in the same direction as the BBS indices in 22½ cases, and in the opposite direction in 22½ cases (the situation of change in one index and no change in the other was counted as one-half in agreement and one-half opposed). Similarly, in the central region, with four sets of comparisons for seven species, 28 in all, 16 cases showed changes in the same and 12 in the opposite direction. Evidently the two surveys are not sampling the same populations. The restriction of the BBS to roads is part of the problem, although the road network in the prairie provinces is probably the most uniform of any area of Canada. The most important factor, however, is probably the dates, as the USFWS surveys are carried out in May and the BBS in June, at least three weeks later. Not only are the ducks at different stages of their breeding cycle at the times of the two surveys, but there is also time for major changes in the water regime. In 1973, the spring was very dry on the prairies, and the USFWS indices showed the lowest level of the period for most of the dabbling ducks. However, June was generally wet, with most weather stations east of the Alberta foothills reporting rainfall much above average; BBS coverage was mainly in the second half of June, after heavy rains early in the month, but water birds were still generally at their lowest levels of the period in 1973. With the superabundance of water in 1974, following record snowfalls, both the USFWS and BBS indices showed general increases from 1973 to 1974, but this was almost the only good agreement between the surveys.

4.6. Red-winged Blackbirds and corn

Finally, there are some sustained increases, presumably reflecting birds which are successfully responding to changes in their environments. Of these, by far the most obvious at present is the Red-winged Blackbird. Originally a marsh-nesting

Plate 5

Figure 11

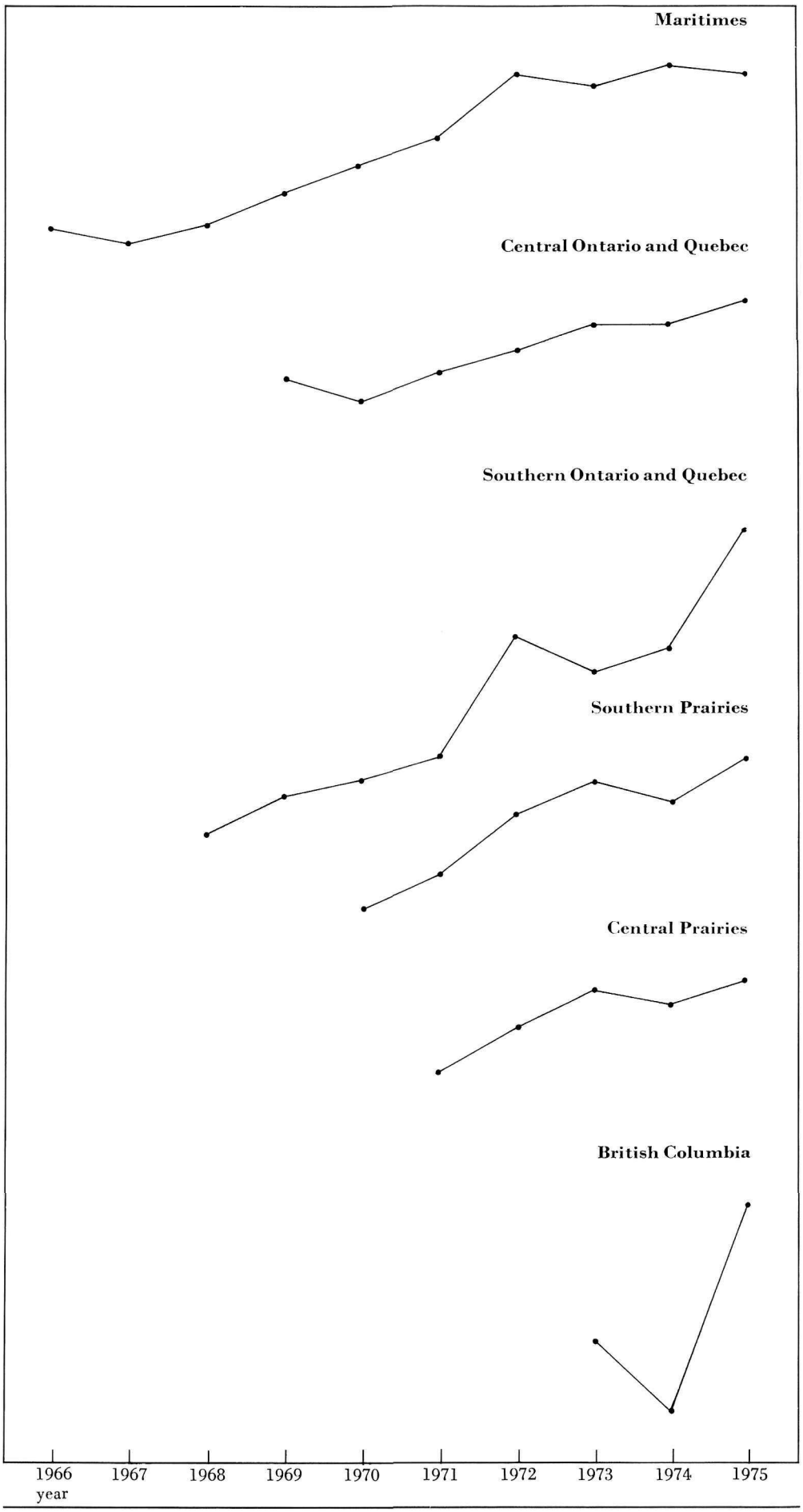
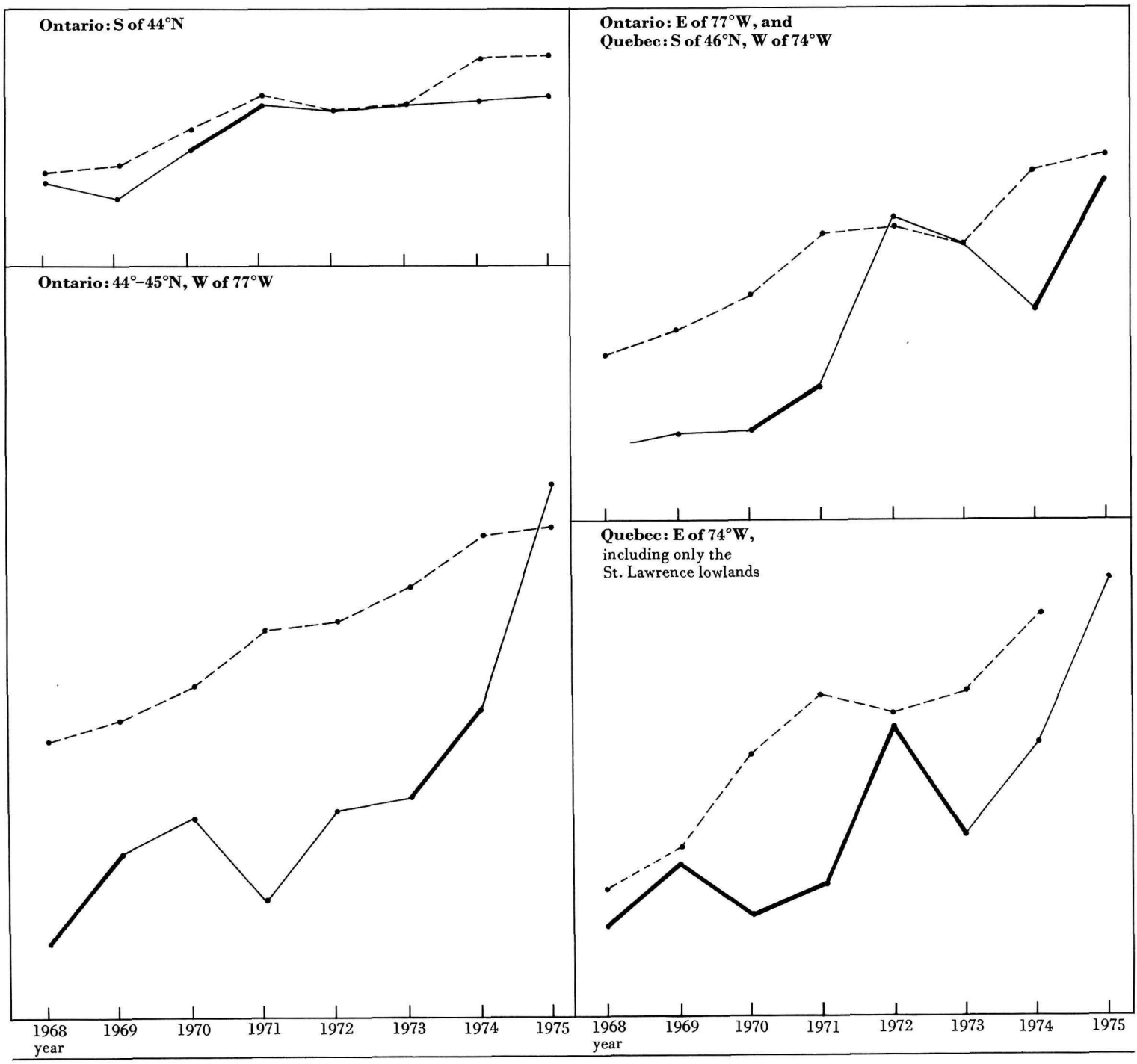


Figure 11
Trends in index numbers for Red-winged Blackbird populations across Canada, 1966–75 (from Tables 3 to 8)

species, in parts of its range this bird has adapted to upland fields for nesting. For example, in Illinois Graber and Graber (1963) estimated that from 1907–1909 to 1957–58 field nesting had increased from 40 to 97% of the total population, which had grown from 50 to 100% in the same period despite the loss of about 90% of the original marshes. There are no comparable data from former years in Canada, but even during the BBS period the Red-winged Blackbird indices have increased markedly and consistently in all regions except British Columbia (Fig. 11). In the Maritimes this is partly due to an increase in its geographic range, as the species apparently only reached Prince Edward Island and most of Nova Scotia as a breeding bird after 1920 (Tufts 1962, Godfrey 1952), and it is still spreading in parts of Nova Scotia. A more general explanation of recent increases, however, is as a response to increased areas planted to corn, on which Redwings are an increasingly important agricultural pest. In this context, we should point out that none of the other common "blackbirds" (Starling, Common Grackle, Brown-headed Cowbird) show similar upward trends in any region. The increases in the Redwing indices are steeper in the largely open regions than in the more forested ones. Subdivision of the southern Ontario and Quebec region data showed (Fig. 12) that the indices for the long-established "corn belt" from Toronto to Windsor, Ontario, remained relatively constant. Elsewhere in Ontario and in Quebec the indices increased dramatically, by the end of the period actually reflecting higher mean numbers of Redwings per route than in the main corn-growing area. Figure 12 also shows the steady increases in area planted to corn in these regions (O.M.A.F. 1968–75), the percentage increase having been considerably greater than in the corn belt. Red-winged Blackbirds have been abundant in all these areas for many years, so abundant that few people have attempted to monitor their numbers systematically, and there has

Figure 12
Trends in index numbers for Red-winged Blackbird populations, southern Ontario and Quebec, subdivided regionally, compared with trends in areas planted to corn, 1968–75. Heavy line indicates statistically significant trend. Solid line indicates bird indices, dotted line the corn area indices

Figure 12



been a tendency to discount the complaints of distressed corn farmers. On the prairies, waterfowl damage to crops, mainly wheat, has tended to distract attention from blackbird damage to corn or other grains, but it seems likely that, at least in Manitoba, corn area has increased recently. This is also possible in Prince Edward Island (H. W. Johnston, unpubl. data), but is not a likely explanation for Redwing changes in Nova Scotia and New Brunswick.

4.7. Other apparently thriving birds

A few other species also show upward trends, of which that for Rose-breasted Grosbeak is apparent in all three eastern regions. Inexperienced observers easily confuse the song of this species with those of the (much commoner) American Robin, but only in the Maritimes is there even a slight suggestion of a concomitant decline in robin indices which might support this explanation. Other species showing upward trends include Killdeer in the Maritimes; Winter Wren, Ruby-crowned Kinglet, and American Redstart in central Ontario and Quebec; Great Blue Heron, Traill's Flycatcher, Black-capped Chickadee, House Wren, and White-throated Sparrow in southern Ontario and Quebec; Common Yellowthroat, House Sparrow, and Northern (Baltimore) Oriole in the southern Prairies; and Barn Swallow in the central Prairie Provinces. Of these, the first is probably a case of range expansion, as Squires (1952) and Tufts (1962) described the Killdeer as "uncommon" in New Brunswick and "rare" in Nova Scotia; it is now recorded annually on most New Brunswick and Prince Edward Island BBS routes and on some farmland routes in western Nova Scotia, and the increase has been obvious from casual observations since about 1965. The samples for several of the other species are small, and data for the Traill's Flycatcher complex in Ontario include both song-types (mainly Alder, however), which were not distinguished until 1973, following recognition of these separate species in the A.O.U. Checklist (A.O.U. 1973). It seems likely that continued surveys will tell us better how many of these trends can be taken seriously, and suggest their possible causes.

5. Breeding bird surveys in the past, present, and future

There have been many attempts to monitor numbers of birds in the breeding season, over short or long periods and covering small or large areas. There has never previously been an attempt to use one well-standardized method to sample a wide range of species over such an extensive area as that covered by the BBS in Canada and the United States. Even the relatively small part of Canada served by roads, and thus accessible to the BBS, is two-fifths as large as the whole continental United States, although it contains only one-tenth of the human population, so we have undertaken an immense task. Any attempt at monitoring animal numbers by a new method is an act of faith, in the hope or expectation that the results will prove worthwhile. We must now consider to what extent the BBS has justified our faith in it, and how far we can and should depend on it in the future.

To a considerable extent the initial, short-term objectives have been met. We have been able to detect and measure both year-to-year and continuing changes in the relative abundance of a number of species. Some of these changes can be correlated with random or continuing changes in their environments. Although this report covers ten years of the BBS in Canada, data for the whole period covers only a very small part of the total area now sampled, and we can anticipate that continuing trends will become apparent in other regions as their coverage approaches that now available for the Maritimes. In addition, there are various additional uses of BBS data as standardized distributional indices, potentially very valuable but outside the scope of the present report.

Nevertheless, we must not look at the performance of the BBS through the

Table 12
Number of routes completed in the Breeding Bird Survey, Canada, 1966–75, compared to all routes surveyed in any year

Province	Total routes surveyed in 1966–75	Numbers of routes surveyed in 1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Nfld.	6								2	4	**6***
PEI	4	2	**4**	**4**	**4**	3	3	2	**4**	**4**	**4**
NS	24	16	20	20	20	20	21	**23**	20	19	17
NB	27	15	19	22	23	23	**24**	**24**	22	21	17
Que.	44	3	7	17	20	**33**	25	28	24	21	24
Ont.	67		4	41	40	47	53	47	55	58	**61**
Man.	16		11	11	12	11	11	**14**	13	**14**	13
Sask.	29			3	6	11	13	20	**28**	19	19
Alta.	45			5	7	11	17	27	**36**	31	33
BC	74			16	16	17	12	9	38	**53**	50
Yukon	7							1	5	**7**	5
Total	343	36	65	139	148	176	179	194	247	251	249

* The figures in bold-faced type represent the greatest number of routes surveyed in one year for each province.

proverbial rose-tinted glasses. The sampling intensity in most of Canada is low, and two of the regions in our analyses are heterogeneous assemblages of surveys from all areas to the north of major agricultural settlement. We examined the data regionally in order to reduce the effects of changes from one cause in any particular area cancelling out changes in the opposite direction from another cause and area; but it is hardly realistic to expect that environmental factors will act uniformly throughout regions that extend from Cabano to Kenora or from Dauphin to Dawson Creek. Even in the best sampled areas it has been a continuing effort to maintain the present level of coverage, and in the east where the surveys began earlier the numbers of surveys have been declining for several years (Table 12). Only in Ontario is there any suggestion that regular surveys might be further increased. Enthusiastic regional co-ordinators can and have improved local coverage considerably, but such efforts sooner or later reach a point where all available routes within acceptable distance are assigned. It is doubtful that payment of operating expenses would ensure continuing coverage of routes far from the homes of most observers, so it is unlikely that we can much improve on the best levels of coverage achieved to date.

The present level of BBS coverage is only just sufficient for our purposes. The trends described for the Maritimes were becoming apparent after 6 or 7 years, with in most cases over 30 comparable routes used in each year-to-year comparison. No other region has ever exceeded this level, and with smaller samples trends take longer to emerge and/or are less clear when they do. With 8 years' data from southern Ontario and Quebec and 23 to 30 comparable surveys per comparison, only the trend for Red-winged Blackbirds was really convincing, and with shorter periods and generally smaller samples still less can as yet be inferred from data in the other regions. It is clear that we cannot afford any decrease in the effort if we are to continue this kind of monitoring.

Compared to any previous attempts at monitoring numbers of most birds in Canada and the United States, the BBS has been a resounding success, and one would like to see it continuing unaltered for many years. Unlike those of many other government projects, the financial requirements of the BBS are so small that it is unlikely to fall victim to a budget cut in Canada. Even if the computerized file in the US were cut out, the continuation of the Canadian program would not be jeopardized, as we have always used manual sorting for our analyses. The price and availability of gasoline for private cars is unlikely to restrict the willingness of our present co-operators, since the cost incurred in carrying out a survey is minor compared to many other forms of recreation. It seems likely that the BBS can continue in its present form for another 5–10 years, but its long-range future is less certain.

If we cannot count on continuing the BBS indefinitely, it is essential that some alternative method be evolved to run in parallel with the BBS for a number of years, so as to avoid a break in continuity when the present method is terminated. Any method involving decreased mobility will pose increased difficulties in sampling in a representative way, since the potential observers are less uniformly distributed than are the existing BBS routes. There

will thus be a concentration of effort near major settlements and a general under-representation of remote areas, but this may not be wholly bad since the areas most influenced by man will still be accessible. The samples obtained per unit of time will generally be smaller since, unlike the BBS, it will not be possible to sample a new lot of birds every 5 minutes. Most birds are detected in the first 2–3 minutes at a stop (Blondel *et al.* 1970, Jørgensen 1974, my own unpublished data), so increasing the length of time at each stop will not increase the samples proportionately, although it may decrease their variability somewhat. The distance between stops would also have to be reduced if observers were not to spend most of their time and effort travelling. The size of samples could be increased by counting while travelling between stops as well as at the stops (Bond 1957), but this would introduce greater variability owing to the varying ease of travel in different habitats. The same difficulty also applies to any strip counts, most of which (e.g. Merikallio 1958, as reviewed by Järvinen and Väisänen 1973, Emlen 1971) also involve estimating the distances at which birds are detected. I believe that some variant of the BBS method, using fewer but longer stops at shorter intervals so as to allow use of non-mechanized transport, is probably the best alternative approach, and in fact workers in France (Blondel *et al.* 1970) and Sweden (S. Svensson, pers. comm.) are evolving basically similar methods. I have found that a survey made with 15 stops of 10 minutes each at 500 m intervals, using paths in forested areas, requires roughly the same time as the present BBS method but considerably more physical effort, while yielding only 30–40% as many birds. In areas with roads or paths, the effort and time could be reduced by using a bicycle or horse, and with canals or extensive open marshes canoes might be used. Such a method would be applicable in many regions (tundra, mountains, some forests, some wetlands) not accessible to the present BBS coverage, and more investigations of this approach are needed.

In conclusion, I would suggest that the BBS is an outstanding example of effective co-operation between private citizens and government agencies, providing maximal information at minimal cost. The idea that this exemplifies the government exploiting unpaid helpers is quite invalid when it is realized that CWS — and also USFWS — exists to serve the birds and the people interested in them. Any information that may help to counter trends harmful to bird numbers is helping both the birds and those watching them. The role of the public servants should be to standardize the methods and to co-ordinate their use by interested people, rather than to build up an expensive bureaucracy to do the whole job at public expense. Obviously, this principle cannot be applied to every government project, but here it is clearly the best way, and we hope that the co-operation on the BBS will continue far into the future.

It is a truism to say that no method will work equally well in all situations. Under the circumstances prevailing in Canada, it seems probable that the BBS method — perhaps with minor differences in detail — was the best that could have been evolved for the purpose. For the sake of comparability, it is desirable that the method should be retained in its present form as long as possible, but for the same reason we should explore alternative methods that may ultimately have better prospects.

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Appendices

Appendix 1
Migratory Non-Game Bird Studies
Bureau of Sport Fisheries and Wildlife
Migratory Bird and Habitat Research Laboratory
Laurel, Maryland 20810

Cooperative Breeding Bird Survey of North America

Purpose: To obtain, by random sampling, an index of abundance of breeding birds. This Survey provides information on distribution and relative abundance of North American birds, and specifically measures changes in abundance that result from such factors as changes in land use and widespread applications of pesticides.

Sampling Technique: Each one-degree block of latitude and longitude (about 55 miles wide, east to west, by 70 miles long) is sampled by one or more random transects or "routes." In some States west of the 100th meridian the sample size is two routes for each block, 2 x 2 degrees. The number of routes per degree block varies according to the numbers of qualified observers available, but preferably is uniform within a given State or Province. *Starting points* and compass directions have been determined *at random*. Each route is covered once each summer by the following standardized procedure: *Begin exactly one-half hour before sunrise;* make *50 stops one-half mile apart* and *count all birds* heard at each stop or seen within one-fourth mile *during* a *3-minute* watching and listening period. *One observer* must do all the observing on a given route, but he may have an assistant to help with recording or driving. Unless driving conditions are very poor, most routes should be completed in 4 to 4½ hours.

Time Period: In most States, routes should be run in June. In Canada and bordering States the first week of July is acceptable (except in Ohio, Pa., and southern N.Y.). In California, Nevada, Arizona, New Mexico, Texas, and Florida routes may be run as early as May, at the discretion of the State Coordinator(s). In general, select a date as near as possible to last year's.

Scouting of Routes is strongly recommended. More leisurely trial runs may be made in advance to become familiar with songs and calls and with roads and stopping locations. A single route may be run more than once if the observer wishes to have the practice, but only one coverage of a route should be reported, this must not be the best of several coverages, but the first one made under satisfactory conditions of weather and familiarity with birds along the route.

Strict adherence to rules is essential for statistical analysis of results!

Directions for Running Routes

Equipment: Clip board, pencils, forms supplied by the Migratory Bird and Habitat Research Laboratory, map, binoculars, watch with second hand (or automatic 3-minute timer), gasoline, thermometer.

Weather: To be comparable, routes must be run under satisfactory weather conditions: good visibility, little or no precipitation, light winds. Occasional light drizzle or a very brief shower may not affect bird activity, but fog, steady drizzle, or prolonged rain should be avoided. Except in those prairie States and Provinces where winds normally exceed Beaufort 3, counts preferably should be made on mornings when the wind is less than 8 m.p.h. and not taken if the wind exceeds 12 m.p.h. If you can walk faster than the wind is blowing, winds are very satisfactory.

Wind speed codes
(enter Beaufort Numbers on Summary Sheet)

Beaufort Number	Wind Speed miles per hr.	Indicators of Wind Speed
0	Less than 1	Smoke rises vertically.
1	1 to 3	Wind direction shown by smoke drift.
2	4 to 7	Wind felt on face; leaves rustle.
3	8 to 12	Leaves and small twigs in constant motion; wind extends light flag.
4	13 to 18	Raises dust and loose paper; small branches are moved.
5	19 to 24	Small trees in leaf begin to sway; crested wavelets form on inland waters.

Sky condition codes
(enter these Weather Bureau code numbers on Summary Sheet)

0 Clear or a few clouds.
1 Partly cloudy (scattered) or variable sky.
2 Cloudy (broken) or overcast.
4 Fog or smoke.
5 Drizzle.
8 Shower(s).

Start 30 minutes before official sunrise. Consult enclosed map, or newspaper or Weather Bureau, for sunrise time. If starting point is more than 25 miles from the city of reference, start 4 minutes earlier for each degree block (55 mi). east of the city or 4 minutes later for each degree block to the west. Be at the starting position at least 2 minutes before official start, to record weather and speedometer reading. The starting point is the first counting station (stop #1).

Look and listen for exactly 3 minutes and record the number of birds of each species seen within ¼ mile in all directions and all birds of each species heard regardless of distance; limiting distance for birds seen may be judged as half the distance to the next stop.

Drive 0.5 mile to the next stop. If this stop falls in a place where it is dangerous to stop or where local noise is excessive, the stop may be moved as much as 0.1 mile (forward or back). Do not record any bird seen or heard while driving between stops unless it is subsequently heard at the next stop during the prescribed 3-minute period. In case of excessive traffic noise, up to one additional minute (but no more) may be added to a few stops – but not routinely to all stops. It is important to complete the 50 stops on schedule because singing decreases appreciably soon after 9 a.m.

Speedometers vary slightly so please *mark* on your map the number and exact position of *one or more stops every few miles* — whenever there is a convenient landmark. This will enable you or another observer to stop at the same spots in a subsequent year and to make any necessary adjustments in speedometer readings.

Make 50 stops. Each route consists of *exactly 50 stops* (24½ miles). Allowing 3 minutes for each stop and 2 minutes driving time between stops, approximately 12 stops will be covered per hour and the entire route will take a little over 4 hours.

What Birds to Count: Count individuals of all species (including Rock Doves) seen or heard that can be identified. Any bird known to be a non-breeder (late migrant, injured bird, or summer vagrant) should be included but marked on the Summary Sheet as such. Species recorded that are not found on the form should be added at the bottom. Estimates are permissible only in those cases where a flock is too large to count, bird by bird, in the brief time it is seen. Do not use check marks even for abundant species. No one will detect all birds within hearing or seeing distance of his stops. Hundreds of birds will be missed. Observers should not try to estimate birds that are missed or include them on their report forms even if they are known to be present. We wish to have reported only those birds actually seen or heard during the prescribed 3-minute stops. Be careful not to count any bird(s) known or strongly suspected to be a bird counted at the previous stop.

Record Keeping: Two types of report forms are enclosed. *Take both* in the field with you. The summary form is for recording weather conditions at the beginning and end of the count and for reporting a summary of observations that should be compiled after the count has been completed. The

form with the 11 columns after each species is to be used for recording birds in the field. *Get familiar with this form* so you can locate the species rapidly. Use one sheet for each ten consecutive stops. Number the first and last stop at the top of the columns, and enter the starting and ending time for each page. The additional spaces for time and speedometer reading for intermediate stops on each page of the Field Sheet are provided for the convenience of the observer (and such data may prove to be valuable).

Reporting Results: If for any reason it should be impossible for you to cover your route during the prescribed period, please contact your coordinator to see whether arrangements might be made for another observer to run the route, or for you to cover it on a slightly later date. The *five original Field Sheets* (representing 50 stops), *one Summary Sheet, the starting time map* and the *route map* should be sent to Migratory Non-Game Bird Studies, Migratory Bird and Habitat Research Laboratory, Laurel, Maryland 20810 *as soon as possible after completion of the count.* The map will be returned the following year with new forms. An extra set of forms is provided for your records. You will want to keep a copy of your data so that you can check your machine listing at a later date.

Upon completion of the route, coverage data should be transferred from the Field Sheet to the Summary Sheet. The species totals for each of the 5 Field Sheets should be entered under the appropriate page total columns on the Summary Sheet. The sum of these 5 columns is entered in the Total Indiv. column. The number of stops, out of the total of 50, upon which each species was seen is entered in the Stops per Spec. column (e.g., if Robins are recorded on 15 different stops out of the 50, enter the number 15 in the Stops per Spec. column). Please double check the transfer of data to your Summary Sheet. In the past we have found that many observers omitted species when they transferred data to the Summary Sheet. Please send us your *original* Field Sheets. We are not concerned if they are "soiled"; we find that copied Field Sheets tend to be less accurate than the originals.

Be sure to furnish all information requested at the top of the Summary Sheet. Please write plainly as all information must be punched. Only 14 spaces can be allotted for the observer's last name and initials. Married women should circle the Mrs. title but use their *own* initials, not those of their husbands, as the title is not punched because of space limitations.

All forms must be completed and returned by July 31

Processing of Results: Upon receipt of the forms the Summary Sheets are checked against the Field Sheets, addresses are checked, AOU numbers added, and continuity and type codes entered. Data from the Summary Sheet are then punched onto magnetic tape. A machine listing will be mailed to each observer and a State tabulation will be mailed to each coordinator. An analysis of population changes for the entire area covered will later be sent to each participant. Data on distribution and comparative abundance of individual species will be available to research workers on request.

Drivers who itemize deductions on their Income Tax Returns may make a deduction for mileage necessary for the scouting and running of assigned Breeding Bird Survey routes. This should be reported on Form 2106, Statement of Employee Business Expenses, which can be obtained from any Internal Revenue Service office (US only).

Details of Laying Out Routes: Route maps will be provided for each cooperator. Last-minute adjustments will have to be made in some routes because of impassable roads or heavy traffic, so the procedure for laying out routes is given here in detail. It is important that routes sample urban and suburban areas as well as rural and wilderness areas, so routes should *not* be changed to avoid populated areas or to include favorite birding localities.

Routes will proceed in the specified direction, as closely as possible, unless or until reaching (1) the edge of the one-degree block; (2) a State or Provincial line; or (3) a body of water that cannot be crossed by bridge. Upon (or at the last chance before) reaching such a barrier, turn clockwise and continue. If the route will reach a dead end before the 50th stop, change any or all of it (except the starting point) as necessary to make a continuous route that does not duplicate itself or another route. Maintain the direction as closely as possible to the original direction, or the next direction clockwise, returning to the original direction at the first opportunity. If routes must cross, omit from the second route any stop that falls within one-half mile of any stop on the first route; add the extra stop at the end. If one route must run along a short portion of another route, the first route has priority and the second route should skip the duplicate stops and add them at the end. If possible, avoid Federal numbered highways, Interstate highways, and State numbered highways as well as other roads that are apt to have heavy traffic at the time of day you will be there. If it is necessary to traverse a well-traveled highway for a short distance, and if traffic interferes seriously with observations, make counts at the first two stops on this highway (if this can be done safely),

then proceed without stopping until you can leave the highway (then stop about ¼ mile after leaving it). Add the extra stops at the end of the route.

Appendix 2
Statistical analysis of yearly changes

Formation of the estimate of change and its standard error

The sample design is stratified random, as described in Robbins and Van Velzen (1967). Degree blocks are the strata, with randomly chosen routes within each. In some coastal areas where degree blocks consist mainly of water, two or more were combined to form a single stratum. Several routes were chosen within each degree block but, as will be discussed later, in some areas very few are covered in the survey.

To measure the change in a particular species between two successive years, the following quantity was used:

$R = (\bar{Y} - \bar{X})/\bar{X}$ where
$\bar{X}$ = mean no. of birds/route in the 1st year, and
$\bar{Y}$ = mean no. of birds/route in the 2nd year.

Hence 100 x R is the percentage increase in the number of birds observed in the second year over that in the first. The means, $\bar{X}$ and $\bar{Y}$, are averages of the birds observed on each route weighted according to the area the route represents, i.e.,

$$\bar{X} = (1/A)\sum_i\sum_j a_{ij}X_{ij}$$
$$\bar{Y} = (1/A)\sum_i\sum_j a_{ij}Y_{ij} \text{ where}$$

X_{ij} = no. of birds observed on the jth route in the ith degree block in the 1st year

Y_{ij} = no. of birds observed on the jth route in the ith degree block in the 2nd year

a_{ij} = area represented by (also called the 'weight') the jth route in the ith degree block, and

$$A = \sum_i\sum_j a_{ij}$$

Since the routes are randomly chosen within strata, a_{ij} is the same for all routes within a given stratum, i.e., $a_{ij} = a_i$ = (area of the ith stratum) / (number of routes in the ith stratum).

The variance of R is estimated by using the variance formula of a ratio (see Kendall and Stuart, 1963:232).

$$\text{var } R = (\bar{Y}/\bar{X})^2 [(\text{var } \bar{Y})/\bar{Y}^2 + (\text{var } \bar{X})/\bar{X}^2 - 2\text{cov}(\bar{X},\bar{Y})/\bar{X}\bar{Y}] \text{ where}$$
$$\text{var } \bar{X} = (1/A^2)\sum_i a_i^2(\Sigma X_{ij}^2 - n_i\bar{X}_i^2)/[n_i(n_i - 1)]$$
$$\text{var } \bar{Y} = (1/A^2)\sum_i a_i^2(\Sigma Y_{ij}^2 - n_i\bar{Y}_i^2)/[n_i(n_i - 1)]$$
$$\text{cov}(X,Y) = (1/A^2)\sum_i a_i^2(\Sigma X_{ij}Y_{ij} - n_i\bar{X}_i\bar{Y}^2)/[n_i(n_i - 1)]$$

n = no. of comparable routes in the ith stratum
$\bar{X}_i = \sum_j X_{ij}/n_i$
$Y_i = \sum_i Y_{ij}/n_i$

These are the variance and covariance formulae for weighted means in a stratified random sample (see Cochran 1963: chapt. 5).

Modifications required by noncoverage or incomparability of routes

In many cases, there are one or no routes in a stratum which are comparable between the two successive years for which we wish to measure the change. In this case the variance expressions given above are invalid. To circumvent this problem several strata are 'collapsed' to form one larger stratum in which there are at least two comparable routes.

Then, var R is calculated as though all the comparable routes (n_i of them) were chosen at random within the large stratum. This will generally tend to overestimate the variance. To minimize this effect, strata were combined which were as similar as possible with respect to breeding bird habitat. Where routes are very sparse, degree blocks were collapsed into strata roughly following ecological boundaries. Further, in comparing different pairs of years, strata may be collapsed into different groups depending upon which routes are comparable.

There are practical limitations to collapsing strata. For example, two routes might be in one degree block (each with a weight of ½ degree block), while in a collapsed stratum 3 routes might represent 21 degree blocks (each with a weight of 7 degree blocks). In this case the large weight of the latter routes completely overshadows the small weight of the former and leads to a large variance. To reduce this effect it was arbitrarily decided to set a maximum weight of 2.5 degree blocks for a route even though this meant some of the degree blocks were not accounted for. This leads to a bias, but is probably the lesser of two evils.

Confidence limits

The 95% limits given for R are two standard deviations on each side of the estimate. This tacitly assumes that R is normally distributed. This is a reasonable approximation in view of the fact that the coefficients of variation of $\bar{X}$ and $\bar{Y}$ are generally much less than one and $\bar{X}$ and $\bar{Y}$ are themselves approximately normal.

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Appendix 3
Species poorly represented on Breeding Bird Survey

a. Poorly sampled because habitat incompatible with most roads:
Most water birds (loons, grebes, petrels, herons, geese, ducks, rails, sandpipers, gulls, terns, alcids, marsh wrens);
forest birds with faint voices (Brown Creeper, Golden-crowned Kinglet, Cape May Warbler);
far northern birds generally.

b. Poorly sampled because distribution non-random for other reasons:
Flocking birds (gulls, terns, Bank and Cliff Swallows; to some extent also Starlings, blackbirds, Evening Grosbeaks, Lark Buntings, longspurs).

c. Poorly sampled because presence in an area erratic, or very mobile:
Chimney Swift, Violet-green, Tree, and Barn Swallows, Cedar Waxwing, Pine Siskin, American Goldfinch, Black-billed Cuckoo.

d. Poorly sampled because active or vocal at other times of day only:
nocturnal birds (American Woodcock, owls, goatsuckers).

e. Poorly sampled because scarce (need higher sampling intensity):
Hawks, eagles, falcons (except American Kestrel), owls, hummingbirds (except Rufous H.), Black and Vaux's Swifts, Say's Phoebe, White-breasted Nuthatch, Dipper, Loggerhead Shrike, Connecticut Warbler, Scarlet Tanager, Pine Grosbeak, Grasshopper and Sharp-tailed Sparrows, and many species that occur in Canada only along the United States border or in southern British Columbia.

Appendix 4
Scientific names of birds and other organisms named in the text and tables*

Birds
(order follows A.O.U. Check-list (1957))

Common Loon *Gavia immer*, **3, 4, 8**
Great Blue Heron *Ardea herodias*, 51; **3, 4, 5, 8**
American Bittern *Botaurus lentiginosus*, 44; **6, 7**
Mallard *Anas platyrhynchos*, 41, 42, 46; **5, 6, 7, 8**
Black Duck, *A. rubripes*, **3**
Gadwall *A. strepera*, 43, 47; **6**
Pintail *A. acuta*, 41, 42, 46; **6, 7**
American Wigeon *A. americana*, 43, 47; **6, 7**
Blue-winged Teal *A. discors*, 41, 42, 46; **6, 7**
Northern Shoveler *A. clypeata*, 41, 42, 46; **6, 7**
Canvasback *Aythya valisineria*, 43, 47; **6**
Lesser Scaup *A. affinis*, 43, 47; **6, 7**
Swainson's Hawk *Buteo swainsoni*, **6**
Marsh Hawk *Circus cyaneus*, **6**
Peregrine Falcon *Falco peregrinus*, 40
American Kestrel *F. sparverius*, 57; **4, 7, 8**
Ruffed Grouse *Bonasa umbellus*, 7; **7**
Ring-necked Pheasant *Phasianus colchicus*, 7; **8**
Whooping Crane *Grus americanus*, 40
Sora *Porzana carolina*, 44; **6, 7**
American Coot *Fulica americana*, 41, 44, 47; **6, 7**
Killdeer *Charadrius vociferus*, 27, 51; **3, 4, 5, 6, 7, 8**
American Woodcock *Philohela minor*, 57
Common Snipe *Capella gallinago*, 44; **3, 4, 5, 6, 7, 8**
Willet *Catoptrophorus semipalmatus*, 45; **6**
Marbled Godwit *Limosa fedoa*, 45; **6**
Wilson's Phalarope *Steganopus tricolor*, 45; **6**
Glaucous-winged Gull *Larus glaucescens*, **8**
Herring Gull *L. argentatus*, **3, 4**
Ring-billed Gull *L. delawarensis*, **6**
Franklin's Gull *L. pipixcan*, **6, 7**
Black Tern *Chlidonias niger*, 45; **6, 7**
Band-tailed Pigeon *Columba fasciata*, **8**
Rock Dove, *C. livia*, 7, 41; **5, 6, 7, 8**
Mourning Dove *Zenaida macroura*, 7; **5, 6, 7**
Black-billed Cuckoo *Coccyzus erythrophthalmus*, 57; **4**
Black Swift *Cypseloides niger*, 57
Chimney Swift *Chaetura pelagica*, 57; **3, 5**
Vaux's Swift *C. vauxi*, 57
Rufous Hummingbird *Selasphorus rufus*, 57; **8**
Belted Kingfisher *Megaceryle alcyon*, **3, 4, 5, 8**
Common (including Yellow- and Red-shafted) Flicker *Colaptes auratus*, 40, 41; **3, 4, 5, 6, 7, 8**
Yellow-bellied Sapsucker *Sphyrapicus varius*, 38: **3, 4, 8**
Hairy Woodpecker *Picoides villosus*, **4, 8**
Eastern Kingbird *Tyrannus tyrannus*, **4, 5, 6, 7, 8**
Western Kingbird *T. verticalis*, **6**
Great Crested Flycatcher *Myiarchus crinitus*, **5**
Eastern Phoebe *Sayornis phoebe*, 28; **4, 5, 7**
Say's Phoebe *S. saya*, 57
Yellow-bellied Flycatcher *Empidonax flaviventris*, 28
Willow Flycatcher *E. traillii*, **8**
Traill's (including Willow and/or Alder) Flycatcher, 51; **5**
Alder Flycatcher *E. alnorum*, 28, 34, 51; **3, 4, 7**
Least Flycatcher *E. minimus*, 28, 36, 37; **3, 4, 5, 6, 7, 8**
Hammond's Flycatcher *E. hammondii*, 28
Dusky Flycatcher *E. oberholseri*, 28
Eastern Wood Pewee *Contopus virens*, **3, 5**
Western Wood Pewee *C. sordidulus*, **7, 8**
Olive-sided Flycatcher *Nuttallornis borealis*, **8**
Horned Lark *Eremophila alpestris*, 8, 27, 41; **5, 6, 7**
Violet-green Swallow *Tachycineta thalassina*, 57; **8**
Tree Swallow *Iridoprocne bicolor*, 37, 40, 57; **3, 4, 5, 6, 7, 8**
Bank Swallow *Riparia riparia*, 57; **3, 4, 5, 8**
Rough-winged Swallow *Stelgidopteryx ruficollis*, **8**
Barn Swallow *Hirundo rustica*, 51, 57; **3, 4, 5, 6, 7, 8**
Cliff Swallow *Petrochelidon pyrrhonota*, 57; **3, 4, 5, 6, 7, 8**
Purple Martin *Progne subis*, **5**
Blue Jay *Cyanocitta cristata*, 41; **3, 4, 5**
Black-billed Magpie *Pica pica*, 27; **6, 7**
Common Raven *Corvus corax*, **3, 4, 7, 8**
Common Crow *C. brachyrhynchos*, **3, 4, 5, 6, 7, 8**
Northwestern Crow *C. caurinus*, **8**
Black-capped Chickadee *Parus atricapillus*, 51; **3, 4, 5, 7, 8**
Chestnut-backed Chickadee *P. rufescens*, **8**
White-breasted Nuthatch *Sitta carolinensis*, 57
Red-breasted Nuthatch *S. canadensis*, 27; **4, 8, 11**
Brown Creeper *Certhia familiaris*, 57
Dipper *cinclus mexicanus*, 57
House Wren *Troglodytes aedon*, 27, 51; **5, 6, 7**
Winter Wren *T. troglodytes*, 27, 51; **3, 4, 8**
Gray Catbird *Dumetella carolinensis*, 39; **3, 5, 6, 7**
Brown Thrasher *Toxostoma rufum*, **5, 6**
American Robin *Turdus migratorius*, 12, 28, 51; **3, 4, 5, 6, 7, 8**
Varied Thrush *Ixoreus naevius*, **8**
Wood Thrush *Hylocichla mustelina*, 28; **5**
Hermit Thrush *Catharus guttatus*, 28; **3, 4**
Swainson's Thrush *C. ustulatus*, 28, 37; **3, 4, 7, 8**
Gray-cheeked Thrush *C. minimus*, 28
Veery *C. fuscescens*, 8, 28; **3, 4,,5, 8**
Golden-crowned Kinglet *Regulus satrapa*, 57
Ruby-crowned Kinglet *R. calendula*, 27, 51; **3, 4, 7, 8**
Sprague's Pipit *Anthus spraguei*, **6**
Cedar Waxwing *Bombycilla cedrorum*, 41, 57; **3, 4, 5, 8**
Loggerhead Shrike *Lanius ludovicianus*, 57
Starling *Sturnus vulgaris*, 8, 49, 57; **3, 4, 5, 6, 7, 8**
Yellow-throated Vireo *Vireo flavifrons*, 28
Solitary Vireo *V. solitarius*, 28; **3, 8**
Red-eyed Vireo *V. olivaceus*, 28, 37, 39; **3, 4, 5, 6, 7, 8**
Philadelphia Vireo *V. philadelphicus*, 28
Warbling Vireo *V. gilvus*, 28, 41; **5, 6, 7, 8**
Black-and-white Warbler *Mniotilta varia*, 34, 37; **3, 4**
Tennessee Warbler *Vermivora peregrina*, 35, 38; **3, 4, 7**
Orange-crowned Warbler *V. celata*, **8**
Nashville Warbler *V. ruficapilla*, 36; **3, 4**
Northern Parula Warbler *Parula americana*, 34; **3**
Yellow Warbler *Dendroica petechia*, 34; **3, 4, 5, 6, 7, 8**
Magnolia Warbler *D. magnolia*, 34; **3, 4**
Cape May Warbler *D. tigrina*, 38, 57
Yellow-rumped (including Myrtle and Audubon's) Warbler *D. coronata*, 35, 37, 39; **3, 4, 8**
Townsend's Warbler *D. townsendi*, **8**
Black-throated Green Warbler *D. virens*, 35; **3**
Blackburnian Warbler *D. fusca*, 35, 38; **3**
Chestnut-sided Warbler *D. pensylvanica*, 8, 36; **3, 4**
Bay-breasted Warbler *D. castanea*, 35, 38; **3**
Ovenbird *Seiurus aurocapillus*, 8, 39; **3, 4, 5, 7**
Northern Waterthrush *S. noveboracensis*, **3, 8**
Connecticut Warbler *Oporornis agilis*, 57
Mourning Warbler *O. philadelphia*, 39; **3, 4**
MacGillivray's Warbler *O. tolmiei*, **8**
Common Yellowthroat *Geothlypis trichas*, 34, 39, 51; **3, 4, 5, 6, 7, 8**
Wilson's Warbler *Wilsonia pusilla*, **8**
Canada Warbler *W. canadensis*, 39; **3, 4**
American Redstart *Setophaga ruticilla*, 39, 51; **3, 4, 5**

*Light numbers are page numbers; bold numbers are table numbers.

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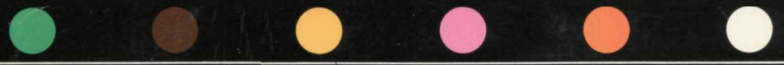
Canada's vast area includes regions that differ in climate, soils, vegetation, human land-use — and birds. The six major regions shown on this map reflect these differences and the Breeding Bird Survey in Canada follows these groupings



Boreal and sub-arctic forests

B.C. forest regions

Prairie and parkland

Farmland and northern hardwoods forest

Acadian forest

Tundra