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(editors)

Monitoring bird populations: the Canadian experience

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A member of the Environmental Conservation family

Cover photo: Volunteers on a birding survey
(Photo: Erica H. Dunn)

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Contents

Introduction

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Declines in some species of birds have raised concerns in conservationists, as have the destruction and fragmentation of habitat on breeding grounds, on wintering grounds, and along migratory routes. Development of the North American Waterfowl Management Plan and implementation of the Partners in Flight program are reflections of these concerns. However, if we want to take action on changes in bird populations, we must first be able to detect them; then, once we have taken action, we must determine whether that has led to the desired effect. Both these ends are accomplished through population monitoring.

The number of programs designed to monitor bird numbers is on the increase, and evaluation of existing programs is under way. Therefore, when the opportunity arose for the Society of Canadian Ornithologists (SCO) to sponsor a symposium at its joint meeting with the Wilson Ornithological Society (WOS) in Guelph, Ontario, in 1993 (29 April – 2 May), we decided to invite papers on the monitoring of bird populations. Although such studies are proceeding all over North America, it seemed appropriate to draw together work being done in Canada under the title "Monitoring bird populations: the Canadian experience." We wished to present a broad picture of the programs designed to monitor species ranging from seabirds, waterfowl, and shorebirds to migratory and resident landbirds, whether run as government programs or by nongovernmental organizations, and to emphasize the role of volunteers in many of these programs. Monitoring should ideally cover all species and geographic areas, which is a challenge not yet met in Canada, in part because of our immense size and relatively small population (concentrated in the south). A summary at this time helps us to identify gaps in our monitoring coverage and to make plans to fill them.

The papers in this publication are those presented at the SCO–WOS meeting, revised for publication. The diverse depth of treatment among the papers, although typical of symposia, reflects reality, in that not all monitoring programs in Canada have attained the same degree of coverage, statistical precision, or thoroughness of analysis. Although more recent monitoring results are now available for some species groups, these papers provide an up-to-date summary of the kinds of monitoring programs currently under way in Canada.

This volume covers all the major, broad-scale, multispecies monitoring programs in Canada aimed at tracking changes in species abundance. There are many other more local monitoring programs (e.g., tracking owls in Manitoba, the Red-shouldered Hawk Survey in Ontario, and game bird harvest surveys in many provinces) and a few national-scale surveys aimed at particular species (e.g., the Canadian Lakes Loon Survey), which are not covered in any detail here. (For further information and for updates on monitoring results, readers are referred to *Bird Trends*, published annually by the Canadian Wildlife Service [CWS] and available free from the Migratory Birds Conservation Division, CWS, Environment Canada, Ottawa, Ontario K1A 0H3).

Monitoring can track not only the abundance of bird populations, but also demographic characteristics, such as natality and mortality. Monitoring of demographic characteristics is treated in this volume insofar as data are being collected; for most species groups, however, few data are available. Several important North American demographic monitoring programs are not covered at all: Monitoring Avian Productivity and Survivorship (or MAPS, a constant-effort mist-netting program; see DeSante et al. 1992), BBIRD (a nest monitoring program; see Martin and Geupel 1993), and Nest Records Schemes. There are fewer than a dozen MAPS and BBIRD stations in Canada at present, and these are too scattered across the country to provide reliable figures on survival and productivity, even at a regional level. Nest Records Schemes have a long history in Canada and are organized regionally (see listing in each issue of *Bird Trends*). Baillie (1990) explains how rates of survival and productivity can be determined from Nest Records Scheme data and used in an integrated population monitoring program, but little such work has taken place in Canada to date.

The first few papers in this publication deal with aquatic birds, which are monitored by government agencies, particularly CWS. Ornithologists sometimes forget that wildlife managers began to measure waterfowl populations long before there were comparable studies of landbirds. Dale Caswell and Kathy Dickson remind us that waterfowl surveys began in earnest in Canada in the 1950s and have since been expanded using aerial and ground studies, assessment of habitat, and monitoring of productivity. Examples are given of surveys on the prairies, in eastern Canada, and in the Arctic and Hudson Bay lowlands. David Nettleship describes comprehensive studies undertaken by CWS in Arctic and eastern Canada, which concentrate on distribution, abundance, breeding performance, and factors contributing to population changes. Guy Morrison, Connie Downes, and Brian Collins present data from the Maritimes Shorebird Survey from 1974 to 1991. The methods are shown to be sensitive to population changes and indicate declines in shorebirds as a group. This program deals with migratory birds and makes extensive use of volunteers.

The remaining papers deal mainly with landbirds, and most methods rely heavily on participation by volunteers. Michael Bradstreet and Erica Dunn describe both the international Breeding Bird Survey (BBS), which began in Canada in 1966, and the more recent Forest Bird Monitoring Program, organized by CWS. Results tell us which species are most in need of further research and suggest that causes of decline must be investigated on a case-by-case basis. Mike Cadman discusses grid-based atlases, now available for several provinces, which involve a prodigious amount of volunteer time. André Cyr, Jacques Larivée, and Erica Dunn describe a checklist program that began among birdwatchers in the early 1950s in Quebec and discuss the current status of checklist projects in other parts of Canada.

Two papers deal with migratory and wintering birds. David Hussell discusses extraction of trends from counts of migrating birds. Results from the Long Point Bird Observatory and a hawkwatch at Grimsby, Ontario, correlate with BBS data. As most Canadian birds breed beyond the area covered by the BBS, a chain of migration monitoring stations across the country would be valuable in tracking these northern breeding populations. Erica Dunn and John Sauer evaluate Christmas Bird Counts and Project FeederWatch (begun in Canada and now continental in scope) as a means of monitoring winter populations.

In the final paper, Connie Downes and Dan Welsh provide an overview of landbird monitoring in Canada, both by government and by nongovernmental organizations. They argue for a more integrated approach to provide a more complete picture and to make the best use of available financial and volunteer resources.

Should the reader be interested in greater detail on Canadian monitoring programs or results, he or she should feel free to contact the editors or individual authors for further information.

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Evaluating the status of waterfowl populations in Canada

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Abstract

Because waterfowl are hunted, their population status has been evaluated for decades. This paper describes the types of waterfowl monitoring in place in Canada, when monitoring programs began, and the extent of their geographic coverage. We do not give details about methods or results, but we do mention examples. As most waterfowl populations are shared with the United States, the programs described here are conducted cooperatively among the Canadian Wildlife Service, U.S. Fish and Wildlife Service, provincial/territorial agencies, and state agencies. Monitoring programs include population surveys on breeding, staging, or wintering areas, leg-banding or other kinds of marking, and surveys of annual harvest. Special research programs are designed to elucidate the causes of population change. Despite the participation of a large number of partners and the size of programs already in place, there remain important gaps in our knowledge.

Résumé

Parce qu'on la chasse, on surveille la population de la sauvagine depuis des décennies. Le présent article décrit les mécanismes de surveillance en place au Canada, indique le moment où les programmes de surveillance ont débuté et précise la zone couverte. Les auteurs ne donnent pas de détails sur les méthodes ni sur les résultats mais offrent des exemples. La population de la plupart des espèces de sauvagine se retrouvant des deux côtés de la frontière, les programmes décrits se poursuivent en coopération avec le Service canadien de la faune, le Fish and Wildlife Service des États-Unis, les organismes provinciaux et territoriaux et les agences d'État. Parmi ces programmes, on retrouve les relevés aux aires de nidification, de repos ou d'hivernage, le baguage des pattes ou d'autres méthodes d'identification et le dénombrement des prises annuelles. Des programmes de recherche spéciaux ont été mis sur pied pour élucider les causes d'une fluctuation de la population. En dépit de la participation d'un grand nombre de personnes et de l'importance des programmes en place, nos connaissances souffrent toujours de lacunes importantes.

1. Introduction

Recruitment and mortality rates of wildlife vary in response to weather, climate, habitat loss, competition for resources, environmental contamination by pollutants, and other factors. However, waterfowl differ from most other migratory bird populations in being subject to mortality from hunting. Hunting is both a major component of waterfowl mortality and the factor most amenable to management, and, as such, it must be regulated to keep it at a sustainable level. For these reasons, monitoring programs for waterfowl species have been in place for decades.

The utility of monitoring data has grown substantially from its original intent to manage hunting. It is also instrumental in the evaluation of large-scale habitat improvement programs, such as those sponsored by the North American Waterfowl Management Plan (NAWMP) and implemented through its joint ventures. In Canada, the habitat-oriented joint venture programs include the Eastern Habitat (EHJV), Prairie Habitat (PHJV), and Pacific Coast Habitat (PCJV) joint ventures. The species research programs are the Black Duck (BDJV) and Arctic Goose (AGJV) joint ventures. In fact, information from monitoring programs was instrumental in the initial development of the NAWMP and its population goals. Monitoring is used for evaluating protected area programs, for assessing environmental effects such as climate change, and as an indicator of environmental quality for Environment Canada's State of the Environment initiative. Waterfowl monitoring data also provide some of the baseline information needed as we move towards an ecosystem approach to wildlife management and conservation.

The aim of this paper is to describe in a general way the types of waterfowl monitoring in place in Canada, when monitoring programs began, and the extent of their geographic coverage. We make no attempt to give details about methods or results, because these are fully treated elsewhere (as referenced herein). A summary of the status of migratory game birds, made possible by the monitoring programs, is given in Wyndham and Dickson (1996).

Most waterfowl populations are shared with the United States, and some species are also shared with Central and South American countries. As a result, the programs described here are conducted and funded cooperatively among the Canadian Wildlife Service (CWS), U.S. Fish and Wildlife Service (USFWS), provincial/territorial agencies, and state agencies.

There are three types of monitoring programs for waterfowl in Canada: population surveys, banding/marking, and harvest surveys. In addition, there are special research programs designed to clarify the causes of population change.

In general, it is assumed that an increasing or stable population is healthy, whereas a declining population (in comparison to some threshold value) requires attention. Surveys take place on breeding, wintering, or migration areas and, depending on the time of year, include breeding adults, nonbreeders, subadults, and/or young birds. Although monitoring of population size is valuable, it does not provide information on the causes of the trends observed. However, when numbers are assigned to age-classes, a survey can include assessment of reproductive success.

Banding and other kinds of marking are commonly used to help identify migration routes or staging and wintering areas of birds from particular breeding grounds. In addition, band recoveries help in estimating population parameters, such as annual survival rates, and in partitioning of mortality among different seasons of the year and among different sources. When representative samples of birds are banded in a variety of breeding and staging areas, differential patterns in mortality can be compared with local changes in population size to help explain population trends. Markers that allow recognition of live individuals from a distance also permit estimation of population size through a variation on mark–recapture techniques (Hestbeck et al. 1990).

Harvest surveys estimate the mortality due to sport hunting by monitoring the size and composition of the kill. For populations with little direct information of other kinds, the kill per unit effort by hunters is sometimes used as an index of population trend. Harvest can also be compared with other parameters, such as the size of the breeding population or its production of young, to determine whether trends in population size are coincident with changes in the rate of harvest. The proportion of young birds in the harvest, corrected for age-specific differences in vulnerability to hunting mortality, can provide information on annual productivity.

Results from monitoring of population trends, annual production, survival and recovery rates, and hunting mortality are of importance in themselves. However, other research is usually required to link observed trends in these parameters with the causal factors. Trends cannot be explained adequately without understanding the relationships among these parameters and associated ecological factors.

Each of these monitoring and research areas is described below in greater detail.

2. Population surveys

2.1 *Ducks*

In Canada, the majority of surveys for duck population trends are conducted on the breeding grounds, but some are carried out at important staging areas. Few surveys are undertaken in winter, except for counts of ducks overwintering in the Great Lakes (annually in Ontario) and in parts of the Maritimes (at less regular intervals).

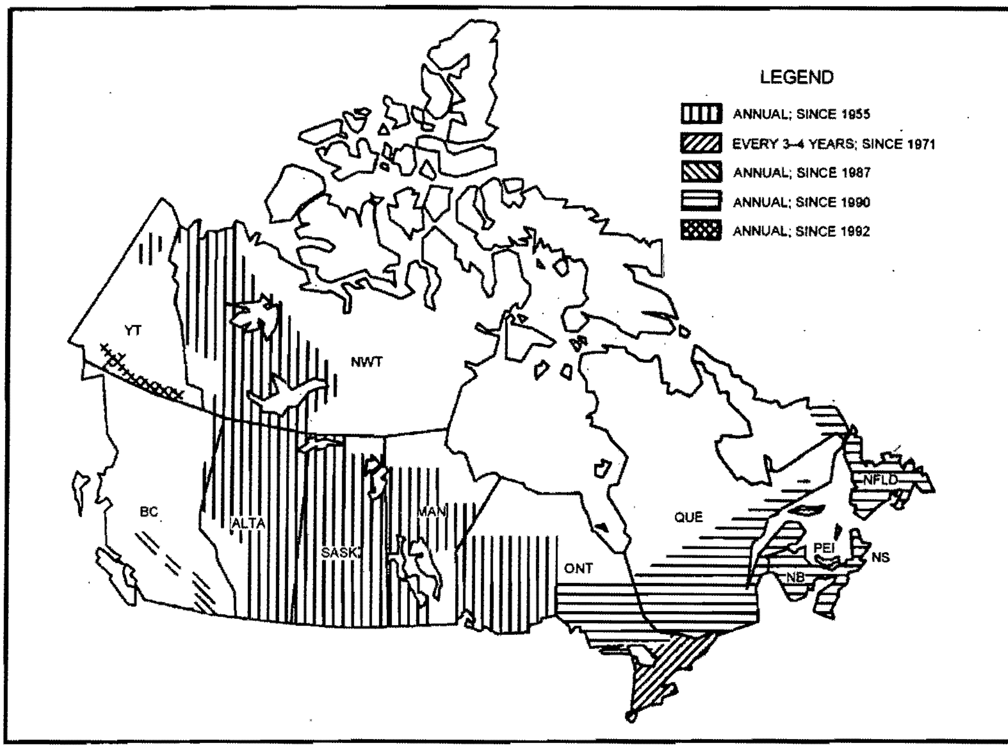
The grasslands and parklands of Prairie Canada support the largest breeding population of ducks in Canada. Because of the significance of its contribution to the continental duck population, this region has been the subject of long-term monitoring. Experimental aerial surveys to estimate the size of the breeding population began in 1947, and the technique was modified and improved over the next few years. The status of these duck populations has been evaluated annually in May since 1955 in Manitoba, Saskatchewan, Alberta, the Mackenzie Valley of the Northwest Territories, Old Crow Flats in northern Yukon, and various parts of Alaska (Fig. 1). The aerial crew consists of a biologist–pilot and a second observer. They cover a series of fixed transects at a standard speed and under specified conditions, as described in the Standard Operating Procedures manual (Department of the Interior and Environment Canada 1987).

Aerial surveys are biased because of species-specific differences in visibility and the effect of vegetation on numbers observed. Therefore, concurrent ground surveys are needed to provide correction factors for visibility bias, and these were initiated in the southern Prairies in 1961. Ground observers survey fixed-transect segments for comparison with the aerial counts. The ground crews began to collect information describing the condition of wetlands and surrounding uplands in the 1980s (Environment Canada 1989). To improve precision of the estimates and to evaluate the effectiveness of the PHJV at improving prairie duck habitat, the number of units surveyed by ground crews was increased in the 1990s. The corrected aerial survey achieves a coefficient of variation of about 5% for Mallards *Anas platyrhynchos* over the entire survey area, about 10% for each crew area (group of strata covered by a single aerial crew), and from 10 to 37% for each stratum (Smith 1995). The survey areas in Manitoba, Saskatchewan, and Alberta (Fig. 1) are covered again in early July so that estimates can be made of brood production and late-nesting effort.

In contrast to the Prairie region, population trends for ducks breeding in eastern Canada, British Columbia, and the southern Yukon have traditionally been less well studied. Trends inferred from surveys on wintering grounds in the United States are useful for studying changes in overall population size, but not for monitoring the status of various subpopulations across the breeding range. To evaluate trends in populations of ducks breeding in the grasslands of interior British Columbia, a ground survey was initiated in 1987 (Fig. 1). The technique and results through 1996 are presented in Breault (1996). A ground survey of breeding waterfowl in the southern Yukon began in 1992 (Fig. 1) (Hawkings and Hughes 1996).

There is a historical database for populations on the breeding grounds in eastern Canada, but it is not continuous. This is in part because the east contributes fewer birds to the continental duck populations, in part because it is difficult to work in boreal forest (which comprises the large part of duck habitat in the east), and, finally, because survey expense is high relative to the number of ducks present. Moreover, duck habitat in

Figure 1
Survey coverage for populations of ducks breeding in Canada



eastern Canada is thought to be relatively constant in quantity (in comparison to the Prairies, where cyclic droughts have considerable impact on habitat and therefore on waterfowl population sizes).

In Ontario, the relative abundance of breeding ducks was measured by ground surveys in 1951 (Boyd 1974). Surveys from 1971 to the present (Dennis et al. 1989) documented the simultaneous decline of American Black Ducks *Anas rubripes* and increase of Mallards in southern parts of this province. Some early information on ducks in boreal Ontario was recorded by Kaczinski and Chamberlain (1968) in the late 1950s and 1960s. R.K. Ross (Ross 1987; Ross and Fillman 1990) has been surveying waterfowl population densities in northern Ontario since about 1980.

Surveys of breeding areas have also been going on in Atlantic Canada since the 1930s, with varying levels of intensity (Erskine 1987). During the early years, biologists from the USFWS visited the Atlantic provinces and produced reports (unpublished) giving their impression of population trends. Since that time, increasingly systematic surveys have been implemented. In the late 1950s, ground surveys of breeding waterfowl were initiated in Prince Edward Island, and they continue today, although they have not been run continuously. Waterfowl in forested parts of Quebec, Labrador, and the Maritimes were studied in the late 1950s and 1960s (Kaczinski and Chamberlain 1968) and in Newfoundland and Labrador in the early 1970s (Boyd 1974), late 1970s, and early 1980s (Erskine 1987).

There has recently been renewed interest in eastern waterfowl populations, and the BDJV provides the resources required to increase monitoring in eastern Canada and the northeastern United States. Among other objectives, the foremost goal of the BDJV is to monitor the size of breeding duck populations. The new resources have allowed continuous coverage since 1990 of the major part of the American Black Duck breeding range (Fig. 1).

The BDJV survey is designed to provide population estimates and trends, primarily for American Black Ducks and Mallards, and uses a variety of survey techniques. Fixed-wing aircraft are used on linear transects in the southern, relatively open habitats, whereas helicopters are used to cover rectangular plots in the forested northern areas. Ground counts are conducted on Prince Edward Island, as they have been historically. The coefficient of variation for the American Black Duck population estimate in each province ranges from a low of 10% in each of Ontario and Quebec to a high of 20% in the Atlantic provinces. All waterfowl species are counted, as are loons, Great Blue Herons *Ardea herodias*, some gulls, and conspicuous raptors. (The latter were selected as nongame species that could be counted reliably from the air.)

Sea ducks (Harlequin Duck *Histrionicus histrionicus*, eiders, scoters, and Oldsquaw *Clangula hyemalis*) are the least well surveyed of all Canada's duck species. In some areas, there are irregularly conducted ground and fixed-wing surveys for American Eiders *Somateria mollissima dresseri*, and there is currently an attempt to make these more consistent, both temporally and spatially. There are no breeding population surveys for Northern Eiders *S. m. borealis*, Hudson Bay Eiders *S. m. sedentaria*, eastern scoters, or Oldsquaw. The USFWS recently implemented an annual aerial transect survey of sea ducks wintering on the east coast of Canada and the United States.

2.2 *Geese*

Goose population trends traditionally have been monitored by counting geese on the wintering grounds in the United States. Changing winter distributions have led to increasing overlap of populations from different breeding areas, which makes these data difficult to interpret and means that trends cannot be tied to distinct breeding populations. Monitoring of goose population trends on the breeding grounds was not common in the past because, with a few exceptions, geese nest in the Arctic and sub-Arctic regions of the country, where surveys are logistically difficult and expensive. However, there has recently been a change in focus towards activities on the breeding grounds. As an example of this shift, the goose population formerly known as the Tennessee Valley Population (TVP) of Canada Goose *Branta canadensis* is now known as the Southern James Bay Population (SJBP) in recognition of its breeding area. Resources for breeding ground surveys have been increased through the AGJV of the NAWMP and through wildlife management initiatives of northern Aboriginal land claim settlements.

As an index to breeding success in the Arctic, habitat conditions and goose nesting phenology (parameters such as dates of nest initiation, clutch size, and proportion of adults nesting) have been evaluated at selected sites annually since 1988 (Nieman et al. 1993). This survey also has an experimental component to estimate the actual size of breeding populations in particularly important nesting areas. Other multispecies population surveys in the Arctic, sponsored by the AGJV and land claim agreements, are in various stages of development. They are not yet considered as monitoring activities, but they will test experimental designs and provide baseline data for future monitoring programs. One example is a mid-August productivity survey on the Great Plain of the Koukdjuak (southern Baffin Island), which is being developed to estimate the number of breeding pairs and production for small Canada Geese of the Tall Grass Prairie Population (TGPP), Lesser Snow Goose *Chen caerulescens caerulescens*, Ross' Goose *C. rossii*, and Atlantic Brant *Branta bernicla hrota*. Similarly, transect surveys in the Queen Maud Gulf (central Arctic) and the Mackenzie Delta region (western Arctic) are being developed to provide estimates of goose densities in those areas.

For Lesser Snow Goose and Ross' Goose, the difficulty of conducting annual surveys over vast reaches of the Arctic has been addressed by developing a system of photographic inventories. These geese nest in colonies and are readily visible on photographic images taken from airplanes. The survey began in 1972 and is planned to be repeated at each major colony at about five-year intervals (Fig. 2). Results of intensive work in the Queen Maud Gulf Migratory Bird Sanctuary, N.W.T., are described in Kerbes (1994), and in Southampton and Baffin islands by Reed et al. (1987).

The entire population of Greater Snow Goose *Chen caerulescens atlantica* breeds in the Canadian Arctic and passes through the St. Lawrence River Valley in southern Quebec during migration. For this species, it has been found most effective to monitor the population trend by conducting counts during migration (Gauvin and Reed 1987). Each spring, a photographic census is carried out in the St. Lawrence Valley (Fig. 3), and counts in the fall allow the annual production of young to be estimated. The photo counts were done at intervals prior to 1969 and continuously since.

The eastern segment of the midcontinental population of Greater White-fronted Goose *Anser albifrons* breeds at low densities over a wide area in the central Arctic. These birds are also surveyed most effectively at important staging areas, in this case on the South Saskatchewan River (Fig. 3), where the whole population passes through southern Saskatchewan and Alberta during a short predictable time interval in fall. A new experimental survey combining aerial and ground counts has been implemented to evaluate the effectiveness of counting Greater White-fronted Geese on the fall migration (Nieman 1993).

Two subspecies of brant (Atlantic Brant and Black Brant *Branta bernicla nigricans*) round out the final goose species breeding in Arctic Canada. Trends in brant populations are currently monitored via aerial and ground counts on U.S. wintering areas, and indirect indices are provided by sport harvest surveys. As mentioned above, estimates for Atlantic Brant on breeding areas are now being developed as part of the multispecies experimental surveys that include the Spicer Islands, southwestern Baffin Island, and Southampton Island.

Populations of Canada Geese nesting in the Arctic are included in the experimental multispecies surveys described above. Two populations of Canada Geese breeding in sub-Arctic areas have been monitored systematically for several years. The survey technique for the Eastern Prairie Population (EPP) was initially developed in the 1970s (Malecki et al. 1981) and refined as described in Humburg et al. (in press) (Fig. 3). Transects are flown in small fixed-wing aircraft at specified speeds and altitude, and all geese observed within the fixed-width transect are counted. Also, counts of the Mississippi Valley Population (MVP) on its breeding grounds are described in a report by the Mississippi Flyway Council Technical Section (1991).

Recently, an annual breeding season survey was implemented to estimate the size of the Southern James Bay Population (SJBP) of Canada Goose (Leafloor 1992), and 1993 was the first year of what is hoped will become a long-term program counting Canada Goose numbers nesting in northern Quebec (Bordage and Plante 1993) and Labrador (Bateman 1993) (Fig. 3). In both cases, surveys of the breeding grounds were called for when other population indices suggested declining trends. For trends of most other migrating populations of Canada Goose, however, wildlife agencies have had to rely on surveys on wintering areas.

There are also some populations of Canada Goose (large races) that nest in the southern parts of Canada. The increase in range and density of large Canada Geese in southern Ontario was documented by ground surveys conducted at intervals since 1971 (Dennis et al. 1989) (Fig. 3). Rapid and steady increases in large Canada Geese have also been documented in southern British Columbia (Smith 1993), as well as for the Rocky Mountain Population (RMP) of Canada Goose nesting in southern Alberta (Department of the Interior 1993). The latter are counted incidentally as part of the annual breeding duck population surveys described above.

Figure 2
Coverage of photographic inventories for major breeding colonies of Lesser Snow Geese and Ross' Geese

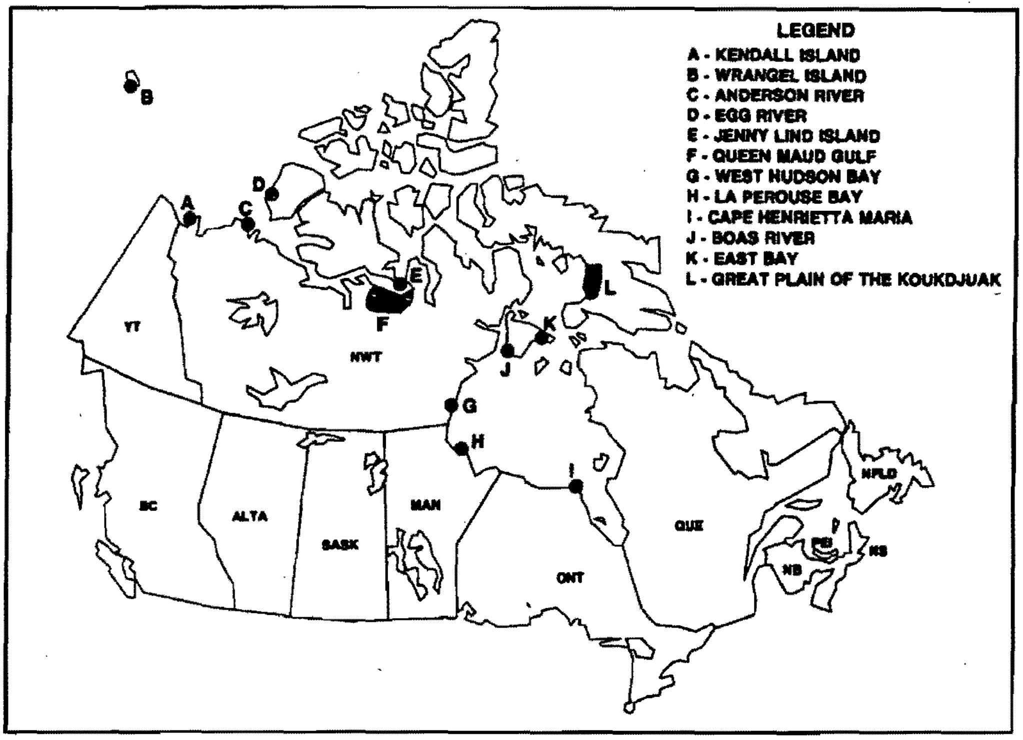
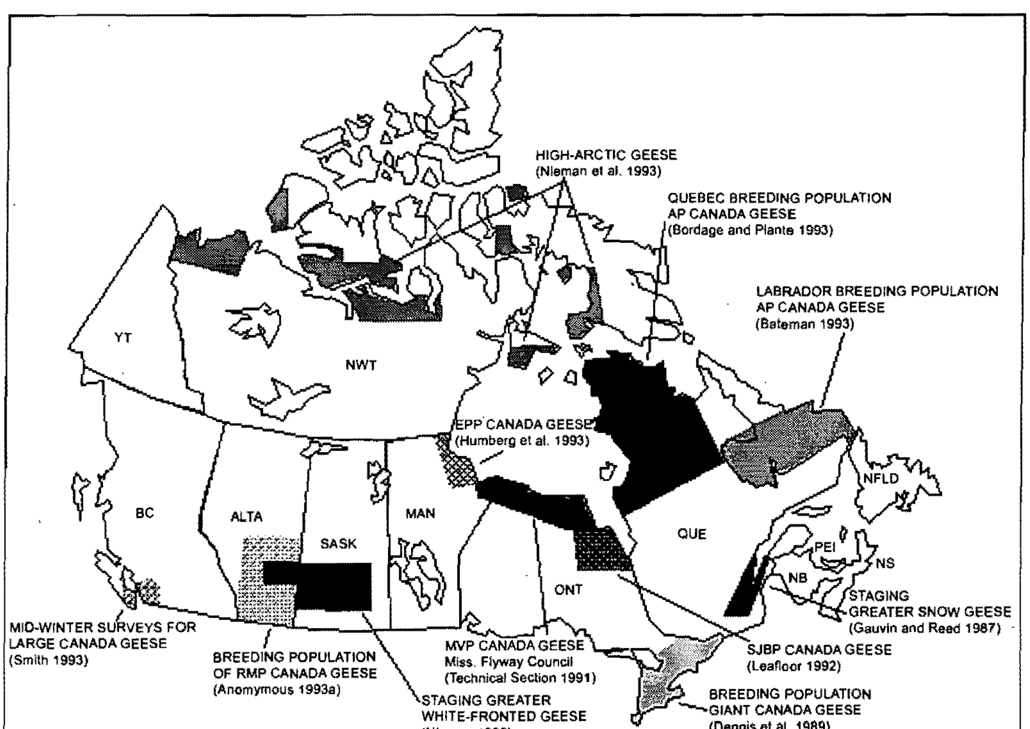


Figure 3
Survey coverage for breeding, staging, or wintering populations of geese in Canada. AP = Atlantic Population; EPP = Eastern Prairie Population; MVP = Mississippi Valley Population; RMP = Rocky Mountain Population; SJBP = Southern James Bay Population.



3. Banding

Duck banding programs have been in place for many years in Canada as part of a coordinated continental plan to sample populations. An early plan for duck banding in North America, prepared in 1959 by CWS and the USFWS, was "continental" in nature, in that it did not consider the need to have representative samples of banded birds from discrete subpopulations. That document was revised in 1989 (Department of the Interior and Environment Canada 1989) to reflect the programs that had been modified as they expanded in the 1970s. On the Prairies, for example, sample sizes were augmented to increase the precision of estimates of survival and recovery rates for birds in smaller geographic units. Banding effort was further increased in the 1990s to address requirements for evaluating the success of the PHJV in improving prairie waterfowl breeding habitat. The 1990s have also seen intensified efforts to band boreal ducks in western Canada, as well as to increase banded samples in eastern Canada and British Columbia.

Most effort has been directed towards banding Mallards and American Black Ducks, and enough information exists to estimate annual recovery and survival rates. The distribution of banding stations that capture primarily those two species is shown in Figure 4. For most other ducks, the band recovery data are sufficient for examining geographic patterns of band recoveries, but not for estimating survival and recovery rates. There have been individual studies to address specific questions for other species. For example, thousands of Northern Pintail *Anas acuta* have been banded at Mills Lake, N.W.T., and many Canvasback *Aythya valisineria* have been banded in the Minnedosa area of southern Manitoba.

Short-term banding studies have been conducted in the past for most goose populations. The usual objective was to generate recoveries that would identify the breeding, migration, and wintering areas of specific populations. Efforts to band specific goose populations intensified in the 1970s. For example, large numbers of Lesser Snow Geese were banded at the colonies in west Hudson Bay, and Maltby-Prevett et al. (1975) used bands on Atlantic Brant to tie wintering areas in Europe and North America to specific breeding populations. In addition, many EPP Canada Geese were banded to obtain information on survival and recovery rates.

From 1987 to 1990, a "white goose" marking program was implemented to mark Lesser Snow Geese and Ross' Geese with neck collars at major breeding colonies across the Arctic (Kerbes 1990). Neck collars gave more information than the traditional leg-banding program, because they allowed for multiple sightings of individual birds over several years. The information gathered from an extensive network of observers throughout the Canadian Prairies and the Central and Mississippi states permitted separation on the wintering grounds of individuals from different breeding areas, estimation of survival rates, partitioning of mortality, and indirect measures of population size, all of which are needed for more precise management of individual populations. This program was the forerunner of the current "dark goose" marking initiative, in which Canada Goose and Greater White-fronted Goose are the targets of an Arctic-wide leg band and neck collar program. Supported by the AGJV and land claim settlements, there is now an effort to mark samples from all populations of dark geese across the entire Arctic.

4. Harvest surveys

Harvest information for Canada has been collected from volunteer sport hunters every year since 1967 as part of a national survey conducted by CWS. These data are collected by means of questionnaires and provide measures of hunter effort and success rates (Harvest Questionnaire Survey) as well as estimates of the kill of each species (Species Composition Survey). The sampling design and parameter estimation are described in detail by Cooch et al. (1978), and the annual results are published in CWS *Progress Notes* (e.g., Lévesque et al. 1993).

Harvest data are also invaluable as indices of population trends for species that are not subject to direct population surveys (e.g., brant, scoters, Oldsquaw, eiders). The national harvest program has recently undergone many improvements. For example, standard errors are now being produced for all estimates. An important gap remains, however, in that we are currently unable to measure harvest by Aboriginal people.

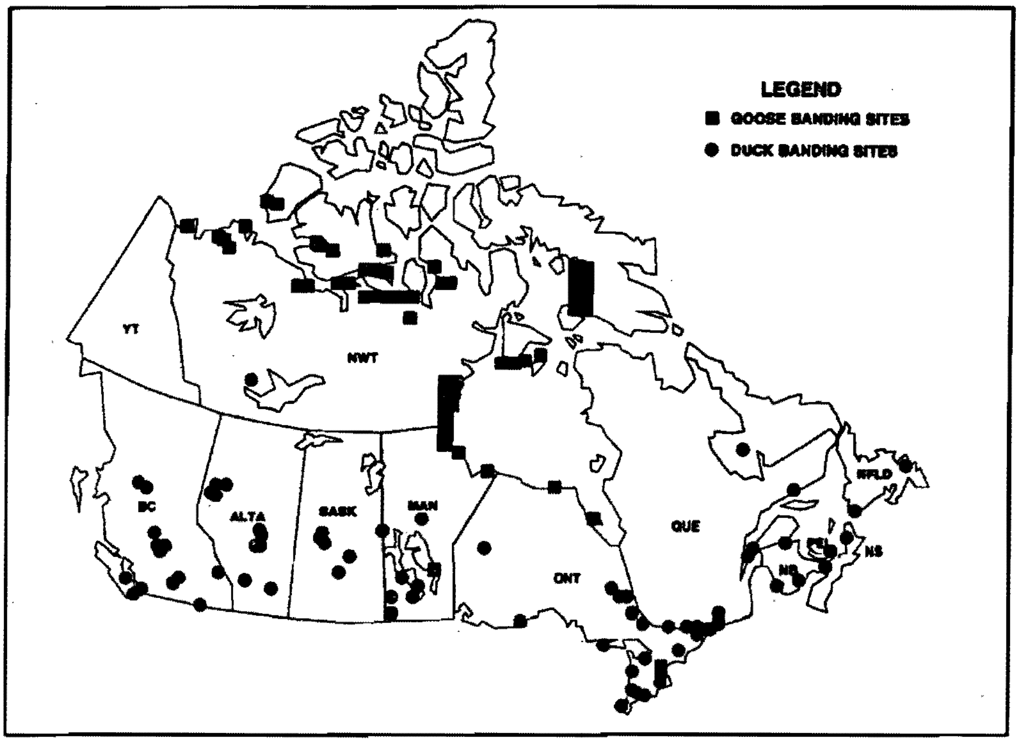
By nature of its sampling frame, the CWS national harvest survey does not allow precise estimates of harvest for small geographic areas, for species that are harvested by relatively few hunters, or for species that are primarily harvested very late in the season (e.g., sea duck harvest). Local studies are carried out when such data are important for effective management. For example, during three consecutive hunting seasons (1977/78 through 1979/80), a special survey was conducted to question Newfoundland hunters specifically about their kill of sea ducks and murres. The results showed that, in this case, the national survey was substantially underestimating the kill of sea ducks (Wendt and Silieff 1986).

5. Research

It is beyond the scope of this paper to describe the diverse research projects being undertaken on waterfowl populations in Canada. However, many such projects contribute significantly to our ability to understand the trends detected by the monitoring programs described above and to project future trends. For example, monitoring has shown that some Lesser Snow Goose populations have been increasing dramatically. Overgrazing near important colonies on west Hudson Bay has been documented by Kerbes et al. (1990), who found that, at some sites, disturbance of the soil was sufficient to ensure that the vegetation that reestablishes will be quite different from the original plant community. It was suggested that availability of food will limit further expansion of goose colonies in this region and that overgrazing will affect other species.

Research on waterfowl populations is conducted by academics, federal and provincial/territorial scientists, and biologists in nongovernmental organizations. Coordination among agencies is facilitated through a number of bodies, such as the CWS Waterfowl Committee, the NAWMP joint ventures, and the flyway councils.

Figure 4
Location of stations where ducks (primarily Mallards and American Black Ducks) and geese were banded in 1993.



6. Conclusion

The information gained from large-scale monitoring provides the common ground for policy and management discussions at all levels of responsibility for the conservation of waterfowl populations (local, provincial/territorial/state, national, and international). Each year, the monitoring data are made available to all partners and interested parties through CWS annual reports on the status of migratory game birds in Canada (e.g., Wyndham and Dickson 1996).

A good example to demonstrate integration of various data sets is the Prairie Canada Mallard Harvest Strategy (Environment Canada et al. 1993). The strategy establishes target population levels in each jurisdiction and objectives for harvest rate based on data from population surveys, band recovery and bird survival rates, and sport harvest information.

For the most part, waterfowl population monitoring is done by professionals, with contract and volunteer assistance (volunteers may assist in bird counts or at banding stations). It is paid for primarily by governments with support from nongovernmental organizations backed mostly by sport hunters. Despite the input of resources from a large number of partners and the size of programs already in place, there remain important gaps in our knowledge.

Among waterfowl species, ducks that breed in the grasslands and parklands (e.g., Mallards, Northern Pintails, Gadwalls *Anas strepera*) enjoy a standardized long-term monitoring program, such that important changes in status are observed when they occur. Some goose populations have also been evaluated consistently for a long time (e.g., Greater Snow Goose, EPP Canada Goose). Monitoring programs for populations that breed in other parts of Canada are less consistent or of shorter duration (Greater White-fronted Goose, Barrow's Goldeneye *Bucephala islandica*, Hooded Merganser *Lophodytes cucullatus*, Atlantic Population [AP] Canada Goose). Currently, the most poorly monitored waterfowl are species that breed in the Arctic or sub-Arctic, nest at low densities over large areas, winter offshore or where breeding units are mixed together, or are poorly represented in the sport hunter survey (e.g., King Eider *Somateria spectabilis*, Common Eider *S. mollissima*, three species of scoters, Harlequin Duck, Oldsquaw). For these species, even the current status is not well-known, and significant changes could easily pass unnoticed.

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Long-term monitoring of Canada's seabird populations

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Abstract

This paper describes the Canadian Wildlife Service Seabird Program, which was established in 1971 to conserve and protect seabirds in coastal waters of Canada. The aim of the program is to collect detailed information on patterns of distribution, levels of abundance, ecological requirements, and factors contributing to changes in key population parameters for species occupying our marine waters through part or all of the year. Long-term studies have begun to reveal significant changes. In general, highly specialized species such as terns and alcids have steadily decreased in numbers, whereas the more generalized and adaptable species such as fulmars and gulls have increased dramatically. Despite great progress in monitoring Canada's seabirds, much remains to be done. In particular, there is a need to balance the monitoring of population size with studies of demography and other means of elucidating causes of change.

Résumé

Ce document décrit le programme pour les oiseaux de mer du Service canadien de la faune, établi en 1971 afin de conserver et de protéger les oiseaux de mer dans les eaux côtières du Canada. Le but du programme est de recueillir de l'information détaillée sur les tendances de distribution, l'abondance des populations, les exigences écologiques et les facteurs qui contribuent aux changements des paramètres des populations importantes d'espèces qui occupent nos eaux une partie de l'année ou tout au long de l'année. Des études à long terme ont commencé à démontrer des changements considérables. En général, le nombre des espèces très particulières telles que les sternes et les alcidae diminue régulièrement, tandis que le nombre des espèces plus adaptables dont la distribution est plus généralisée telles que les fulmars et les goélands a augmenté de façon dramatique. Même si des progrès importants ont été faits dans le domaine de la surveillance des oiseaux de mer au Canada, il reste beaucoup à faire. Il faut, en particulier, équilibrer la surveillance des populations à l'aide d'études de démographie et autres moyens d'expliquer les causes des changements.

1. Introduction

Canada is bordered by three oceans, and vast numbers of seabirds utilize its inshore and offshore waters throughout the year. Breeding populations in the eastern Canadian Arctic and Atlantic Canada are among the largest in the world, as are wintering populations in coastal regions of British Columbia, Newfoundland and Labrador, and the Newfoundland Grand Banks. Breeding seabirds tend to be concentrated at relatively few sites and often in dense colonies. During the nonbreeding season, the birds are usually restricted to nutrient-rich waters, upwellings, or other oceanographic features that bring food to the surface and concentrate it there. An obvious consequence of clumped distribution throughout the year is a high risk of exposure to pollution and other hazards of human activities, including offshore oil drilling and mining, commercial fisheries, hunting, and use of toxic chemicals. Additional threats to seabirds include disturbance from tourism, human predation, introduction of alien predators into breeding sites, and climate change.

Several other characteristics of seabirds make them vulnerable as a group: they are long-lived, reach sexual maturity slowly, and have low reproductive rates with correspondingly slow recovery rates. These features, as well as frequent wide variations in breeding performance from one year to the next, make it difficult to determine the factors responsible for change and to distinguish between natural and human-induced causes.

2. Canadian Wildlife Service (CWS) Seabird Program

Ten marine bird colonies have been regularly monitored along the Gulf of St. Lawrence north shore since 1925 as part of a general conservation effort to protect all marine birds in the region from unsustainable illegal hunting (Lewis 1925; Nettleship and Lock 1973; Nettleship 1977a). However, the establishment of a formal seabird program by the Government of Canada to systematically monitor seabirds country-wide came much later. An increased awareness of the vulnerability of seabirds, combined with the discovery of oil on the North Slope of Alaska in 1968 and the likelihood of extensive oil drilling on Canada's continental shelf and Arctic islands, led CWS to initiate a comprehensive investigation of seabirds in eastern Canada in 1971 (Nettleship 1972a, 1973a, 1977a).

This paper describes the history and present investigations of the CWS Seabird Program in eastern Canada, but brief reference is also made to seabird monitoring in other parts of the country. Virtually all monitoring programs for seabird populations in Canada are executed, directed, or commissioned by CWS.

At the outset (1971), emphasis was placed on Arctic and eastern Canada, where the breeding populations of Canadian seabirds are among the largest and most at risk to proposed industrial activities. The initial aims of CWS monitoring were to:

- catalogue breeding sites (locations, species composition, population sizes) in the eastern Canadian Arctic and in the Atlantic north of 40°N and west of 40°W;
- measure productivity and other primary demographic parameters of representative species of differing ecological types; and
- collect quantitative observations of the distributions of seabirds at sea.

The overall objective was to compile old and new information on seabird colonies in order to develop a seabird monitoring system sufficiently sensitive to detect real population changes in bird numbers, both at sea and at breeding colonies, and to establish a baseline from which to measure future change and to determine cause-and-effect relationships. This was to be accomplished by the establishment of a comprehensive biological monitoring system (BMS) estimated to require about 20 years to put in place. The task was formidable. The geographic area is immense, and there was almost no existing information. Distribution and species composition of the major colonies in Atlantic Canada were reasonably well-known, but estimates of the sizes of those populations were restricted to orders of magnitude at best. Details of Arctic seabirds were very sketchy, limited to what could be gleaned from the records of 19th-century Arctic explorers and the more recent work done in the 1950s on Thick-billed Murres *Uria lomvia* (Tuck 1961). Vast lengths of coastlines in the central and eastern Arctic and in the less remote regions of Atlantic Canada remained to be examined. Immediate needs were clear: statistically sensitive census techniques had to be developed and tested, and species and colonies had to be selected for long-term biological monitoring (changes in population size and reproductive performance).

By 1975, considerable progress had been made. Survey procedures had been established for colony census work (Nettleship 1972b, 1976; Birkhead and Nettleship 1980) and for recording birds at sea (Brown et al. 1975: Appendix 1). Between 1972 and 1975, I and a small number of part-time summer workers surveyed thousands of kilometres of coasts by air and sea and recorded several thousand seabird colonies, only a small number known previously (for survey details, see Map 1i — Colony Surveys in Brown et al. 1975). Colony locations were mapped from the air, water, and land, and measures were taken to estimate population sizes. Quantitative observations of seabirds at sea were collected by full-time and part-time observers under the direction of R.G.B. Brown using a system of 10-minute watches that culminated in a total of over 60 000 records by 1975 (for details of at-sea effort, see Map 1a–h in Brown et al. 1975).

The preliminary results of these studies were summarized in Brown et al. (1975) and Nettleship and Smith (1975), and a review (Nettleship 1977a) highlighted accomplishments, identified information gaps, and focused attention on seabird management needs and future research. Supplements and updates followed on breeding distributions (Nettleship 1980; Nettleship and Birkhead 1985) and on pelagic distributions (Brown 1986). Together, these databases provide some of the information needed for assessing present and proposed resource developments in coastal waters in eastern Canada (Nettleship 1991a, 1993).

The current focus of the CWS Seabird Program in eastern Canada is the Biological Monitoring System component of the program (Nettleship 1977a, 1991a, 1993) — i.e., measurement of reproductive performance and other primary demographic parameters of key seabird species at representative sample sites (e.g., Gaston and Nettleship 1981; Birkhead and Nettleship 1987a, 1987b, 1987c). Based upon the findings of the 1972–1975 colony surveys, a network of long-term biological studies was set up that samples each oceanic zone (high Arctic, low Arctic, boreal); samples species that are generalist and specialist, sedentary and migratory, low and high trophic feeders; and samples colonies near the centre and edge of those species' breeding ranges. A list of the main features studied is given in Table 1. The populations selected for monitoring either represent a significant proportion of the species' total numbers or make up a large fraction of the avian biomass of the region. The aim is to detect long-term geographic shifts in density as well as overall change in population size and to gather demographic data that may elucidate causes of population change.

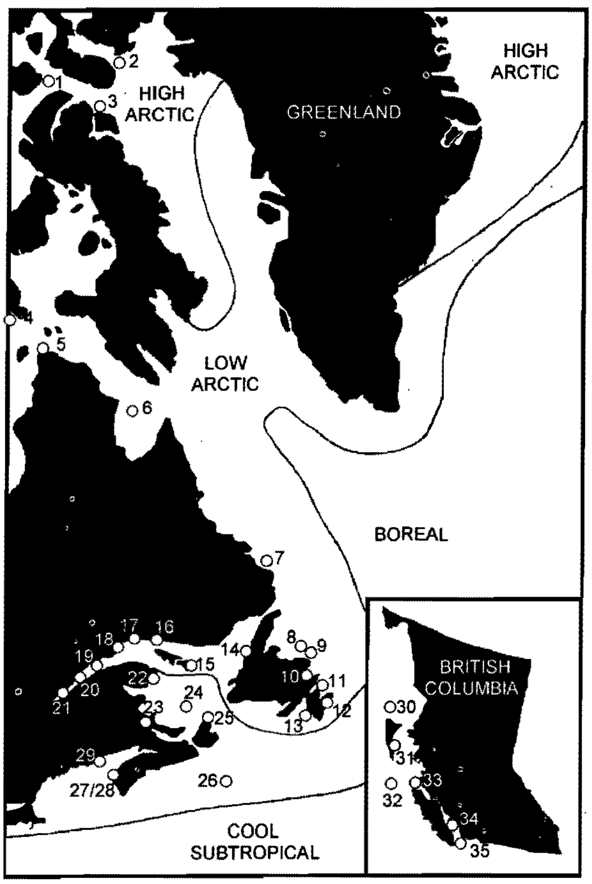
In Arctic regions (north of 60°N), comprehensive baseline studies have been established at six locations since 1975 (see Fig. 1: sites 1–6), covering Northern Fulmar *Fulmarus glacialis*, Black-legged Kittiwake *Rissa tridactyla*, Thick-billed Murre, and Black Guillemot *Cepphus grylle* (Table 2). These studies are supplemented by less exhaustive documentation of breeding biology for Glaucous Gull *Larus hyperboreus* and Ivory Gull *Pagophila eburnea*. South of 60°N, there are 14 baseline sites (marked with an asterisk in Table 2) for monitoring 13 principal species: Leach's Storm-Petrel *Oceanodroma leucorhoa*, Northern Gannet *Sula bassanus*, Double-crested Cormorant *Phalacrocorax auritus*, Black-legged Kittiwake, Herring Gull *Larus argentatus*, Great Black-backed Gull *L. marinus*, Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea*, Razorbill *Alca torda*, Thick-billed Murre, Common Murre *Uria aalge*, Black Guillemot, and Atlantic Puffin *Fratercula arctica* (Fig. 1, Table 2); these monitoring studies are supplemented by studies on Great Cormorant *Phalacrocorax carbo*, Ring-billed Gull *Larus delawarensis*, Caspian Tern *Sterna caspia*, Roseate Tern *S. dougallii*, and Common Eider *Somateria mollissima*.

Although the largest seabird monitoring effort has been directed towards maritime Arctic and eastern Canada, considerable advancement in seabird monitoring has also occurred both in the Great Lakes region and on the Pacific

Table 1
A sample of the factors to be studied in each component of the Biological Monitoring System of the CWS Seabird Program

Distribution and abundance	Demography	Causation
General breeding distribution	Phenology of breeding	Habitat needs
Patterns in distribution and abundance	Age at first breeding	Climate/ocean change
Population size by site	Clutch size and fecundity	Mortality factors
Population change by site	Fledging success	Chick growth
	Recruitment rate	Body condition
	Survival	Diet
	Effects of age on demography	Food availability

Figure 1
Locations of major seabird monitoring sites in Canada. See Table 2 for site names and species studied at each location.



coast. Colonial waterbirds in the Great Lakes system include both freshwater species and marine species that have become secondarily adapted to freshwater habitats. These have been censused sporadically for a considerable time (see Blokpoel and Scharf 1991) and in a systematic and comprehensive manner since 1989 (see Blokpoel and Tessier 1991, 1993). Since the early 1970s, certain species have also been used to monitor toxic contaminants in the Great Lakes (Weseloh et al. 1979, 1995; Ludwig et al. 1995).

In British Columbia, extensive mapping of colonies began in the late 1940s under the aegis of the British Columbia Provincial Museum, and this effort expanded after establishment of the B.C. Nest Records Scheme at the University of British Columbia in 1955 (see Drent and Guiguet 1961). Colony surveys continued and were extended with intensive baseline censuses performed by CWS from 1982 to 1986 (Rodway 1991). Pelagic surveys of seabirds at sea on the west coast began in 1981, when CWS decided to assess potential effects of environmental perturbations on pelagic bird populations (Vermeer et al. 1983). Realization of the need for a monitoring system increased following the recent major oil spills off the west coast (i.e., *Nestucca*, *Exxon Valdez*). Although a permanent monitoring system for colonially breeding seabirds in British Columbia is not in place and long-term trends are not available, significant advancements have been made (e.g., Rodway 1991; Gaston 1992a; Vermeer et al. 1993, 1997).

3. Brief overview of Canadian seabird population status

Populations of most seabird species in eastern Canada and the northeastern United States were decimated by human predation and disturbance through the 18th and 19th centuries (e.g., Drury 1973–74; Nettleship and Birkhead 1985). Once the worst human pressures were removed at the beginning of the 20th century, remnant populations began to show signs of recovery. The general increase continued until the 1930s, by which time some species, such as the large gulls (Great Black-backed Gull, Herring Gull), were more numerous than they had been before the 19th-century exploitation. Most species (Northern Gannet, cormorants, terns) showed a slow but steady growth during this period, but others, such as the alcids (Razorbill, Common Murre, Atlantic Puffin) did not regain their former abundance and distribution, especially towards the southern limit of their breeding ranges and in the more remote and inaccessible regions (e.g., North Shore Gulf of St. Lawrence, southern Labrador), where protection could not be enforced (Nettleship 1977a; Nettleship and Birkhead 1985).

A marked change in population histories took place after 1940. By contrast to the earlier growth and expansion shown by most species, a general slowing down or reversal of population trends began. Large gulls and some other species capable of utilizing fish offal from the expanding commercial fisheries seem not to have been involved in this decrease; their population growth continued, often at a remarkably rapid rate. However, the more specialized species (particularly the terns and auks) in all parts of the North Atlantic are currently experiencing sudden and dramatic population declines that appear to be associated with the ever-increasing human exploitation of

Table 2
Principal monitoring sites and studies of marine birds in marine regions of Canada. The list includes both CWS–BMS seabird monitoring sites (i.e., census and measurement of breeding performance), shown with asterisks, and those restricted to counts of birds alone (standard monitoring site). Numbers refer to colony locations shown on Figure 1, and years given in parentheses after baseline year indicate earliest time for which some useful count data exist.

Location	Species	Count method	Baseline year	Counts	Population status
High Arctic					
1. Prince Leopold I.*	Northern Fulmar	D	1975	8	=
	Glaucous Gull	D	1975	8	–
	Black-legged Kittiwake	D	1975	8	=
	Thick-billed Murre	D	1972 (1965)	8	= or +
	Black Guillemot	D	1976/77	4	?
2. Coburg I.*	Black-legged Kittiwake	D/P	1973	6	?
	Thick-billed Murre	P	1973	6	?
3. Cape Hay (Bylot I.)*	Black-legged Kittiwake	D/P	1972	5	?
	Thick-billed Murre	P	1972	5	=
Low Arctic					
4. Coats I.*	Glaucous Gull	D	1984 (1981)	10	=
	Thick-billed Murre	D/P	1981 (1972)	14	+
5. Eastern Digges I.*	Thick-billed Murre	D	1980 (1972)	5	–?
6. Akpatok I.*	Thick-billed Murre	D/P	1982 (1972)	3	–?
Newfoundland–Labrador					
7. Gannet Is.*, Labrador	Common Murre	D	1979	6	–
	Thick-billed Murre	D	1979	6	–
	Razorbill	D	1979	6	–
	Atlantic Puffin	D	1979	6	–
8. Wadham/S. Cabot	Common Murre	D	1969	4	?
	Atlantic Puffin	D	1969	4	?
9. Funk I.*	Northern Gannet	P/D	1972	Frequent	+
	Common Murre	P	1972	6	+ or =
	Atlantic Puffin	D	1969	3	=
10. Terra Nova	Common/Arctic terns	D	1975	Annual	–
	Common Tern	D	1975	Annual	–
11. Baccalieu I.*	Leach's Storm-Petrel	D	1976	3	?
	Northern Gannet	P/D	1972	5	+ or =
	Atlantic Puffin	D	1976	4	?
12. Witless Bay*	Leach's Storm-Petrel	D	1973	3	–
	Great Black-backed Gull	D	1968	Frequent	+
	Herring Gull	D	1968	Frequent	+
	Black-legged Kittiwake	D/P	1973	4	+
	Common Murre	P	1972	5	+
	Black Guillemot	D	1968	Frequent	?
	Atlantic Puffin	D	1967	Frequent	–
13. Cape St. Mary's*	Northern Gannet	P/D	1972	5	+ or =
	Common Murre	D	1980	Annual	–
14. Gros Morne	Common/Arctic terns	D	1975	Annual	=
	Common Tern	D	1975	Annual	=
Northern Gulf of St. Lawrence					
15. Anticosti I.	Northern Gannet	P	1969	5	= or –
16. Mingan I.*	Common Tern	D	1972	4	+
	Arctic Tern	D	1978	4	+
17. Carrousel I.*	Black-legged Kittiwake	D/P	1972 (1940)	5	+
18. Lower North Shore*	Great Cormorant	D	1972 (1925)	6	–
	Double-crested Cormorant	D	1972 (1925)	6	+
	Common Eider	D	1972 (1925)	6	–
	Great Black-backed Gull	D	1972 (1925)	6	+
	Herring Gull	D	1972 (1925)	6	+ or –
	Ring-billed Gull	D	1972 (1925)	6	–
	Caspian Tern	D	1972 (1925)	6	–
	Common/Arctic terns	D	1972 (1925)	6	–
	Common Murre	D	1972 (1925)	6	+
	Razorbill	D	1972 (1925)	6	+ or –
	Black Guillemot	D	1972 (1925)	6	=
	Atlantic Puffin	D	1972 (1925)	6	–

Continued

Table 2 *(cont'd)*
Principal monitoring sites and studies of marine birds in marine regions of Canada. The list includes both CWS–BMS seabird monitoring sites (i.e., census and measurement of breeding performance), shown with asterisks, and those restricted to counts of birds alone (standard monitoring site). Numbers refer to colony locations shown on Figure 1, and years given in parentheses after baseline year indicate earliest time for which some useful count data exist.

Location	Species	Count method	Baseline year	Counts	Population status
19. Pilgrim Is.*	Double-crested Cormorant	D	1971	5	+
	Razorbill	D	1971	5	+
20. St. Lawrence estuary (includes Brandy Pot Is.* and Île-aux-Pommes*)	Double-crested Cormorant	D	1963	Frequent	–
	Common Eider	D	1963	Frequent	=
	Ring-billed Gull	D	1976	Frequent	+
	Great Black-backed Gull	D	1963	Frequent	+
	Black Guillemot	D	1976	Frequent	+
21. Quebec City	Ring-billed Gull	D	1983	4	+
22. Bonaventure I.*	Northern Gannet	D/P	1969	Frequent	+
	Black-legged Kittiwake	P	1974	3	+
	Common Murre	D	1974 (1914)	6	+
Southern Gulf of St. Lawrence, Scotian Shelf, and Bay of Fundy					
23. Kouchibouguac	Common Tern	D	1970	Frequent	+
24. Magdalen Is.	Northern Gannet	P	1969	7	+
	Common Tern	D	1972	3	+
	Arctic Tern	D	1972	3	?
25. Cape Breton I.	Common/Arctic terns	D	1975	Frequent	–
26. Sable I.*	Common/Arctic terns	D	1971	5	–
	Roseate Tern	D	1971	5	–
	Herring Gull	D	1970	6	?
	Great Black-backed Gull	D	1970	6	?
27. The Brothers	Roseate Tern	D	1987	Annual	?
28. Peters I.	Common/Arctic terns	D	1980	Frequent	–
29. Machias Seal I.*	Arctic/Common terns	D	1972 (1947)	Frequent	=
	Atlantic Puffin	D	1972	Frequent	=?
British Columbia[a]					
30. Lucy I.	Rhinoceros Auklet	D	1983	5	?
31. Laskeek Bay	Pelagic Cormorant	D	1985	Annual	–
	Glaucous-winged Gull	D	1985	Annual	?
	Ancient Murrelet	D	1984	Annual	–
32. Triangle I.	Rhinoceros Auklet	D	1976	11	?
	Tufted Puffin	D	1976	11	?
33. Pine I.	Rhinoceros Auklet	D	1983	3	?
34. Strait of Georgia	Double-crested Cormorant	D	1959	3	+
	Pelagic Cormorant	D	1959	3	+
	Glaucous-winged Gull	D	1959	3	+
35. Mandarte I.	Double-crested Cormorant	D	1915	8	+
	Pelagic Cormorant	D	1959	7	+
	Glaucous-winged Gull	D	1915	8	+
	Pigeon Guillemot	D	1961	3	+

Notes and abbreviations:
1. Biological Monitoring System (BMS) site.
2. Count method: D = direct, P = photographic.
3. Counts (N): Annual = yearly since baseline year; Frequent = not yearly.
4. Population status: trend of population (in equilibrium or not); codes: – declining, + increasing, = stable, ? unknown. Combinations indicate uncertainty or variable changes.

[a] Scientific names not given in text: Rhinoceros Auklet *Cerorhinca monocerata*, Pelagic Cormorant *Phalacrocorax pelagicus*, Ancient Murrelet *Synthliboramphus antiquus*, Glaucous-winged Gull *Larus glaucescens*, Tufted Puffin *Fratercula cirrhata*, Pigeon Guillemot *Cepphus columba*.

the marine environment (Nettleship 1977a, 1991a, 1996; Evans and Nettleship 1985; Nettleship and Evans 1985).

The present status of monitoring of Canada's seabirds is summarized briefly in the autumn 1992 issue of *Bird Trends* (Nettleship 1992a; Gaston 1992b; and others). More comprehensive trend data on Canadian seabirds have been summarized in three groups of publications:

- those that examine trends in populations of several species that reproduce in the same geographic area (e.g., Nettleship and Lock 1973; Nettleship 1973b, 1974, 1977b; Gaston et al. 1985; Nettleship et al. 1990; Gaston 1991a; Blokpoel 1992; Chapdelaine and Brousseau 1992; Kaiser 1992; Lock 1992; Vermeer 1992; Chapdelaine 1995; Vermeer et al. 1997);
- those that treat populations of single species within a region or at a specific colony location (e.g., Nettleship 1975, 1991b, 1992b, 1992c; Gaston and Nettleship 1981; Nettleship and Chapdelaine 1988; Nettleship et al. 1990; Gaston 1992c; Gaston et al. 1993; Chapdelaine and Bédard 1995; Nettleship and Duffy 1995); and
- those that deal with topics critical to the welfare of seabirds and to the management of population data (e.g., Bartonek and Nettleship 1979; Nettleship et al. 1984; Nettleship and Hunt 1988; Gaston 1991b; Nettleship 1991a, 1992d, 1993, 1994, 1996; Piatt et al. 1991; Blanchard and Nettleship 1992; Chardine 1992; Nettleship and Duffy 1992; Lock et al. 1994).

4. Conclusions

There are many specific gaps in our current knowledge that need to be addressed in the future: for example, we still know little about distribution in the nonbreeding season and how that changes from year to year. More generally, we should work to expand a system similar to the Biological Monitoring System of the CWS Seabird Program along the Atlantic seaboard to all regions of Canada. Seabird researchers and managers in different regions — indeed, in different countries — need to work together to ensure that results are compatible, that there is no duplication of effort, and that there are no large gaps in our knowledge. Finally, we must ensure that monitoring is not done in isolation, but is combined with studies of the causes of population change and is actually applied to management and conservation problems. In the future, however, the larger challenge may well be the attainment of such goals in the present climate of diminishing resources and diminishing governmental interest in the conservation of seabirds and the marine ecosystems they occupy.

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Monitoring shorebird populations in Canada: the Maritimes Shorebird Survey and shorebird population trends, 1974–1991

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Abstract

Few long-term shorebird monitoring programs have been organized in Canada. The most extensive data come from the Maritimes Shorebird Survey (MSS), in which shorebirds are counted by volunteer observers during fall migration. Population trends were estimated for 12 species of shorebirds using MSS data from the period 1974–1991. Results showed significant declines in Semipalmated Sandpiper *Calidris pusilla* and Least Sandpiper *C. minutilla*, whereas marginally significant declines occurred in Black-bellied Plover *Pluvialis squatarola*, Red Knot *C. canutus*, and Short-billed Dowitcher *Limnodromus griseus*. A marginally significant increase was found in Whimbrel *Numenius phaeopus*. Other survey programs have also noted declines in shorebird populations. Most long-term data come from eastern North America, and there is a need for information from other parts of the continent and for species of shorebirds that do not gather in large concentrations at coastal sites.

Résumé

Le Canada compte peu de programmes de surveillance des oiseaux de rivage à long terme. Les données les plus importantes viennent du Relevé des oiseaux de rivage des Maritimes (RORM), programme dans le cadre duquel des observateurs bénévoles dénombrent les oiseaux de rivage lors de leur migration automnale. On a estimé les tendances de la population de 12 espèces grâce aux données de cette enquête, entre 1974 et 1991. Les résultats révèlent une baisse importante de la population de Bécasseau semipalmé (*Calidris pusilla*) et de Bécasseau minuscule (*C. minutilla*), alors que celle de Pluvier argenté (*Pluvialis squatarola*), de Bécasseau maubèche (*C. canutus*) et de Bécasseau roux (*Limnodromus griseus*) a diminué de façon marginale. On a également noté un redressement léger mais significatif de la population de Courlis corlieu (*Numenius phaeopus*). D'autres programmes de recensement ont aussi révélé un recul de la population des oiseaux de rivage. Il s'agissait dans la plupart des cas d'études à long terme venant d'autres parties du continent et de relevés d'espèces qui ne se rassemblent pas en grand nombre dans les sites côtiers.

1. Introduction

The purpose of this paper is to review some of the work that the Canadian Wildlife Service (CWS) and other agencies have been doing to monitor the status of shorebird populations in Canada. To a large extent, data suitable for analyzing shorebird population trends have come from programs that were originally set up to provide information on shorebird distribution. Although knowledge of the distribution of shorebirds has developed to the point where nationally and internationally coordinated conservation schemes have become a reality, much less is known about how shorebird numbers may be varying. Obtaining suitable data for population trend analysis for shorebirds in the western hemisphere is not straightforward, in any part of the annual cycle.

In the Arctic, for instance, where many species of shorebirds breed, nesting populations often occur at very low densities and are usually spread out over enormous geographical ranges, making any sort of monitoring operation logistically difficult or impractical. Some potential exists for obtaining information on trends by revisiting areas that have been surveyed either occasionally or regularly over the past 20–25 years (e.g., study areas at Lake Hazen [Gould 1988], Truelove Lowland [Pattie 1990], and Churchill [Gratto-Trevor 1994; Morrison et al. 1995]), but to date no quantitative comparisons have been made. Further efforts are being undertaken by CWS to unearth and compile bird records accumulated over long-term projects run by museums, universities, or other organizations working in the North. In 1995, a Northwest Territories Bird Checklist Survey program was started by CWS, in which persons visiting any location within the Northwest Territories were asked to complete a bird checklist, including a series of questions designed to provide information on breeding conditions experienced by shorebirds and other birds. The project is intended to accumulate information on distribution, abundance, and breeding status of bird species in the Arctic, and it may provide data suitable for trend analysis. The first two years have produced a very encouraging response, and many government-based agencies concerned with conservation issues are cooperating in the scheme.

Few shorebirds winter in Canada, so wintering ground surveys would be possible only for a limited number of species. Whereas wintering areas in the United States or other fairly heavily populated areas could be covered by volunteer surveys, many of the shorebird wintering areas farther south in South America are located in remote areas where comprehensive surveys are not possible. Some information is being gathered from such areas, however, as part of the International Shorebird Survey (ISS) scheme (similar to the Maritimes Shorebird Survey [MSS] scheme, see below) coordinated through the Manomet Center for Conservation Sciences and under the Neotropical Waterbird Census organized by Wetlands International (Wetlands for the Americas).

Shorebirds are most accessible in Canada at their stopover sites on migration, where many species concentrate in large numbers and can be counted regularly. The largest scheme of this type in Canada is the MSS, a project that involves a network of volunteer observers who count shorebirds at regular intervals during migration periods at sites on the east coast of Canada. The MSS was started in 1974 and is the longest-running shorebird survey program conducted by CWS. Data from the MSS not only have been used to identify the most important areas for shorebirds in eastern Canada (Morrison et al. 1991, 1995), but have also been valuable in the development of the Western Hemisphere Shorebird Reserve Network (WHSRN) (see Myers et al. 1987) and in assessing shorebird population trends (Morrison et al. 1994b, 1994c). Counts made in such areas, however, are difficult to interpret, for several reasons. Estimating the total number of birds using the site, or deriving a suitable index, is complicated by the phenomenon of "turnover," in which the regular arrival of "new" birds and departure of "old" birds already at the site lead to a constantly changing population of individuals. (Turnover has been shown to be rather different on the Atlantic and Pacific coasts of Canada, where small peeps [*Calidris* spp.] spend averages of some 10–15 days vs. 2–3 days at migration stopover areas, respectively [see Morrison et al. 1994a].) Moreover, declines in numbers at a given site may reflect changing conditions, in response to which birds move to other, more profitable areas, rather than indicating a true decline in overall population size. Nevertheless, large-scale changes in shorebird populations should be reflected in standardized counts of migrants if they are taken over a suitably extensive area.

Shorebird distribution in other parts of Canada has been investigated by a variety of methods. Volunteer networks similar to the MSS scheme have been operated by CWS in both Ontario and Quebec, although with smaller numbers of participants. In Quebec, ornithologists participated in a five-year survey program similar to the MSS between 1987 and 1991 (Bourget 1994), and CWS staff have also carried out shorebird surveys along the St. Lawrence River (Brousseau 1981; Maisonneuve 1982); this information has been used to document critical sites in the province (Maisonneuve et al. 1990; Morrison et al. 1995). Information on shorebird population trends in Quebec has been obtained from the Étude des Populations d'Oiseaux du Québec (ÉPOQ) database, derived from checklists submitted by volunteers, for the years 1969–1988 (Larivée 1989). On the Prairies, aerial surveys and ground counts have been conducted since 1987 by governmental and nongovernmental agencies and volunteers to identify key staging areas (Dickson and Duncan 1994; Morrison et al. 1995). In western Canada, research on the migration strategies of Western Sandpipers *Calidris mauri* is contributing to an internationally coordinated investigation of the ecology of shorebirds on the Pacific flyway (Butler and Elner 1994). A further source of information on shorebird population trends across the entire country has been the Breeding Bird Survey (BBS), currently coordinated in Canada at the CWS National Wildlife Research Centre. Data are obtained by volunteers who conduct a series of roadside counts located at fixed intervals along a predetermined road route. The BBS provides coverage mainly for species that do not breed in the Arctic and in many cases do not gather on migration in large numbers at coastal stopover areas, and the information it obtains is thus often complementary to that obtained from schemes involving counts at migration areas or in the Arctic.

Knowledge of whether populations are increasing or decreasing is of basic interest for management and conservation of all species, but there are particular reasons to be concerned about the welfare and future conservation of shorebirds (Myers et al. 1987). Many shorebird populations in the western hemisphere undertake very long migrations, some species moving from breeding grounds in the Canadian Arctic to wintering grounds in Tierra del Fuego at the southern tip of South America (Morrison 1984; Morrison and Ross 1989). Many species depend on coastal wetlands to a marked degree both during migration and in winter, with large proportions of the population occurring at a restricted number of sites, so that the birds are particularly vulnerable to loss or degradation of habitat. Extensive loss of wetlands has already occurred and is continuing in North America, and coastal and other habitats used by shorebirds are threatened by a variety of industrial and recreational developments throughout the ranges of the birds (Senner and Howe 1984; Bildstein et al. 1991; Morrison 1991). Shorebirds on migration are particularly vulnerable to such threats because of the high energy demands of long flights. We need to know whether these factors are currently affecting shorebird populations using North American flyways.

Morrison et al. (1994a) and Morrison (1994) provided a preliminary assessment of the status of shorebird populations in Canada and pointed out that, for most species and most parts of Canada, currently available information is inadequate for the authoritative assessment of status or trends. Most of the survey schemes mentioned above, however, have been consistent in suggesting that declines have occurred in shorebird populations. Statistical analyses of data from the MSS (Morrison et al. 1994b, 1994c) and from the complementary ISS (Howe et al. 1989) operating on the east coast of the United States have shown that declines took place in a number of shorebird species, especially during the latter part of the 1970s. Declines have also been suggested by studies in Quebec (Larivée 1989) and James Bay (Morrison et al. 1991), and results from the BBS show declines for some species breeding in southern Canada (Erskine et al. 1992; Downes and Collins 1996). The results of these studies are considered below, with emphasis on the MSS.

2. Methods

MSS volunteers adopt a clearly defined study area in the Atlantic provinces of Canada and count shorebirds every second weekend during the period of southward migration from late July to late October. Emphasis is placed on making counts in a consistent manner — at the same stage of the tide and over the same route — so that data collected on different days are as comparable as possible. Some 276 sites were censused at least once during 1974–1991, although many of these were visited infrequently. Sample sizes of sites useful for population trend analysis generally fell in the range 30–80, depending on species. Peak migration periods for each species were defined by graphing the mean number of the species occurring for each five-day period between 1 July and the end of the season over all years. Most species showed two or more peaks; observations of age and plumage confirmed that the first peak generally consisted of adult birds. Visual inspection of the graphs then enabled the peak period of migration for adults of that species to be determined. The annual index of abundance at each site was defined as the mean of all counts occurring during the peak period of abundance (Morrison et al. 1994b). The maximum count occurring during the peak period was also tested as a possible annual index but was found to be unduly sensitive to occasional atypical counts (e.g., as a result of unusual weather). Thirteen species of shorebirds were selected for analysis (Table 1). They were species considered to have an ecological preference for coastal stopover sites with intertidal feeding areas, rather than inland freshwater habitats, and thus were likely to use MSS sites on a regular as opposed to opportunistic basis.

Several methods were used for assessing population trends or changes. The first was route regression analysis, originally developed for analyzing data from the Canadian and U.S. BBS and modified for use with MSS data. In this method, population trends are first estimated for each individual site through linear regression of the log-transformed annual population indices, and the overall trend is then calculated as a weighted average of the individual route trends. Two types of weighting factors can be used — first, the mean number of birds occurring at the site, and second, the precision of the slope estimate. When both factors are used together, trends at sites with large numbers of birds are very heavily emphasized; when only slope precision weighting is used, the final trend estimate tends to reflect what is happening at a much broader range of sites in terms of the numbers of birds found at the sites. Both weighting methods should be included in the analysis. Although it is clearly important to be aware of changes in numbers occurring at major sites, it may also be important to detect changes occurring at sites with lower numbers of birds if declines in populations are likely to be observed first at such sites.

The second method used for assessing population trends was Theil's nonparametric trend test: this is a ranking procedure that produces an unbiased and robust estimate of a slope coefficient. Trend estimates from the individual sites are combined to produce an overall estimate across all sites, this time without any weighting. Significance levels are computed through a randomization test based on 1000 permutations of the data.

The third method did not attempt to assess trends or slopes, but simply attempted to answer the direct question: has there been a change in abundance of the birds? To do this, the study period was divided into three equal subsets of four years, and paired t-tests were carried out to compare the mean numbers present during each period.

3. Results

3.1 Trends

Results of the trend analyses reported by Morrison et al. (1994b, 1994c) may be summarized as follows. Route regression analysis (Table 1) showed that when sites were weighted by both mean count and slope precision, abundance of nine of the 13 shorebird species analyzed decreased between 1974 and 1991. Most of the trends were less than 3% per year, and only one species, the Least Sandpiper *Calidris minutilla*, showed a statistically significant decline — although the large decline reported for the Red Knot *C. canutus* (15.3%/year) was notable. With slope precision alone as the weighting factor, route regression analysis showed that 11 of the 13 species declined over the study period, a significant tendency across species. The larger negative trends for Semipalmated Sandpipers *Calidris pusilla*, Least Sandpipers, and Short-billed Dowitchers *Limnodromus griseus* using this analysis were all statistically significant, and knots again showed a high rate of decline.

Trend analyses using Theil's nonparametric slope estimate indicated that nine of the 12 species analyzed showed declines; declines were statistically significant for Semipalmated Sandpipers and Least Sandpipers ($p < 0.05$), whereas another three species showed declines that were of borderline significance (p values lying between 0.05 and approximately 0.1): the Black-bellied Plover *Pluvialis squatarola*, Short-billed Dowitcher, and Red Knot. The Whimbrel *Numenius phaeopus* showed a borderline increase (Table 1).

Paired t-test comparisons (see Morrison et al. 1994b) between mean numbers of birds recorded during early, middle, and recent years of the study indicated that most species decreased between the early and middle years of the study, when 12 of the 13 species declined — a significant tendency across species — three of which were statistically significant or nearly so. Differences between recent and early counts were less consistently negative, although four species decreased significantly as a result of continuing declines between recent and middle years. In more recent times (i.e., comparing recent with middle counts), average differences were less consistently negative, with only one decrease of borderline statistical significance.

Trend analysis for these subsets of years supported the above conclusions. Although route regression analysis assumes that trends are constant in magnitude and direction over the analysis period, in reality there is no reason that this should be so, and analysis of subsets of years showed that, in fact, trends were not regular between 1974 and 1991 (Morrison et al. 1994b). During the latter half of the 1970s, route regression analysis (using slope-precision-only weighting) indicated that 11 of the 13 species declined, a significant trend across species, with

Table 1
Population trends for 13 species of shorebirds in Atlantic Canada, 1974–1991, calculated by different methods ((1)–(3)), and trends from International Shorebird Survey (ISS) sites in the eastern United States during 1972–1983 (4) (summarized from Morrison et al. 1994b)

	Population trend (%/yr)			
	Route regression		Theil	ISS
Species	(1)	(2)	(3)	(4)
Black-bellied Plover *Pluvialis squatarola*	−3.9	+0.9	−(*)	−5.4(*)
American Golden-Plover *P. dominica*	−0.3	−0.6	−	
Semipalmated Plover *Charadrius semipalmatus*	+3.6	−2.8	+	−9.5
Willet *Catoptrophorus semipalmatus*	−1.1	−0.0	−	+0.2
Whimbrel *Numenius phaeopus*	+0.7	−0.1	+(*)	−8.3**
Ruddy Turnstone *Arenaria interpres*	+1.2	+0.4	+	−8.5
Red Knot *Calidris canutus*	−15.3	−5.2	−(*)	−11.7
Sanderling *C. alba*	−1.5	−4.2	−	−13.7**
Semipalmated Sandpiper *C. pusilla*	−1.1	−8.1*	−*	−6.7
Least Sandpiper *C. minutilla*	−13.2*	−7.4**	−*	+2.9
White-rumped Sandpiper *C. fuscicollis*	−2.9	−0.0		
Dunlin *C. alpina*	−1.3	−0.5	−	
Short-billed Dowitcher *Limnodromus griseus*	+1.4	−6.5*	−(*)	−5.5*

(1) weighted by slope precision and mean count
(2) weighted by slope precision only
(3) nonparametric method
(4) ISS results from Howe et al. (1989)
(*) = $0.05 < P < 0.1$, * = $P < 0.05$, ** = $P < 0.01$

four of the individual species trends being of borderline significance. In contrast, during the first half of the 1980s, nine of the 13 species actually increased, also a significant tendency across species, with one positive trend being statistically significant. During the latter part of the 1980s, although the majority of species (nine of 13) showed negative trends, none was statistically significant, nor was the tendency across species significant (Morrison et al. 1994b).

3.2 *Statistical power of the surveys*

A major question is whether we really have enough data to be able to detect trends that may be occurring. Or, put another way, have we done enough sampling? This question has rarely been addressed for these types of surveys. Statistical power analysis of MSS data showed that the surveys would be able to detect a 5% annual population change 80% of the time and a 2% annual change for all species except American Golden-Plover *Pluvialis dominica* and Whimbrel with coverage of 40–50 sites for the 18-year period 1974–1991 (Morrison et al. 1994b). Power analysis is critical in deciding whether the data are capable of detecting an effect that is being examined and is valuable in assessing future survey design — e.g., in deciding how many sites need to be covered for how many years in order to detect a given rate of change in the population.

4. Discussion

Information suggesting declines in shorebird populations has come from a number of other regional studies, mostly in eastern Canada and the United States. Howe et al. (1989), in an analysis of data from the ISS for the period 1972–1983 for the east coast of the United States, showed patterns of change at migration sites that were similar to those found in eastern Canada. The ISS results showed many significant declines for individual species for this period (Table 1), with a predominance of declining species. Similarly, the MSS data from the period 1974–1983 showed 10 of 13 species with negative trends, most of which were larger than those shown in Table 1 (which were based on the longer, total study period) (Morrison et al. 1994b). Thus, both studies noted strong declines during the 1970s.

Habitat alterations and losses appear to have led to declines in numbers of shorebirds at some sites along the St. Lawrence River (Morrison et al. 1991, 1995). Data collected by the ÉPOQ between 1969 and 1988 showed declines in a number of shorebird species, the greatest being for the Solitary Sandpiper *Tringa solitaria* (Larivée 1989). Aerial surveys of the Ontario coasts of James Bay and Hudson Bay suggest that numbers of shorebirds have declined over the past 15–20 years (Morrison 1991; R.I.G. Morrison and R.K. Ross, unpubl. data). Erskine et al. (1992) reported that BBS data showed significant declines Killdeer *Charadrius vociferus*, Spotted Sandpiper *Actitis macularia*, and Common Snipe *Gallinago gallinago* in several parts of Canada. More recent analyses of BBS data from the period 1966–1994 by Downes and Collins (1996) showed that Killdeer and Lesser Yellowlegs *Tringa flavipes* had declined significantly across Canada, with Spotted Sandpiper declining in two of six ecozones and Common Snipe and Marbled Godwit *Limosa fedoa* declining in one ecozone. The Upland Sandpiper *Bartramia longicauda* was the only species to register a significant increase, this being in the Prairies ecozone (the species tended to increase nationally up to 1980 but decline thereafter). Farther north, repeated censuses of study plots near Churchill, Manitoba, revealed substantial decreases in numbers of Semipalmated Sandpipers and Red-necked Phalaropes *Phalaropus lobatus* (Gratto-Trevor 1994; C. Gratto-Trevor, unpubl. data, cited in Morrison et al. 1994a). It is not known to what extent this phenomenon has occurred in other parts of the Arctic. A qualitative assessment of shorebird population trends and status based on discussions and questionnaires completed by members of the CWS Shorebird Committee suggested that declines outnumbered increases where populations were thought to have changed, although it was clear that currently available information is inadequate to provide an authoritative assessment for most species and regions of Canada (Morrison 1994; Morrison et al. 1994a).

Causes of declines in shorebird populations are potentially complex and may occur at many points during the annual migrations of the birds. Is it possible to locate where the causes for decline are occurring? Species that declined in the present study came from many parts of the Arctic, from mid- and high latitudes to low-Arctic and boreal areas, stretching from the eastern to the central Arctic. Their wintering grounds lie from the southern tip of South America through its northern coast to the southern United States. They feature long-, middle-, and relatively short-distance migrants. They are of a wide variety of sizes and morphologies.

Despite these ecological dissimilarities, the marked synchrony in trends across species noted during the late 1970s (decreases) and early 1980s (increases) (see results above) indicate that some "universal" factors may be affecting all species. Analysis using different weighting methods indicated that population changes were widespread and were not occurring only, for instance, at sites with large numbers of birds. It appears possible that a series of poor breeding years in the Canadian Arctic during the 1970s (1972, 1974, 1978) may well have contributed to general decreases in populations observed during the latter part of that decade. Poor weather is one possible cause of lowered breeding success and increased chick and adult mortality, and it is interesting to note that Boyd (1992) found that declining knot populations in the United Kingdom during the 1970s were associated with particularly low mean June temperatures during that period on their breeding grounds: indeed, in 1974, many knots are known to have starved to death during a period of exceptionally bad weather on Ellesmere Island (Morrison 1975). Preliminary analyses of weather conditions in the Canadian Arctic during the period of the MSS also indicate that severe conditions in the 1970s may have been linked to the declines in shorebirds noted on the east coast of Canada at that time (R.I.G. Morrison, unpubl. data).

Habitat loss is another "universal" factor that could be affecting many species at once. All the species analyzed share the feature of occurring in large concentrations during migration and on the wintering areas, and most migrate principally through the east coast of North America, although not necessarily through the same region.

5. Conclusions

Despite the consistency of the available evidence that shorebirds as a group may be declining, the data on which this assessment is based are rather fragmentary. Further work is needed to confirm trends and to identify the reasons for the declines in shorebird populations noted in this paper. Most of the statistical analyses have been carried out on information gathered in eastern Canada and the United States, and further work is needed on populations passing through other parts of the continent and on species that may be more widely dispersed or do not concentrate in large numbers at coastal locations (Morrison et al. 1994a). In the meantime, however, our results underline the need for ongoing conservation efforts to preserve key sites used by shorebirds during their spectacular migratory travels.

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Using breeding season surveys to monitor changes in Canadian landbird populations

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Abstract

The Breeding Bird Survey (BBS) is a breeding season, point count survey conducted from roads, and it is the primary means of monitoring change in populations of Canadian landbirds. Results indicate that 15 Canadian species have declined severely since 1966, whereas others have serious declines in a particular region. Results can be used to test whether ecologically similar groups of species are in trouble and to identify individual species in need of more research or conservation. Much of Canada's land mass is inaccessible for BBS coverage, necessitating other strategies for monitoring species that live in remote areas. Moreover, certain species are poorly covered by the BBS, even in human-populated areas. A few examples of alternative breeding season surveys are described briefly, including the Forest Bird Monitoring Program, the Marsh Monitoring Program, owl monitoring, and special studies of single species.

Résumé

Le Relevé des oiseaux nicheurs (RON) est un exercice consistant à dénombrer les espèces aviaires à certains endroits, à partir des routes, pendant la période de nidification. C'est aussi le moyen principal utilisé pour surveiller les changements de population des espèces terrestres d'oiseaux au Canada. Les résultats révèlent que la population de 15 espèces canadiennes a dangereusement diminué depuis 1966, alors que d'autres ont vu leur population baisser sérieusement dans certaines régions. On peut se servir des données du RON pour voir si des groupes écologiquement semblables éprouvent des difficultés et pour identifier les espèces justifiant de plus amples recherches ou des efforts de protection plus soutenus. Le RON ne couvre qu'une fraction du territoire canadien, ce qui exige l'adoption d'autres stratégies pour surveiller les espèces qui vivent dans les régions éloignées. Par ailleurs, certaines espèces sont mal couvertes par le RON, même dans les régions habitées. Suivent quelques exemples de programmes de recensement des oiseaux nicheurs dont on donne une brève description, notamment le Programme de surveillance des oiseaux forestiers, le Programme de surveillance des marais, les Programmes de recensement des hiboux et des études spéciales portant sur telle ou telle espèce.

1. Introduction

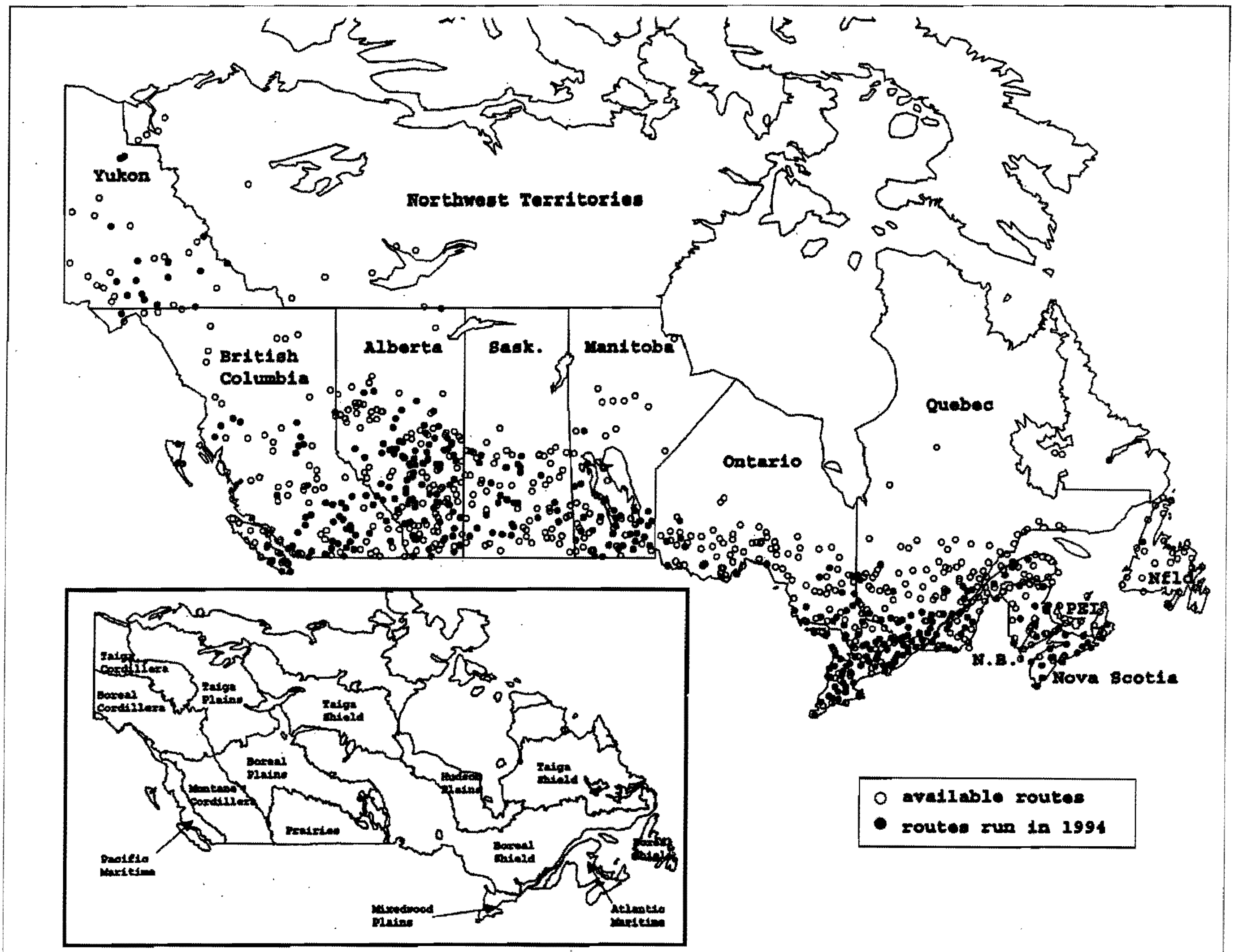
The most straightforward method for tracking changes in bird abundance is to undertake surveys during the breeding season. Most species are relatively easy to detect and identify at that time, as they are in bright plumage and often sing. Moreover, because birds are tied down by reproductive activities, a single day's count gives a reasonably repeatable picture of numbers present. Finally, birds are more evenly and predictably spread across the landscape during the breeding season than in other seasons, facilitating the design of representative sampling schemes. Birds can also be counted during migration and in winter, but at these times of year they are more likely to be moving around, and individuals from many breeding populations may be mixed together. Populations do not all change in parallel; if we are to focus conservation action effectively, we must know which population is the one most in need of attention. In Canada, breeding season surveys are the best means of linking trends to specific populations.

The main subject of this paper is the Breeding Bird Survey (BBS), which is the primary program for monitoring landbird abundance in North America. However, the BBS is limited in its coverage, both in geographic terms and in terms of species surveyed, and we briefly mention several other breeding season programs used in Canada to fill gaps in the BBS. Only landbird surveys are considered here, whereas surveys for seabirds, shorebirds, and waterfowl are described in other papers in this symposium.

2. Breeding Bird Survey

The BBS was started in North America in 1966, and most of the populated parts of Canada were covered by 1968. The survey is organized by the Biological Resources Division of the U.S. Geological Survey (formerly the U.S. Fish and Wildlife Service) and the Canadian Wildlife Service. The organizers provide instructions and collate and analyze the data, but most of the fieldwork is done by skilled amateurs.

Figure 1
Canadian Breeding Bird Survey routes and ecozone boundaries. Filled circles indicate routes run in 1994 (from Downes and Collins 1996).



BBS routes are 39.4-km stretches of secondary road, whose starting points have been chosen by stratified random sampling. The density of routes covered in each one-degree block of latitude and longitude depends on human population density. In remote parts of Canada, there may be only one route per degree block, and remote routes are less likely to be covered regularly. Where there are no roads at all, of course, there is no BBS coverage, and this includes much of the country's land mass (Fig. 1). Although the BBS is extremely valuable where coverage is good (see below), the lack of coverage of certain species and of large geographic areas has led Canada to become a leader in developing alternative strategies for monitoring its landbirds (e.g., Hussell, this volume).

BBS routes are visited once per year, with counts starting a half hour before dawn. The observer drives to each of 50 stops (spaced at 0.8-km intervals) and records all birds seen or heard within 400 m of the stop during a three-minute period (Peterjohn 1994). The same observer is encouraged to cover the route year after year, to avoid any effect of individual variation in detecting birds.

Results are subjected to a "route regression" analysis routine that fits a trend to the annual bird numbers from each route (taking any change of observer into account). The trend for a geographic region is considered to be the average of all the individual route trends in that region (after various weighting procedures; Downes and Collins 1996). In the United States, the basic geographic unit for which average trends are calculated is a physiogeographic region; in Canada, trends are calculated for larger ecozones, as shown in Figure 1. Results have been compiled here for BBS trends in Canada from 1966 to 1994 (Downes and Collins 1996), to illustrate what can be learned from it.

In Table 1, we list the Canadian species that have declined significantly by 3% or more a year. Species showing a consistent pattern of negative trends across all ecozones, regardless of trend magnitude, include Northern Pintail,[1] American Bittern, American Coot, Lesser Yellowlegs, Spotted Sandpiper (east only), Killdeer, Short-eared Owl, Black-billed Cuckoo, Chimney Swift, Barn Swallow, Loggerhead Shrike, Northern Flicker, Boreal Chickadee, Olive-sided Flycatcher, Horned Lark, European Starling, Gray Catbird, Wood Thrush, Savannah

[1] Species names listed in Tables 1 and 4 are not given in the text.

Table 1
Species with significantly declining trends of ≥3% per year, 1966–1994[a]

Zone/Species	Trend (%/yr)	No. of routes
Canada		
Northern Pintail *Anas acuta*	−7.1	175
Sprague's Pipit *Anthus spragueii*	−6.9	94
Band-tailed Pigeon *Columba fasciata*	−6.3	24
Rusty Blackbird *Euphagus carolinus*	−5.7	170
Blackpoll Warbler *Dendroica striata*	−4.9	147
Chimney Swift *Chaetura pelagica*	−4.9	157
Black Tern *Chlidonias niger*	−4.7	167
Blue Grouse *Dendragapus obscurus*	−4.6	39
Boreal Chickadee *Parus hudsonicus*	−4.6	209
Lesser Yellowlegs *Tringa flavipes*	−4.5	113
Loggerhead Shrike *Lanius ludovicianus*	−4.1	93
Eastern Meadowlark *Sturnella magna*	−3.7	120
White-winged Scoter *Melanitta fusca*	−3.4	26
American Coot *Fulica americana*	−3.3	158
American Dipper *Cinclus mexicanus*	−3.1	17
Pacific Maritime		
Pine Siskin *Carduelis pinus*	−10.2	24
Brewer's Blackbird *Euphagus cyanocephalus*	−9.5	17
Band-tailed Pigeon *Columba fasciata*	−5.7	20
Great Blue Heron *Ardea herodias*	−5.7	16
Olive-sided Flycatcher *Contopus borealis*	−5.7	21
Killdeer *Charadrius vociferus*	−5.0	17
Willow Flycatcher *Empidonax traillii*	−3.7	19
Barn Swallow *Hirundo rustica*	−3.0	21
Montane Cordillera		
House Sparrow *Passer domesticus*	−7.2	22
European Starling *Sturnus vulgaris*	−6.1	50
Ruffed Grouse *Bonasa umbellus*	−5.1	39
Purple Finch *Carpodacus purpureus*	−4.8	31
Olive-sided Flycatcher *Contopus borealis*	−3.7	52
Boreal Plains		
Franklin's Gull *Larus pipixcan*	−10.1	43
Veery *Catharus fuscescens*	−7.6	31
Northern Pintail *Anas acuta*	−7.1	36
Rusty Blackbird *Euphagus carolinus*	−6.9	17
American Coot *Fulica americana*	−5.4	43
Lesser Yellowlegs *Tringa flavipes*	−4.9	41
Killdeer *Charadrius vociferus*	−4.7	66
Short-eared Owl *Asio flammeus*	−4.1	19
Black-billed Cuckoo *Coccyzus erythropthalmus*	−4.0	26
House Sparrow *Passer domesticus*	−3.9	53
Horned Grebe *Podiceps auritus*	−3.2	25
Prairies		
Northern Pintail *Anas acuta*	−8.4	89
American Bittern *Botaurus lentiginosus*	−7.7	61
Sprague's Pipit *Anthus spragueii*	−7.3	67
Lesser Yellowlegs *Tringa flavipes*	−6.3	41
Black Tern *Chlidonias niger*	−5.3	78
Loggerhead Shrike *Lanius ludovicianus*	−5.2	63
Northern Flicker *Colaptes auratus*	−4.7	71
Killdeer *Charadrius vociferus*	−3.3	92
American Wigeon *Anas americana*	−3.0	80
Boreal Shield		
Wood Thrush *Hylocichla mustelina*	−5.8	53
Horned Lark *Eremophila alpestris*	−5.7	28
Rusty Blackbird *Euphagus carolinus*	−5.2	59
Brown-headed Cowbird *Molothrus ater*	−4.8	91
Killdeer *Charadrius vociferus*	−4.3	89
Green-winged Teal *Anas crecca*	−4.2	22
Common Grackle *Quiscalus quiscula*	−3.9	107
Boreal Chickadee *Parus hudsonicus*	−3.7	71
Gray Catbird *Dumetella carolinensis*	−3.7	75
Red-winged Blackbird *Agelaius phoeniceus*	−3.6	105
Scarlet Tanager *Piranga olivacea*	−3.4	72
Olive-sided Flycatcher *Contopus borealis*	−3.1	94

Continued

Table 1 *(cont'd)*
Species with significantly declining trends of ≥3% per year, 1966–1994[a]

Zone/Species	Trend (%/yr)	No. of routes
Mixedwood Plains		
Ring-necked Pheasant *Phasianus colchicus*	−13.3	25
Brown-headed Cowbird *Molothrus ater*	−4.7	46
Spotted Sandpiper *Actitis macularia*	−4.2	42
Eastern Meadowlark *Sturnella magna*	−4.1	46
Bobolink *Dolichonyx oryzivorus*	−3.9	46
Brown Thrasher *Toxostoma rufum*	−3.3	44
Atlantic Maritime		
Vesper Sparrow *Pooecetes gramineus*	−11.3	35
Blackpoll Warbler *Dendroica striata*	−10.7	41
Pine Grosbeak *Pinicola enucleator*	−8.6	42
Common Tern *Sterna hirundo*	−7.7	20
Brown-headed Cowbird *Molothrus ater*	−7.3	66
Horned Lark *Eremophila alpestris*	−6.8	26
Chimney Swift *Chaetura pelagica*	−6.3	59
Rusty Blackbird *Euphagus carolinus*	−5.9	51
Boreal Chickadee *Parus hudsonicus*	−5.6	62
Black-billed Cuckoo *Coccyzus erythropthalmus*	−4.3	45
House Sparrow *Passer domesticus*	−4.1	64
Bobolink *Dolichonyx oryzivorus*	−3.0	63
White-throated Sparrow *Zonotrichia albicollis*	−3.0	67

[a] From Downes and Collins (1996).

Sparrow *Passerculus sandwichensis*, White-throated Sparrow *Melospiza melodia*, Song Sparrow, Bobolink, Brown-headed Cowbird, Rusty Blackbird, Purple Finch, and House Sparrow (Downes and Collins 1996).

As shown in Table 2, about half of all Canadian species covered by the BBS are declining (including all levels of decline). If population change were occurring randomly, we would expect 50% of species to be going up and 50% to be going down entirely by chance (it is quite rare for there to be no change at all). In Canada as a whole, the ratio of increasing to decreasing species does not in fact differ from 50:50 (statistically speaking; using a chi-square test). In the Montane Cordillera, Boreal Plains, and Mixedwood Plains ecozones (see Fig. 1), more species are increasing than would be expected by chance.

By looking at all species at once, including those without significant trends, we may be masking patterns in the smaller number of species with important trends. We therefore repeated the comparison of increasing and decreasing species, but we included only those with statistically significant trends. As shown in Table 2, the results were about the same (although significance levels declined because sample sizes were smaller).

There has been a good deal of popular conservation concern in North America over the possible decline of many long-distance species that winter south of the continental United States — species commonly called Neotropical migrants. We therefore divided Canada's species into categories of migratory distance and repeated the analysis described above for ecozones. Again, we found no difference in the expected 50:50 ratio of increases and declines (top of Table 3), so there is no evidence that Neotropical migrants as a group are in trouble (although some individual species certainly are).

Authors who have examined BBS data on a continental scale have come to a similar conclusion. They have also noted that more grassland- and scrub-nesting species are declining than are increasing, whereas in

Table 2
Percentage of increasing and decreasing trends among Canadian species covered by the BBS, by ecozone (1966–1994)[a]

	All trends				Significant trends			
Ecozone	% inc.		% dec.	N[b]	% inc.		% dec.	N
Pacific Maritime	38		62	69	33		67	15
Montane Cordillera	67	**	32	121	74	*	26	31
Boreal Plains	57	*	40	145	57		43	35
Prairies	57		42	130	56		44	32
Boreal Shield	54		46	155	48		52	42
Mixedwood Plains	64	**	36	108	65		35	34
Atlantic Maritime	51		45	126	50		50	44
Canada	51		46	260	53		47	87

[a] Trend data from Downes and Collins (1996). Percentages do not always add to 100 because trends of 0% are excluded. Asterisks indicate a significant difference from a 50:50 ratio (using a binomial test: * = $P < 0.05$, ** = $P < 0.01$).
[b] N = number of species

Table 3
Percentage of increasing and decreasing trends among Canadian species covered by the BBS, by migration and habitat categories (1966–1994)[a]

	All trends				Significant trends		
	% inc.		% dec.	N	% inc.	% dec.	N
Migration category							
Resident	57		40	29	64	36	14
Short-distance	52		46	91	51	49	35
Long-distance	54		43	104	52	48	31
Habitat category							
Wetland	51		48	62	57	43	23
Scrub	48		48	30	50	50	10
Woodland	60	*	37	86	64	36	28
Grassland	24	*	76	21	17	83	6
Urban	45		45	10	33	67	6

[a] Notes as in Table 2. Category designations from Peterjohn and Sauer (1993).

woodland species the opposite is true (e.g., Askins 1993). We looked at this for Canada alone, and, as shown in Table 3 (bottom), grassland birds are also declining as a group in this country, and woodland birds are also increasing.

Another approach to this question, besides examining the proportion of species in a group that are declining, is to ask whether the population trend for the species group as a whole is declining. (Thus, numbers of grassland species on each route would be added together prior to analysis.) The overall trend for all species combined is significantly downward for grassland-, scrub-, and urban-nesting species and for short-distance migrants that winter in the southern United States (C. Downes, pers. commun.). For these groups, then, even if only about half the species are going down, the decreases are more pronounced than the increases.

The species most in trouble (Table 1) are diverse in taxonomy, habitat, wintering area, and food habits, and the causes of decline are probably equally diverse. Special studies are needed to identify the causes on a case-by-case basis. BBS results can be used in guiding our research so that the species most in need will receive attention first. Several priority-setting systems have been developed for monitoring, research, and conservation (e.g., Hunter et al. 1993), and the BBS trend is nearly always one of the important criteria.

As described above, the BBS is conducted from roadsides and depends on detecting birds by sight and sound; a species must be encountered fairly regularly for analyses to be meaningful. On a Canada-wide scale, the BBS is deemed to monitor 260 species out of the 436 that breed regularly in the country. Criteria for adequate coverage are that the species be detected on at least 15 routes (all years combined), with more than 40 individuals recorded each year (Downes and Collins 1996). The species missed by the BBS include Arctic-nesting shorebirds, seabirds, secretive species such as raptors and rails, and very rare birds. Other breeding season studies have been designed to monitor trends in some of these birds (see papers in this volume on waterfowl, shorebirds, and seabirds). A few breeding surveys that cover landbirds are described briefly below.

3. Other breeding season surveys

3.1 *Forest bird monitoring*

The BBS is currently unable to tell us whether changes in bird numbers are occurring across all habitat types or only in certain ones. The Forest Bird Monitoring Program (FBMP) was developed in part to address this issue for woodland birds. FBMP sites are usually established in protected areas where there is some expectation that the forested habitat will be available for monitoring over many years. At each site, there are 3–5 stations, located at least 250 m apart, at which detailed habitat measurements are taken.

Volunteers visit each station twice during the breeding season and record all individual birds detected by sight or sound within any distance during a 10-minute period. The highest count for each species from the two visits is used as the station estimate. The program was started in Ontario but is now beginning to be applied elsewhere as well.

Ontario data have been analyzed using a procedure similar to that applied to BBS data (see above). Table 4 summarizes results for species with significant FBMP trends. Confidence intervals are wide (with only seven years of data), but there are nonetheless some important differences from BBS trends for the same period — for example, Ovenbird declining in the FBMP but increasing in the BBS. This might mean that Ovenbirds are declining in forests (FBMP result) but that the amount of forested landscape in Ontario is increasing as a result of reforestation (BBS result). Alternatively, the Ovenbird decline might be restricted to certain habitat types that are frequently sampled by the FBMP but rarely by the BBS. Additional work is needed before we can decide on the correct interpretation, but the monitoring data themselves help us formulate appropriate questions for further research. Across all species, the FBMP and the BBS appear to produce similar trends (C. Downes, pers. commun.).

3.2 *Marsh bird monitoring*

Although some marsh-nesting birds are adequately sampled by the BBS (such as Sora *Porzana carolina* and American Bittern), many are poorly sampled, at least on a regional level (e.g., other rails, gallinules). In part, this is

Table 4
Significant trends (1988–1994) from Ontario's Forest Bird Monitoring Program, compared with BBS trends for Ontario[a]

Species	FBMP trend[b]	No. of FBMP stations	BBS trends[b]	No. of BBS routes
Cedar Waxwing *Bombycilla cedrorum*	−7.1	180	−3.9	68
Golden-crowned Kinglet *Regulus satrapa*	−14.7	84	−11.4*	13
Veery *Catharus fuscescens*	−7.4	390	−2.6	62
Solitary Vireo *Vireo solitarius*	9.7	80	−0.8	32
Black-throated Green Warbler *Dendroica virens*	7.6	275	2.5	44
Black-throated Blue Warbler *Dendroica caerulescens*	7.6	192	−6.7	26
Ovenbird *Seiurus aurocapillus*	−3.5	536	0.5	64
Yellow Warbler *Dendroica petechia*	12.7	65	0.1	69
Rufous-sided Towhee *Pipilo erythrophthalmus*	−19.1	49	4.8	31
Common Grackle *Quiscalus quiscula*	6.5	144	−3.9	69

[a] FBMP data from Cadman (1996); BBS data from C. Downes (pers. commun.).
[b] All FBMP and asterisked BBS trends significant at $P < 0.05$ (no other BBS trends significant).

because roads often skirt around marsh habitat, but it also results from the fact that many marsh species are very secretive.

In 1994, the Marsh Monitoring Program was begun in Ontario, and the next year it was expanded to the entire Great Lakes basin. Volunteers make 2–3 evening visits to marsh sites between April and July and conduct 10-minute point counts. All species seen and heard within 100 m are reported, and a special tape is played part of the time in order to stimulate calling. In 1995, 173 routes were surveyed (each with 4–8 stations; Chabot 1996). The survey is too new for any trends to be discernible, but Virginia Rail *Rallus limicola* ranked among the 10 most commonly detected species, indicating that the survey protocol is detecting the species it was designed to survey.

3.3 *Owl monitoring*

Owls are another group of species poorly sampled by the BBS, in part because they nest much earlier than the BBS target dates. Owl monitoring surveys using taped playbacks in a standardized manner have been run since 1991 in Manitoba (Duncan and Duncan 1994/95), where about 100 volunteers cover nearly 50 routes. This has spawned similar surveys in Saskatchewan and Ontario. In the latter province, a project that started in 1995 attracted 73 teams to cover 84 routes in central and northern areas, where over 200 Boreal Owls *Aegolius funereus* were detected (Heagy 1996). Continuation and expansion are planned.

3.4 *Single-species monitoring*

Although this publication concentrates on broad-scale, multispecies monitoring programs, it should be noted that many species can be monitored only with species-specific surveys. For example, some species are too sparsely distributed to be detected often enough by broad-scale surveys for trend estimation, and many of these are vulnerable species for which we most need information. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assigns species to risk categories (vulnerable, threatened, endangered, or extirpated), and a related committee (Recovery of Nationally Endangered Wildlife Committee, or RENEW) develops monitoring and recovery plans for species in the first three categories. In addition to the plans developed by this group, there are studies designed to monitor other rare species, and surveys are currently under way for Marbled Murrelet *Brachyramphus marmoratus*, Peregrine Falcon *Falco peregrinus*, Red-shouldered Hawk *Buteo lineatus*, Whooping Crane *Grus americana*, Piping Plover *Charadrius melodus*, Burrowing Owl *Athene cunicularia*, Loggerhead Shrike, Henslow's Sparrow *Ammodramus henslowii*, Baird's Sparrow *A. bairdii*, and others. Still other programs compile information on breeding sites of rare species (including historical breeding evidence and habitat details) and identify similar areas where searches can be made for additional breeders (Austen et al. 1994).

Another important set of single-species studies consists of upland game bird surveys conducted by provincial governments (e.g., Saskatchewan Department of the Environment and Resource Management 1994). Data collected from hunters generate abundance and annual productivity indices, and some breeding density studies are done. There are many other examples of single-species surveys, but most are local or regional in coverage rather than national, unlike most other programs covered by this symposium.

4. Conclusion

The BBS is the primary breeding season survey for Canadian landbirds. There are more gaps in geographic coverage in Canada than in the United States as a result of the limited road system in northern Canada. In both countries, however, there are species that are poorly sampled by the BBS even where routes are run, and there will always be a need for specially designed surveys to cover these.

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Breeding bird atlases in Canada

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Abstract

Volunteer-based breeding bird atlas projects provide a means of monitoring bird distribution and, to a lesser extent, relative abundance. Atlas projects have been completed in the Maritime provinces, Quebec, Ontario, and Alberta. About 4400 volunteers have contributed 270 000 hours of fieldwork and 750 000 records to those projects. Goals, methods, and results of those projects are discussed, along with those of similar grid-based data compilation projects in other provinces.

Résumé

Les projets d'atlas des oiseaux nicheurs entrepris par des bénévoles servent à surveiller la distribution des oiseaux et, dans une moindre mesure, leur abondance relative. Des exercices de ce genre ont été menés à bien dans les Maritimes, au Québec, en Ontario et en Alberta. Environ 4 400 bénévoles ont consacré 270 000 heures de travail sur le terrain et effectué 750 000 relevés dans le cadre de leurs activités. Les buts, les méthodes et les résultats des projets en question sont examinés et comparés à ceux des projets de recensement par quadrillage analogues entrepris dans d'autres provinces.

1. Breeding bird atlases — general background

Breeding bird atlas projects are undertaken to provide a detailed picture of the distribution and, to a lesser extent, relative abundance of the birds breeding in a particular area — usually a country, state, province, or county. Although the purpose of atlases is not primarily to monitor avian populations, they do have a valuable monitoring component. Detailed distribution maps provide insight into the factors that determine the distribution of the species, such as land use and habitat. Atlases provide a baseline for comparing previous and future distributions and are intended to be repeated at regular intervals. By monitoring the rate and pattern of distribution changes, it is expected that breeding bird atlases will provide insight into the causes of those changes and therefore can contribute to management activities. Robbins (1990) lists the following additional applications of atlas data:

- mapping range expansions and contractions,
- detecting and monitoring population changes,
- documenting the effects of habitat fragmentation,
- defining boundaries of ecological regions (bird districts),
- land use planning — identification of special areas,
- correlating bird distribution with cover type and land use,
- providing an impartial means of defining rarity, and
- combining data from adjacent provinces and states.

Atlas projects are well-designed to encourage large-scale volunteer participation. They operate over a definite time period, usually five years, have clearly defined coverage goals, involve birdwatching at the discretion of the birdwatcher and are thus enjoyable for participants, and have a clearly defined product (a published atlas). A successful breeding bird atlas often leads to other atlas projects, such as those of winter birds (e.g., Lack 1986) or herpetofauna (e.g., Oldham 1990), and stimulates increased involvement in other survey programs.

Fieldwork for the first breeding bird atlas project, which culminated in *The Atlas of the Breeding Birds in Britain and Ireland* (Sharrock 1976), began in the late 1960s. Breeding bird atlas projects are relatively new to North America, but they have rapidly become widespread. As of August 1987, there were 41 provincial or state-wide breeding bird atlas projects proposed, under way, or complete in North America, and six county atlases were either under way or proposed in California and Oregon. All states and provinces in northeastern North America, except Newfoundland, have undertaken atlas projects, providing greatly expanded understanding of the distribution and relative abundance of breeding species in that area.

In undertaking an atlas, the area to be "atlased" is divided into grid "squares" or "blocks." Volunteer birdwatchers are asked to log a minimum number of hours of fieldwork in each square, reporting those species for which breeding evidence is observed. All breeding species are covered, but nocturnal and difficult-to-detect species are less well represented. Standardized categories of breeding evidence were devised for the British atlas (Sharrock 1976), and modified versions of those categories have been used in all subsequent breeding bird atlases. Categories and codes were revised for use in North America by the North American Ornithological Atlas Committee (NORAC) and published in the *Handbook for Atlasing American Breeding Birds* (NORAC 1990). (NORAC was established to facilitate breeding bird atlasing in the Americas by providing guidelines for atlasing standards and by providing a regular means of communication between states and provinces involved in or planning atlases. Its handbook was translated into Spanish to encourage the undertaking of atlas projects in Latin America and the Caribbean.)

Projects are usually steered and managed by one or more volunteer expert committees and have a small paid staff. To assist in coordinating fieldwork, volunteer regional coordinators are appointed for subregions. Regional coordinators are key to the success of the project, providing local expertise, motivating volunteers, and coordinating their fieldwork.

2. Breeding bird atlases in Canada

In Canada, breeding bird atlas projects have been completed for the Maritime provinces (Erskine 1992), Quebec (Gauthier and Aubry 1995, 1996), Ontario (Cadman et al. 1987), and Alberta (Semenchuk 1992). Table 1 summarizes the scope of the projects, their time period, and the coverage obtained. Pilot work on an atlas of breeding birds of the Northwest Territories was undertaken in the late 1980s, but the size of the area and the small number of resident naturalists led to the shelving of the project. Certain other regions have atlas-like programs, which are described in the next section.

Each province based coverage on the 10-km Universal Transverse Mercator (UTM) square, which is shown on topographic maps. However, because of the large size of Canadian provinces, and because much of the relatively small population is concentrated in southern areas, sampling regimes were incorporated to suit the circumstances in each province, as described below. All atlases used similar breeding evidence categories, but recording and use of abundance estimates varied among projects. Participants were provided with instruction manuals, data cards, and rare species documentation forms. Supplemental methods, natural history information, hints, and results were provided through regular newsletters.

2.1 Maritime provinces

The three Maritime provinces (Nova Scotia, New Brunswick, and Prince Edward Island) combined efforts in a single atlas project. Initially, emphasis was put on covering one in four 10-km squares; by the end of the project, however, data were collected from most squares. Volunteers were given the option of estimating the number of breeding pairs of each species in a square on a modified logarithmic scale: 1, 2–10, 11–100, 101–1000, 1001–10 000, 10 000+. Outlying estimates were omitted, and the population of birds was calculated for each of the provinces and the three combined (Field and Payzant 1992). The calculated population estimates were used in the published atlas for some species, but data from other sources were used for the remainder, depending on the perceived reliability of the data for that species.

2.2 Quebec

Quebec concentrated its effort on the "Québec méridional" from the U.S. border north to 50°30'N. It contains 5225 10-km squares: roughly 1850 accessible squares, 1850 remote squares, and 1500 in "wilderness" with difficult access. Volunteers were encouraged to cover the accessible squares, whereas assistants were paid to atlas the remote squares. In total, 2464 squares were visited and about 1500 were considered to be adequately covered. Separate French (Gauthier and Aubry 1995) and English (Gauthier and Aubry 1996) versions of the atlas have been published.

2.3 Ontario

The Ontario atlas was the first undertaken in Canada. Every 10-km square was covered in southern Ontario (approximately from Sault Ste. Marie south). In northern Ontario, the goal was to obtain data from at least one 10-km square in each 100-km "block." All 1824 squares in southern Ontario were visited, and 1834 squares were visited within the 137 100-km blocks in the north. Only one northern block was missed entirely. Coverage of remote areas of northern Ontario was accomplished largely by teams of atlasers travelling by canoe along major rivers and on free-of-charge plane and helicoptor flights into small communities and remote localities (provided on a space-available basis by the Ontario Ministry of Natural Resources and cooperating commercial airlines). Many of the volunteers covering remote areas were from outside Ontario and were attracted to the project by an extensive promotional campaign.

Abundance was estimated on an optional basis using the same categories described above for the Maritimes atlas. Population estimates were not calculated, but, after omitting outlying records, estimates were displayed in the published atlas using histograms for both northern and southern Ontario.

2.4 Alberta

As was likely true of all atlas projects, initial surveying in Alberta focused on regions with the most birdwatchers, in this case the Grassland and Parkland natural regions. In the final two years, a greater emphasis was placed on rural and remote areas in the Foothills, Rocky Mountain, and Boreal Forest regions. Southern and northern Alberta each contained 46 100-km blocks, subdivided into 10-km squares. One in four of the 10-km squares in southern Alberta and one square in every 100-km block in the north were designated priority squares. Nonpriority squares were covered when convenient for atlasers or during travel to priority squares. Rare or colonial species were recorded regardless of square priority. Data were received from an average of 38 squares per block in the south and nine squares per block in the north, but not all priority squares were covered.

Abundance data were collected only for the first year of the project. An analysis indicated that the data were not collected consistently, so these data were not recorded in subsequent years.

Table 1
Summary of coverage in breeding bird atlas projects

Region covered	No. of species	No. of squares covered	No. of volunteers	No. of hours	No. of records	Years of fieldwork
Maritimes	224	1 529	1 120	43 090	144 642	1986–1990
Quebec	248	2 464	960	66 174	202 521	1984–1989
Ontario	292	3 727	1 351	123 879	407 000	1981–1985
Alberta	270	2 206	943	40 000		1987–1991
Total		9 926	4 374	273 143	754 163	

3. Atlas-like projects in Canada

Other provinces have undertaken or are undertaking projects to map bird distribution on a grid basis, but these projects are not "breeding bird atlases," in that they have not focused entirely on breeding birds, have not attempted systematic coverage, and have not involved a large-scale volunteer network for the specific purpose of atlasing. As such, the data are collected over a longer time period than is typical of a breeding bird atlas, and coverage is more strongly biased in favour of heavily populated areas.

Campbell et al. (1990) summarized nonpasserine bird distribution in British Columbia by season on the basis of 1:50 000-scale National Topographic Maps, equal to blocks sized 15 minutes latitude by 30 minutes longitude. Data were compiled from the B.C. Nest Records Scheme, whose database is housed at the Royal British Columbia Museum.

A similar effort is under way in Manitoba, in the production of a new *Birds of Manitoba*. This project will map available information on the same grid as *The Birds of British Columbia* (Campbell et al. 1990). The project began in 1985 and is expected to be published in the near future.

The Canadian Wildlife Service in the Yukon is compiling a database of bird records from the Yukon and intends to produce a publication including seasonal distribution maps based on the topographic map grid system or 50-km grid squares. Publication is scheduled for 1997.

The *Atlas of Saskatchewan Birds* (Smith 1996) summarizes seasonal bird distribution by 1:50 000-scale topographic map grid. Data collection was a joint project of the Saskatchewan Natural History Society and the Canadian Wildlife Service and began in 1983. The atlas data consist of historical records combined with records from a directed volunteer and staff effort. Records of seasonal occurrence and breeding evidence have been divided into two time periods: pre-1966 and 1966–present.

4. Future projects

Breeding bird atlas projects are now complete in the provinces most likely to undertake them. Ontario is planning to repeat its breeding bird atlas 20 years after the first project began, beginning in 2001, and other provinces are likely to repeat their projects after a similar interval. The second atlas in Britain (Gibbons et al. 1993) documented many important changes over 20 years, and, judging from distribution changes already apparent in Ontario, the second round of Canadian atlases should be equally informative.

It may be possible to improve the potential for using atlas data to quantify distributional changes over time by calculating by square the number of birds seen per unit effort, as was done for the second British atlas. However, additional standardization reduces the appeal of the program to volunteers, and any such changes should be carefully considered before being adopted in Canada, where the number of volunteers per unit area is far lower than in Britain.

Atlas and atlas-like projects have provided a more precise and quantitative assessment of bird distribution in each province than was previously available through regional guides or overviews such as Godfrey's (1986) *Birds of Canada*, and they have greatly increased knowledge of the status of many of Canada's birds. The project organizers and particularly the volunteers whose efforts have made them possible are to be congratulated on their efforts.

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Monitoring bird populations with checklist programs

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Abstract

Checklists (records of birds seen or heard on field trips) can be compiled to document the status of birds in a given region or time period. Quebec has had an organized checklist compilation program for more than 45 years, and several other Canadian projects were recently begun, following the success of the Quebec program. Guidelines have been prepared to encourage new programs to collect data in the most scientifically valuable manner. Analysis of checklist data suggests that such programs contain useful information on changes in bird population status and may serve as an early warning of negative trends.

Résumé

Les feuillets d'observation (listes d'oiseaux observés ou entendus lors des randonnées) peuvent être compilées pour faire ressortir la situation d'une espèce dans une région donnée ou à une période précise. Le Québec dispose d'un programme structuré de cueillette des données ainsi relevées depuis plus de 45 ans et plusieurs autres projets canadiens ont récemment vu le jour face au succès remporté par le programme québécois. Des lignes directrices ont été rédigées afin que les données des nouveaux programmes soient recueillies de la manière la plus utile qui soit sur le plan scientifique. L'analyse des données suggère que les programmes de ce genre nous renseignent sur les fluctuations des populations et pourraient servir d'avertissement précoce en cas de tendances négatives.

1. Introduction

Watching birds as a hobby has increased exponentially during this century, aided by the development of birding tools such as field guides and optical equipment. One sign of the popularity of birding is the publication of hundreds of regional and local "checklists," which summarize the status of local avifauna. These are often printed with space for recording birds seen or heard on a particular field trip.

Checklists are used in different ways to record field observations. Some people keep year lists, and others use a single list for each birding trip; some record a species' presence with a tick mark (the "check" of the checklist), whereas others write in the number of each species seen.

Birders' checklists are often compiled to produce regional and seasonal status reports (e.g., David 1980, 1996; Temple and Cary 1987; Cyr and Larivée 1995), but until quite recently this was a tedious task. Now that computers are becoming widespread, the opportunities for pooling data are growing almost daily.

Realization of this fact has led to a greater scrutiny of checklist programs to determine whether they have the potential to monitor populations. This paper will describe the status of checklist programs in Canada, especially the one in Quebec, with a focus on the use of checklist data to track population trends.

2. Canadian checklist programs

In 1948, Brother Victor Gaboriault started a cooperative program for collecting sightings of birds on field checklists (David 1978), which led to a publication on the birds of the Montreal and Quebec City regions (Gaboriault 1951). After Gaboriault's death, the program was revitalized by the formation of Le Club des Ornithologues de Québec, which compiled data from checklists in order to publish seasonal reports in a bulletin. In 1975, Jacques Larivée undertook to computerize the data, developing data entry software, coding systems, and a database management system (Larivée et al. 1987). Since then, the project has been called "ÉPOQ" (Étude des Populations d'Oiseaux du Québec, or Population studies of Quebec's birds) and is operated through the Association Québécoise des Groupes d'Ornithologues (a federation of provincial bird clubs). Currently, the database includes over 3 million records from 220 000+ checklists, for 3900+ localities. Over 10 000 checklists are now submitted annually, following coding, keypunching, and evaluation of records by local bird clubs. Each checklist reports the number of birds of each species seen on a single day, at one locality (an area of about 3.2 km^2). ÉPOQ is the largest and longest- running formal checklist compilation program in North America.

The province of Alberta began a checklist project in 1994, following the ÉPOQ model, except that checklists are submitted directly to the organizing group, the Alberta Federation of Naturalists. About 200 lists were compiled in the pilot year. Human population density is much lower in Alberta than in Quebec, so central compilation may remain feasible even if the program grows substantially. Naturalists' groups in Manitoba and Saskatchewan are also interested in starting checklist surveys (C. Downes, pers. commun.).

In 1995, the Canadian Wildlife Service organized a pilot project to see whether there was any potential for a checklist program in the Northwest Territories. In this remote region, there is much to be learned about the basic status of the avifauna. If tourists, geologists, and others could be persuaded to fill in checklists regularly, a great many biological inventory data might be recorded that would otherwise be lost. The pilot project garnered 69 lists from 29 groups or individuals, widely spread across the Northwest Territories (C. Downes, pers. commun.). This excellent start led to the establishment of a regular project in 1996.

3. Value of checklists for monitoring population change

Checklist protocols from U.S. and Canadian projects were studied in 1995 by the North American Migration Monitoring Council, a group with U.S. and Canadian government and nongovernmental organization members that is interested in using migration counts to track population change (Blancher et al. 1994). This group made recommendations on methodology for checklist programs in order to encourage the collection of data that will be useful for a variety of scientific applications (Dunn 1995). The main recommendations are that each checklist report numbers of birds seen (as opposed to a checkmark alone), on a single day (vs. weekly totals), at a single locality of less than one minute of latitude and longitude (about 3.2 km^2). All the formal checklist compilation programs in Canada follow protocols recommended in these guidelines.

The main use of checklists in the past has been to document the status of birds in a region and to illustrate timing and patterns of migration (e.g., David 1980, 1996; Temple and Cary 1987; Larivée 1993; Cyr and Larivée 1995). Data have also been used for other purposes, such as assessing the relative importance of migratory stopover sites (Remsen et al. 1996), documenting breeding phenology (Larivée 1990), and monitoring the frequency of albinism in birds (Larivée 1995). In a few cases, trends in checklist data have been used as indicators of trends in bird populations (Larivée 1989a, 1989b; Temple and Cary 1990; Hill and Hagan 1991; West 1992; Cyr and Larivée 1993, 1995). Finally, checklist programs provide valuable experience in record keeping and may help encourage people to take part in formal population monitoring programs such as the Breeding Bird Survey (BBS).

The use of checklist programs to document population trends can be criticized on many grounds. There are no restrictions on where birders go or how long they observe on a given day and no tests of identification skills (although beginners rarely contribute their lists). If birders abandon localities that lose their interesting birds and visit mainly productive sites, then numbers of birds recorded will not reflect population change. This problem is likely to be most severe in smaller programs, in which relatively few sites are visited.

Several studies have examined the ability of checklist data to document population change. West (1992) presented trends in one-day counts in Delaware. Dunn and Hussell (1995) used West's (1992) data to show that of 99 species breeding in Delaware, checklist trends agreed in direction with eastern U.S. BBS trends in 72% of cases.

Wisconsin Checklist Project (WCP) data have also been analyzed. This program compiles frequency-of-occurrence records on a weekly basis by county. Temple and Cary (1990) showed that WCP indices showed patterns of relative abundance similar to those of Christmas Bird Counts and the BBS. In an analysis of nine-year trends in frequency of reporting, Rolley (1994) showed that WCP trends for 138 species were more similar in direction to BBS trends than would be expected by chance; of 32 species with significant trends in both programs, only two differed in direction of trend.

In a similar analysis using ÉPOQ data from Quebec, Cyr and Larivée (1993) reported on trends in reporting frequency for 74 species. For summer data only (the season from which results would be expected to correspond most closely to the BBS), there was agreement in direction of trend between the two programs in 66% of species, and there were no disagreements among the 14 species with significant trends in both programs.

Dunn et al. (1996) analyzed ÉPOQ data from the migration seasons alone. Trends were calculated for 58 species, on date-adjusted indices based on either reporting frequency or abundance. Frequency indices from spring corresponded well with BBS trends in direction, but fall indices did not. Trends in abundance corresponded well in both seasons. ÉPOQ trends were more positive than BBS trends, which could result from positive bias in checklist counts or from the two programs sampling different populations. (A similar analysis of summer data could help distinguish between these possibilities.) Dunn et al. (1996) also showed that sample sizes could be relatively small (500–1000 lists per migration season) and still give similar results. A negative ÉPOQ trend from the migration season was a good predictor of a negative trend in the BBS, and the authors concluded that ÉPOQ could therefore be used as an early warning of negative trends in species that breed north of the area of BBS coverage.

Further analyses are required to determine whether these results are consistent among data sets from different areas, to determine which season produces the most reliable trend information, and to investigate further the causes of discrepancy between checklist and BBS trends for individual species. Improvements in analysis methods may improve the precision of trends derived from checklist programs — for example, by imposing a post-hoc randomization of sample sites on the data set prior to analysis. It may also be possible to encourage participants to visit preselected study sites on a regular basis. Nonetheless, it is already clear that checklist data do contain trend information.

Caution should be applied in using checklist surveys as population monitoring programs, because they do not have a randomized sampling scheme or standard count protocol; at the same time, we should not ignore the useful information they have to offer on population change, particularly for species that are poorly covered by other monitoring programs.

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Monitoring migrants to detect changes in populations of birds breeding in Canada: present status and future prospects

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Abstract

Counting and other methods of sampling migrants, such as mist-netting, have not been widely used to monitor population changes in birds. Because of the confounding effects of weather on numbers of migrants sampled, special methods are required to extract information on population levels from counts of migrants. Trends in the abundance of small landbirds at Long Point Bird Observatory, Ontario, and of hawks at Grimsby, Ontario, are positively correlated with Breeding Bird Survey (BBS) trends in Ontario and Quebec, indicating that migration sampling can generate useful information on changes in bird populations. In Canada, a high proportion of terrestrial bird species are migrants. The BBS covers only the southern fringe of the country, and huge areas of the breeding ranges of many species are unmonitored by the BBS. Therefore, a chain of migration monitoring stations across the northern limit of the area monitored by the BBS in Canada would be valuable for tracking population changes in birds breeding in northern regions of Canada. By 1993, several stations monitoring small landbirds formed a partial chain from Alberta to Ontario. Other sites were operated as pilot programs in British Columbia, Alberta, Ontario, Quebec, and New Brunswick in 1994–1995. Additional stations specialize in counting migrating hawks. To use these counts effectively for monitoring population changes, regular analyses and timely reporting of results are needed from a coordinated national or international program.

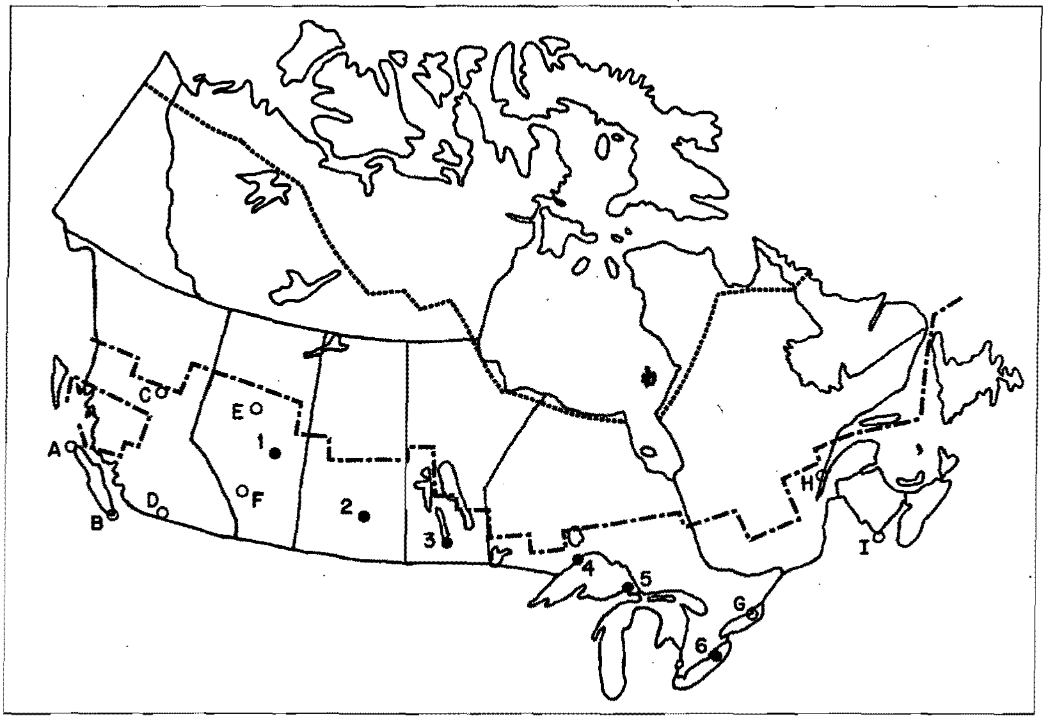
Résumé

Le dénombrement et les autres méthodes d'échantillonnage des oiseaux migrateurs, comme l'usage de filets japonais, ne servent pas beaucoup à surveiller la fluctuation de la population d'oiseaux. Des méthodes spéciales sont nécessaires si on veut se renseigner sur l'importance de la population à partir du dénombrement des oiseaux migrateurs, à cause des effets confondants du climat sur le nombre d'oiseaux échantillonnés. Les tendances relatives à l'abondance des petits oiseaux terrestres, à l'observatoire d'oiseaux de Long Point, en Ontario, et des faucons, à Grimsby (Ontario), ont été positivement corrélées au Relevé des oiseaux nicheurs (RON) en Ontario et au Québec, signe que l'échantillonnage durant la migration peut nous donner des renseignements utiles sur les fluctuations de la population d'oiseaux. Bon nombre d'espèces terrestres canadiennes sont des oiseaux migrateurs. Or, le RON ne couvre que le sud du pays. Une grande partie des aires de nidification de maintes espèces ne sont pas touchées. Il vaudrait donc la peine de créer une chaîne de postes de surveillance à la limite nord de la région que couvre le RON, au Canada. On pourrait ainsi suivre les mouvements de la population d'oiseaux qui nidifient dans le nord du pays. En 1993, plusieurs stations de ce genre pour les petits oiseaux terrestres formaient une chaîne partielle, de l'Alberta à l'Ontario. D'autres sites ont été exploités dans le cadre de programmes pilotes en Colombie-Britannique, en Alberta, en Ontario, au Québec et au Nouveau-Brunswick, en 1994 et 1995. Il existe des stations spécialisées dans le dénombrement des faucons migrateurs. Pour utiliser ces relevés à bonne fin et établir les variations de la population, il est nécessaire d'effectuer des analyses régulières et de signaler les résultats en temps opportun dans le cadre d'un programme national ou international bien structuré.

1. Introduction

Canada is a large country, and much of it is inaccessible by road. Consequently, the roadside counts of the Breeding Bird Survey (BBS) monitor Canadian breeding bird populations mainly in the south, adjacent to the U.S. border (Fig. 1). Numbers of species and bird population densities decline at higher latitudes; nevertheless, it is clear that there are massive areas of forested land and tundra and large populations of some species that are not monitored by the BBS. A recent survey indicated that there are 77 species of terrestrial birds for which less than half of the breeding range in Canada and Alaska is adequately covered by the BBS (Dunn 1992). Of these, 35 species winter mainly south of the United States, so their winter populations are not monitored by Christmas Bird Counts (Dunn 1992). Counting migrants could enable us to monitor changes in some of these northern populations that are not monitored in other ways. Moreover, certain species, such as some raptors, are poorly covered by the BBS because they occur in low densities or are inconspicuous during the BBS. Some of these birds can be counted more easily during migration,

Figure 1
Breeding Bird Survey (BBS) coverage in Canada and locations of migration monitoring stations. The dot–dash line shows the northern limit and western limit (in central British Columbia) of contiguous BBS routes (from Erskine 1990). Many routes are not surveyed every year, particularly in the northern parts of this area. A few additional routes are surveyed farther north, including some in the Yukon and Northwest Territories. The broken line shows the approximate northern limit of trees. Solid circles show locations of migration monitoring stations operating in 1993–1995 and earlier. Open circles show stations operating as pilot programs in 1994–1995. Numbers and letters refer to the key in Table 4.



when they concentrate in large numbers at geographic barriers.

Because Canada is a high-latitude country, it has an exceptionally large proportion of migrants. Using Godfrey's (1986) *The Birds of Canada* and other standard references (mainly Robbins et al. 1966), I categorized 267 species of terrestrial birds that breed in Canada as resident, mainly resident, migratory, or mainly migratory (Table 1). This survey showed that 74.5% of the species were either totally migratory (57.3%) or mainly migratory (17.2%) and indicates that there is good potential for monitoring populations of a substantial proportion of Canada's breeding birds by counting them during migration.

In principle, any method of sampling migrants can potentially be used to detect population trends. Methods that have been investigated include regional checklist or "bird list" programs (see Cyr et al., this volume), single- or multiple-day spring counts, and acoustic and radar sampling of nocturnal migrants (see Dunn and Hussell 1995). In this brief paper, however, I focus on the more traditional methods of sampling migrants by counting them or capturing them for banding at sites operated daily or near-daily throughout one or both migration seasons.

2. Background on the use of migration counts for population monitoring

Migration counts have several advantages as well as some disadvantages for monitoring populations (Hussell 1981; Dunn and Hussell 1995). An important drawback is that the numbers of migrants that concentrate at favourable observation sites vary enormously with weather conditions (Richardson 1978, 1990), and therefore the total count in any year can be greatly influenced by the weather in that year. Nevertheless, migration counts do contain information on population change, and the challenge is to separate that information from the "noise" and extract it from the data. There is increasing evidence and a growing consensus that it is feasible to do that. The possibilities for analysis of migration counts range from simple summation of annual totals (e.g., Bednarz et al. 1990) to multivariate approaches that take into account the confounding effects of weather, multiple sites, and incomplete coverage (e.g., Hussell and Brown 1992; Hussell et al. 1992; for a fuller discussion of the options, see Dunn and Hussell 1995).

Attempts have been made to use migration counts to monitor populations of migrants in Great Britain, Sweden, Poland, Germany, Canada, the United States, and elsewhere (e.g., Spofford 1969; Busse 1973, 1976; Berthold and Schlenker 1975; Nagy 1977; Langslow 1978; Svennson 1978; Hussell 1981, 1985; Berthold et al. 1986, 1993; Jones 1986; Svensson et al. 1986; Stewart 1987; Mueller et al. 1988; Bednarz and Kerlinger 1989; Titus et al. 1989, 1990; Titus and Fuller 1990; Hill and Hagan 1991; Hagan et al. 1992; Hussell and Brown 1992; Hussell et al. 1992; Pyle et al. 1994). These studies vary in objectives and the sophistication of their analyses. Some of the best examples in North America involve counts of

Table 1
Numbers and percentages of migrants and residents among terrestrial bird species[a] that breed in Canada

Status[b]	No. of species	% of total
Migratory	153	57.3
Mainly migratory	46	17.2
Mainly resident	6	2.3
Resident	62	23.2
Total	267	100.0

[a] Species included were in the following orders: Falconiformes, Galliformes, Columbiformes, Cuculiformes, Strigiformes, Caprimulgiformes, Apodiformes, Coraciiformes, Piciformes, and Passeriformes.
[b] Migratory: All of the Canadian breeding range vacated in winter. Mainly migratory: At least 50% of the Canadian breeding range vacated in winter. Mainly resident: Less than 50% of the Canadian breeding range vacated in winter. Resident: All of the Canadian breeding range occupied in winter.

Table 2
Patterns of change in annual migration indices at Long Point Bird Observatory during three periods: 1961–1970, 1970–1979, 1979–1988[a]

	No. of species		
Change[b] pattern	Tropical[c]	Temperate[c]	Total
– – –	5	1	6
– – +	2	2	4
– + –	16	0	16
+ –	1	2	3
+ + –	0	0	0
+ – +	1	13	14
– + +	7	3	10
+ + +	0	1	1
Total	32	22	54

[a] From Hussell et al. (1992), Table 2.
[b] Change pattern indicates direction of change (+ or –) in 1961–1970, 1970–1979, and 1979–1988, respectively.
[c] Wintering area; see Hussell et al. (1992) for details.

migrating hawks, including a recent analysis of 50 years of counts at Hawk Mountain, Pennsylvania (Bednarz et al. 1990).

There are several migration stations across Canada that collect migration data in some form, but none has been operating as long or as effectively as Long Point Bird Observatory (LPBO) on Lake Erie. The potential usefulness of monitoring migrants can be seen from some of the LPBO results. For example, an analysis of patterns of change in 54 species from 1961 to 1988 showed that most species fluctuated in numbers, with tropical migrants tending to decline in the 1960s, increase in the 1970s, and decrease again in the 1980s, while most temperate migrants followed the opposite pattern (Table 2). Despite these fluctuations, populations of nine of 33 tropical migrants and three of 23 temperate migrants were judged to have had consistent downward trends over the 28 years (Table 3), although some of them have since recovered (Francis 1995, 1996).

A few authors have addressed the question of validation of migration counts by comparing them with independent measures of population change. In Sweden, counts of migrants at Ottenby and Falsterbo were positively correlated with breeding bird counts in southern Sweden (Svensson et al. 1986; Svensson 1993). Trends in numbers of migrants captured in mist-nets at Manomet, Massachusetts, in 1970–1988 tended to be positively correlated with trends measured by the BBS in regions to the north of Manomet (Hagan et al. 1992). Changes in counts of migrants on southeast Farallon Island, California, were significantly correlated with trends in the BBS in western North America (Pyle et al. 1994). In Ontario, trends of spring counts of hawks migrating at Grimsby were positively related to BBS trends for the same species in Ontario (Hussell and Brown 1992). Trends in small landbird migrants at Long Point in 1967–1987 were also strongly related to trends in the BBS in Ontario (Fig. 2; Hussell et al. 1992). Other examples documented recently include a strong correlation ($r_s = 0.75$) between fall banding indices derived from mist-net captures at two sites in Michigan and mean BBS trends in that state for 11 migrants that breed north of the banding sites (Dunn and Hussell 1995).

Because population trends may vary geographically, it is important to identify the appropriate breeding range when using independently devised trends based on

Table 3
Species showing persistent long-term declines at Long Point Bird Observatory from 1961 to 1988[a]

Wintering area/species	Net change (%/yr)
Tropical	
Veery *Catharus fuscescens*	–3.3
Gray-cheeked Thrush *C. minimus*	–3.4
Swainson's Thrush *C. ustulatus*	–2.9
Wood Thrush *Hylocichla mustelina*	–6.0
Gray Catbird *Dumetella carolinensis*	–3.5
Nashville Warbler *Vermivora ruficapilla*	–2.9
Ovenbird *Seiurus aurocapillus*	–2.9
Northern Waterthrush *S. noveboracensis*	–4.0
Rose-breasted Grosbeak *Pheucticus ludovicianus*	–2.4
Temperate	
Brown Thrasher *Toxostoma rufum*	–3.3
Rufous-sided Towhee *Pipilo erythrophthalmus*	–4.1
White-throated Sparrow *Zonotrichia albicollis*	–2.6

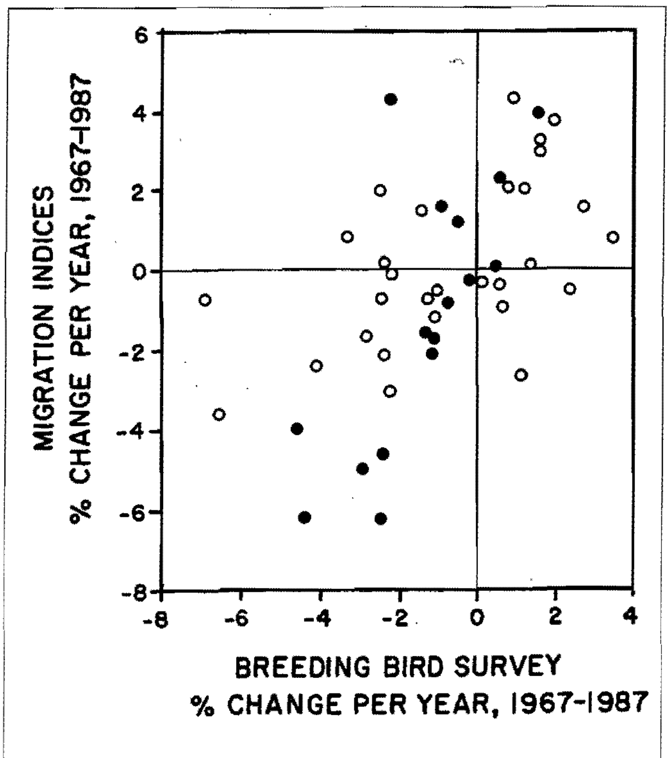
[a] From Hussell et al. (1992), Table 1. Recent data (1989–1995) for Gray-cheeked and Swainson's thrushes, Nashville Warbler, Ovenbird, and Northern Waterthrush indicate that their populations have recovered, and therefore they would not appear in an updated list (Francis 1995, 1996).
[b] All changes were significant: $0.01 < P < 0.05$ for Rose-breasted Grosbeak and White-throated Sparrow, $P < 0.01$ for all other species.

the BBS to validate migration count trends. I refined the comparison of Long Point and BBS trends (Fig. 2; Hussell et al. 1992) by excluding species whose breeding ranges extend far to the north of the region covered by the BBS in Ontario (i.e., north of 50°N). Using only the 16 species that meet this more rigorous criterion, we found a stronger positive correlation ($r_s = 0.750$) between the migration counts and the BBS (Fig. 2). These results indicate that, with appropriate analysis methods, migration counts track population trends.

3. Current status of migration monitoring in Canada

Reported declines in Neotropical migrants (Robbins et al. 1989; Terborgh 1989; Askins et al. 1990) helped to catalyze the recent formation by the U.S. Fish and Wildlife Foundation of the Neotropical Migratory Bird Conservation Program (NTMBCP) — Partners in Flight (PIF). Meanwhile, the Canadian Wildlife Service

Figure 2
Rates of change in migration indices at Long Point versus trends in the Breeding Bird Survey (BBS) in Ontario, 1967–1987 (from Hussell et al. 1992). Each point represents one species. Solid circles = species judged to be well-monitored by the BBS (see text); open circles = all other species. Spearman rank correlation coefficient, $r_s = 0.599$ for all species ($n = 45$), $r_s = 0.750$ for well-monitored species ($n = 16$), $P < 0.001$ for both correlation coefficients.



has been instrumental in developing a landbird conservation strategy for Canada, via the Canadian Landbird Conservation Working Group (1996). The inadequacy of the BBS for monitoring inaccessible northern populations of landbirds was recognized by the Monitoring Working Group of PIF in a needs assessment (NTMBCP Monitoring Working Group 1992), as well as in the *Canadian Landbird Monitoring Strategy* (Anonymous 1994). Both suggested that a series of migration monitoring stations could help fill this gap, and the PIF group specifically proposed that "if validation studies are positive, a series of migration monitoring stations should be established along the northern edge of the more inhabited regions of Canada" (which coincides with the northern edge of intensive BBS coverage). To deal with the question of validation, the PIF group also proposed that "a workshop be held to evaluate the potential of these stations and to look at ways to validate population indices derived from migration counts." This workshop, convened by the U.S. Fish and Wildlife Service and Canadian Wildlife Service in cooperation with LPBO, was held at Simcoe, Ontario, on 14–17 September 1993. It covered a range of programs that potentially could contribute to monitoring populations of migrants, including bird observatories, intensive and casual banding, migration counts, checklist or "bird list" programs, and spring "Big Day" counts. Among other recommendations, the report of the workshop (Blancher et al. 1994) essentially endorsed

Table 4
Migration monitoring stations

ID[a]	Station/site location
1	Beaverhill Bird Observatory, Beaverhill Lake, Alta.
2	Last Mountain Bird Observatory, Last Mountain Lake, Sask.
3	Delta Marsh Bird Observatory, Delta, Man.
4	Thunder Cape Bird Observatory, Thunder Cape, Ont.
5	Whitefish Point Bird Observatory, Whitefish Point, Mich.[b]
6	Long Point Bird Observatory, Long Point, Ont.
A	Triangle Island, B.C.
B	Rocky Point, B.C.
C	Mackenzie, B.C.
D	Vaseux Lake, B.C.
E	Lesser Slave Lake Bird Observatory, Lesser Slave Lake, Alta.
F	Inglewood Bird Sanctuary, Calgary, Alta.
G	Prince Edward Point, Ont.
H	Tadoussac, Que.
I	Grand Manan, N.B.

[a] Number or letter on map in Figure 1. Numbers indicate stations operating in 1993 and earlier. Letters indicate stations operating as pilot programs in 1994–1995.
[b] Although this station is not in Canada, it clearly forms a link in the chain of stations that monitor populations of migrants breeding in northern Canada.

the PIF proposal for a series of migration monitoring stations across Canada and presented a plan to implement the program. The first step was formation of a Canada–U.S. "Migration Monitoring Council" to establish standard procedures and promote a coordinated continental program.

To use migration counts effectively for monitoring northern populations, we must first establish minimum acceptable standards for collecting field data and for participation in the program. Second, we need to identify which stations are essential components of the program and promote the development of those stations. And third, we need to develop the capacity to analyze the data and report the results in a timely manner. To do these things, we will need some form of coordinating group to oversee and promote the program. The workshop report proposed a structure for doing this. In the present fiscal climate, it is unlikely that governments will undertake full responsibility for funding, coordination, and analysis of migration monitoring, as they have for the BBS. Recognizing this, the workshop report proposed a joint effort by governments, nongovernmental organizations, and volunteers.

Some progress has already been made along these lines. LPBO produced a manual that describes how to set up and operate a migration monitoring station for small landbirds (McCracken et al. 1993). Subsequently, the Migration Monitoring Council recommended methods for collecting data for monitoring populations by counting and capture of migrants (Hussell and Ralph 1996). By 1993, a partial chain of stations already existed near the northern limits of BBS coverage from Alberta east to Ontario, and additional sites were explored in 1994–1995 (Fig. 1, Table 4). These stations, which are involved primarily in counting and banding small landbirds, could form the foundation of a Canadian migration monitoring program. Other stations could be added to fill in gaps and extend the chain. Several stations specializing in counting hawks (not shown in Fig. 1) use standardized procedures recommended by the Hawk Migration Association of

North America and could contribute valuable information on Canadian raptor populations.

Existing stations are operated mainly by nongovernmental organizations, but some are run by government agencies or individuals. Funding comes from a variety of sources, including provincial and federal governments, corporate contributions, and often substantial private donations. All stations depend on a strong volunteer component in field operations. Although the manuals and guidelines mentioned above (McCracken et al. 1993; Hussell and Ralph 1996) have contributed to developing a consistency of approach among the small landbird stations, there is, as yet, no formal mechanism for coordinating the program. Moreover, analysis capability is limited, except at LPBO (see below).

One of the keys to successful use of migration counts for monitoring populations (and perhaps the most difficult one to achieve) will be the ability to put together the funding and other resources needed to ensure proper coordination of the program, including analysis of the data and reporting the results in a timely manner. Recently, a new national program, Bird Studies Canada (BSC), was formed under the auspices of LPBO. BSC is governed by a council whose members are drawn from all regions of Canada, and its mandate includes coordination of a Canadian migration monitoring network. An ornithologist has been hired whose duties will include analysis and reporting the results of the migration monitoring program.

4. Conclusions

Counting and banding migrants are intrinsically exciting experiences for many people. The challenge is to conduct these activities in ways that can also contribute useful information on changes in bird populations. The initial steps have been taken to show that this is possible, but much remains to be done to develop a comprehensive continental migration monitoring program. Because a high proportion of Canadian birds are migratory and breed in relatively inaccessible northern regions of the country, Canadian ornithologists, birders, and bird banders have an opportunity to play an important role in a North American program for monitoring birds during migration.

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Monitoring Canadian bird populations with winter counts

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Abstract

Two winter bird surveys in Canada have range-wide population monitoring potential: Christmas Bird Counts (CBCs) and Project FeederWatch (PFW). CBC trends are shown to be correlated to Breeding Bird Survey (BBS) trends, whether or not part of the winter range lies outside the CBC coverage area. Some species are poorly covered by this survey (e.g., seabirds, nocturnal species, and Neotropical migrants). Only eight Canadian breeding species that are not sampled by the BBS have their winter range well-covered by the CBC, but the CBC should be valuable as an independent source of trend data for many more species, including northern nesters with only marginal BBS coverage. More work is needed to show whether PFW trends match BBS trends; even if they do, PFW covers relatively few species, and most are monitored already by the BBS and/or CBC.

Résumé

Deux enquêtes hivernales offrent des possibilités intéressantes pour surveiller la population d'oiseaux canadiens sur l'étendue de leur aire : le Recensement des oiseaux de Noël et le projet Tournesol (PT). Les tendances du Recensement des oiseaux de Noël semblent confirmer celles du Relevé des oiseaux nicheurs (RON), qu'une partie de l'aire hivernale de ces derniers déborde ou non de la région que couvre le Recensement des oiseaux de Noël. Certaines espèces sont mal servies par cette enquête (oiseaux de mer, espèces nocturnes et oiseaux migrateurs néotropicaux). À peine huit espèces d'oiseaux nicheurs canadiens non échantillonnées par le RON ont une aire hivernale que couvre bien le Recensement des oiseaux de Noël. Cependant, cette enquête présenterait de l'utilité en tant que source indépendante de données sur les tendances pour un nombre accru d'espèces, notamment celles qui nichent dans le nord et que couvre mal le RON. Il faudrait approfondir les recherches pour voir si les tendances du PT épousent celles du RON. Même dans ce cas, le PT s'applique à un nombre relativement restreint d'espèces, la plupart déjà surveillées dans le cadre du RON ou du Recensement des oiseaux de Noël.

1. Introduction

Many Canadian breeding species nest in remote northern regions where they cannot be readily surveyed in the nesting season. However, many of the species that are inaccessible in summer are migratory and can be counted either on migration or in winter.

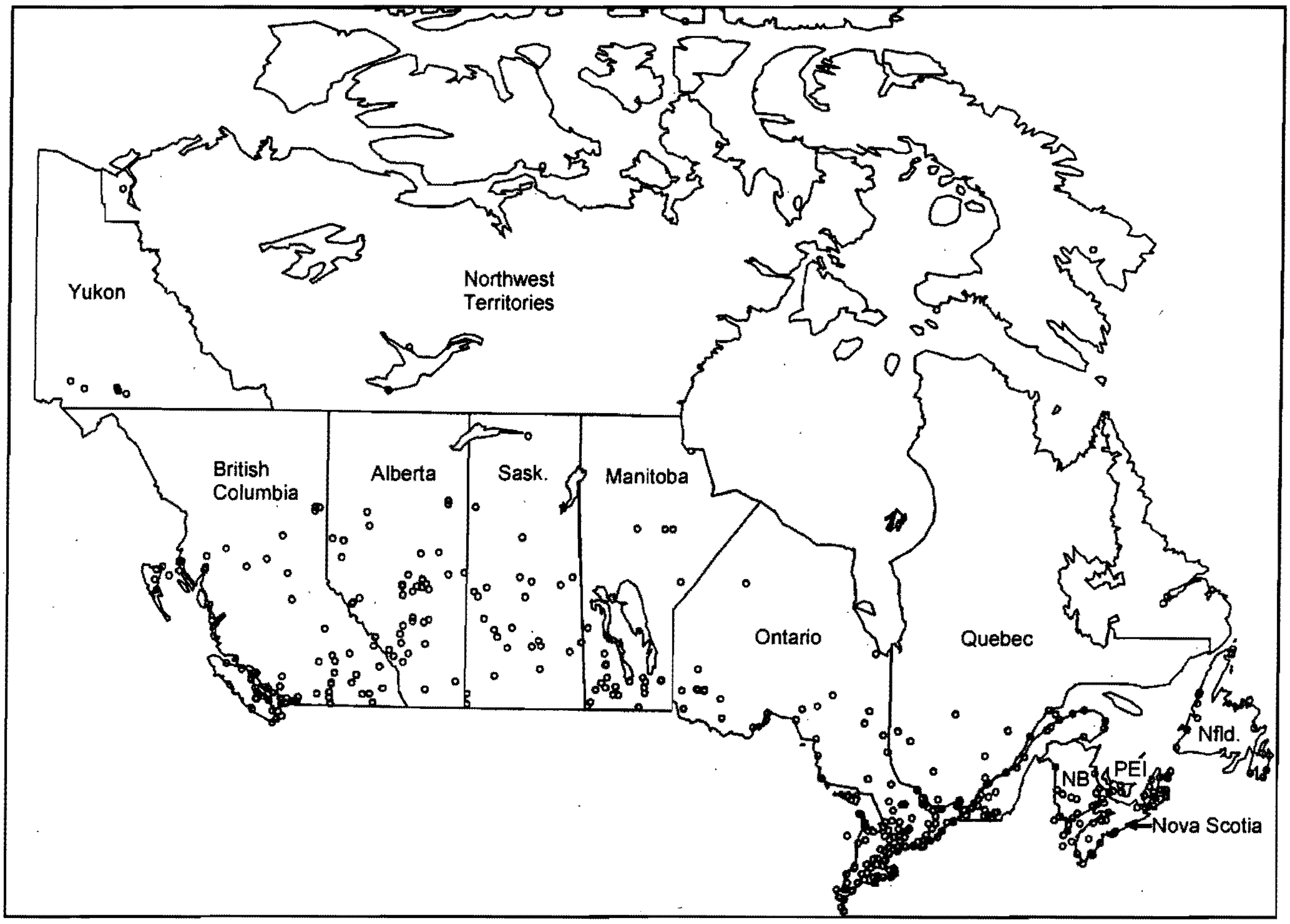
The aim of this paper is to review the strengths and limitations of using winter counts to monitor populations and to indicate which Canadian breeding species are most appropriately monitored in that season. We deal here only with range-wide trends, which for North America can be derived from two surveys: Christmas Bird Counts (CBCs) and Project FeederWatch (PFW). Another important winter survey, the Mid-winter Waterfowl Count, is not covered here. There are regional winter surveys (e.g., checklist project in Quebec; see Cyr et al., this volume), but these may give misleading trend results. To the extent that populations alter their distribution within and among winters (as is known to occur in many species), regional trends could reflect spatial rather than population change.

2. Christmas Bird Counts

The CBC, organized by the U.S. National Audubon Society, was begun in 1900 as a recreational event aimed at getting people to look at birds rather than killing them in traditional Christmas hunts. Twenty-six localities were surveyed the first year (two in Canada), and the popularity of CBCs spread rapidly throughout North America (Root 1988) (Fig. 1). CBC sites are circles of 24.1-km diameter within which observers count all birds they can find on a single calendar day within two weeks of Christmas Day (Butcher 1990).

There are many concerns about using CBC data to detect population trends (see review in Bock and Root 1981). For example, there are no restrictions on number or skill of observers, amount of time spent in the field, or distance travelled. In recent times, there has been an increase in exotic transport (e.g., by snowmobile or motorboat), which allows greater coverage than in earlier years, and there has been a trend towards including data collected by people who stay at home all day to record birds at their feeders (Dunn 1995). Most circles are either near populated areas or in relatively pristine parks and so are not representative of all landscape types.

Figure 1
Christmas Bird Count sites in Canada in 1994/95



Nonetheless, these problems may not be crucial. Users can to some extent correct the data for variable effort, by dividing bird numbers by number of observers, party-hours in field, or miles travelled (e.g., Butcher and McCulloch 1990). Bias in location of CBC sites should not affect trends as long as there is no long-term trend in the degree of bias. Studies of the effects of weather on CBC results have shown that it has relatively little influence on effort (Falk 1979) or on number of species seen (Smith 1979), although more work is needed on these subjects. When data are pooled over broad regions across many years, the noise of unstandardized data may to a large extent be cancelled out.

Several studies have indicated that CBCs do, in fact, document trends similar to those detected by independent population surveys. CBCs perform well in documenting gross changes such as periodic irruptions of finches (Bock and Lepthien 1976a) or range expansions (Hamilton 1992). Butcher et al. (1990) found similarity between CBC trends and trends from the Breeding Bird Survey (BBS) in six of seven species examined, and Hagan (1993) showed that CBC trends in the Rufous-sided Towhee *Pipilo erythrophthalmus* had the expected relationship to BBS trends. A comparison of CBC and BBS trends for several hundred species found significant correlation between them (J.R. Sauer, unpubl. data).

Here we look in more detail at the data set analyzed by J.R. Sauer. Data consisted of continental trends from the CBC and BBS for 1966–1988, for 239 species. Both sets of trends were calculated using the route regression analysis routinely used for the BBS (Geissler and Sauer 1990). Trends were not normally distributed, so all comparisons between programs were made using Spearman rank correlation.

In his original analysis, J.R. Sauer (unpubl. data) excluded certain species because they are poorly covered by CBCs. These included birds that are secretive (e.g., owls), occur offshore (seabirds), or are very locally distributed (e.g., Whooping Crane *Grus americana*). Other species were eliminated because nearly all of the winter range is south of the United States, where very few CBCs are conducted. However, Sauer's analysis did include many species that winter partly in the United States and partly farther south. If there is any tendency for winter distribution to shift over time, then CBC trends may not reflect population change in these species.

Some species have indeed altered their winter range in historic times (e.g., Middleton 1977; Mirarchi and Baskett 1994), others are more migratory in certain years than in others (Bock and Lepthien 1976b; Smith 1986),

Table 1
Spearman rank correlation between CBC and BBS trends

Species with whole winter range well-covered by CBC	Species not wholly covered by CBC	All species
All trends, significant or not		
0.49***	0.45***	0.46***
(94)	(145)	(239)
Trends significant in CBC		
0.72***	0.63***	0.66***
(36)	(53)	(89)

Note: ** = P < 0.01, *** = P < 0.001. Sample size in parentheses.

and still others may move farther south in midwinter if weather conditions are poor (Niles et al. 1969; Terrill and Ohmart 1984). If species that winter partly outside the CBC coverage area behave in the same ways, then winter counts may not detect trends accurately. To test this possibility, we compared BBS and CBC trends for all the species originally analyzed by J.R. Sauer and then repeated the analysis for only those species whose winter range is well-covered by the CBC.

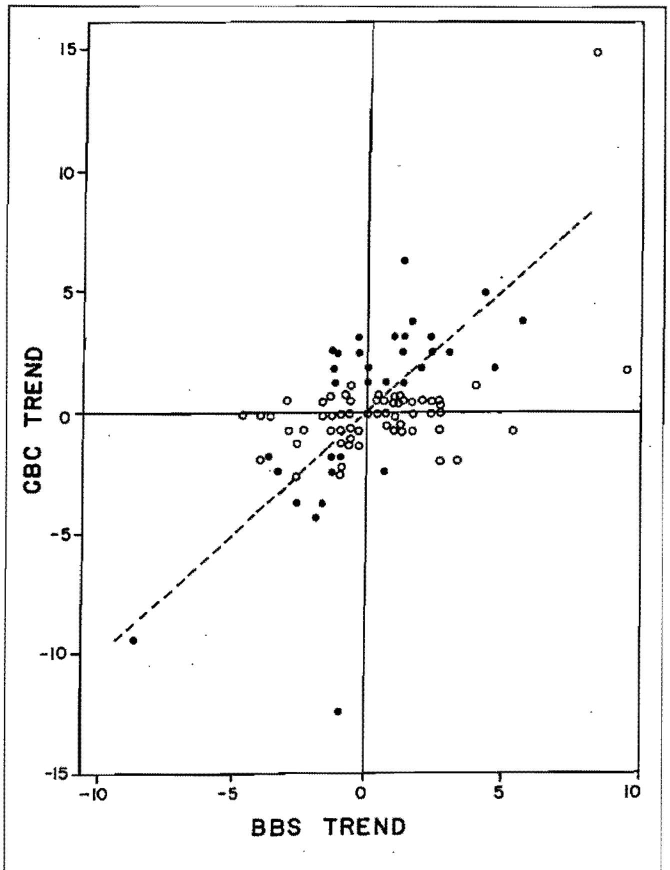
As shown in Table 1, this restriction did not make an important difference in results, suggesting that movement within the winter range may not be as serious a problem as hypothesized. If only significant CBC trends are considered, agreement with the BBS is stronger, but there is still little difference between the two sets of species.

Correlation alone is not a good indicator that two programs are tracking the same phenomena. Ideally, magnitude and direction of trends should also agree. As shown in Figure 2, this is largely the case, although there is a good deal of discrepancy for individual species. Correspondence is best for species whose CBC trends are statistically significant (solid symbols in Fig. 2). (Plots of all other comparisons to BBS that are mentioned in the text were similar, and this example was chosen for display only because it contained the largest group of species that could be shown clearly on a single graph.)

These results are another indication that the CBC does, indeed, reflect population trends. Refinements of the database might improve results further. For example, Figure 2 indicates that significant CBC trends are usually good indicators of direction of BBS trend (if not of magnitude), except that the CBC often shows a positive trend where the BBS is negative (upper left-hand quadrant of Fig. 2). However, all of those species are common feeder visitors for which CBC trends are known to be biased in an increasingly positive direction (Dunn 1995), and correction of that bias might bring results into line with BBS trends.

Assuming for the remainder of this discussion that the CBC is indeed a useful population monitoring tool, how important is it likely to be for Canadian monitoring goals? Table 2 lists the Canadian breeding species whose breeding populations are not covered by the BBS but which are frequently seen on CBCs. As indicated by the coverage codes, the majority of these species may not be well-covered by the CBC either. Numbers of coastal or oceanic species can vary widely from year to year according to sea conditions (most of the seabirds), and, indeed, CBC trends for seabirds do not match well with

Figure 2
Plot of continental trends for 1966–1988 from CBC vs. BBS (% population change per year), for species whose winter range is well-covered by the CBC. Solid symbols indicate species whose CBC trends are statistically significant ($P < 0.05$). Dashed line shows where points would fall if magnitude of trends in both surveys were equal.



fragmentary evidence from other sources (Table 2). The shorebirds winter primarily in South America, and numbers remaining in North America might well be unrepresentative of overall population trend (although CBC trends for shorebirds match reasonably well with data in Table 2 from Morrison et al., this volume). Nocturnal owls are hard to detect, and there have been changes over time in the effort put into finding them in CBCs. Finally, irruptive species occupy different portions of the winter range in different years, where there may be very different levels of CBC coverage, and the great variation in extent of irruption may mask any long-term trends.

There are eight Canadian breeding species for which the CBC is likely to be the best currently available source of trend information and whose winter ranges are also well-covered by the CBC (species capitalized in Table 2). Four of these are declining significantly according to the CBC (Long-eared Owl, Snow Bunting, Harris' Sparrow, and American Tree Sparrow[1]), suggesting that further work should be done to confirm the trends and seek the causes.

In addition, the CBC may be the best currently available source of data for certain irruptive species.

[1] Scientific names of species that are given in Tables 2 and 3 are not provided in the text.

Table 2
Canadian breeding species poorly covered by the Breeding Bird Survey but regularly seen on Christmas Bird Counts[a]

CBC coverage code[b]	Species	CBC trend[c]	Other evidence[d]
c	Pacific Loon *Gavia pacifica*	5.5	
c	Red-throated Loon *G. stellata*	−1.4	Stable[e]
c	Northern Fulmar *Fulmarus glacialis*	−3.6	
c	Northern Gannet *Sula bassanus*	6.1**	Increasing[e]
c	Great Cormorant *Phalacrocorax carbo*	0.7	Trend unclear[e]
c	Pelagic Cormorant *P. pelagicus*	−1.7	Trend unclear[e]
	Tundra Swan *Cygnus columbianus*	3.4**	Stable/increasing[f]
	Trumpeter Swan *C. buccinator*	10.4**	Stable/increasing[f]
	Greater White-fronted Goose *Anser albifrons*	7.5+	Stable/increasing[f]
	Lesser Snow Goose *Chen caerulescens caerulescens*	−2.3	Stable/increasing[f]
	Ross' Goose *C. rossii*	6.3	Increase[f]
c	Atlantic Brant *Branta bernicla hrota*	−3.4**	Stable[f]
c	Greater Scaup *Aythya marila*	−3.4**	Stable[f]
c	Common Eider *Somateria mollissima*	1.5	Stable?[f]
c	King Eider *S. spectabilis*	1.2+	Decrease?[f]
c	Black Scoter *Melanitta nigra*	3.1**	Scoters decreasing as a group[f]
c	White-winged Scoter *M. fusca*	1.4	Scoters decreasing as a group[f]
c	Surf Scoter *M. perspicillata*	1.0	Scoters decreasing as a group[f]
c	Harlequin Duck *Histrionicus histrionicus*	−0.8	Decrease[f]
c	Oldsquaw *Clangula hyemalis*	0.0	Decrease[f]
c	Barrow's Goldeneye *Bucephala islandica*	2.1	Stable/increasing?[f]
c	American Black Oystercatcher *Haematopus bachmani*	−1.1	Stable?[g]
c, s	Piping Plover *Charadrius melodus*	−0.9	Decrease[g]
c, s	Semipalmated Plover *C. semipalmatus*	1.3+	Stable?[g] Increase[h]
c, s	Black-bellied Plover *Pluvialis squatarola*	0.5	Decreasing?[g] Decrease[h]
c, s	Lesser Golden-Plover *P. dominica*	−0.7	Stable?[g] Decrease[h]
c, s	Whimbrel *Numenius phaeopus*	−0.2	Stable/decrease?[g] Increasing[h]
c, s	Greater Yellowlegs *Tringa melanoleuca*	0.6	Stable?[g]
c, s	Solitary Sandpiper *T. solitaria*	−0.2	Stable?[g]
c, s	Short-billed Dowitcher *Limnodromus griseus*	2.3	Decreasing?[g] Unclear[h]
c, s	Long-billed Dowitcher *L. scolopaceus*	9.2**	Decrease?[g]
c, s	Stilt Sandpiper *Calidris himantopus*	2.9**	Stable?[g]
c, s	Ruddy Turnstone *Arenaria interpres*	1.2*	Stable[g] Increase[h]
c, s	Black Turnstone *A. melanocephala*	−0.7	Stable?[g]
c, s	Surfbird *Aphriza virgata*	−1.2	Stable[g]
c	Purple Sandpiper *Calidris maritima*	3.7*	Stable?[g]
c, s	Red Knot *C. canutus*	3.8**	Stable/decreasing?[g] Decreasing[h]
c, s	Dunlin *C. alpina*	−1.9*	Stable?[g] Decreasing[h]
c, s	Sanderling *C. alba*	−1.3+	Stable/decreasing?[g] Decreasing[h]
c, s	Semipalmated Sandpiper *C. pusilla*	−13.7**	Stable/decreasing?[g] Decreasing[h]
c, s	Western Sandpiper *C. mauri*	−0.7	Stable?[g]
c, s	Least Sandpiper *C. minutilla*	−0.2	Stable/decreasing?[g] Decreasing[h]
c	Pomarine Jaeger *Stercorarius pomarinus*	5.5	
c	Parasitic Jaeger *S. parasiticus*	0.3	
c	Bonaparte's Gull *Larus philadelphia*	5.6**	
c	Mew Gull *L. canus*	−1.6	
c	Glaucous Gull *L. hyperboreus*	5.3	Trend unclear[e]
c	Iceland Gull *L. glaucoides*	6.3+	
c	Black-legged Kittiwake *Rissa tridactyla*	−7.3*	Mainly increasing[e]
c	Razorbill *Alca torda*	−7.9	Mainly increasing[e]
c	Common Murre *Uria aalge*	−5.9	Mainly increasing[e]
c	Thick-billed Murre *U. lomvia*	29.5**	Trend unclear[e]
c	Black Guillemot *Cepphus grylle*	1.8	Trend unclear[e]
c	Pigeon Guillemot *C. columba*	−0.4	Increasing?[e]
c	Marbled Murrelet *Brachyramphus marmoratus*	1.2	
c	Ancient Murrelet *Synthliboramphus antiquus*	0.3	Mainly decreasing[e]
c	Rhinoceros Auklet *Cerorhinca monocerata*	15.6*	
	ROUGH-LEGGED HAWK *Buteo lagopus*	−0.1	Stable?[g]
s	Peregrine Falcon *Falco peregrinus*	0.0	Increase[g]
i	Gyrfalcon *F. rusticolus*	1.9**	
	Spruce Grouse *Dendragapus canadensis*	2.8*	
n	LONG-EARED OWL *Asio otus*	−1.6*	
i	Great Gray Owl *Strix nebulosa*	0.5	
i	Snowy Owl *Nyctea scandiaca*	−0.4	
n	Eastern Screech-Owl *Otus asio*	3.0**	
n	Western Screech-Owl *O. kennicottii*	2.1**	
n	Northern Saw-whet Owl *Aegolius acadicus*	0.3	
	Northern Hawk-Owl *Surnia ulula*	−1.3*	
	Three-toed Woodpecker *Picoides tridactylus*	0.5	
	Northwestern Crow *Corvus caurinus*	2.5+	
i	Northern Shrike *Lanius excubitor*	0.2	
s	Water Pipit *Anthus spinoletta*	−2.1**	

Continued

Table 2 (*cont'd*)
Canadian breeding species poorly covered by the Breeding Bird Survey but regularly seen on Christmas Bird Counts[a]

CBC coverage code[b]	Species	CBC trend[c]	Other evidence[d]
i	Bohemian Waxwing *Bombycilla garrulus*	–1.0	
	AMERICAN TREE SPARROW *Spizella arborea*	–2.1**	
	HARRIS' SPARROW *Zonotrichia querula*	–2.2*	
	GOLDEN-CROWNED SPARROW *Z. atricapilla*	–0.8	
	LAPLAND LONGSPUR *Calcarius lapponicus*	2.1	
	SMITH'S LONGSPUR *C. pictus*	0.8	
	SNOW BUNTING *Plectrophenax nivalis*	–2.1+	
i	Common Redpoll *C. flammea*	–0.5	
i	Hoary Redpoll *Carduelis hornemanni*	–0.5	
i	Rosy Finch *Leucosticte arctoa*	–3.2	

[a] List includes species seen on >50 Christmas Bird Counts but <10 Breeding Bird Survey routes. Capitalized species are those for which the CBC is likely the best available source of trend data and which also have most or all of their winter ranges well-sampled by the CBC.
[b] Coverage code indicates that CBC samples may be inadequate because the species' winter range is largely coastal or oceanic (c) or south of the CBC coverage area (s), because the species is nocturnal (n), or because the species is irruptive (i) (see text).
[c] Continental trends for 1959–1988 (Sauer et al. 1996), expressed as percent decline per year. Asterisks indicate statistically significant trends: + = 0.05 > P < 1.0, * = P < 0.05, ** = P < 0.01.
[d] May be based on fragmentary evidence or data from one region only.
[e] Compiled from various articles in Hyslop and Kennedy (1992).
[f] Compiled from various articles in Hyslop (1996).
[g] Compiled from various articles in Hyslop (1993/1994).
[h] Morrison et al. (this volume).

These birds occupy different portions of the winter range in different years, where there may be very different levels of CBC coverage (and therefore quality of data). These variations introduce "noise" that may require decades or more of data collecting before significant overall trends can be detected; nonetheless, the CBC is all we have to work with for certain species.

The main value of CBCs for Canadian monitoring, aside from providing trend data for the eight species noted above, is to give independent evidence of trends that can be compared with results of other surveys, such as the BBS. Each program has limitations and biases, and agreement among independent data bolsters our confidence that a real population change has taken place. Such independent evidence will be particularly valuable for species that have BBS coverage in a restricted portion of the total breeding range (Table 3). For example, the strong negative CBC trend in Rusty Blackbird suggests that the parallel decrease in the BBS is not an artifact of limited sampling during the breeding season, but rather reflects range-wide decline.

There are limitations to use of the CBC for monitoring purposes, however, even if trend detection were wholly accurate. Although Canadian participation in the CBC is high relative to population density (Table 4), count sites are sparse or absent in most of the country (Fig. 1). The CBC in Canada primarily monitors resident species, which are also covered by the BBS (although this duplication can be useful). Most of the Canadian migratory species that are covered by the CBC winter primarily in the United States, where CBC coverage is generally good, but Canadians have little ability to improve that coverage if we think it desirable.

Another difficulty with CBC data arises because birds from many different breeding areas mix together on the wintering range (e.g., Dolbeer 1978). Thus, noteworthy trends can be obscured, and it may not be possible to determine whether a decline is general or restricted to a particular breeding population. On the other hand, CBC trends might bring to light problems in a particular section of the wintering ground that could be undetectable in breeding season surveys.

Despite its limitations, the CBC has a role to play in Canada's monitoring strategy. Analysis methods should be further developed in order to extract the most value from this important data set.

3. Project FeederWatch

The progenitor of PFW was the Ontario Bird Feeder Survey, begun in 1976 by the Long Point Bird Observatory. Participants counted birds at their feeders over two-day periods, once every two weeks from November to April, recording the peak number of each species seen at any one time. The aim of the survey was not to monitor populations, but to learn more about distribution and its shifts through the winter and the effects of weather, habitat, and food conditions on numbers of birds at feeders, as well as to introduce beginning birders to collecting survey data. However, results agreed encouragingly with CBC data, suggesting that feeder counts might track changes in winter abundance and distribution (Dunn 1986).

The survey was expanded North America-wide in 1987 as PFW, under the joint direction of the Cornell Laboratory of Ornithology and the Long Point Bird Observatory (now handled in Canada by Bird Studies Canada). Methods are the same as in the Ontario survey, but data are submitted on computer-readable forms that allow rapid editing and production of reports. Participants pay an annual fee that covers the cost of the project and its newsletter and which, coincidentally, tends to discourage participation by people with poor identification skills. Currently, data are submitted annually by more than 5000 people, well-distributed across the populated portions of the continent. As with CBCs, Canadian participation is especially high (Table 4), perhaps because feeding birds is more important to maintaining winter sanity in Canada than it is in warmer regions.

Table 3
Species with marginal Breeding Bird Survey coverage for which Christmas Bird Counts should be particularly valuable in documenting trends for Canadian breeding populations

Species	Trend[a] CBC	BBS
Group 1: Species in which 50%+ of North American breeding range is north of BBS coverage but substantial part of winter range is in United States and Canada		
Winter Wren *Troglodytes troglodytes*	0.7	1.5
Ruby-crowned Kinglet *Regulus calendula*	1.3**	−2.1*
Varied Thrush *Ixoreus naevius*	−0.5	5.5**
Yellow-rumped Warbler *Dendroica coronata*	1.2*	2.5**
Le Conte's Sparrow *Ammodramus leconteii*	−0.5	1.2
White-throated Sparrow *Zonotrichia albicollis*	−0.4	−1.2*
White-crowned Sparrow *Z. leucophrys*	−1.9**	−2.2**
Fox Sparrow *Passerella iliaca*	0.2	2.4*
Rusty Blackbird *Euphagus carolinus*	−9.4**	−8.7**
Group 2: Species in which 50%+ of Canadian breeding range is north of BBS coverage but substantial part of winter range is in United States and Canada		
Bald Eagle *Haliaeetus leucocephalus*	1.7*	4.5
Northern Harrier *Circus cyaneus*	−0.5	−0.5
Sharp-shinned Hawk *Accipiter striatus*	1.6**	0.0
Red-tailed Hawk *Buteo jamaicensis*	2.3**	1.8**
Short-eared Owl *Asio flammeus*	−2.1**	−0.2
Northern Flicker *Colaptes auratus*	−0.9*	−3.1**
Eastern Phoebe *Sayornis phoebe*	0.6	−0.6
Horned Lark *Eremophila alpestris*	−1.3	−0.5
American Crow *Corvus brachyrhynchos*	3.3**	0.9+
Golden-crowned Kinglet *Regulus satrapa*	2.4**	−1.1
Townsend's Solitaire *Myadestes townsendi*	1.6*	3.2
Hermit Thrush *Catharus guttatus*	0.9	1.6+
American Robin *Turdus migratorius*	0.5	1.1*
Savannah Sparrow *Passerculus sandwichensis*	−0.4	−0.5
Song Sparrow *Melospiza melodia*	−0.2	−1.2**
Chipping Sparrow *Spizella passerina*	1.1	−0.2
Dark-eyed Junco *Junco hyemalis*	−1.0	−0.6
Swamp Sparrow *Melospiza georgiana*	−0.5	0.9

[a] Trend for 1966–1988, expressed as percent decline per year. Significance symbols as in Table 2.

Table 4
Distribution of winter count sites (in year indicated)

Region[a]	No. of counts/million people CBC (1991)	PFW (1992)
Far North	53	47
Canadian provinces	9	29
Northern U.S.	6	17
Southern U.S.	5	8

[a] Far North = Alaska, Yukon, and Northwest Territories for CBC, and Alaska only for PFW. Southern U.S. = Arizona east to North Carolina and all states to south (California is classified as "northern U.S.").

Mourning Dove *Zenaida macroura*, House Finch *Carpodacus mexicanus*, Pine Siskin *Carduelis pinus*, and American Goldfinch *C. tristis* increased significantly at feeders from 1976 to 1988 in Ontario, where there has been the longest feeder survey coverage. All but the latter species also increased in Ontario over the same period according to the CBC, but the CBC further documented significant increases in Black-capped Chickadee *Parus atricapillus* and White-breasted Nuthatch *Sitta carolinensis* that feeder counts did not record (Dunn 1991). House Sparrows *Passer domesticus* declined in Ontario feeder counts, in agreement with breeding survey data from some parts of eastern Canada.

Although PFW does show trends that may reflect population change, its role as a monitoring tool is still uncertain. The similarity of feeder count and CBC data (Dunn 1986, 1991, and unpubl. data) is not an entirely satisfactory test, because CBC results include feeder counts and are therefore not wholly independent sources of data. Both surveys could be biased if birds increase attendance at feeders during winters with deep snow or natural food shortage, making numbers appear to increase even when population size is relatively low.

Most of the 89 species that routinely visit feeders in North America are resident year-round or are short-distance migrants that are well-covered by the BBS, so it should be possible to compare PFW with BBS trends in order to test the validity of feeder counts for population monitoring. This will likely be done once PFW has accumulated enough years of data. However, even if more careful analysis indicates that feeder counts produce sound data on population trends, PFW will remain a lower priority for monitoring purposes than CBCs, because it covers relatively few species.

The primary value of PFW for monitoring may be in its ability to track irruptive species through the entire winter season (i.e., those species that move south into populated parts of Canada only periodically). It is difficult to detect long-term trends in species with high annual fluctuation, but at least PFW provides more consistent annual indices than CBCs, because the latter often miss late-winter invasions entirely.

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Monitoring Canada's landbirds — an integrated approach

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Abstract

Canada is moving towards a system of integrated monitoring. This country's population monitoring programs are run by a variety of groups and have different goals. There is a need for coordination and communication to identify and fill gaps in species and geographic coverage and types of data. Data collection techniques and analysis methods need work to make results more robust and to promote comparison of results among surveys. Results must be disseminated if they are to play a role in conservation decisions. Canada's goals and a framework for monitoring landbirds are outlined in the *Canadian Landbird Monitoring Strategy*. The Canadian government has statutory responsibilities for the management of migratory birds, and the Canadian Wildlife Service expects to play a major role in the development of integrated monitoring.

Résumé

Le Canada s'approche peu à peu d'un système de surveillance intégré. Divers groupes poursuivent des programmes recensant la population canadienne et visent des objectifs variés. Une certaine coordination et la communication s'avèrent nécessaires si on veut cerner et combler les lacunes au niveau des espèces et des régions couvertes ainsi que des données diffusées. Les techniques de collecte des données et les méthodes d'analyse se doivent d'être améliorées afin d'accroître l'utilité des résultats et d'en promouvoir la comparaison d'une enquête à l'autre. Il faut aussi communiquer les résultats pour qu'ils jouent un rôle dans les décisions en matière de conservation. La stratégie nationale de surveillance des oiseaux terrestres décrit les objectifs canadiens et établit le cadre d'un programme de surveillance des oiseaux terrestres. De par la loi, la gestion des oiseaux migrateurs incombe au gouvernement fédéral et le Service canadien de la faune s'attend à ce que celui-ci joue un rôle capital dans l'élaboration d'un programme de surveillance intégré.

1. Introduction — the need for integrated monitoring

In Canada, there is a wide variety of population surveys for birds, reflecting a diversity of groups involved in monitoring (see preceding papers in this volume). For example, the Canadian Wildlife Service conducts population and harvest surveys on waterfowl and coordinates volunteer-based programs such as the Maritimes Shorebird Survey, the Breeding Bird Survey (BBS), and the Ontario Forest Bird Monitoring Program (FBMP) for landbirds. Provincial and territorial wildlife agencies have a growing interest in bird monitoring, particularly in relation to the effects of land use on wildlife. Cooperative efforts between government and nongovernmental organizations (NGOs) have helped establish such programs as the Canadian Migration Monitoring Network and the Marsh Monitoring Program. Canada has a rich history of naturalist clubs in every province in which birds are often a primary interest. Careful records kept by these groups and individuals have made major contributions to our knowledge of bird distribution and abundance in this country.

This diversity of surveys exists for many reasons. Some programs were developed to provide information on a specific group of birds for management purposes (e.g., the waterfowl population and harvest surveys used to set hunting regulations). Others, such as the Christmas Bird Count (CBC), began as a community social event and only later added a degree of standardization and began to be used as a source of information on bird populations. Canada's various surveys are also designed to gather information at different geographic scales and levels of precision. Figure 1 provides examples of landbird surveys, ranging at one end of the scale from geographically broad-based surveys (e.g., breeding bird atlases), through habitat-specific surveys (e.g., the FBMP) that can be interpreted at a regional or site level, to those specifically designed to gather information on individual pairs of birds (e.g., the Nest Records Schemes).

Despite this diversity of interests in monitoring, there is a common shared goal: conservation of birds. The Canadian ornithological community now needs to develop a higher level of cooperation, so that accurate information about population trends can be gathered and used to help develop appropriate conservation action. This should involve government agencies responsible for wildlife and land management, other professionals in the academic and NGO communities, and the birding public who actively participate in surveys. Cooperative efforts will also require development of specific goals and an

Figure 1
Spatial and measurement scales for songbird monitoring programs. BBS = Breeding Bird Survey; FBMP = Forest Bird Monitoring Program; MAPS = Monitoring Avian Productivity and Survival

Geographic Scale	Country ⟷ Province ⟷ Region ⟷ Local area ⟷ Site					
Program	**Atlas**	**Migration Monitoring**	**BBS**	**FBMP**	**MAPS**	**Nest Records**
Measurement Scale	Presence absence	Relative abundance	Relative abundance	Site-specific relative abundance	Productivity & survival	Individual productivity & survival

administrative structure that will ensure continued coordination and communication. Through such a shared initiative, greater efforts can be put into effective conservation than if this were the sole responsibility of one agency.

The main steps in managing wildlife populations are to (1) establish management objectives, (2) monitor populations, (3) assess results and establish priorities for further action, (4) conduct applied research as necessary, and (5) take conservation action as needed. There are, of course, many feedback loops in this series of steps.

This paper discusses one step in such a management scheme: monitoring. It summarizes the current needs and describes initiatives for achieving a nationwide monitoring program that will provide accurate information on population trends for all Canadian birds. We concentrate on issues related to landbirds.

2. Government perspective on integrated monitoring

Under the Migratory Birds Convention, signed over 80 years ago, Canada recognized the important role that migratory birds play in the ecosystem, and the federal government assumed responsibility for their conservation and protection. Much of the attention in the federal government has historically been directed towards game birds and the obvious need for management of populations that are hunted. The Canadian Wildlife Service also coordinates some monitoring for nongame birds, but, with the number of issues surrounding nongame bird conservation, there is clearly more work needed.

In recent years, the federal government's interest in monitoring bird populations has become both more formal and more generalized. For instance, the *Canadian Biodiversity Strategy* (Environment Canada 1995), drafted in response to the 1992 signing of the international Framework Convention on Biological Diversity, contains directives for the development and implementation of monitoring programs and the conservation of habitat. Responsibilities for monitoring are also outlined in *A Wildlife Policy for Canada* (Environment Canada 1990), drafted with participation from the federal, provincial, and territorial governments, Aboriginal organizations, wildlife professionals, and the general public. *A Wildlife Policy for Canada* recognizes the need for a national program for monitoring the status of, and trends in, biodiversity.

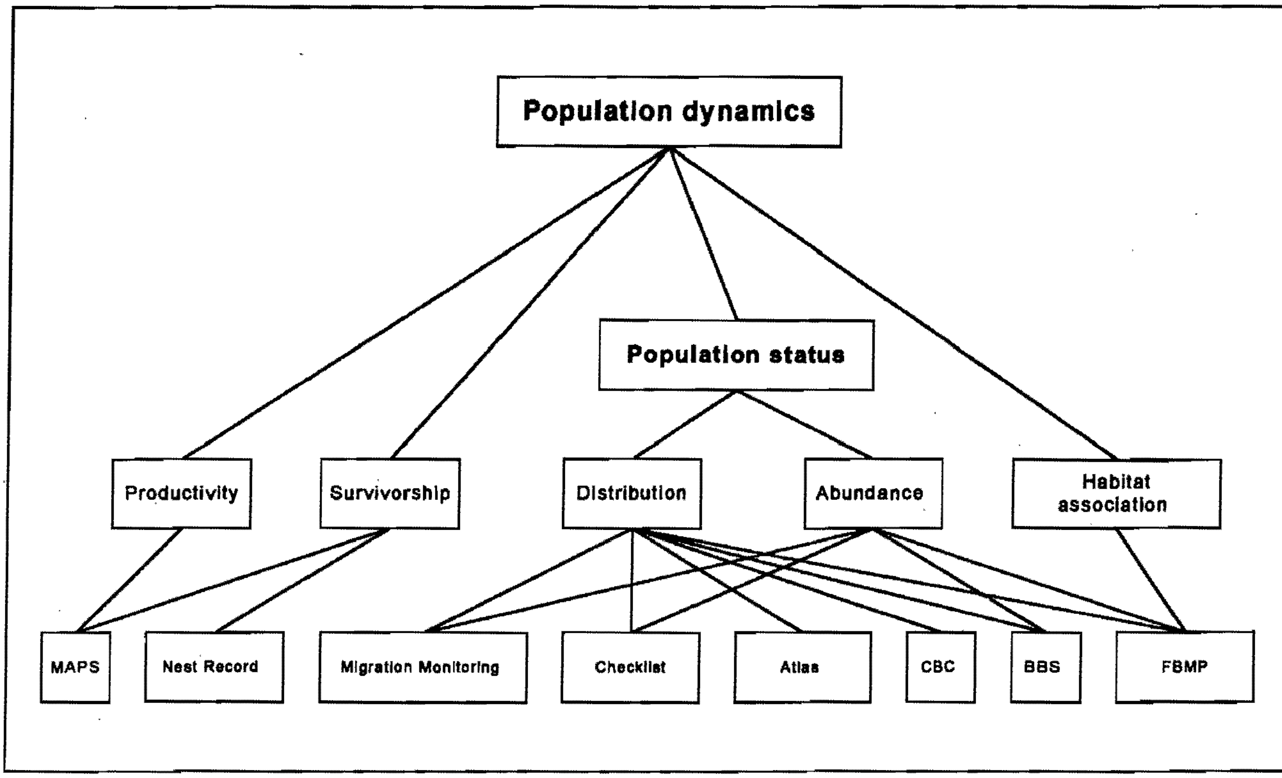
In 1996, a document was released that outlines national and regional needs and initiatives that support landbird conservation in Canada: *A Framework for Landbird Conservation in Canada* (Environment Canada 1996a). One of those initiatives was the release in 1994 of the *Canadian Landbird Monitoring Strategy* (Environment Canada 1994). This strategy was developed in consultation with government, NGOs, and the public. It provides a framework for integrating landbird monitoring activities, whether conducted by government or other groups, and recommends a suite of surveys best suited to providing data on the status, population trends, and population dynamics of landbirds.

The *Canadian Landbird Monitoring Strategy* also encourages the development of regional monitoring plans that will contribute to and build on the national strategy. For example, Ontario has adopted and adapted the national strategy to include surveys that fulfill regional needs (Environment Canada 1996b). Such an approach has proved successful in encouraging cooperation and communication among organizations, promoting the thorough evaluation of survey techniques, identifying data gaps, and developing regional monitoring strategies. The *Canadian Landbird Monitoring Strategy* has helped encourage volunteer participation by publicizing the need for volunteers and providing summaries of the major monitoring activities, thus allowing volunteers to select surveys most suited to their skills and interests.

3. Components of an integrated monitoring program

The term "integrated monitoring" is used to describe a coordinated approach to bird monitoring. Because there are many players involved in monitoring birds in Canada, at many geographic levels, a coordinated approach is needed if we are to identify important gaps in our knowledge and avoid duplication in coverage that is wasteful of human and financial resources. Each program makes its own individual contribution to our understanding of the status of bird populations, but each becomes far more valuable when it is joined with others. Putting all the different contributions together is a major goal of an integrated monitoring program. The integrated results of monitoring need to be publicized and acted upon where conservation action is indicated. Individual project organizers may do this admirably with their own data, but some larger, coordinating group needs to do it with the integrated data. Finally, all parties engaged in monitoring can cooperate in designing and disseminating training programs for the people who collect data, as the techniques are similar across many monitoring programs.

Figure 2
Contributions of surveys recommended by the *Canadian Landbird Monitoring Strategy* to the assessment of landbird population dynamics



Below are some of the issues a good integrated monitoring program should address.

3.1 Coverage

Ideally, we should have routine monitoring in place that covers every species and geographic area and which generates data for all key aspects of population dynamics (i.e., abundance, distribution, productivity, survivorship). Although this ideal situation will never be possible, we should ensure that, at a minimum, we track abundance in as many species as possible, in all major biogeographic areas. In Canada, data collection for those species monitored through volunteer surveys tends to be concentrated in the south, where volunteers are more plentiful. The territories, Newfoundland, and the northern parts of most provinces are not well-covered. Boreal- and tundra-breeding songbirds are not well-monitored, and there are also gaps in species coverage for groups such as nocturnal birds, some marsh species, and rare and secretive birds. The assessment of coverage and identification of data gaps are ongoing functions of a good monitoring program.

3.2 Addressing causes of population change

Monitoring the abundance of birds provides information on population trends and changes in distribution and is the primary goal of a monitoring program. However, it is also necessary to understand the causes of such change. Surveys that collect data on productivity and survivorship can provide clues to the causes of change by indicating whether changes are accompanied by shifts in natality or mortality. For landbirds, there are several surveys that potentially provide such information, although their ability to do so has not yet been evaluated (e.g., the Monitoring Avian Productivity and Survivorship [MAPS] program, Nest Records Schemes, and Migration Monitoring; Fig. 2). More work is needed in the development and evaluation of surveys to provide good demographic data for landbirds. For waterfowl, the collection of productivity and survivorship information is incorporated into the design of some major monitoring surveys. Because of logistic difficulties in monitoring shorebirds and seabirds, the collection of productivity and survival information has usually been addressed through specific research projects rather than ongoing monitoring programs, but Nettleship (elsewhere in this volume) describes systematic demographic sampling for seabirds.

Clues to causes of population change can also be obtained by contrasting the results of surveys with different designs. For example, if results from both the BBS (which monitors species in a variety of habitats) and the FBMP (which monitors birds in forest habitat) indicate that a species is declining, this suggests that loss of forest habitat in the breeding area is not the main cause.

Although monitoring may provide some clues as to the causes of worrisome changes, its main value in this area lies in helping us assess the status of species and set priorities for further research and conservation attention. Because our financial and logistic resources are limited, emphasis should be placed on understanding the ecology and population dynamics of those species that monitoring tells us are in trouble, so we will know what conservation action will be most effective.

3.3 *Assessing surveys*

One of the aims of an integrated monitoring program is to assess the quality of surveys and reduce duplication of efforts. However, some degree of overlap among surveys can be useful. Several landbird surveys contribute information on bird abundance, for example (Fig. 2), but each survey tracks a somewhat different set of species, thus filling in gaps in species coverage. For those species that are duplicated, such data will allow cross-checking and reinforcement of results. Because each survey uses different methods and has different biases, we may never be completely confident in any one survey's ability to monitor trends; however, when the results of several independent surveys are in agreement, it reinforces the conclusion that an actual change in population has occurred. When results disagree, it forces a closer examination of survey techniques and interpretation of results. Some valuable comparisons have recently been made among surveys (Dunn and Hussell 1995; Dunn et al., in press; several papers in this volume).

3.4 *Analyzing and distributing raw data*

To ensure that surveys provide precise, unbiased information, there is a need to refine survey techniques for the collection of data and to develop and use appropriate statistics for the analyses of data. Comparisons of analytical techniques have been discussed in this symposium in relation to the Maritimes Shorebird Survey (Morrison et al., this volume), and there are comparisons for the BBS (James et al. 1996; Sauer et al. 1996; Thomas 1996). New surveys will benefit from this sort of rigorous approach to data analysis.

If monitoring results are to be integrated, data from all surveys must be readily accessible. A balance is needed between encouraging the use of the data for conservation purposes, restricting access to sensitive data, and respecting ownership of certain databases. Nonetheless, for most surveys we should ensure at least that data are on computer and up-to-date. Databases should use software that is commonly available, and routine reporting and summary programs should be developed. In most surveys, the database is managed by the respective coordinating organization, and advances in computer technology should ensure broader access to electronic databases.

Ideally, a coordinated monitoring program would also ensure that data would be available for population modelling. However, this has very rarely been done, even for common species (Marchant et al. 1990). Some integration of data has been done for rare species (e.g., species status reports developed for the Committee on the Status of Endangered Wildlife in Canada). There are several roadblocks to more extensive integration of results. First, many questions remain about the appropriate statistical techniques for integrating data of different types and from different sources. Perhaps more importantly, however, there are insufficient data from multiple surveys for most Canadian species to allow extensive integration of results. As examples, there are very few mortality and natality data for most passerines, and often population trend data are available only for one season (summer, migration, or winter, but not all three).

3.5 *Promoting conservation action*

Monitoring is not a goal in itself, but rather is one step towards effective bird conservation. Using results of monitoring from a variety of sources, a commonly agreed-upon list of species of concern should be developed to help establish conservation priorities. At this stage, the need for applied research and the development of conservation action plans for particular species can be determined in relation to established management objectives. Finally, an integrated monitoring program plays an important role after conservation action has taken place. Monitoring is the means of reassessing the status of species on an ongoing basis and demonstrating whether conservation action has had the desired effect on population size.

An integrated monitoring program should also strive to make results and their interpretation widely available, as these are usually more valuable than raw data to users. Summaries of bird population trends must be published regularly if the data are to be of use in decision making by wildlife managers and conservationists. In response to this need, the Canadian Wildlife Service publishes the annual newsletter *Bird Trends* (Hyslop 1996) to report on population trends of all Canadian bird species and to publicize sources of data. The newsletter is sent to a broad audience of professional and amateur ornithologists. To keep volunteer participants interested, regular feedback on survey results is important, and most volunteer-based surveys publish their own newsletters.

3.6 *Training*

Finally, training of volunteers is essential if an active monitoring program is to continue into the future, as so many of our important surveys rely on skilled volunteer help. In Canada, the pool of committed, highly skilled birders is relatively small, and many individuals are already overworked. If monitoring programs are to continue and expand, a means of training potential participants in bird identification and survey techniques is required to encourage new recruits.

4. Conclusions

Although there are currently many monitoring programs in Canada, there is much more that needs to be done to fill in data gaps for species and geographic coverage, improve analytical techniques, and integrate resulting data. Increased communication and cooperation among government, academia, and NGOs will be a key component in the development of a comprehensive system of bird monitoring in Canada.

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