Migratory game bird hunters and hunting in Canada

edited by
H. Boyd and G. H. Finney

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A hunter and his dog with decoy geese at Delta Marsh, southern end of Lake Manitoba. Photo by J. Ford Bell

Contents

Canada Geese in the vicinity of Grassy Island Lake, near Consort, in east-central Alberta. Photo by G. W. Beyersbergen

Introduction

by H. Boyd

Foreword

A number of abbreviations and notations appear throughout this publication. Most are explained at first mention in each paper. To ensure there is no ambiguity, some of the conventions are explained here also.

The most frequently used abbreviations are CWS (Canadian Wildlife Service), NHS (National Harvest Survey) and SCS (Species Composition Survey).

"Season" refers to hunting season, unless otherwise indicated.

Each hunting season is identified by the year in which that season begins, even though the season extends into the following calendar year. For example, the hunting season that begins in September 1975 and ends in March 1976 is referred to as the 1975 hunting season. Notations such as 1976-77 refer to two different seasons: the 1976-77 hunting season and the 1977-78 hunting season.

"Permit" refers to the Canada Migratory Game Bird Hunting Permit, unless otherwise indicated.

The scientific names of species mentioned in this text are listed in the Glossary on page 125.

Unless otherwise indicated, all authors are with the Migratory Birds Branch, Canadian Wildlife Service, Ottawa K1A 0E7.

In Canada provincial governments are responsible for natural resources, with two notable exceptions in cases where the resources are shared internationally as well as between two or more provinces. One of these international exceptions is the protection and wise use of migratory birds, which in 1916 became the subject of the Migratory Birds Convention between the United States of America and Great Britain on behalf of Canada. The federal responsibilities under that convention were embodied in the Migratory Birds Convention Act of 1917 and the methods of conservation are further spelled out in the Migratory Birds Regulations proclaimed annually under the act. Although the fundamental purpose of the convention and act is to authorize activities intended to preserve species from extinction and unwarranted destruction, several groups of species, termed "migratory game birds" in the convention, are identified as the legitimate quarry of people hunting for subsistence or recreation. The convention set limits to the times of year when migratory game birds could be hunted, with a general prohibition on hunting between 10 March and 1 September (with some exceptions for Indian subsistence hunters) and a maximum open season length in any one region of three and a half months within those five and a half months. The act and regulations also make it possible to impose bag limits on the numbers of birds that can be taken in one day or held in possession.

At first, season lengths and bag limits were large. With the growth of the population more people hunted. As their quarry seemed to become scarcer, the limits began to be reduced. Remarkable as it may now seem, decisions about the appropriate limits were made for nearly 50 years without any extensive and systematic collection of information about the numbers of the quarry species or about the hunters and their kill. Eventually it became obvious that management in ignorance, however well-intentioned, was unsatis-

factory. The need was felt first in the United States, with its much larger human population. Growing competition in many areas for evidently dwindling supplies of ducks and other migratory game birds made more stringent regulation of hunting necessary. The United States also took the lead in exploring ways of monitoring the numbers of breeding waterfowl and their breeding success. As it was obvious that most waterfowl were breeding in Canada, especially after the destruction of much of the productive habitat in the northern United States, the U.S. Fish and Wildlife Service (USFWS) obtained the consent and support of the federal and provincial governments to monitoring breeding in Canada. After exploration, mostly by aerial surveys, a large-scale monitoring program was made operational in 1955 and has continued and improved ever since.

Shortly afterwards, the USFWS embarked on an ambitious national survey of migratory game bird hunters and hunting, using questionnaires mailed annually to large numbers of hunters identified by means of the purchase of "duck stamps" (Migratory Bird Hunting and Conservation Stamps). An up-to-date account of the U.S. system and its principal results have been provided in the environmental assessment statement prepared in 1975 by USFWS to meet the requirements of the (U.S.) Natural Environmental Policy Act.

Five years or so behind the United States, Canada embarked in 1966 on the systematic collection of national statistics concerning hunters of migratory game birds and their impact on various species. This report describes the genesis and development of the Canadian national migratory game bird surveys and summarizes some of the principal results. In addition to providing national statistics, the survey system as now refined can be used to look at specific problems and ones principally of local or regional interest. This report looks at some of these additional uses and some possibilities of the system.

Thanks primarily to the co-operation of the great body of hunters who provide remarkably reliable information about their activities, and secondarily to the skill of the little group of people who have designed and refined the surveys, and the larger, but still very small, group who have carried them out, we believe that Canada has the best surveys of migratory game bird hunters and hunting in the world. We are not blind to the many possible sources of bias that remain or to the imprecision of some of our estimates. We know that the surveys are blunt instruments and that the fields in which they are used are complex and variable. Because of limited resources and the nature of the subject, it will probably not be practicable to effect further great increases in the accuracy or precision of the information yielded by the surveys we describe. Nor can they provide more than a small, though a highly significant, part of the information needed to ensure that the migratory game birds of Canada continue to flourish and to provide Canadians — and others — with recreation and food.

Most of the information collected by the national surveys emerges in the form of numbers, frequently quite large ones and sometimes calculated in tedious, though basically very simple, ways. We would be foolish to suppose that the results make exciting reading, although we have tried to avoid jargon and unnecessary obscurity. Our aim is to provide a reliable account of the basic facts that have emerged from the first decade of the national migratory game bird surveys, and to suggest how we hope to develop more effective probes for finding out not only what is happening but why, and to work towards a genuine craft of migratory game bird management as the need for it grows. While it is still possible for us (thanks to the natural abundance of Canada and the relatively small number of Canadians) to get away with very primitive activities based on a meagre and outmoded theoretical framework, there cannot be many years left before difficult decisions and hard bargaining will be necessary. We offer this modest first collection not only for the use of natural resources administrators and managers in both levels of governments but, more importantly, to all Canadians, whether or not they be hunters, who have an interest in the continual well-being of some of Canada's most spectacular assets.

Part 1
The survey system

The Canada Migratory Game Bird Hunting Permit and associated surveys

by F. G. Cooch, S. Wendt,
G. E. J. Smith, and G. Butler

1. Abstract

The obligatory purchase of a permit by hunters of migratory birds was introduced in 1966 to provide a basis for obtaining annual information about the numbers of hunters, their activities, and the kinds and numbers of birds they kill. This is an account of the purposes and functioning of the permit system, the National Harvest Survey, and the Species Composition Survey as they were in 1977. Developments and improvements made since the inception of the surveys in 1967, intended to increase their usefulness, reliability, and efficiency and to reduce their costs, are described. The principal results of the surveys are summarized.

2. Introduction

Sound management of migratory game bird hunting in North America, like any other system of intensive exploitation of a renewable resource, depends on reliable information about what is happening to the stocks and among the exploiters. The recognition of the need for reliable nationwide information in Canada led the provincial and federal governments to agree to collect appropriate data. The decisive step was taken in 1966, when it became obligatory for a would-be hunter of migratory game birds to possess a Canada Migratory Game Bird Hunting Permit.[1] Although a nominal fee ($2.00) was charged for the permit, its purpose was not to raise revenue but to provide a register of hunters who could be asked for information about their hunting, particularly the species and numbers of migratory birds killed.

The introduction of the annual permit in 1966 was followed in 1967 by that of the National Harvest Survey (NHS) and the Species Composition Survey (SCS). The NHS is carried out by means of mail questionnaires sent to selected permit purchasers, who provide data on their hunting activity and success, and on the species of birds they take. For the SCS, other permit purchasers supply wings and tail-fans so the age and sex composition of the kill can be calculated.

By 1968 all these activities were computerized. Benson (1971*a*) summarized the purposes of the permit and surveys, described the survey procedures, and reported some of the major results obtained up to 1969.

The development of efficient, effective and reliable mail surveys is far from easy. Since that initial review a great deal of work has gone into the improvement and expansion of the surveys. This report describes the permit and survey systems in 1977, some of the problems identified to date, and how we have dealt with them. It also reviews the results and discusses the limitations of the surveys. The papers which follow this one describe, in greater detail, some of these survey results and their bearing on migratory game bird management in Canada and North America.

Information on hunting collected annually can never be as detailed and reliable as managers would like. Yet, now that data from a run of years are available, we can identify significant variations in effort, success, and kill in different parts of the country. Gradually it will become possible to identify the causes of these variations and so, we hope, replace the conventional wisdom of hunters and administrators with a more objective and effective basis for decision-making.

3. The present national permit and survey system

The possession of a valid permit is required by all hunters of migratory game birds except Indians, Inuit and, in the N.W.T., other holders of a General Hunting Licence. Those qualifications mean that a substantial number of hunters are omitted from the permit and survey system. To some native people, migratory birds are important for subsistence for short periods of the year and are taken in relatively large numbers; many other native people make little or no use of migratory birds (section 6.3.). Hunters who do not buy a permit or who otherwise hunt illegally are also not considered. Their impact on migratory game bird populations is not well known, but illegal kill apparently varies substantially among regions (section 6.2.).

Despite these deficiencies, our data cover most migratory game bird hunting in Canada and provide an index to fluctuations in hunting activity, which we hope is adequate for the purposes of continental management of migratory game birds.

3.1. The Canada Migratory Game Bird Hunting Permit

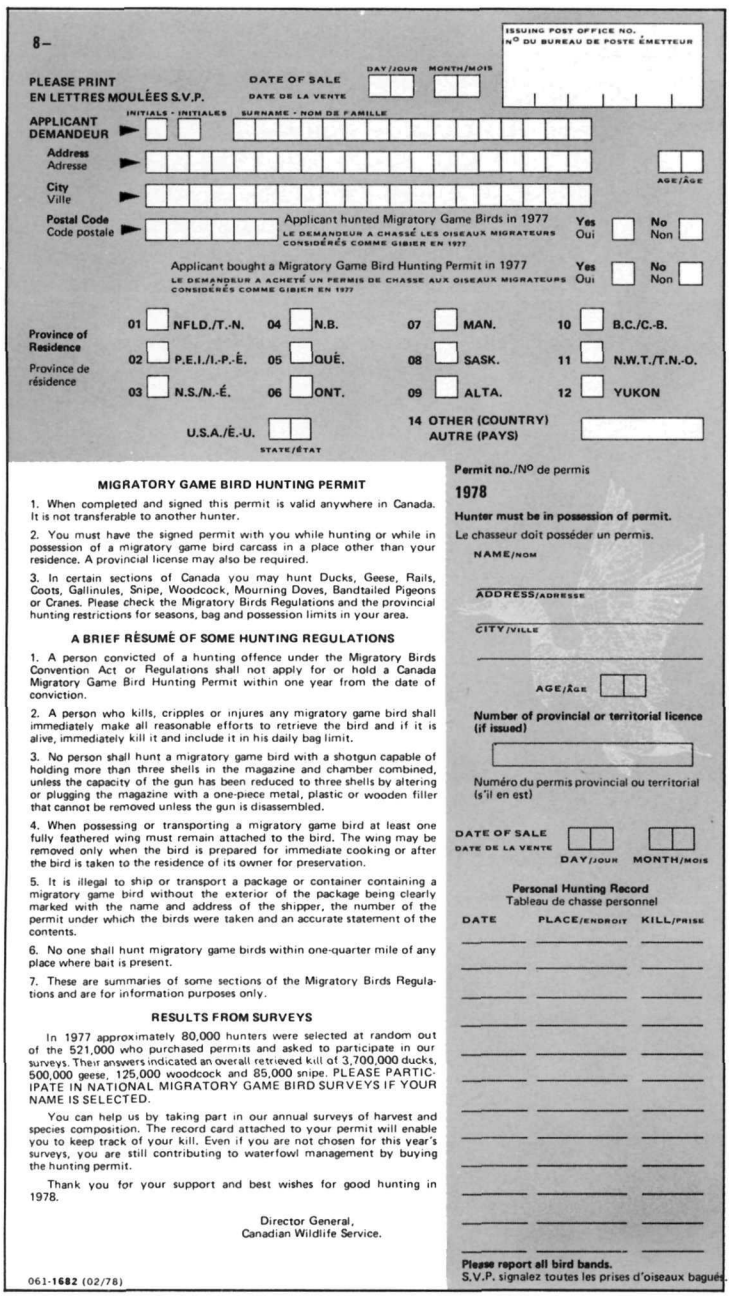
Permits are sold primarily at post offices throughout Canada, from August to March. Attached to each permit (Fig. 1) is a postcard which the postmaster tears off, completes with information about the purchaser, and mails to the Canadian Wildlife Service (CWS), Ottawa. The information from this card is used to build a file of all permit purchasers on magnetic tape. The postcard provides eight pieces of information: permit number, date of sale, identifying number of the issuing post office, the name and address of the hunter, age of hunter, whether the hunter hunted migratory game birds during the previous year, whether he bought a permit that year, and the province, state or country of residence.

The initial decision to issue uniquely numbered permits to hunters, rather than unnumbered "duck stamps" as in the United States, was one of fundamental importance. It made possible the establishment of a sampling universe for the selection of hunters to receive NHS questionnaires and parts envelopes for the SCS.

The post office uses the computerized record of permit purchasers (Permit File) as an aid in its audit of sales by individual post offices. The Permit File is also used by CWS staff to help the Royal Canadian Mounted Police (RCMP) and provincial enforcement officers, to whom enforce-

[1] Unless otherwise indicated, "permit" refers to a Canada Migratory Game Bird Hunting Permit in this paper.

Figure 1
A sample of the 1977 Migratory Game Bird Hunting Permit application form (two sides)



8–

ISSUING POST OFFICE NO. / N° DU BUREAU DE POSTE ÉMETTEUR

PLEASE PRINT / EN LETTRES MOULÉES S.V.P.

DATE OF SALE / DATE DE LA VENTE — DAY/JOUR — MONTH/MOIS

APPLICANT / DEMANDEUR — INITIALS · INITIALES — SURNAME · NOM DE FAMILLE

Address / Adresse

City / Ville — AGE/ÂGE

Postal Code / Code postale

Applicant hunted Migratory Game Birds in 1977 / LE DEMANDEUR A CHASSÉ LES OISEAUX MIGRATEURS CONSIDÉRÉS COMME GIBIER EN 1977 — Yes / Oui — No / Non

Applicant bought a Migratory Game Bird Hunting Permit in 1977 / LE DEMANDEUR A ACHETÉ UN PERMIS DE CHASSE AUX OISEAUX MIGRATEURS CONSIDÉRÉS COMME GIBIER EN 1977 — Yes / Oui — No / Non

Province of Residence / Province de résidence

01 NFLD./T.-N. 04 N.B. 07 MAN. 10 B.C./C.-B.
02 P.E.I./I.-P.-É. 05 QUÉ. 08 SASK. 11 N.W.T./T.N.-O.
03 N.S./N.-É. 06 ONT. 09 ALTA. 12 YUKON
U.S.A./É.-U. — STATE/ÉTAT — 14 OTHER (COUNTRY) / AUTRE (PAYS)

MIGRATORY GAME BIRD HUNTING PERMIT

1. When completed and signed this permit is valid anywhere in Canada. It is not transferable to another hunter.

2. You must have the signed permit with you while hunting or while in possession of a migratory game bird carcass in a place other than your residence. A provincial license may also be required.

3. In certain sections of Canada you may hunt Ducks, Geese, Rails, Coots, Gallinules, Snipe, Woodcock, Mourning Doves, Bandtailed Pigeons or Cranes. Please check the Migratory Birds Regulations and the provincial hunting restrictions for seasons, bag and possession limits in your area.

A BRIEF RÉSUMÉ OF SOME HUNTING REGULATIONS

1. A person convicted of a hunting offence under the Migratory Birds Convention Act or Regulations shall not apply for or hold a Canada Migratory Game Bird Hunting Permit within one year from the date of conviction.

2. A person who kills, cripples or injures any migratory game bird shall immediately make all reasonable efforts to retrieve the bird and if it is alive, immediately kill it and include it in his daily bag limit.

3. No person shall hunt a migratory game bird with a shotgun capable of holding more than three shells in the magazine and chamber combined, unless the capacity of the gun has been reduced to three shells by altering or plugging the magazine with a one-piece metal, plastic or wooden filler that cannot be removed unless the gun is disassembled.

4. When possessing or transporting a migratory game bird at least one fully feathered wing must remain attached to the bird. The wing may be removed only when the bird is prepared for immediate cooking or after the bird is taken to the residence of its owner for preservation.

5. It is illegal to ship or transport a package or container containing a migratory game bird without the exterior of the package being clearly marked with the name and address of the shipper, the number of the permit under which the birds were taken and an accurate statement of the contents.

6. No one shall hunt migratory game birds within one-quarter mile of any place where bait is present.

7. These are summaries of some sections of the Migratory Birds Regulations and are for information purposes only.

RESULTS FROM SURVEYS

In 1977 approximately 80,000 hunters were selected at random out of the 521,000 who purchased permits and asked to participate in our surveys. Their answers indicated an overall retrieved kill of 3,700,000 ducks, 500,000 geese, 125,000 woodcock and 85,000 snipe. PLEASE PARTICIPATE IN NATIONAL MIGRATORY GAME BIRD SURVEYS IF YOUR NAME IS SELECTED.

You can help us by taking part in our annual surveys of harvest and species composition. The record card attached to your permit will enable you to keep track of your kill. Even if you are not chosen for this year's surveys, you are still contributing to waterfowl management by buying the hunting permit.

Thank you for your support and best wishes for good hunting in 1978.

Director General,
Canadian Wildlife Service.

061-**1682** (02/78)

Permit no./N° de permis

1978

Hunter must be in possession of permit.
Le chasseur doit posséder un permis.

NAME/NOM

ADDRESS/ADRESSE

CITY/VILLE

AGE/ÂGE

Number of provincial or territorial licence (if issued)

Numéro du permis provincial ou territorial (s'il en est)

DATE OF SALE / DATE DE LA VENTE — DAY/JOUR — MONTH/MOIS

Personal Hunting Record
Tableau de chasse personnel

DATE	PLACE/ENDROIT	KILL/PRISE

Please report all bird bands.
S.V.P. signalez toutes les prises d'oiseaux bagués.

Business Reply Mail
No Postage Stamp Necessary if mailed in Canada
Postage will be paid by

Correspondances réponses d'affaires
Se poste sans timbre au Canada
Le port sera payé par

POSTES CANADA POSTAGE — DOE / MDE 1

Director General,
Canadian Wildlife Service,
Department of Fisheries and the Environment
Ottawa, Canada
K1A 0E7

Le directeur général,
Service canadien de la faune,
Ministère des Pêches et de L'Environnement
Ottawa, Canada
K1A 0E7

CANADA — **HUNTING PERMIT** — **PERMIS DE CHASSE** — **$3.50**

SIGNATURE

Permit is not transferable — Le permis est strictement personnel

MIGRATORY GAME BIRD HUNTING PERMIT

PERMIS DE CHASSE aux OISEAUX MIGRATEURS CONSIDÉRÉS COMME GIBIER

Valid during open season until March 10, 1979.

En vigueur jusqu'au 10 mars 1979 durant les saisons de chasse.

ISSUED UNDER THE MIGRATORY BIRDS CONVENTION ACT
DELIVRÉ EN VERTU DE LA LOI SUR LA CONVENTION CONCERNANT LES OISEAUX MIGRATEURS

Personal Hunting Record
Tableau de chasse personnel

DATE	PLACE/ENDROIT	KILL/PRISE

Please report all bird bands.
S.V.P. signalez toutes les prises d'oiseaux bagués.

PERMIS DE CHASSE AUX OISEAUX MIGRATEURS CONSIDÉRÉS COMME GIBIER

1. Une fois rempli et signé, le permis est valide partout au Canada. Il est strictement personnel.

2. Vous devez porter le permis signé sur vous tout le temps que vous chassez ou que vous êtes en possession d'une carcasse d'oiseau migrateur considéré comme gibier ailleurs qu'à votre résidence. Il est également possible que vous soyez tenu de posséder un permis provincial.

3. Dans certaines parties du Canada, vous pouvez chasser le canard, l'oie et la bernache, le râle, la foulque, la gallinule, la bécassine, la bécasse, la tourterelle triste, le pigeon du Pacifique ou la grue. Pour ce qui est des saisons de chasse, des maximums de prises et des règles concernant la possession en vigueur dans votre région, veuillez consulter le Règlement concernant les oiseaux migrateurs et prendre connaissance des restrictions imposées à la chasse par les autorités provinciales.

BREF RÉSUMÉ DU RÈGLEMENT DE CHASSE

1. Il est interdit à quiconque a été reconnu coupable d'une infraction en vertu de la Loi sur la Convention ou du Règlement concernant les oiseaux migrateurs de faire une demande ou d'être titulaire d'un permis canadien de chasse aux oiseaux migrateurs considérés comme gibier pendant l'année qui suit sa condamnation.

2. Quiconque tue, estropie ou blesse un oiseau migrateur considéré comme gibier doit s'efforcer, autant que faire se peut, de récupérer immédiatement l'oiseau, et, si celui-ci est vivant, le tuer sur-le-champ et le compter dans son maximum de prises de la journée.

3. Il est interdit de chasser un oiseau migrateur considéré comme gibier au moyen d'un fusil de chasse pouvant contenir plus de trois cartouches dans le magasin et la chambre ensemble, à moins que ledit fusil n'ait été modifié ou obstrué à l'aide d'un bouchon de métal, de plastique ou de bois d'une seule pièce qui ne puisse s'enlever que si le fusil est démonté de manière à ne pouvoir contenir plus de trois cartouches.

4. Lorsqu'on a en sa possession ou qu'on transporte un oiseau migrateur considéré comme gibier, il est obligatoire que l'oiseau conserve au moins une aile intacte et munie de toutes ses plumes. L'aile peut être enlevée au moment où l'oiseau est préparé en vue de la cuisson immédiate ou après que l'oiseau a été emmené à la résidence de son propriétaire en vue de le conserver.

5. Il est interdit d'expédier ou de transporter un colis ou un contenant qui renferme un oiseau migrateur à moins que ne soient nettement marqués sur la surface extérieure du colis ou du contenant le nom et l'adresse de l'expéditeur, le numéro du permis autorisant la capture de l'oiseau et une déclaration exacte du contenu du colis ou du contenant.

6. Il est interdit de chasser les oiseaux migrateurs considérés comme gibier dans un rayon d'un quart de mille d'un endroit où un appât a été placé.

7. Ceci est un résumé de certains articles du Règlement concernant les oiseaux migrateurs, qui ne vise qu'à informer les chasseurs.

RÉSULTATS D'ENQUÊTES

En 1977, quelque 80,000 chasseurs choisis au hasard parmi les 521,000 personnes qui ont acheté un permis ont été invités à participer à nos enquêtes. D'après leurs réponses, on a tué quelque 3,700,000 canards, 500,000 oies et bernaches, 125,000 bécasses et 85,000 bécassines. NOUS VOUS PRIONS DE PARTICIPER AUX ENQUÊTES NATIONALES SUR LES OISEAUX MIGRATEURS CONSIDÉRÉS COMME GIBIER SI VOTRE NOM EST CHOISI.

Vous pouvez nous aider en participant aux enquêtes annuelles sur les prises et sur les espèces capturées. La carte jointe à votre permis vous permettra de consigner vos captures. Même si vous n'êtes pas choisi pour participer à l'enquête de cette année, vous contribuez à la gestion de la sauvagine en achetant le permis de chasse.

Nous vous savons gré de votre appui. Nous vous souhaitons une excellente chasse en 1978.

Le Directeur-général du Service canadien de la faune

Figure 2
NHS hunting zones, 1976–77

Figure 2

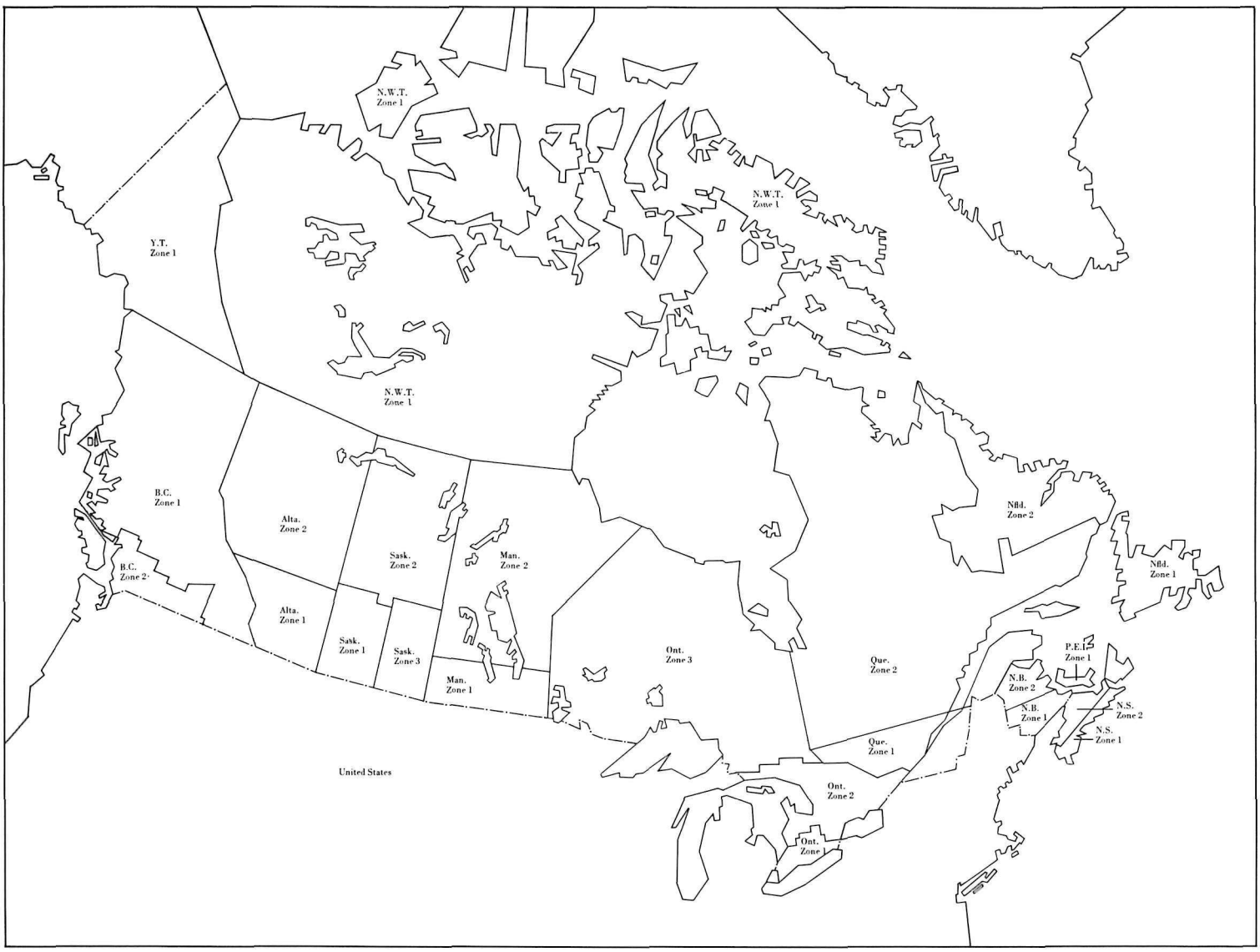


Figure 3
Migratory Game Bird Hunting Permit sales by province of purchase, residence, and renewal status, 1976

ment of the Migratory Birds Convention Act is delegated, verify the claims of individuals who are unable to produce their permit.

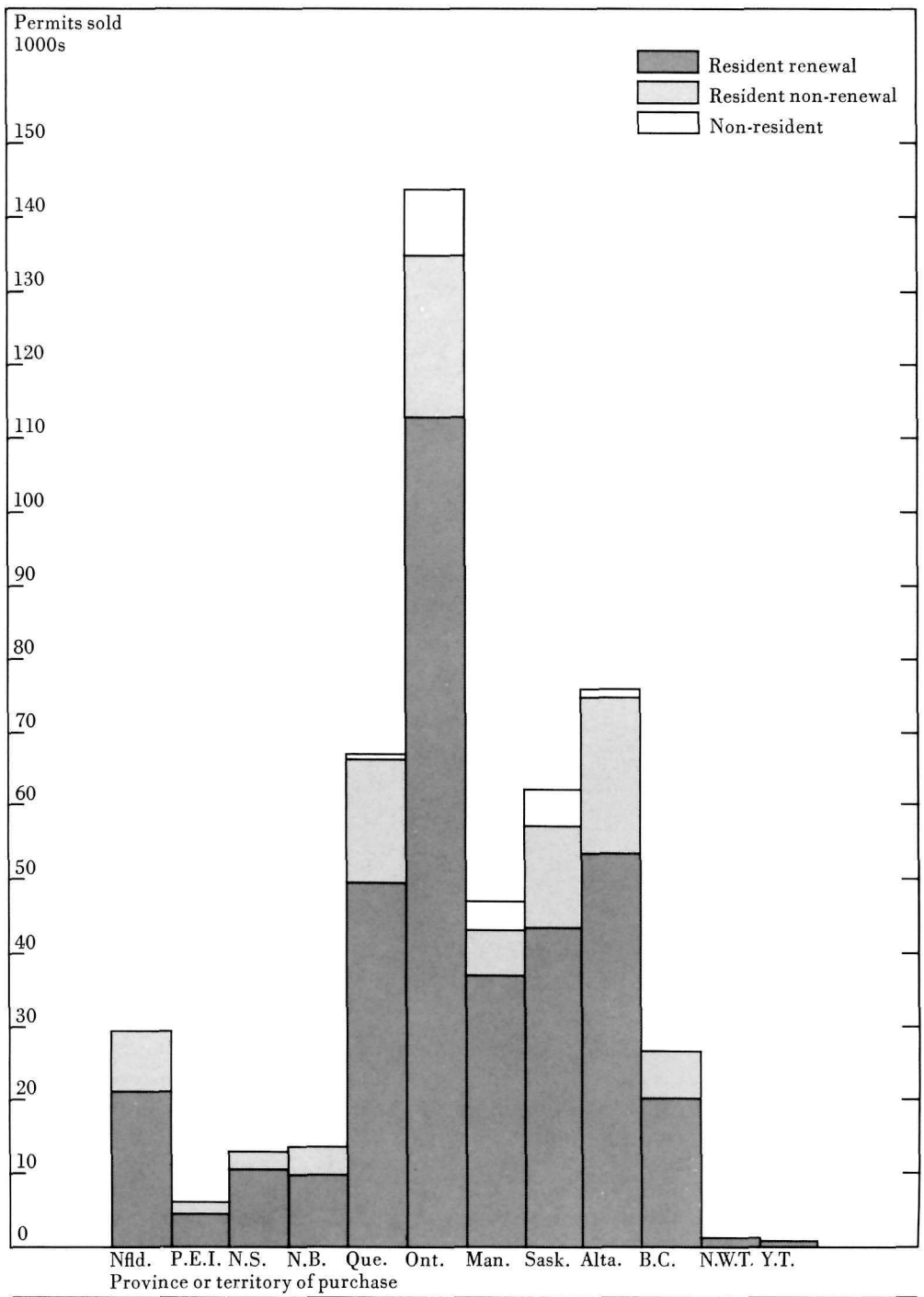
For purposes of the NHS, Canada has been divided into 23 zones (Fig. 2). The number of the issuing post office is used to identify the latitude and longitude of the place of sale and assign each permit record to the zone of purchase.

Hunters who indicate that they bought a permit in the previous year are termed "renewals"; those who did not are "non-renewals". Hunters who live in Canada are "residents"; those who live in another country are "non-residents". Applicants for permits are asked to state whether they hunted and purchased a permit in the preceding year, because persistent hunters tend to hunt more often and kill more birds than do novices or intermittent hunters. The sampling scheme for the NHS is designed to accommodate differences among these groups and hence reduce a major bias in the estimates of hunting activity and kill that became apparent in the early years of the surveys.

The Permit File is a major source of information about migratory game bird hunters. Canadian sales have increased steadily from 1966 when 380 059 permits were sold, to 1977 when sales reached 520 530 (section 7.1.). Figure 3 depicts the distribution of 1976 permit sales by province of purchase, and residence and renewal status. Permits were not required in the territories until 1974; hence the records are incomplete for those areas.

Before 1972, permits were edited manually before the data were placed on tape. Since 1972 the largely unedited permit data have been placed directly on discs from which a tape is produced. Errors are now corrected after the data are on the computer file. The same edit criteria are applied each year to detect errors and correct them where possible. The output, a file of the names, addresses, hunting experience, and provinces of residence of migratory game bird hunters, consequently

Figure 3



has fewer errors. All records with incomplete information are flagged on the computer tape and disregarded when a sample is selected for survey purposes; however, those records are included when data on permit sales are assembled and the extrapolation factors are developed (section 4.1.).

3.2. The National Harvest Survey

Permit records with apparently valid addresses form the universe for the selection of hunters for the NHS. To allow time for labelling questionnaires and to avoid sampling a hunter in both the NHS and SCS, most names are chosen from the previous year's Permit File. Respondents among this group who report kills are "renewals" of the current year. To counteract the upward bias in kill estimates that would result if this group alone were sampled, some non-renewals are selected from the current Permit File.

The Permit Files are sorted by post office number and records are selected systematically from each of the up to 92 strata, made up of four hunter groups within each of the 23 geographic zones shown in Figure 2.

Sample code	Description of hunter group	Sample drawn from
A	Residents who did not purchase a permit in the previous year	Current file
B	Residents who bought a permit a year previously but not in the year prior to that	Previous year's file
D	Residents who bought a permit in the preceding 2 years	Previous year's file
E	Non-residents	Current file

In areas where there are not enough non-residents to justify an E sample, non-residents are pooled with residents for samples A, B, and D. In 1977, there were sufficient non-resident hunters to warrant drawing E samples in all zones west of Nova Scotia, except British Columbia zone 2 and the territories.

Table 1
Sampling intensity and response of Migratory Game Bird Hunting Permit purchasers in the NHS, 1976

Zone		Total permit sales	Total contacts	Sampling intensity (%)	Total responses	Response rate (%)
Nfld.	01	27 227	2968	10.9	1135	38.2
	02	2394	1239	51.8	215	17.3
P.E.I.		5756	1039	18.1	343	33.0
N.S.	01	8112	1555	19.2	695	44.7
	02	5214	1318	25.3	656	49.8
N.B.	01	9411	2268	24.1	1152	50.8
	02	4332	1067	24.6	439	41.1
Que.	01	52 090	3389	6.5	1922	56.7
	02	14 363	1507	10.5	811	53.8
Ont.	01	41 441	3005	7.3	1592	53.0
	02	77 109	1591	2.1	908	57.1
	03	25 266	2623	10.4	1456	55.5
Man.	01	38 355	2510	6.5	1427	56.8
	02	8326	1248	15.0	609	48.8
Sask.	01	23 986	1372	5.7	631	46.0
	02	10 967	2005	18.3	834	41.6
	03	26 716	2097	7.8	999	47.6
Alta.	01	30 920	2036	6.6	1007	49.5
	02	44 819	3697	8.2	1657	44.8
B.C.	01	12 257	1384	11.3	741	53.5
	02	14 304	1418	9.9	643	45.3
N.W.T.		893	642	71.9	291	45.3
Yukon		513	479	93.4	234	48.8
Canada		484 771	42 457	8.8	20 397	48.0

Table 1 shows the intensity of sampling in the 1976 NHS.

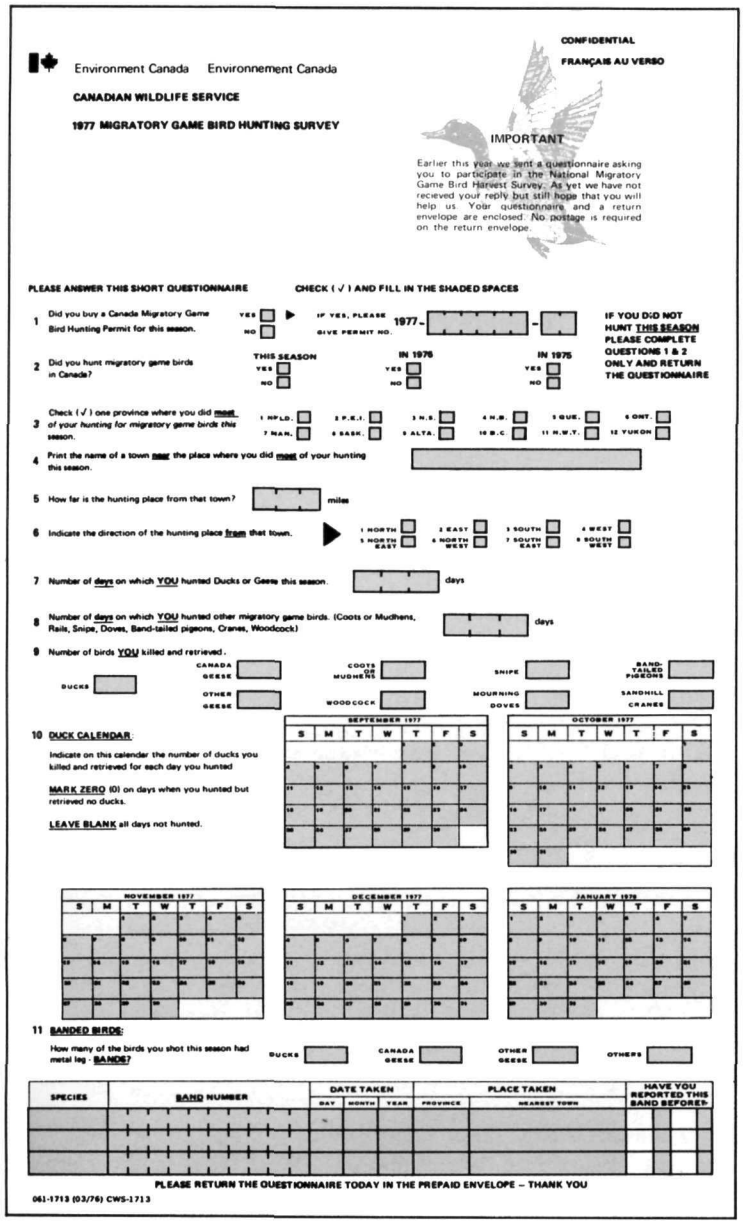
Once the names are selected, labelled questionnaires are prepared and stored until CWS regional biologists report that hunting in their areas has essentially stopped due to cold weather. Hunters receive their forms in November or December, except in coastal British Columbia and Nova Scotia, where the forms are sent in January. As responses are received, the permit numbers from the labels are keypunched. Those hunters who do not respond are sent another questionnaire. This second mailing takes place throughout January in most areas of Canada. In 1977, an additional postcard reminder was sent to the sampled hunters approximately one week after they received the questionnaires. The impact of this experiment on response rate has yet to be assessed.

In addition to the label, which provides a link to the Permit File and sales data, there are 11 questions on the questionnaire (Fig. 4). Some hunters in samples B and D may not have purchased permits in the current year and therefore will respond negatively to the first question, "Did you buy a Migratory Game Bird Hunting Permit for this season?". All other respondents — all of samples A and E and some of samples B and D — are "potential hunters". Permit purchasers who indicate that they went hunting are "active hunters".

The balance of the questionnaire addresses the questions:

Where did you hunt?
How many days did you hunt?
What did you kill?
When did you kill ducks?

Figure 4
A sample of the NHS questionnaire, 1977



Environment Canada Environnement Canada

CANADIAN WILDLIFE SERVICE

1977 MIGRATORY GAME BIRD HUNTING SURVEY

CONFIDENTIAL

FRANÇAIS AU VERSO

IMPORTANT

Earlier this year we sent a questionnaire asking you to participate in the National Migratory Game Bird Harvest Survey. As yet we have not recieved your reply but still hope that you will help us. Your questionnaire and a return envelope are enclosed. No postage is required on the return envelope.

PLEASE ANSWER THIS SHORT QUESTIONNAIRE — CHECK (✓) AND FILL IN THE SHADED SPACES

1 Did you buy a Canada Migratory Game Bird Hunting Permit for this season. YES NO ▶ IF YES, PLEASE GIVE PERMIT NO. 1977 –

IF YOU DID NOT HUNT THIS SEASON PLEASE COMPLETE QUESTIONS 1 & 2 ONLY AND RETURN THE QUESTIONNAIRE

2 Did you hunt migratory game birds in Canada? THIS SEASON YES NO — IN 1976 YES NO — IN 1975 YES NO

3 Check (✓) one province where you did most of your hunting for migratory game birds this season. 1 NFLD. 2 P.E.I. 3 N.S. 4 N.B. 5 QUE. 6 ONT. 7 MAN. 8 SASK. 9 ALTA. 10 B.C. 11 N.W.T. 12 YUKON

4 Print the name of a town near the place where you did most of your hunting this season.

5 How far is the hunting place from that town? miles

6 Indicate the direction of the hunting place from that town. 1 NORTH 2 EAST 3 SOUTH 4 WEST 5 NORTH EAST 6 NORTH WEST 7 SOUTH EAST 8 SOUTH WEST

7 Number of days on which YOU hunted Ducks or Geese this season. days

8 Number of days on which YOU hunted other migratory game birds. (Coots or Mudhens, Rails, Snipe, Doves, Band-tailed pigeons, Cranes, Woodcock) days

9 Number of birds YOU killed and retrieved.

DUCKS — CANADA GEESE — OTHER GEESE — COOTS OR MUDHENS — WOODCOCK — SNIPE — MOURNING DOVES — BAND-TAILED PIGEONS — SANDHILL CRANES

10 DUCK CALENDAR:

Indicate on this calendar the number of ducks you killed and retrieved for each day you hunted

MARK ZERO (0) on days when you hunted but retrieved no ducks.

LEAVE BLANK all days not hunted.

SEPTEMBER 1977 — OCTOBER 1977 — NOVEMBER 1977 — DECEMBER 1977 — JANUARY 1978

11 BANDED BIRDS:

How many of the birds you shot this season had metal leg - BANDS?

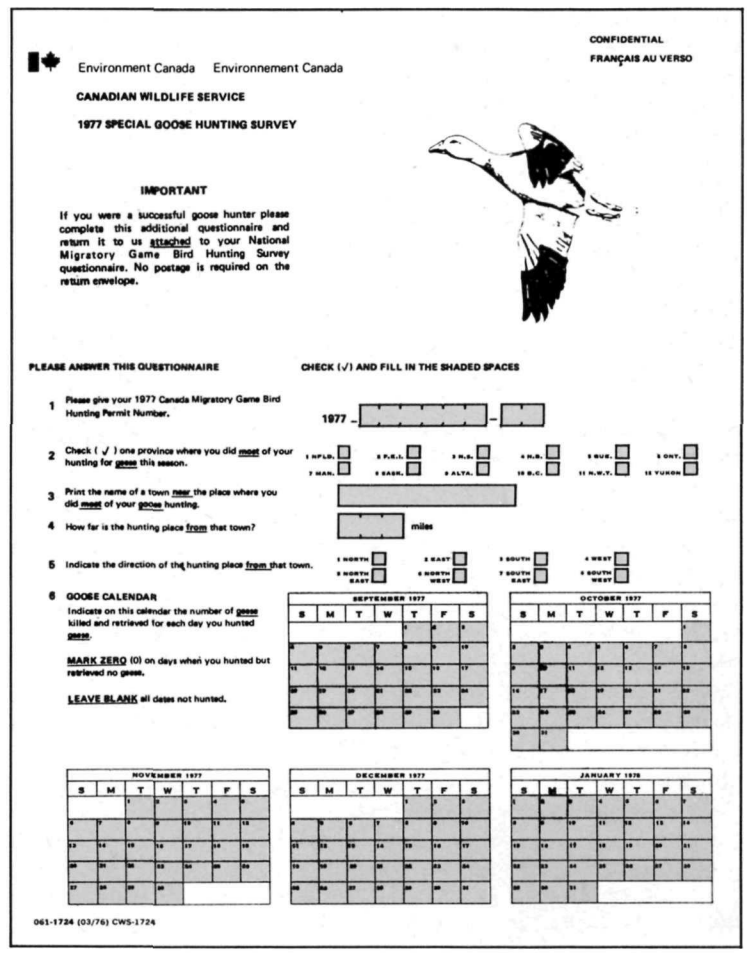
DUCKS — CANADA GEESE — OTHER GEESE — OTHERS

SPECIES	BAND NUMBER	DATE TAKEN DAY	DATE TAKEN MONTH	DATE TAKEN YEAR	PLACE TAKEN PROVINCE	PLACE TAKEN NEAREST TOWN	HAVE YOU REPORTED THIS BAND BEFORE?

PLEASE RETURN THE QUESTIONNAIRE TODAY IN THE PREPAID ENVELOPE – THANK YOU

061-1713 (03/76) CWS-1713

Figure 5
A sample of the NHS special goose questionnaire, 1977



Environment Canada Environnement Canada

CANADIAN WILDLIFE SERVICE

1977 SPECIAL GOOSE HUNTING SURVEY

CONFIDENTIAL

FRANÇAIS AU VERSO

IMPORTANT

If you were a successful goose hunter please complete this additional questionnaire and return it to us attached to your National Migratory Game Bird Hunting Survey questionnaire. No postage is required on the return envelope.

PLEASE ANSWER THIS QUESTIONNAIRE — CHECK (✓) AND FILL IN THE SHADED SPACES

1 Please give your 1977 Canada Migratory Game Bird Hunting Permit Number. 1977 –

2 Check (✓) one province where you did most of your hunting for geese this season. 1 NFLD. 2 P.E.I. 3 N.S. 4 N.B. 5 QUE. 6 ONT. 7 MAN. 8 SASK. 9 ALTA. 10 B.C. 11 N.W.T. 12 YUKON

3 Print the name of a town near the place where you did most of your goose hunting.

4 How far is the hunting place from that town? miles

5 Indicate the direction of the hunting place from that town. 1 NORTH 2 EAST 3 SOUTH 4 WEST 5 NORTH EAST 6 NORTH WEST 7 SOUTH EAST 8 SOUTH WEST

6 GOOSE CALENDAR

Indicate on this calendar the number of geese killed and retrieved for each day you hunted geese.

MARK ZERO (0) on days when you hunted but retrieved no geese.

LEAVE BLANK all dates not hunted.

SEPTEMBER 1977 — OCTOBER 1977 — NOVEMBER 1977 — DECEMBER 1977 — JANUARY 1978

061-1724 (03/76) CWS-1724

The questionnaire also has a space to record the band numbers of any marked birds which the hunter recovered.

To establish the location of hunting, the hunter is asked to specify a town, a direction from that town, and a distance. The latitude and longitude of the town are taken from a computerized gazetteer, and then co-ordinates for the hunting area are calculated from the distance and direction specified.

The analysis assumes that the hunter specifies the straight line distance between the town and the hunting location. In some instances, distance by road is reported instead; this results in misassignment of hunting areas. In other cases distance between the town of residence and place of hunting is given. The direction is limited to eight compass points, and this causes errors when the distance is large. A demonstration of the effects of these errors is available in the companion paper by Freemark and Cooch (1978). The extent of the problem has been reduced in recent years by the incorporation of improved edit criteria.

Birds are classified as either waterfowl (Anseriformes) or other migratory game birds. Hunter activity is divided correspondingly into "days hunting waterfowl" and "days hunting other migratory game birds".

The question about numbers of birds killed is designed to minimize the requirement for a correct identification of species by the hunter. It has been treated in several ways in the past. In 1976 hunters were expected to distinguish nine avian groups: ducks, Canada Geese, other geese, coots or mudhens, woodcock, snipe, Mourning Doves, Band-tailed Pigeons, and Sandhill Cranes.

Hunters of woodcock and snipe should be able to distinguish their prey from other shorebirds, all of which are protected at present. However, Dobell and Cooch (1976) found that about one-quarter of the limited number of wings received in the 1975 experimental snipe survey were from shorebirds other than Common Snipe. They suggest that estimates of snipe kill from the NHS should be adjusted to allow for this error as soon as a national snipe survey can be implemented.

Hunters of Mourning Doves, Band-tailed Pigeons, and Sandhill Cranes tend to have specialized knowledge of their species. Regulations for these species are very restrictive, both geographically and temporally. Barring the possible confusion of Band-tailed Pigeons with feral Rock Doves, these species are readily identified.

Identification of waterfowl is more complicated. Hunters are asked to record their kills for Canada Geese and other geese separately, because their identification of the Canada Goose is considered to be reliable. Many common names are extant for the species of ducks found in Canada. This, combined with the unfamiliarity of many hunters with the birds they shoot, led to the development of the SCS. The NHS questionnaire provides the total number of ducks or geese killed. The SCS (section 3.3.) allows us to estimate the proportions of various species in this total.

The calendar on the questionnaire asks when the hunter was active, and when he killed ducks. This information is useful in itself and is also used to adjust the SCS data. A separate goose kill questionnaire (Fig. 5) accompanies the NHS questionnaire and provides information on the time of goose harvest. This questionnaire also includes questions to establish the place of hunting, because in some areas this may be different from where the hunter has gone for ducks. Unlike the stratification of the sample for the NHS, only successful goose hunters are asked to respond to this special survey.

The computer record of the NHS data is called the Harvest File.

3.3. The Species Composition Survey

Parts envelopes for the SCS are mailed from mid August to late September and arrive approximately on the opening day of the hunting season in each zone. Because of the early mailing the sample must be chosen from the previous year's Permit File. Only Canadian residents are included because of the problems in mailing waterfowl parts across the border. All resident respondents to the previous year's national surveys who gave a valid permit number are selected from the Permit File and included in the SCS. Five categories of hunters are distinguished in this survey.

Sample	Description
SA	SC, SD, SE, or SF respondent in the previous year
SC	NHS respondent in the previous year who shot more than five waterfowl
SD	NHS respondent in the previous year who shot one to five waterfowl
SE	Renewal hunter of the previous year, not eligible for SA, SC, or SD
SF	Non-renewal hunter of the previous year not eligible for SA, SC, or SD

Hunters who respond to the SCS in group SA are not selected the next year for any survey. Those hunters not flagged during the selection for the SCS are available for the selection of samples B and D of the NHS. By way of illustration someone who buys a permit every year may hav the following route through the surveys: first year, NHS sample D; second year, SCS sample SC; third year, SCS sample SA; fourth year, not selected.

Table 2 shows the intensity of sampling for the SCS in 1977. There are wide differences between zones in the proportion of permit purchasers selected, the highest proportion (up to 26% in New Brunswick zone 02) being in zones where sales are few. The effect of sampling intensity on response rate is obscure. The response rates vary from under 7% to over 33%.

The label produced from the Permit File is affixed to a large envelope which contains either five or ten plastic-lined parts envelopes and a postcard for ordering more. Smith (1974) discusses the merits of sending various numbers of parts

Table 2
Sampling intensity and response in the SCS, 1977

Zone		Sampling intensity*	Response rate†	Mean (parts per responding hunter)
Nfld.	01	2.82	8.77	3.17
	02	14.32	6.78	3.36
P.E.I.		19.29	9.18	3.36
N.S.	01	18.94	14.54	4.20
	02	23.29	14.69	3.78
N.B.	01	10.21	21.12	4.31
	02	26.76	5.91	2.53
Que.	01	4.46	25.18	5.02
	02	10.55	14.44	4.56
Ont.	01	5.59	20.49	4.69
	02	3.16	25.10	4.56
	03	7.10	13.86	4.76
Man.	01	2.71	30.74	4.82
	02	4.62	28.43	5.27
Sask.	01	2.66	27.21	5.10
	02	4.64	25.27	4.86
	03	2.54	26.05	5.35
Alta.	01	2.68	20.40	5.06
	02	1.96	28.53	7.27
B.C.	01	18.67	9.15	4.38
	02	13.18	14.14	6.73
N.W.T.		24.94	5.78	4.23
Yukon		34.10	16.91	6.94
Canada		5.63	17.81	4.87

* Number of envelope sets mailed as % of total permit sales.
† Number of respondents as % of mailing size. This includes only those respondents who gave a 1977 permit number.

envelopes to each hunter and of stratifying the SCS.

The hunter is asked to give his name and address, his current permit number, the place, time, and date of kill, and the band number, if the bird was banded. The latitude and longitude of the place of kill is calculated as for the NHS.

The respondent then mails each part (a duck wing or set of goose rectrices) to CWS. The envelopes are preaddressed to one of six reception centres. In 1976 parts were accumulated at St. John's, Nfld.; Sackville, N.B.; Ste-Foy, Que.; London, Ont.; Saskatoon, Sask.; and Delta, B.C. Immediately upon receipt at one of those centres, the parts are frozen for storage.

In January the parts are shipped to the centre selected as the site of a "wing bee", where a team of waterfowl biologists identifies the species, age, and sex of each part and writes this information on the envelope. The completed but now empty envelopes are then sent to Ottawa, where the data are transferred to magnetic tape.

The computer record of parts survey data is called the Species File. It is processed with the current Permit File to provide hunter data for those envelopes on which the hunter entered a valid permit number. Records which match the Permit File are condensed into the Parts File, which has a record of each responding hunter and a tally of the parts he submitted.

Waterfowl parts which are forwarded to CWS with incomplete information on hunting location and date are excluded from the kill estimates (section 4.2.). Hunters who do not include a valid permit number on the parts envelope are not eligible for selection in sample SA in the following year.

4. Derivation of estimates from the national surveys

Some types of information are computed directly from the sample data and the Permit File. Totals such as kill and days hunted, and averages such as duck kill per hunter are derived directly from responses to the NHS questionnaire. The SCS provides information on the spatial and temporal distribution of the species composition of the kill (e.g. Freemark and Cooch 1978).

4.1. Extrapolation of NHS data

To derive maximum benefit from a survey, the sample results should be related to the universe from which the sample was drawn. In the case of the NHS, an extrapolation factor (*e*-factor), which is the number of hunters represented by an individual respondent, is calculated and stored on the harvest record. Generally, the *e*-factor equals the total permit sales divided by the number of usable responses from the NHS for each of the up to 92 strata. Thus, if N_s is the total sales for stratum s, and r_s is the corresponding number of respondents, the *e*-factor is $e_s = N_s/r_s$.

Because hunters in groups B and D may not have purchased a permit in the current year or may have changed zones of purchase between years, the extrapolation factor for strata made up of these groups is calculated differently. First, an estimate of the number of renewal hunters in zone z is obtained by summing the *e*-factor (Σe_i) for respondents in samples B and D who bought a permit in zone z during the current year regardless of where they bought their previous permit. Let $\hat{N} = \Sigma e_i$. Because the sample was drawn from the Permit File of the previous year, the estimate, $\hat{N}_z$, will differ from the actual number of renewal hunters who bought a permit in the zone (N_z). To compensate, each e_i is multiplied by $N_z/\hat{N}_z$ to form an adjusted *e*-factor ($e_i \cdot N_z/\hat{N}_z$). This replaces the unadjusted figure on the Harvest File. The sum of the adjusted *e*-factors is exactly N_z.

Using the *e*-factors stored on the Harvest File one can estimate extrapolated totals for any subset of the hunting population. This subset can be a province of hunting, a degree block of sale or of hunting, hunters of a specified age group, or any category of interest. If the i^{th} responding hunter in a given category has an *e*-factor e_i and answered X_i to the question of interest, the estimate would be,

$$\hat{X} = \sum_i e_i X_i$$

where the sum is taken over all respondents in the category (t). The calculation of a mean, e.g. geese killed per active hunter, involves the separate calculation of the numerator and denominator: in this example, total geese killed and the total number of active hunters.

Figure 6
Distribution of reported duck harvest and wing receipts over the 1976 hunting season for Ontario, zone 2

Figure 7
Distribution of reported duck harvest and wing receipts over the 1976 hunting season for Saskatchewan, zone 1

Figure 8
Distribution of reported goose harvest and goose tail-feather receipts over the 1976 hunting season for Saskatchewan, zone 1

Figure 6

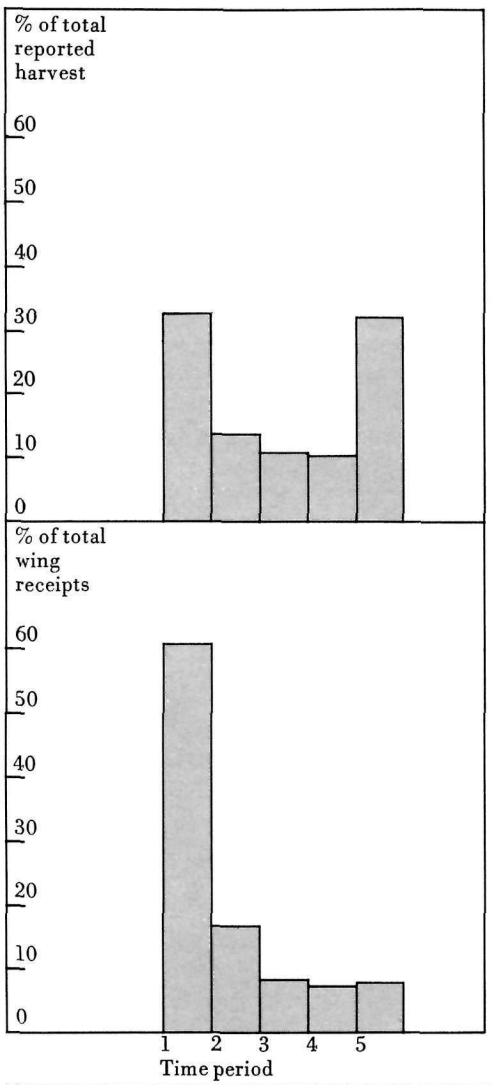


Figure 7

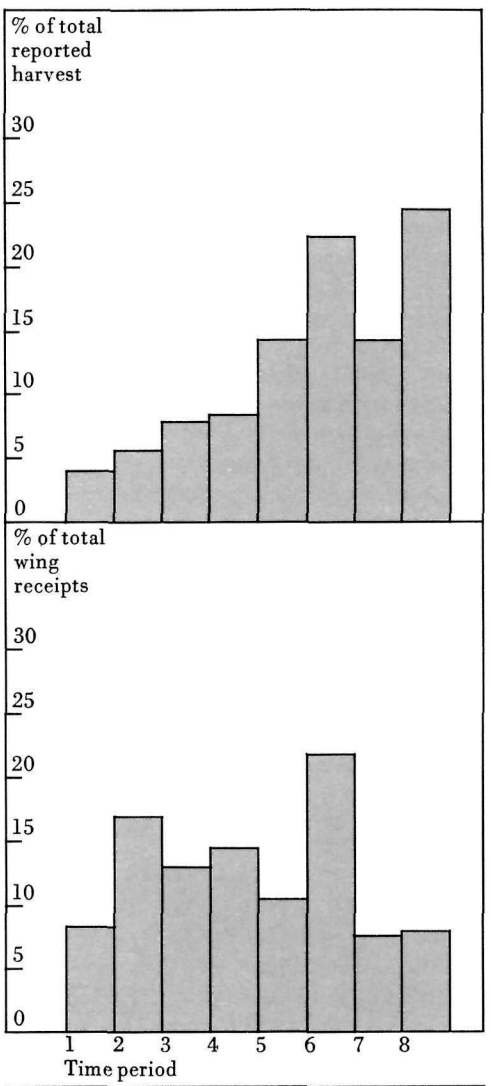
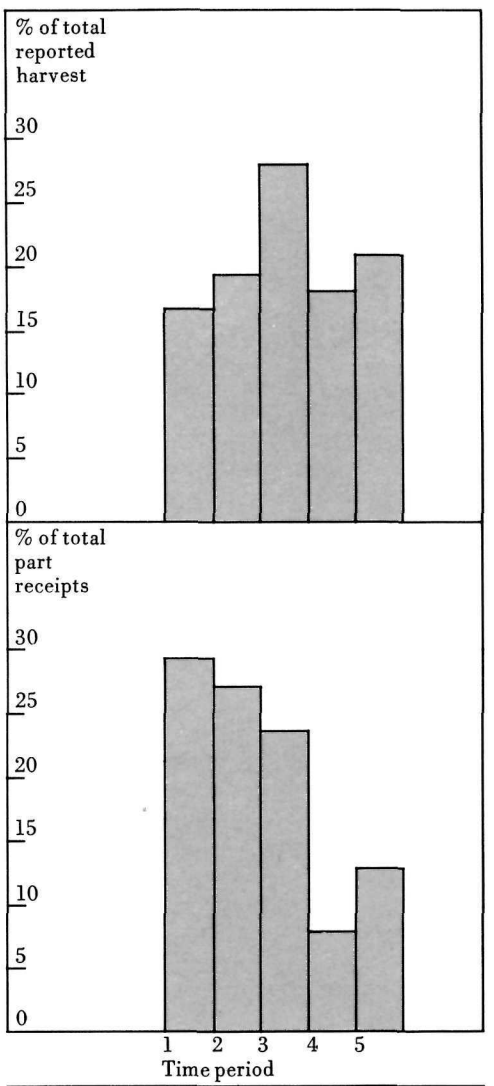


Figure 8



4.2. The combination of the NHS and SCS

After total duck (or goose) kill has been estimated from the NHS, the proportion of each species in the kill is derived from the SCS. For example, if the estimated kill in a zone were 10 000 ducks, and if we received 100 Gadwall parts among a total of 800 parts for that zone, we could estimate a Gadwall kill of 10 000 x (100/800) = 1250.

In practice, this simple method for estimating the kill of a species is unsatisfactory, because we receive a disproportionate number of parts from birds killed early in the hunting season (Figs. 6–8). There are several reasons for this. In areas of good hunting, envelopes may be used up early. Hunters sometimes distribute envelopes among their friends. Few hunters order additional envelopes. Thus kill estimates tend to be inflated for early migrants, such as Blue-winged Teal, and deflated for late migrants.

To reduce this bias, the parts data are adjusted. For each hunting zone, the hunting season is divided into weekly intervals. The duck parts are distributed among the intervals according to date of kill. If necessary, adjacent intervals are combined so that each time interval will

Table 3
Estimated kill of duck species in central Ontario* with and without the temporal adjustment, 1976

Symbol	Variable	Time periods (i) 1	2	3	4	5	6	Total	Estimated kill: Using adjustment	Not using adjustment	Adjusted ÷ unadjusted
H_i	Ducks reported – NHS calendar	1824	947	771	1066	387	1332	6327			
K_i	Estimated duck kill – NHS	146 533	76 079	61 939	85 639	31 090	107 288	508 288	508 288	508 288	1
W_i	Duck parts received – SCS	2065	411	393	447	217	284	3817			
a_i	Each part represents	70.96	185.11	157.61	191.59	143.27	376.79				
W(mall)	Mallard – parts received –	773	152	144	128	38	72	1307	162 780	174 046	0.94
K(mall)	Estimated kill	54 852	28 136	22 695	24 523	5444	27 129				
W(blk)	Black Duck – parts received –	222	39	42	34	13	41	391	53 417	52 067	1.03
K(blk)	Estimated kill	15 753	7219	6619	6514	1863	15 448				
W(wood)	Wood Duck – parts received –	442	83	68	38	3	3	637	66 286	84 826	0.78
K(wood)	Estimated kill	31 365	15 364	10 717	7280	430	1130				
W(red)	Redhead – parts received –	20	9	7	17	6	6	65	10 566	8656	1.22
K(red)	Estimated kill	1419	1666	1103	3257	860	2261				
W(can)	Canvasback – parts received –	3	0	2	3	4	14	26	17 335	11 319	1.53
K(can)	Estimated kill	568	2221	2206	4215	1719	6405				

* Ontario, Zone 2.

contain at least 5% of the receipts for that zone.

For each time interval, the duck kill in the zone is estimated from the duck calendar on the NHS questionnaire. If H_i ducks are reported killed during time interval i, and H is the total ducks killed, then $H = \sum_i H_i$. In the example presented in Table 3 (Ontario zone 2, 1976), $H_1 = 1824$, $H_2 = 947$, and so on. The total kill (K) is estimated from responses to question 9 of the NHS questionnaire (Fig. 4) and the estimated kill during each interval is $K_i = KH_i/H$. In the example, $K = 508\,288$ and $K_1 = 508\,288 \times (1824/6327) = 146\,533$.

The wing receipts from the SCS are first screened so that those with an unknown date or location of kill and those from unknown species are excluded from the calculations. The remaining wings (W) (greater than 99% of total receipts) are allocated to the appropriate time intervals: the total number of wings in interval i is called W_i (e.g. $W_1 = 2065$, $W_2 = 411$, and so on). The W_i wings thus represent the estimated K_i ducks killed. The extrapolation factor, a_i, is equal to K_i/W_i (e.g. $a_1 = 146\,533/2065 = 70.96$).

The number of wings of an individual species received in each interval W_{is} (e.g. W_1 (mall) = 733; W_3 (wood) = 68; etc.) is used together with the extrapolation factors (a_i) to estimate the kill of each species in each time interval (K_{is}). Thus $K_{is} = a_i W_{is}$ and the estimated kill for each species over the season (K_s) is simply the sum of K_{is} (ΣK_{is}).

In the Wood Duck example, $K_1 = a_i \cdot W_1 = 70.96 \times 442 = 31\,365$; $K_2 = 15\,364, \ldots, K_6 = 1130$, and the seasonal total $K = \Sigma K_i = 66\,286$.

As fewer wings are returned later in the season relative to the estimated kill, these wings are weighted more heavily. In the example, the extrapolation factors increased from only 70.96 (a_1) to 376.79 (a_6) over the season. The effect of applying different weights to wing receipts, depending on when the ducks were reported killed, can be seen by reviewing the last three columns of Table 3. The adjusted kill, K_s, is calculated as above; the unadjusted by dividing total wing receipts of a species (W_s) by the total receipts from all species (W) and multiplying by the total estimated kill. Thus $K_s = K \cdot W_s/W$ (e.g. $K = 508\,288 \cdot 1307/3817 = 174\,046$). The ratio of adjusted to unadjusted is presented in the last column. This ratio is usually less than 1.00 for early migrants (e.g. Wood Duck) and greater than 1.00 for late migrants, but tends to be variable for relatively uncommon species (e.g. Canvasback).

Since 1974 an additional adjustment has been made which includes wings from ducks whose date of kill was unknown or outside of the prescribed period (Sept. – Jan.). This adjustment has generally had little effect on the estimates of kill.

5. Major developments in the permit system and national surveys, 1970–77

Benson (1971*a*) outlined the original purpose of the permit system and hunter surveys, and procedures and modifications up to 1970. The system is continually being improved, so that the procedures

used in 1976 and 1977, as reported in the preceding section, differ substantially from the system Benson (1971*a*) described. In this section we review the major changes, and look at both the remaining limitations of the survey data and their increased flexibility and reliability.

5.1. The permit system

The permit design has been modified twice. In 1970 purchasers were asked for the first time whether they had purchased a permit in the previous year. This made possible an improved sampling scheme for the NHS (section 5.2.). In 1972, the permit was completely redesigned. The question related to the sex of the applicant was removed because less than 2% of the permit holders were female. A question was added to discriminate between active and inactive permit holders. A provincial code was added as a suffix of the permit number and a unique range of permit numbers was specified for each province to ensure that all permits were assigned to the correct province of sale.

One weakness of the permit distribution system, which has an effect on permit sales and on whether hunters abide by the law, is that in some parts of the country there have been chronic shortages at the points of sale. The strike of postal workers in autumn 1975 drew attention to this flaw in the system. If hunters did not buy their permits early they could not buy them at all in some places until it was too late to hunt waterfowl. We considered alternative methods of distribution to meet the emergency but realized that, though these would result in more hunters being able to comply with the law, the sampling frame would be seriously distorted by the use of *ad hoc* distribution arrangements. This is the principal reason for resisting suggestions made from time to time by hunters or their representatives that permits should be sold by sporting goods stores and other retail outlets, as are some forms of provincial hunting licences. The only exceptions are in Alberta, where permits are sold by offices of the provincial Treasury Branch, and, on a restricted basis, at some remote hunt camps in northern Ontario and Quebec. The primary purpose of the permit is to provide the sampling universe. Without a consistent and prompt system of permit sales reporting, the selection of samples would be biased.

Improvements in techniques mean that in spite of the increasing numbers of permits sold each year, the staff assigned to process the permits for the CWS population and surveys division has been reduced from 6 to 2, and the date by which 95% of all the permits sold in a season have been audited and recorded on tape has been advanced from 15 January to 30 October. (Midwinter sales are appreciable only in a few areas on the Atlantic and Pacific coasts.)

5.2. The National Harvest Survey

Benson (1971*a*) described the procedures initially used for making contact with hunters selected for the NHS as follows:

> In August, preceding the first opening date, we mail some explanatory literature, a brief report on the previous year's results and abstracts of regulations for the coming season to all hunters who bought permits in the past year. Two mailing lists are used. Those hunters selected for the Harvest Survey sample are informed that they have been included and, in addition to the material just mentioned, receive a card for recording their kill. We mail questionnaires at the end of the season, and follow up with another to those who do not reply to the first. Questionnaires returned by persons who state they did not purchase a permit for the current season are excluded from the sample.

There have been some significant changes.

Explanatory literature is no longer mailed to permit holders of the previous year because it has become too expensive to produce and distribute. Information on the permit application form reminds hunters that they may be selected for one of the surveys, but no specific warning is given to those who will be selected. With the inclusion each year since 1972 of a sample of hunters who did not purchase a permit in the previous year, advance notice to renewals but not to non-renewals could introduce a bias.

5.2.1. Questionnaire design and administration

The NHS questionnaire asks for the following information: (*a*) hunting location, (*b*) hunting effort (days spent hunting); (*c*) hunting success (total killed, by species group) and (*d*) the dates on which birds were killed. The data obtained from returned questionnaires contain two major types of error: "response bias" is the degree to which the reported information is inaccurate, and "non-response bias" is the degree to which respondents are not representative of the parent population. This latter error may arise particularly because some selected hunters fail to respond. We have made considerable efforts to understand and to minimize the impact of these errors.

Response bias can only be measured against the "true" result. This usually requires an additional special study. In an attempt to gauge response biases in the NHS, experimental bag check studies have been carried out in several provinces (Sen 1973), along the lines of a much earlier study in the United States on a supervised hunting area (Atwood 1956). In these studies a hunter's kill was checked on a specified day. The mail questionnaire was sent 1, 2, 3, 4, and 8 weeks (end of season) from the date of the field interview. These studies indicated that the hunters reported more than they actually killed. The amount of exaggeration decreased towards the end of the season when the hunter had bagged his season's kill. Also, the exaggeration was highly significant ($P<0.01$) for bag sizes zero to one, but not for sizes exceeding one, suggesting that the response bias is high for unsuccessful hunters or successful hunters who bag too few ducks during the season. The degree to which this memory bias affects the NHS results is uncertain.

Table 4
Effect of questionnaire design on response rates in the Manitoba special survey, 1976

		Response							
Manitoba	Questionnaire type	% active hunters	% successful hunters	Ducks*/ potential hunter	Ducks*/ active hunter	Ducks*/ successful hunter	Geese*/ potential hunter	Geese*/ active hunter	Geese*/ successful hunter
01	standard	91.0	78.2	7.27	8.00	9.31	2.18	2.40	2.80
	special	89.9	76.6	7.28	8.09	9.51	2.44	2.71	3.19
02	standard	88.5	78.9	9.26	10.47	11.75	1.96	2.21	2.48
	special	86.9	78.9	9.13	10.32	11.58	2.43	2.71	3.18

*Estimated total ducks or geese killed.

Table 5
The effect of non-response bias on estimates of duck kill by province, 1975

	Mailing 1			Mailing 2			Combined		
Province	% active hunters	Kill/ potential hunter	Kill/ active hunter	% active hunters	Kill/ potential hunter	Kill/ active hunter	% active hunters	Kill/ potential hunter	Kill/ active hunter
Nfld.	75	4.1	5.5	59	3.7	6.1	67	3.9	5.7
P.E.I.	83	5.0	6.1	82	5.2	6.3	83	5.2	6.2
N.S.	83	8.0	9.5	77	7.6	9.7	81	7.8	9.5
N.B.	75	4.9	6.5	69	4.6	6.5	73	4.8	6.5
Que.	84	8.4	10.0	70	7.1	10.1	80	8.1	10.0
Ont.	81	7.8	9.5	77	6.7	8.6	80	7.5	9.3
Man.	92	7.4	8.0	85	7.7	9.0	90	7.5	8.3
Sask.	92	14.3	15.6	88	14.1	16.0	91	14.3	15.7
Alta.	87	13.1	15.1	83	10.9	13.1	86	12.5	14.5
B.C.	79	11.9	15.1	74	11.4	15.3	78	11.9	15.2
Canada	84	9.3	11.1	76	8.0	10.5	82	8.9	10.9

Results of the bag check study carried out during fall 1977 to determine the memory bias associated with the NHS are not yet available.

Filion (1976*a*) studied the effect of questionnaire design on response by designing six different questionnaires and comparing them in a pilot survey. He found that hunters who were asked to complete a table indicating where and when they hunted reported fewer ducks killed than those who were simply asked to state the number killed during the season. Response rates were depressed when the questionnaires were made more complicated.

Simpler questions also elicited higher kill estimates in an experimental survey in Manitoba in 1976. In addition to the regular survey sample, a slightly different questionnaire was sent to another group of hunters. In this case the two questions, "How many Canada Geese did you kill and retrieve?" and "How many other geese did you kill and retrieve?", on the regular questionnaire were replaced by a single question, "How many geese did you kill and retrieve?". The use of the single question increased the reported goose kill per potential hunter from 2.40 to 2.71 in zone 01 and from 2.21 to 2.71 in zone 02 (Table 4). The reported kill of ducks was approximately equivalent in the two samples.

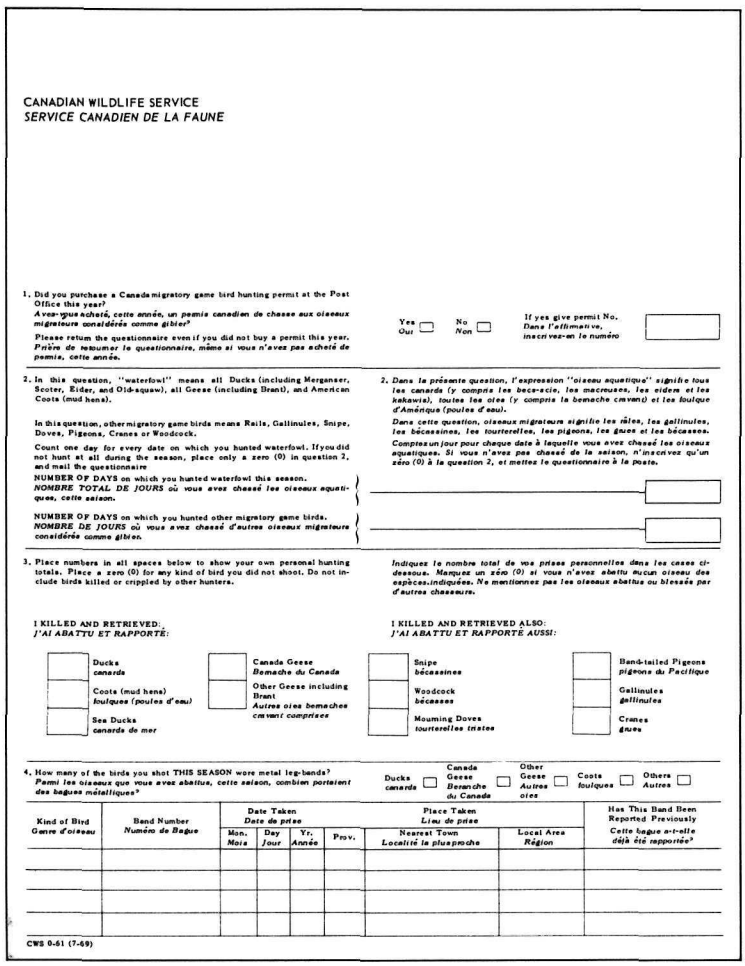
Another source of error arises from the fact that some hunters deliberately supply incorrect information. The causes are no doubt varied. Birds which are taken out of season, in excess of the bag limit, or which are not retrieved, are not likely to be reported. This problem is discussed further in section 6.

The sampling procedure is designed to ensure as much as possible that the permit holders selected for the NHS are representative of the entire hunting population. However, it is still necessary to determine whether the activity and success of respondents differ markedly from those of non-respondents. In order to examine the characteristics of non-respondents, CWS has made several studies using various follow-up techniques and comparing the replies of first wave respondents with those who respond only to later promptings.

Sen (1970*a*, 1971*b*, 1976) and Filion (1975–1976, 1976*b*) found that the estimated kill of ducks by second wave respondents was significantly lower that that reported by first wave respondents. Table 5 compares the 1975 kill per hunter for the two mailings in the NHS. In eight provinces the kill/potential hunter reported in the second mailing was as much as 8% lower. For the other two provinces reported kill/potential hunter was marginally larger. A single mailing would have resulted in inflation of the estimated harvest/potential hunter by as much as 5%. The reported kill per active hunter was not appreciably different between the two mailings, but the proportion of active hunters decreased markedly.

Filion (1974) noted that simple questions tended to enhance response

Figure 9
A sample of the NHS questionnaire, 1969



CANADIAN WILDLIFE SERVICE
SERVICE CANADIEN DE LA FAUNE

1. Did you purchase a Canada migratory game bird hunting permit at the Post Office this year?
Avez-vous acheté, cette année, un permis canadien de chasse aux oiseaux migrateurs considérés comme gibier?
Yes / *Oui* ☐ No / *Non* ☐ If yes give permit No. / *Dans l'affirmative, inscrivez-en le numéro* ☐
Please return the questionnaire even if you did not buy a permit this year.
Prière de retourner le questionnaire, même si vous n'avez pas acheté de permis, cette année.

2. In this question, "waterfowl" means all Ducks (including Merganser, Scoter, Eider, and Old-squaw), all Geese (including Brant), and American Coots (mud hens).
In this question, other migratory game birds means Rails, Gallinules, Snipe, Doves, Pigeons, Cranes or Woodcock.
Count one day for every date on which you hunted waterfowl. If you did not hunt at all during the season, place only a zero (0) in question 2, and mail the questionnaire
NUMBER OF DAYS on which you hunted waterfowl this season.
NOMBRE TOTAL DE JOURS où vous avez chassé les oiseaux aquatiques, cette saison. ☐
NUMBER OF DAYS on which you hunted other migratory game birds.
NOMBRE DE JOURS où vous avez chassé d'autres oiseaux migrateurs considérés comme gibier. ☐

2. *Dans la présente question, l'expression "oiseau aquatique" signifie tous les canards (y compris les becs-scie, les macreuses, les eiders et les kakawis), toutes les oies (y compris la bernache cravant) et les foulque d'Amérique (poules d'eau).*
Dans cette question, oiseaux migrateurs signifie les râles, les gallinules, les bécassines, les tourterelles, les pigeons, les grues et les bécasses.
Comptez un jour pour chaque date à laquelle vous avez chassé les oiseaux aquatiques. Si vous n'avez pas chassé de la saison, n'inscrivez qu'un zéro (0) à la question 2, et mettez le questionnaire à la poste.

3. Place numbers in all spaces below to show your own personal hunting totals. Place a zero (0) for any kind of bird you did not shoot. Do not include birds killed or crippled by other hunters.
Indiquez le nombre total de vos prises personnelles dans les cases ci-dessous. Marquez un zéro (0) si vous n'avez abattu aucun oiseau des espèces indiquées. Ne mentionnez pas les oiseaux abattus ou blessés par d'autres chasseurs.

I KILLED AND RETRIEVED:
J'AI ABATTU ET RAPPORTÉ:
☐ Ducks / *canards*
☐ Coots (mud hens) / *foulques (poules d'eau)*
☐ Sea Ducks / *canards de mer*
☐ Canada Geese / *Bernache du Canada*
☐ Other Geese including Brant / *Autres oies bernaches cravant comprises*

I KILLED AND RETRIEVED ALSO:
J'AI ABATTU ET RAPPORTÉ AUSSI:
☐ Snipe / *bécassines*
☐ Woodcock / *bécasses*
☐ Mourning Doves / *tourterelles tristes*
☐ Band-tailed Pigeons / *pigeons du Pacifique*
☐ Gallinules / *gallinules*
☐ Cranes / *grues*

4. How many of the birds you shot THIS SEASON wore metal leg-bands?
Parmi les oiseaux que vous avez abattus, cette saison, combien portaient des bagues métalliques?
Ducks / *canards* ☐ Canada Geese / *Bernache du Canada* ☐ Other Geese / *Autres oies* ☐ Coots / *foulques* ☐ Others / *Autres* ☐

Kind of Bird / *Genre d'oiseau*	Band Number / *Numéro de Bague*	Date Taken / *Date de prise* Mon. / *Mois*	Day / *Jour*	Yr. / *Année*	Prov.	Place Taken / *Lieu de prise* Nearest Town / *Localité la plus proche*	Local Area / *Région*	Has This Band Been Reported Previously / *Cette bague a-t-elle déjà été rapportée?*

CWS 0-61 (7-69)

5. Please circle the province or territory where you did most of your hunting for migratory birds this season.
Prière d'encercler le nom de la province ou du territoire où vous avez surtout chassé, cette saison, les oiseaux migrateurs.
01 Nfld. – *T.-N.* 05 Que. – *P.Q.* 09 Alta. – *Alb.*
02 P.E.I. – *I.-P.-E.* 06 Ont. 10 B.C. – *C.-B.*
03 N.S. – *N.-E.* 07 Man. 11 N.W.T. – *T.N.-O.*
04 N.B. – *N.-B.* 08 Sask. 12 Yukon

6. Print Name of City, Town or Village (with Post Office) near place where most of your hunting was done, in rectangular box.
Inscrire en lettres moulées dans le rectangle le nom de la localité (Bureau de poste) la plus proche de l'endroit où vous avez chassé le plus.
Indicate with "X" in one of the circles showing direction from town to place where most of your hunting was done.
Indiquer par un "X" dans le cercle approprié dans quelle direction se trouve, par rapport à la localité, l'endroit où vous avez chassé le plus.
Give the distance in miles (Approx.) from town nearest to place where most of your hunting was done.
Donner approximativement, en milles, la distance entre la localité et l'endroit où vous avez chassé le plus.

Northwest / *Nord-ouest* — North / *Nord* — Northeast / *Nord-est*
Distance in Miles / *Distance en milles*
8. — 1. — 2.
West / *Ouest* — Town – *Localité* — East / *Est*
7. — 7.
Distance in Miles / *Distance en milles*
6. Southwest / *Sud-ouest* — 5. South / *Sud* — 4. Southeast / *Sud-est*

7. Did you hunt Migratory Game Birds in Canada?
In / *En* 1967 Yes / *Oui* ☐ No / *Non* ☐
Avez-vous chassé, au Canada, des oiseaux migrateurs considérés comme gibier?
In / *En* 1968 Yes / *Oui* ☐ No / *Non* ☐

8. DUCK CALENDAR: We would like to know when during the season you killed your ducks and how many you killed each day (except Merganser and sea ducks, i.e. Scoter, Eider, and Old-squaw, which in some places have special regulations).
Leave blank all dates you did not hunt waterfowl.
On days you hunted waterfowl during the duck season, show in the correct date-spaces the NUMBER OF DUCKS ONLY that you yourself killed and retrieved. DO NOT show other birds (geese, coots, sea ducks, etc.) in the calendar.
For all days of the ducks season on which you hunted but did not kill any ducks mark zero (0) in the proper date-spaces. Mark zero even if you killed other birds, (such as geese, sea ducks, etc.)

8. *CALENDRIER DE LA CHASSE AU CANARD: Nous aimerions savoir quand, au cours de la saison, vous avez abattu des canards et combien vous en avez abattu chaque jour, (à l'exception des becs-scie et des canards de mer, c'est-à-dire, les macreuses, les eiders et les kakawis, à l'égard desquels il existe, en certains endroits, des règlements spéciaux).*
Laissez en blanc toutes les dates où vous n'avez pas chassé les oiseaux aquatiques.
Pour les jours où vous avez chassé les oiseaux aquatiques, pendant la saison de chasse aux canards, indiquez, à la date voulue, le NOMBRE DE CANARDS SEULEMENT que vous avez vous-même abattus et rapportés. NE PAS INDIQUER au calendrier les autres oiseaux (oies, foulques, canards de mer et autres).
Pour tous les jours de la saison de chasse aux canards où vous avez chassé mais n'avez pas abattu de canard, inscrivez zéro (0) à la date voulue. Inscrivez zéro même si vous avez abattu d'autres oiseaux (tels que oies, canards de mer et autres).

September 1969 *Septembre*

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				
D	L	M	M	J	V	S

October 1969 *Octobre*

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	
D	L	M	M	J	V	S

November 1969 *Novembre*

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						
D	L	M	M	J	V	S

December 1969 *Décembre*

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			
D	L	M	M	J	V	S

January 1969 *Janvier*

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
D	L	M	M	J	V	S

9. In August we sent you a card to keep a record of your harvest. Did you find it useful?
En août, nous vous avons envoyé une fiche pour y noter vos prises. L'avez-vous trouvée utile?
Yes / *Oui* ☐ No / *Non* ☐

rates. He also demonstrated the utility of sending reminders and discussed several techniques for increasing the response, some of which have been introduced to the current system.

Some of the changes in the questionnaire which have improved response rates and encouraged accurate reporting are as follows:

a) The original questionnaire was bilingual. In 1972, the questionnaire was redesigned with English only on one side and French only on the reverse. Defacement, which had occurred on up to 8% of the forms previously, was eliminated and response rates increased. The information received was also more complete.

b) The location finder was redesigned in 1972 to simplify the response (Benson 1971*a* and Fig. 4).

c) Many questions have been simplified and made more comprehensible.

Figure 9 is a reproduction of the 1969 NHS questionnaire. Comparison with Figure 4 demonstrates the changes which have been made in the interval.

5.2.2. Stratification and sample allocation

For the first NHS 10% of 1966 permit purchasers were selected and were issued a card notifying them that they would be questioned concerning their 1967 hunting effort and success. Provinces were used as stratification units. The sampling universe was by necessity one year out of date because the 1967 permits were not processed quickly enough to allow the sample to be drawn from the current year.

In the following year, the 1967 data were used to reallocate the sample among the various strata in order to minimize the calculated variance in the estimate of mean duck kill per active hunter. This was done by choosing a sample size for each stratum proportional to the product of (*a*) the square root of the variance of the estimated duck kill and (*b*) the number of permit holders within the stratum. Cochran (1977) outlined the theory of this procedure, called "optimal allocation" due to Neyman (1934); Sen (1976) described its application.

In 1969 the NHS organizers divided the country into 21 geographical zones in an attempt to make each stratum more homogeneous with respect to hunting patterns and opening dates. Meanwhile, examination of the results of two years of harvest surveys and an additional hunter survey in 1967–68 in southern Ontario (Sen 1970*a*, 1972) showed that the survey did not adequately allow for the effects of hunter experience on the kill. The problem was major and derived from the sampling procedure.

Because the hunters to be questioned in a given year were selected from the Permit File of the previous year, two related problems arose:

a) approximately 30% of the questionnaires were sent to people who did not buy a permit in the current year; and

b) those hunters who did not buy a permit in the previous year but did so in the current year (also about 30%) could not be selected for the NHS. Thus the national estimates obtained by extrapolating from the NHS results to the entire hunter population were likely to be biased upwards as, in effect, every permit holder sampled was a "renewal". The pilot survey in southern Ontario (Sen 1970*a*, 1972) showed that the mean duck kills per hunter during the 1967 and 1968 seasons were 9.40 and 8.90 for those who had purchased a permit in the previous year (renewals) as against 6.67 and 6.50 respectively for new participants. Similarly, the renewals spent more days hunting. All the differences between the classes were statistically significant. As a result, the NHS was overestimating the waterfowl kill (Sen 1970*a*).

In 1972 the incoming permits were divided into two groups: renewals and non-renewals. The latter were processed immediately whereas the former were set aside to be processed later. Renewals, by definition, correspond to hunters who bought permits the previous year, and these hunters could therefore be selected from the previous year's Permit File. Non-renewals were selected from the current Permit File.

Table 6
The effect of hunter characteristics on estimates of duck kill by province, 1975

Zone	Duck kill/potential hunter			% bias ‡
	Renewal*	Non-renewal†	Combined	
Nfld.	4.11	1.83	3.41	20.5
P.E.I.	6.16	2.63	5.53	11.4
N.S.	9.95	3.41	8.54	16.5
N.B.	5.81	2.35	4.81	20.8
Que.	8.57	2.43	7.08	21.0
Ont.	7.21	4.00	6.56	9.9
Man.	7.60	4.64	7.09	7.2
Sask.	14.58	9.42	13.17	10.7
Alta.	13.67	7.75	12.03	13.6
B.C.	12.16	4.41	10.39	17.0
N.W.T.	5.25	7.07	5.49	−4.4
Yukon	9.60	5.55	7.82	22.8
Canada	9.31	5.01	8.30	12.2

* Renewals are hunters who bought permits the previous year.
† Non-renewals are hunters who did not buy a permit the previous year.
‡ Bias if renewals alone are used.

Within each zone, the permits were divided into three hunter groups: A, B, and D as defined in section 3.2. In 1972, an experimental stratum, C, was formed to try to improve the estimates by using successive sampling. The procedure, although it had worked well in simpler survey designs, proved impractical for the NHS (Sen 1971a; Sen, Sellars, and Smith 1975).

Stratification of the sampling universe reached its current form in 1973 with the grouping of non-resident hunters into a fourth sample (E) in each hunting zone having 50 or more non-resident permit holders. Originally, only non-residents drawn in the A samples were transferred to the E sample. By 1975, it had become apparent that renewal and non-renewal non-resident hunters were very similar in their hunting effort and success. Since 1975, all non-residents have become part of sample E.

In order to demonstrate the effect of hunter characteristics on NHS results, we have derived estimates for 1975 using both the current procedures and those which would have been obtained without the modifications (Table 6). Estimates are lower using the new procedure in all but the Northwest Territories, where the reported sport hunt was very small. In three provinces the difference exceeds 20%.

Because of the restructuring of the sampling universe it became necessary to reallocate the sampling effort. In 1973 information from the 1970 survey was used to further refine the sampling procedure when optimal allocation was computed by zone. By 1975 optimal allocation was calculated by strata within zones. The objective in applying the optimal allocation procedure was to reduce the provincial coefficient of variation (c.v.) of the estimated duck kill to 5% and the zonal c.v. to 8%. This was intended to result in provincial estimates of kill being known within 10% (with 95% confidence). Similar but less stringent objectives were established for goose kill in the Prairie Provinces.

The universe size and standard errors from the previous year were used to suggest the optimal zonal and provincial allocation. As no allocation is optimal for more

than one variable, a compromise was necessary. The allocation in any one stratum was generally limited to less than 25% of the total permit sales in that stratum. Because of this constraint, the target c.v.'s could not be reached in all Atlantic Provinces. Table 7 summarizes the results obtained in 1975 using optimal allocation. The 1974 standard errors have been adjusted to their expected value had the larger 1975 sample been selected. Although gains were made in some zones, particularly Newfoundland and British Columbia, there were some disappointing results. In the Prairie Provinces small gains were made in the precision with which goose kill was estimated but, as can be seen from Table 7, the allocation was not optimal for duck kill estimates. The lack of improvement in certain zones, such as 1 and 3 of Ontario, can most likely be explained by the high variability in the number of permit holders and duck kill from year to year. Better estimates of these quantities can be gained by using pooled data from several years. After 1978, a *minimum of four* years of data will be used to allocate the samples. These should not then be greatly affected by year-to-year fluctuations.

Thus the major sampling biases which were present in the 1968–71 surveys have been removed through stratification and the application of appropriate extrapolation factors. In addition, since the 1974-75 season, standard error estimates have been available. A complete account of the standard error calculations is given by Smith (1975). Table 8 compares estimates of mean duck kill per active hunter and their standard errors reported from the 1975 season with those of 1970. The standard errors of 1975, while numerically not greatly reduced from those of 1970, are based on more realistic assumptions. Improved sample allocation is being used in efforts to decrease standard errors.

These represent the major changes in the NHS sampling procedure. The present survey design has been described in section 3.2.

5.3. Species Composition Survey

The principal difficulties with the SCS are (*a*) acquiring an adequate and unbiased sample of duck wings and goose tails, (*b*) ensuring that the material reaches the reception centres in satisfactory condition and (*c*) devising and refining procedures for combining the SCS information with that from the NHS to calculate kill estimates and their variances by species, age, and sex.

Sample selection for the SCS is designed to maximize the return of waterfowl parts per hunter sampled. Large numbers of envelopes are sent out, yet the yield remains low (Table 9). In 1976 approximately 1.1 parts were returned per hunter contacted. There are a variety of reasons for not forwarding parts. The hunter (*a*) may not have bought a permit in the current year, (*b*) may have bought but not been active or, if active, not successful, or (*c*) may have been successful but not co-operative.

To increase the response, respondents to the previous year's surveys are *deliberately resampled* (see section 3.3.) because they are more likely to respond than those chosen randomly from the Permit File. The response, as measured in parts received per sampled hunter, is up to 10 times higher among hunters in categories SA, SC, and SD than it is among those in SE and SF (Table 9).

The initial attempt to purposefully resample individuals was in 1970. At that time, in addition to selections from the Permit File, one-half of the respondents to the previous year's SCS were resampled, as were one-half of the respondents to the previous year's NHS. Between 1970 and 1975 various other changes were made to improve response, resulting in the present sampling scheme outlined in section 3.3. In addition, in 1975 selection criteria were modified so that no hunter was asked to co-operate in the SCS for more than two consecutive years.

The risk in relying on a team of co-operators year after year, as is done in Britain and northwest Europe (Boyd, Harrison, and Allison 1975), is that they may be taking a different mixture of species than the majority of waterfowl hunters.

Within the present SCS, sampling bias is a factor which is endured. The sampling system is designed to maximize returns, and the implementation of a system similar to that used for the NHS which would minimize sampling bias would be too inefficient and costly. Some possible sources of sampling bias which may exist and have yet to be studied include (*a*) more intensive sampling of active and successful hunters than of other groups, and (*b*) the distribution of wing envelopes by sampled hunters to other hunters of unknown experience and success (19% of returns in 1976). To what extent these respondents are representative of all

Table 7
The effect of optimal allocation of stratified samples on zonal co-efficients of variation (c.v.) of total duck kill

Province*	Zone	1974†	1975
Nfld.	01	10.8	7.5
	02	20.8	16.3
P.E.I.		9.9	9.2
N.S.	01	11.7	8.5
	02	11.0	10.3
N.B.	01	8.1	9.6
	02	13.9	12.7
Que.	01	6.4	6.4
	02	14.2	9.3
Ont.	01	4.7	5.5
	02	7.3	6.0
	03	6.0	7.1
Man.	01	3.9	4.5
	02	6.8	7.9
Sask.	01	5.4	5.5
	02	5.7	6.3
	03	5.0	5.2
Alta.	01	4.2	5.0
	02	3.3	4.2
B.C.	01	11.3	9.2
	02	11.6	7.3

* Stratified sampling had not been implemented in the Yukon and N.W.T. in 1974.
† 1974 c.v.'s are adjusted to reflect the provincial sample size used in 1975.

Table 8
Estimates of mean duck kill per active hunter with standard errors by province for 1970 and 1975

	1970				1975			
Province*	Mean	Standard error	% coefficient of variation	Sample size	Mean	Standard error	% coefficient of variation	Sample size
Nfld.	5.44	0.53	9.7	514	5.18	0.33	6.4	873
P.E.I.	8.49	0.65	7.7	291	6.77	0.56	8.3	294
N.S.	8.02	0.45	5.6	393	10.37	0.61	5.9	833
N.B.	7.61	0.38	5.0	629	6.21	0.40	6.4	666
Que.	12.17	0.62	5.1	858	8.92	0.45	5.0	1260
Ont.	8.29	0.29	3.6	1815	8.09	0.28	3.4	2283
Man.	14.34	0.48	3.4	1139	7.79	0.27	3.5	1596
Sask.	18.01	0.61	3.4	1062	14.53	0.40	2.8	1972
Alta.	16.80	0.73	4.4	996	14.18	0.39	2.8	2135
B.C.	12.84	0.57	4.5	907	13.72	0.68	4.9	699
Canada	12.34	0.21	1.7	8604	10.17	0.15	1.5	12 611

* Duck kill estimates are not available for the Yukon and N.W.T. for 1970.

Table 9
Waterfowl parts received per hunter sampled in SCS hunter categories, 1976

	Parts received/hunter sampled				
	Sample*				
Zone	SA	SC	SD	SE†	SF †
Nfld.	1.16	0.59	0.33	0.05	0.11
P.E.I.	3.48	1.21	0.51	0.44	0.30
N.S.	1.81	1.44	0.68	0.44	0.24
N.B.	1.47	1.88	0.52	0.39	0.13
Que.	2.00	1.76	0.82	0.52	0.27
Ont.	1.87	2.02	0.69	0.65	0.34
Man.	2.84	1.65	0.73	0.53	
Sask.	2.34	1.69	0.55	0.83	
Alta.	3.48	1.84	0.63	1.06	0.66
B.C.	4.08	1.76	0.53	0.52	0.16
N.W.T.	1.48	0.59	0.11		
Yukon	5.63	0.82	0.61		
Canada	2.28	1.70	0.62	0.57	0.26

* Sample designation defined in section 3.3.
† Category E and F hunters are not always sampled.

waterfowl hunters in terms of the types of birds they shoot is not known. A tacit assumption of the present design is that the error introduced is not large. Intuitively we find this assumption reasonable but we are presently examining the extent of sampling bias.

Response bias occurs whenever hunters choose to send a non-random selection of their kill. Hunters may choose to send a particular wing because of the prestige of killing that species or because they cannot identify the bird. The tendency to send wings early in the season has been compensated for by the temporal adjustment (section 4.2.).

The problems associated with the transmission of parts through the mails cannot be solved completely. Hunters do not always ensure that the wings and tails are reasonably clean and free of unwanted fragments of skin, muscle, and bone and sometimes allow the birds to remain unfrozen before mailing them. It is not surprising that people delivering mail or in sorting offices object to dealing with smelly and blood-stained packages, sometimes with maggots dropping out of them. In 1970, at the insistence of the postal workers' unions, the paper wing-envelopes were given plastic liners, in the belief that this would reduce the nuisance. Almost certainly the opposite is true, because a sealed plastic container forms a better incubator for bacteria and fungi. The possibility of unpleasant incidents, due to delays in the picking-up and moving of materials, is a constant threat to the future of the SCS, both at a local and national level.

The results of the SCS and the NHS are brought together to produce harvest estimates by species. Until 1972 simple proportions from the SCS were applied directly to the harvest data. In 1972 the

Figure 10
Wing receipts in the SCS for insular Newfoundland, 1968–75

temporal adjustment of the SCS was incorporated (section 4.2.). This modification required melding summary data by time period and zone from the NHS with summary data by species, time period, and zone from the SCS. Currently programs are being developed to calculate standard errors for harvest estimates by species. To accomplish this, standard errors from the NHS and the results from the temporal adjustment procedure must be applied to each record in the Species File.

6. Limitations of the national surveys

The NHS and SCS measure the legal kill by sport hunters of migratory game birds in Canada. The surveys do not provide an estimate of total migratory game bird kill as, for example, illegal kill (section 6.2.) and the kill by Canada's native people (section 6.3.) are not included. Other limitations of the surveys are discussed in the following section.

6.1. Errors and data adjustments

The U.S. Fish and Wildlife Service (USFWS) has run waterfowl harvest surveys similar to the NHS since 1952 and SCS since 1961. The USFWS has investigated biases due to memory lapses and exaggeration (section 5.2.1.), and since 1960 kill estimates have been adjusted to compensate for these errors. The correction factors are a multiplier of between 0.74 to 0.87 for ducks and between 0.80 and 0.87 for geese, depending on the flyway of concern. The USFWS questionnaire asks about crippling loss and from the replies the Americans estimate that about 18% of waterfowl shot are not retrieved (Crissey 1975). They further adjust their estimate of kill accordingly.

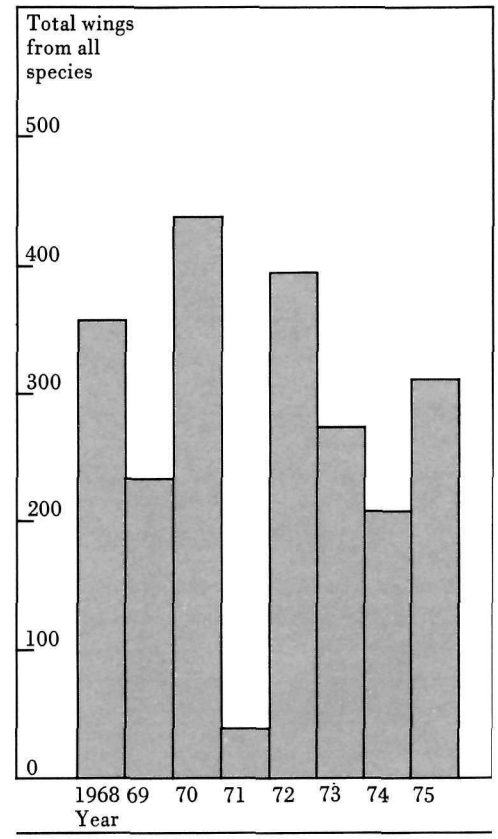
These "correction" factors are not currently applied to Canadian kill estimates because we lack accurate national data on both the degree of memory and prestige bias and the extent of crippling loss. Both are likely to vary spatially and temporally. For example, although Boyd (1971) estimated crippling loss in eastern Canada to be 23% (based on observations of hunters by concealed observers in 1967 and 1968), estimates of 38% provided by G. Hochbaum (pers. comm.) from spy blind operations at Delta, Manitoba (1973, 1974, and 1977) suggest that, at least locally, Boyd's estimates may have been much too low. Similar problems plague the calculation of correction factors in the United States and their usefulness to that survey has been questioned. Until more accurate and comprehensive data become available, these correction factors will not be applied to the NHS.

Data entering the NHS and SCS are routinely edited prior to analysis. Those editing functions, which ensure proper identification, compatible formats, and so on, need not be itemized here, as they do not substantially affect survey results.

The temporal adjustment of the species composition of duck kill, which was first introduced in 1972, noticeably improved the estimates (section 4.2.). However, the species, age, and sex ratios do not necessarily reflect relative abundance of the various populations or cohorts; differential vulnerability must also be considered. In areas where sufficient pre-season banding has occurred, appropriate correction factors can be generated and applied to the ratios reported in the CWS progress notes. An outline of the necessary computations is presented in Appendix 1.

The NHS and SCS were designed to give statistically reliable estimates of total kill for the most important species in each zone. Kill estimates for species which are uncommonly killed (or reported) within a hunting zone can be imprecise. Similarly, kill estimates for restricted areas within a zone may be unreliable because of irregular sampling intensity. If such estimates are required a special, more intensive survey may be used, such as that undertaken to determine Sandhill Crane kill in southern Saskatchewan (Cooch and Smith 1978). Interesting patterns, such as those presented by Freemark and Cooch (1978), can be suggested locally, though the data must be used with caution.

Figure 10



In addition to the above general limitations, isolated difficulties have occurred. For example, the SCS does not adequately account for birds shot in February and March in coastal regions. The kill of wintering ducks is therefore currently underestimated in these zones. Also, many post offices along the north shore of the St. Lawrence east of Sept Iles continue to refuse to handle the permits. In 1971 insufficient SCS envelopes were mailed to Newfoundland. The result of this error is graphically demonstrated in the greatly reduced wing receipts for that year (Fig. 10). A similar but less pronounced loss of data resulted from the post office strikes of 1974 and 1975.

A complete listing of potential biases in various computed estimates is not necessary in this text. Any investigator interested in using specific data should contact the Migratory Birds Branch, CWS, to discover if any relevant factors of this type may be affecting the estimates.

6.2. Illegal kill

The usefulness of measurements of hunting activity based on permit sales and on the NHS and SCS is limited by the following implicit assumptions: all hunters who should be in possession of a permit do in fact obtain one, hunters only hunt during the open season, and hunters do not exceed the prescribed bag and possession limits. In this imperfect world none of those assumptions can be taken for granted and any comprehensive assessment of migratory bird harvest must take into account illegal kill.

Table 10 summarizes convictions under the Migratory Bird Act for the 1974, 1975, and 1976 hunting seasons, for the three most common offences prosecuted: hunting without a permit, hunting out of season, and exceeding bag or possession limits. Data are incomplete for Saskatchewan and Alberta and insufficient for meaningful analysis for British Columbia and the territories.

The usefulness of these data for determining the extent of illegal kill is limited. As the great majority of charges are laid by the RCMP and by provincial game officers rather than by CWS enforcement staff (whose principal task is co-ordination of the activities of the other agencies), CWS records of the ratio of charges laid to hunters observed are incomplete. We are thus not able to distinguish between variations in enforcement effort and variations in illegal activity. The data do show, however, that convictions are not uncommon in any region of Canada and emphasize that for waterfowl managers some knowledge of the extent of illegal kill is essential.

Another approach to quantifying illegal harvest has been through the use of the spy blind. No comprehensive spy blinding program has existed to date in Canada. Table 11 presents some information from several different investigations in eastern Canada, during the period 1968–70. The data record that of 204 hunting parties observed, 11.3% were in violation of at least one regulation of the Migratory Birds Convention Act. A wide variation is apparent among regions in both the number of offences per hour and the percent of observed parties who were in violation.

Additional information is available from a spy blind operation in Delta, Manitoba designed to collect data on crippling loss. A total of 105 hunters were observed for a total of 88.75 hours during the hunting season. A total of 25 offences were recorded: there were nine instances of overpossession, seven ducks were not retrieved,

Table 10
Convictions relating to hunting without a permit, hunting out of season and exceeding bag and possession limits under the Migratory Birds Convention Act and Regulations: pooled data for 1974 to 1976 (except where shown)

	Offence				
Province*	Hunting without a permit	Hunting out of season	Exceeding bag and possession limits	Other offences	Total
Nfld.	40 (44)†	19 (21)	1 (1)	31	91
P.E.I.	19 (50)	6 (16)	0 (0)	13	38
N.S.	34 (38)	16 (18)	2 (2)	38	90
N.B.	28 (18)	104 (65)	1 (1)	27	160
Que.	286 (26)	165 (15)	31 (3)	638	1120
Ont.	236 (27)	90 (10)	82 (9)	462	870
Man.	56 (24)	43 (18)	38 (16)	99	236
Sask.‡	62 (18)	7 (2)	23 (7)	248	340
Alta.‡	47 (31)	32 (21)	13 (9)	60	152

* No data available for B.C.
† Bracketed figures are percentages of totals for each province.
‡ Incomplete data for 1975; no data for 1976.

Table 11
Violations of the Migratory Birds Convention Act and Regulations recorded during spy-blind observations in eastern Canada, 1968–70*

	Province					
	Nfld.	N.S.	N.B.	Que.	Ont.	Total
Hunting parties observed	5	6	17	53	123	204
Hours of observation	4.25	6.50	56.25	100.00	334.75	501.75
No. of violations noted	3	3	3	3	11	23
"Offences per hour"	—	0.13	—	0.03	0.03	0.05
Parties with violations (%)	—	32.1	—	5.7	8.9	11.3

* Offences recorded: outside permitted hours 6; hunting from boat under power 4; shooting protected species 4; out of season 2; exceeding bag limit 2; single cases of shooting from car, unlicensed rifle, unplugged shotgun, failure to retrieve downed birds, one now unidentifiable.

Table 12
Estimated total and per capita annual waterfowl harvest by native people in selected areas of northern Canada

Location, year	Geese		Ducks		Total waterfowl	
	Total	Per capita	Total	Per capita	Total	Per capita
Habay Alberta*						
1966	—	—	—	—	8600	48.0
1967	—	—	—	—	2010	11.5
Eastern James Bay Cree† 1973/74; 1974/75 (average)	98 038	16.2	53 808	8.9	151 846	25.1
Northern Quebec Inuit‡	31 225	8.6	14 870	4.1	46 095	12.7
Great Slave Lake, §|| Mackenzie River and Western Arctic Islands	12 465	0.8#	42 975	2.6	55 440	3.4

* Macauley and Boag 1974.
† James Bay and Northern Québec Native Harvesting Research Committee 1976 Part I.
‡ James Bay and Northern Québec Native Harvesting Research Committee 1976 Part II.
§ Berger 1977*b*.
|| Data extrapolated from poor data base.
Based on population estimates of 16 500 (Berger 1977*a*: 147).

seven non-game birds were shot (including Yellowlegs, Whistling Swans, Double-crested Cormorant, and Snow Bunting) and there were two cases reported of shooting after hours (G. Hochbaum, pers. comm.).

These fragmentary data must be viewed with caution. The areas to be monitored were not selected randomly. There were different investigators and no standard methods were used to acquire the data. Little emphasis was given to hunting out of season. Permits were not usually checked in order to assess compliance in this regard. Nevertheless, there are indications that in some areas of Canada illegal harvest may be an important consideration.

Much remains to be done before the scale of the illegal kill of migratory birds in Canada is established with sufficient reliability to help in the development and application of detailed national and international management plans. However, some adjustment of hunting activity as measured by the NHS and SCS is necessary. The agencies responsible for management and enforcement must obtain better information about illegal hunting and devise ways of reducing it. An extensive and systematic hunter observation program appears to offer the greatest potential for improving our knowledge. Illegal hunting may be raising the total kill of some stocks to dangerously high levels. Even if it is not at present endangering migratory game bird populations, illegal hunting is unfair to law-abiding hunters, who might be subjected to less restraint if illegal activities were diminished.

6.3. Kill by native people

The Migratory Birds Convention Regulations state that any Indian or Inuk or any resident of the Mackenzie District, Northwest Territories, who possesses a General Hunting Licence (GHL) need not hold a Canada Migratory Game Bird Hunting Permit. Also, any Indian or Inuk can take auks, auklets, guillemots, murres, puffins, and scoters for human food or clothing at any time. Otherwise, Indians and Inuit are subject to the laws of general application.

Since the NHS and SCS locate hunters through their permit records, these exemptions from the permit requirement result in the omission of an unknown proportion of migratory bird hunters from the sampling base.

The impact of Indian, Inuit, and holders of NWT General Hunting Licences on migratory bird populations is not well documented. Between 1970 and 1975 there were an average of 2225 GHL holders in the Mackenzie District, mostly Indians, Inuit, or Métis (Berger 1977*b*). Accurate information on the kill of migratory birds is available for only a few northern communities (Table 12). The native people of James Bay and northern Quebec are very dependent on waterfowl. Together they kill approximately 200 000 birds per year (James Bay and Northern Quebec native harvesting research committee 1976). The Indians along the James and Hudson Bay coast of Ontario may kill an additional 30 000 to 38 000 (Hanson and Gagnon 1964).

The data available for the Northwest Territories are based on GHL reports and are both incomplete and inaccurate (Usher 1977, Berger 1977*b*). Most birds are shot outside the legal season because the spring and summer are the only times when they are available and many people depend on them for subsistence purposes. People are, naturally, hesitant to report this kill. In addition, wherever land claims are extant, reporting game harvest is sometimes viewed to run contrary to political self-interest. Any coherent attempts at responsible bird management are therefore frustrated where this mix of circumstances exists.

The Habay, Alberta study shows that for this band of Slave Indians waterfowl represent an important part of the diet, although the annual kill varies greatly, apparently in response to waterfowl density (Macauley and Boag 1974). The community is situated on the Hay Zama Lakes, which are both a good waterfowl production area (by boreal forest standards) and on an important migration route.

Even with the limited data available, it is obvious that migratory bird harvest by native people cannot be ignored in bird management programs. Boyd (1977) showed that in 1973 and 1974 northern Quebec hunters accounted for 17.4% of the total kill of mid-Atlantic Canada Geese, 4.6% of

Table 13
Total Migratory Game Bird Hunting Permit sales in Canada, 1966–1977*

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
1966	13 269	3271	7220	8535	35 868	144 063	37 784	44 744	52 911	32 394	—	—	380 059
1967	14 863	3094	7883	7739	32 491	146 493	35 620	44 651	55 892	33 195	—	—	383 032
1968	17 645	3649	9022	9558	37 110	139 182	38 712	43 596	53 623	33 301	—	—	385 553
1969	19 089	3794	8848	10 110	39 477	134 037	41 611	45 347	53 602	32 764	—	—	389 325
1970	21 347	3926	9926	10 293	46 009	135 231	39 230	47 722	59 986	31 350	—	—	405 650
1971	23 460	4513	11 381	11 146	50 276	133 563	40 960	49 448	62 902	30 225	—	—	418 237
1972	23 682	4492	12 158	11 336	53 982	131 427	41 133	50 004	63 309	31 032	—	—	421 677
1973	27 919	4972	15 071	12 869	57 247	141 277	41 711	51 307	67 012	33 456	—	—	452 841
1974	25 127	5038	13 791	11 916	58 345	136 469	37 167	51 504	66 127	27 764	591	323	434 162
1975	30 115	4963	13 990	12 930	63 768	148 670	42 846	57 723	69 191	25 918	721	485	471 320
1976	29 621	5756	13 326	13 743	66 453	143 816	46 681	61 669	75 739	26 461	893	513	484 771
1977	36 188	6158	15 744	14 209	72 828	156 895	46 438	60 029	82 175	28 357	902	607	520 530

*1966-76 data from Cooch, Newell, and Wendt 1978*a*.
1977 data from National Harvest Survey files.

the Mississippi population, and 4.7% of the Tennessee Valley population. Even the limited data available amount to a waterfowl harvest by native people in excess of 280 000 per year. The upper bound is entirely speculative.

It would be a serious error to assume that the results of the few existing studies are representative of the use of migratory birds by all of Canada's native people. Migratory bird kill has apparently been measured in areas where it was known or suspected to be substantial and ignored elsewhere. CWS has undertaken to collect more reliable information across the country but the task is difficult and results are not yet available.

7. Results of the surveys

7.1. Participation in migratory game bird hunting by Canadians 1966–77 with projections to 1985.

In 1966, when the permit was first introduced, 380 059 were sold. By 1977 the number had climbed to 520 530 (Table 13). Permit sales to non-residents varied between a low of approximately 14 700 in 1966 and a high of 19 800 in 1976, showing no obvious pattern (Cooch 1978*b*). Provinces were grouped to correspond to CWS administrative regions — Atlantic (Nfld., P.E.I., N.B., N.S.); Quebec; Ontario; Western and Northern (Man., Sask., Alta., N.W.T.); Pacific and Yukon (B.C., Y.T.) — and permit sales analyzed for trends between 1966 and 1977. In all regions, except Ontario, and in Canada as a whole, permit sales were well explained by linear trends (Fig. 11). Sales throughout Canada increased significantly at a rate of nearly 12 000 per year; linear increases were also recorded in Atlantic, Quebec, and Western and Northern regions. Sales in the Pacific and Yukon region declined significantly at a computed rate of 550 per year. Permit sales in Ontario dropped steadily between 1966 and 1972 but have been generally increasing for the past five years. Permit sales in Ontario can be approximated by a quadratic; Figure 11 shows the point of inflection to be between 1970 and 1971.

Figure 11 also projects permit sales in 1985: Atlantic, 97 000; Quebec, 100 000; Western and Northern, 221 000; and Pacific and Yukon, 23 000. In Western and Northern region, permit sales have been rising at a faster than linear rate in recent years. Projections for this region are therefore less reliable than those for the Atlantic, Quebec, and Pacific and Yukon regions, where strictly linear trends are more evident.

Projection of permit sales in Ontario based on a quadratic seems unrealistic. We feel that better projections can be made if we assume that sales were decreasing linearly in early years and increasing linearly recently. If we assume that the upward trend began in 1971, the 1985 estimate of permit sales is about 182 000. If the change in trend is assumed to be one year earlier, the 1985 estimate becomes about 175 000, and if only 1972 to 1977 data are used, the 1985 estimate is approximately 187 000. We have no objective way of selecting one of these estimates over the others.

Projected permit sales in Canada in 1985 based on total sales (Fig. 11a) are 591 000. As indicated earlier, however, total sales do not fit a linear model very well. If projected regional totals are summed, the predicted national sales for 1985 are between 616 000 and 628 000, depending on the value assigned to Ontario.

Participation rate is defined as the proportion of the resident male population of Canada[2] between the ages of 15 and 74 who purchase a permit. Over 95% of all

[2] Population statistics supplied by Statistics Canada

Figure 11
Total sales of Migratory Game Bird Hunting Permits, 1966–1977 with projections to 1985 for a, Canada, b, Atlantic region, c, Quebec region, d, Western and Northern region, e, Ontario region, f, Pacific and Yukon region

Figure 11

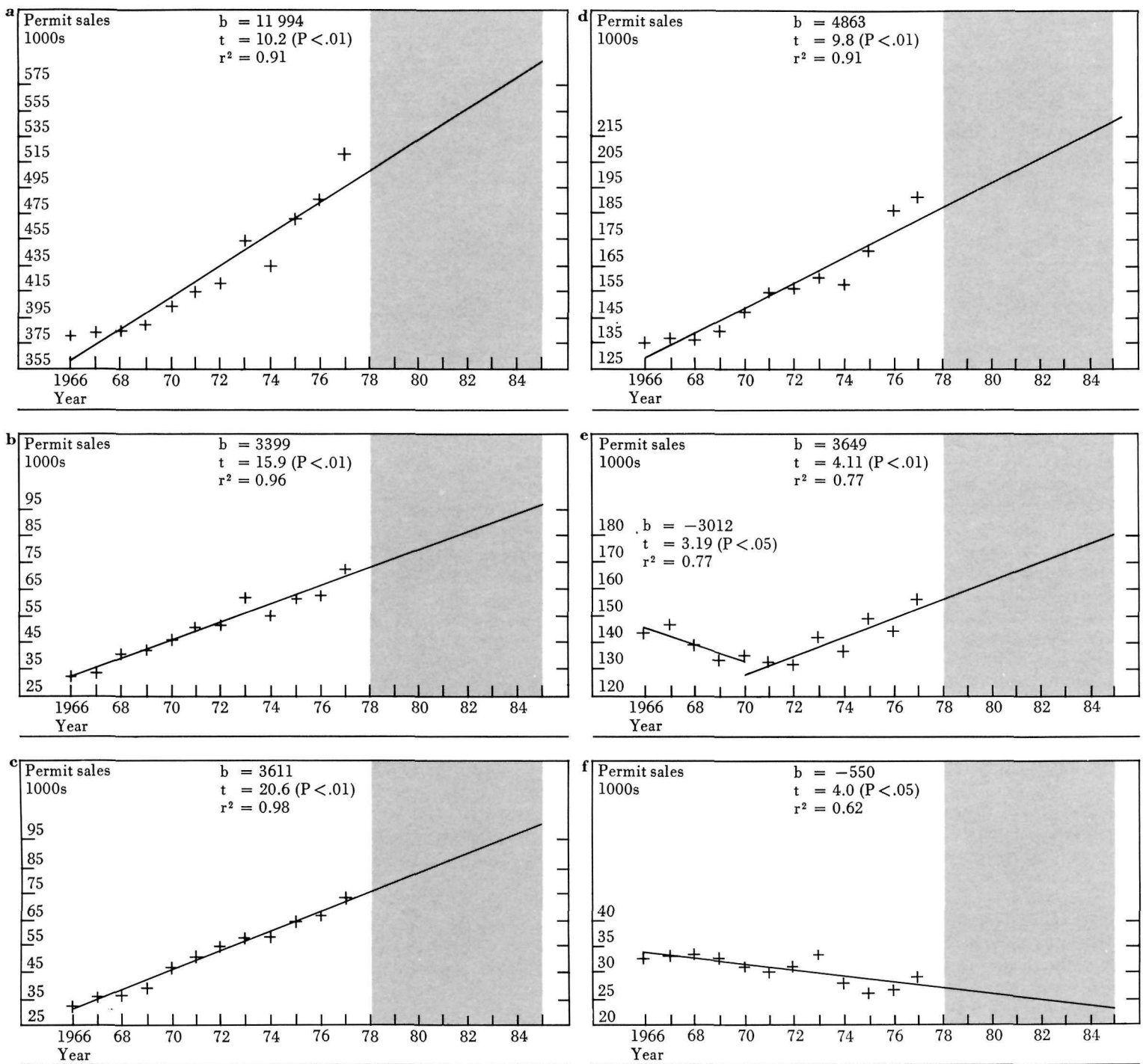


Figure 12
Estimated duck kill in Canada, 1970–77, with 90% confidence intervals for the 1974–76 estimates

migratory bird hunters come from this segment of the population.

The average participation rate in Canada (N.W.T. and Y.T. excluded) between 1966 and 1976 was 5.6%. There has been no noticeable trend nationally (Table 14). The rate in Western and Northern region (N.W.T. excluded), which averaged 12.2% over the period, was much higher than in any other area of Canada. Quebec region had the lowest 10 year average rate at 2.4%; the participation rate increased significantly in the province at an average of 4.33% per year. The participation rate also increased significantly in Atlantic region at approximately this rate but declined dramatically in Pacific and Yukon region (Y.T. excluded) at a rate of 7.67% per year. Ontario region showed a decline over the decade but most of this drop occurred in the first few years. Since 1969 the participation rate has been relatively stable, varying between 4.5 and 5.0%.

Stable participation rates indicate that the same proportion of the population is hunting each year. As the Canadian population continues to grow, the number of migratory game bird hunters will tend to increase. In three regions of Canada, sport hunting of migratory game birds is growing at a faster rate than is the human population. Increasing pressure on migratory game bird populations in Canada can be inferred.

7.2. A summary of the kill of migratory game birds in Canada, 1970–77

7.2.1. Ducks

Ducks make up most of the migratory game bird kill in Canada. In the eight years from 1970 to 1977 the average estimated duck kill by permit holders was 3.7 million (Fig. 12). The kill increased during this period, except in 1973 and 1977. In 1973 poor weather during the hunting season reduced the kill, especially in Saskatchewan and Manitoba. In 1977, the exceptionally dry spring conditions led to a reduced production of young and a substantial decline in the proportion of young in the kill (unpubl. data).

Figure 12

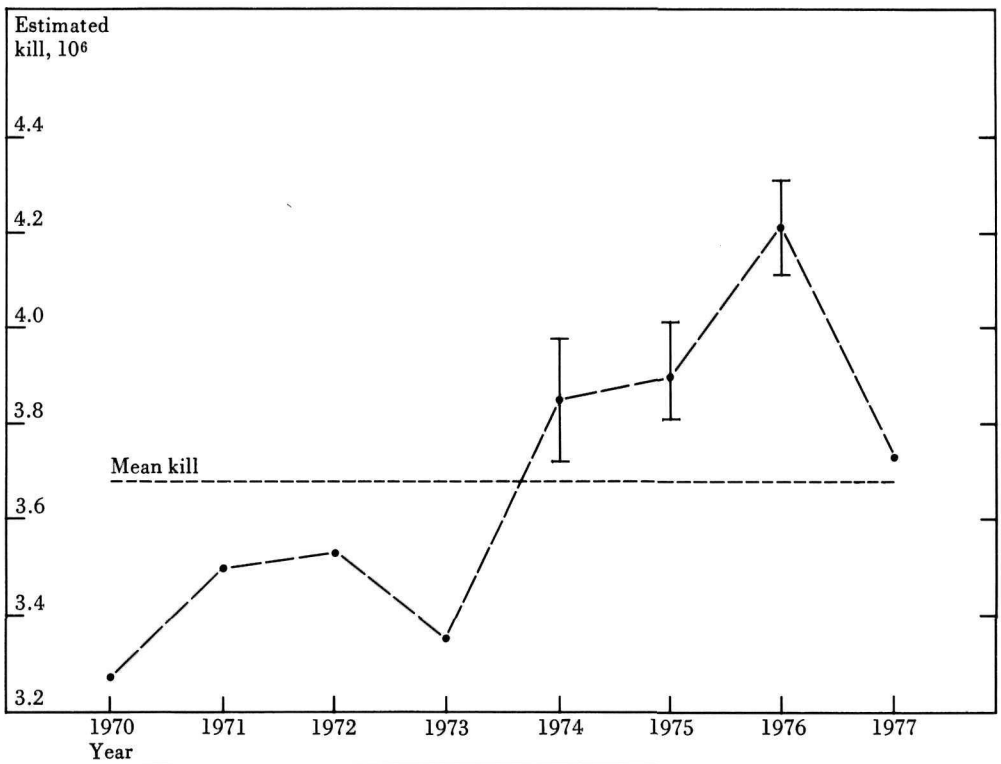


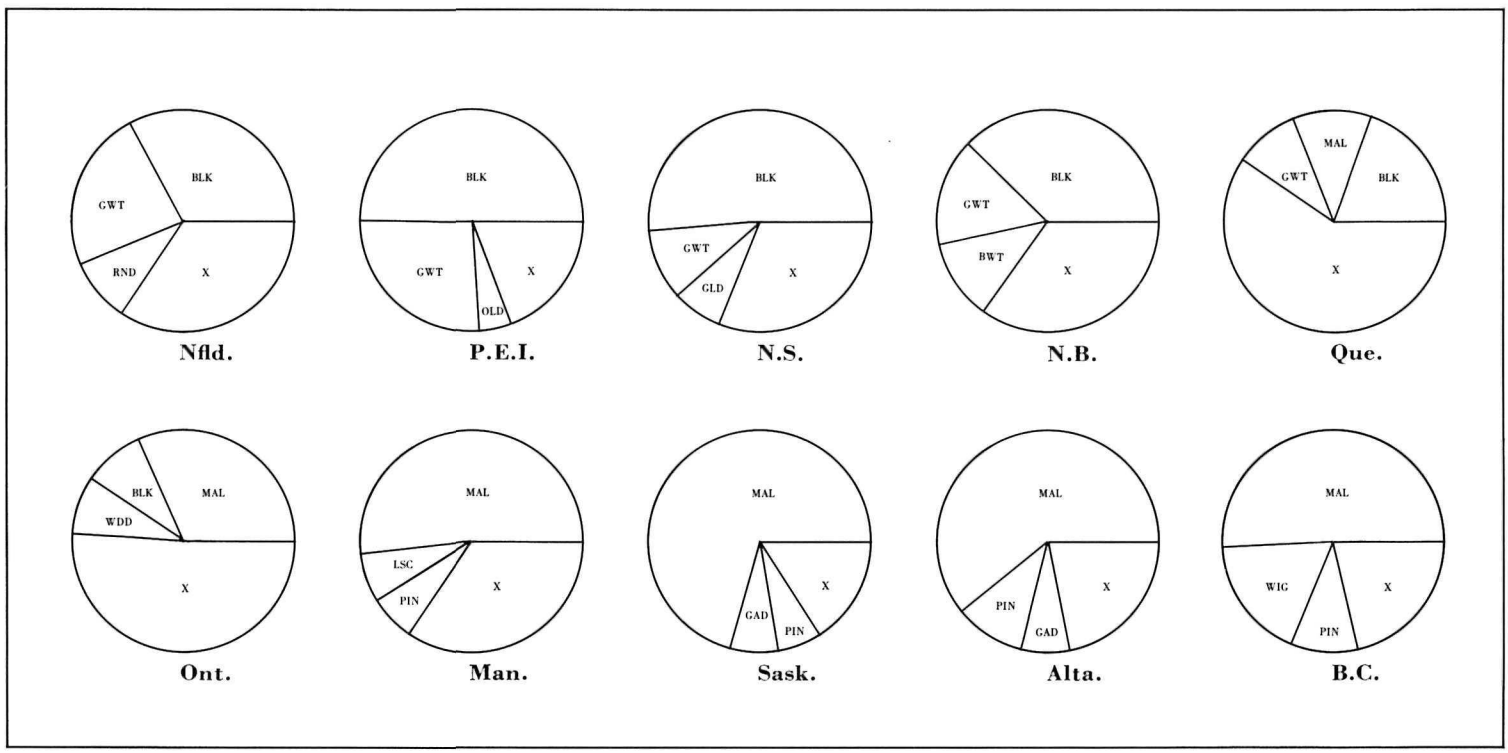
Table 14
Participation of Canadian resident males* in migratory game bird hunting by region, 1966–1976

Region	Participation (%) 1966	1976	Average	Average change per year †
Atlantic	5.3	8.4	7.1	+ 4.65%
Quebec	1.9	3.0	2.4	+ 4.33%
Ontario	6.0	4.6	5.1	− 2.55%
Western Northern‡	12.1	13.1	12.2	+ 0.82%
PacificYukon§	5.2	3.0	4.1	− 7.67%
Canada#	5.7	5.7	5.6	— ‖

* Age 15 to 74.
† Computed from linear least squares approximation.
‡ Excludes the N.W.T.
§ Excludes the Yukon.
‖ No significant trend.
Excludes N.W.T. and Y.T.

Figure 13
Species composition of the duck kill by province as determined by the SCS, 1975

Figure 13



BLK	Black Duck	MAL	Mallard	X All other ducks
BWT	Blue-winged Teal	OLD	Oldsquaw	
GAD	Gadwall	PIN	Pintail	
GLD	Goldeneye	RND	Ring-necked Duck	
GWT	Green-winged Teal	WDD	Wood Duck	
LSC	Lesser Scaup	WIG	American Wigeon	

The general increase in duck kill is related to increases in permit sales (section 7.1.). The average number of ducks killed per permit holder has not varied significantly among years for any region of Canada. Projections of duck kill based on the permit sales projections are given in Table 15. These projections assume that permit sales increase as predicted, that regulations remain the same and that there are no catastrophic declines in duck populations.

Figure 13 depicts the composition of the duck kill in 1975 as determined from the SCS. Mallards account for more than half the kill in the four western provinces and are the most important species in Ontario. East of Ontario the Black Duck dominates.

7.2.2. Geese

Goose kill during 1970–77 averaged 450 000. As with ducks, there was a general increase during this time, but the goose harvest varied more from year to year (Fig. 14). Canada Geese comprise most of the geese shot. Snow Geese are the second most important species and have been shot in increasing proportions during this period in keeping with a growing population (Boyd 1976). White-fronted Geese are also shot in significant numbers, especially in Saskatchewan. Ross' Geese and Brant make up about 1% of the goose kill.

Most geese nest in northern areas where poor weather can severely reduce nesting success; yearly changes in goose kill can largely be explained by weather conditions in the Arctic. In 1972 and 1974 protracted snow cover caused poor production and resulted in declines in kill. In 1973 and 1975 both weather and production were good and kill increased relative to the previous season.

Geese do not reproduce until they are at least two years old. This may account for the low kill in 1976 relative to 1975 despite favourable nesting conditions in 1976, since a large proportion of the population was in the non-breeding cohort and less vulnerable to hunters.

Table 15
Average duck kill per potential hunter, 1972-77, with projections of kill in 1985

Region	Average duck kill per permit sold	Projected 1985 permits sold	Projected 1985 duck kill
Atlantic	4.99	97 000	482 000
Quebec	8.58	100 000	857 000
Ontario	6.07	175 000–187 000	1 063 000–1 137 000
Western & Northern	10.75	221 000	2 375 000
Pacific & Yukon	8.40	23 000	195 000
Canada	8.11	616 000–628 000	4 994 000–5 092 000

Table 16
Estimated kill and accuracy of NHS estimates*, 1976

Species group	Estimated kill†	Accuracy*
Ducks	4 210 000	± 2%
Geese	520 000	± 5%
American Woodcock	159 000	±13%
Common Snipe	107 000	±12%
American Coot	48 000	±16%
Sandhill Crane	1640	±39%
Mourning Dove	3700	±51%
Band-tailed Pigeon	3290	±51%

* 90% confidence level.
† Data from Cooch, Newell, and Wendt 1978 *a,b*.

The larger races of Canada Geese breed in lower latitudes than other geese, so they are not as susceptible to the effects of weather. In Newfoundland, for example, where the Atlantic race of Canada Goose predominates, there were no significant changes in goose kill from 1974 to 1976 (the kill estimate was about 8000 each year).

The generally increasing goose kill reflects the increase in permit sales. The strong dependence of goose production on climate makes projection of goose kill very uncertain even for the near future.

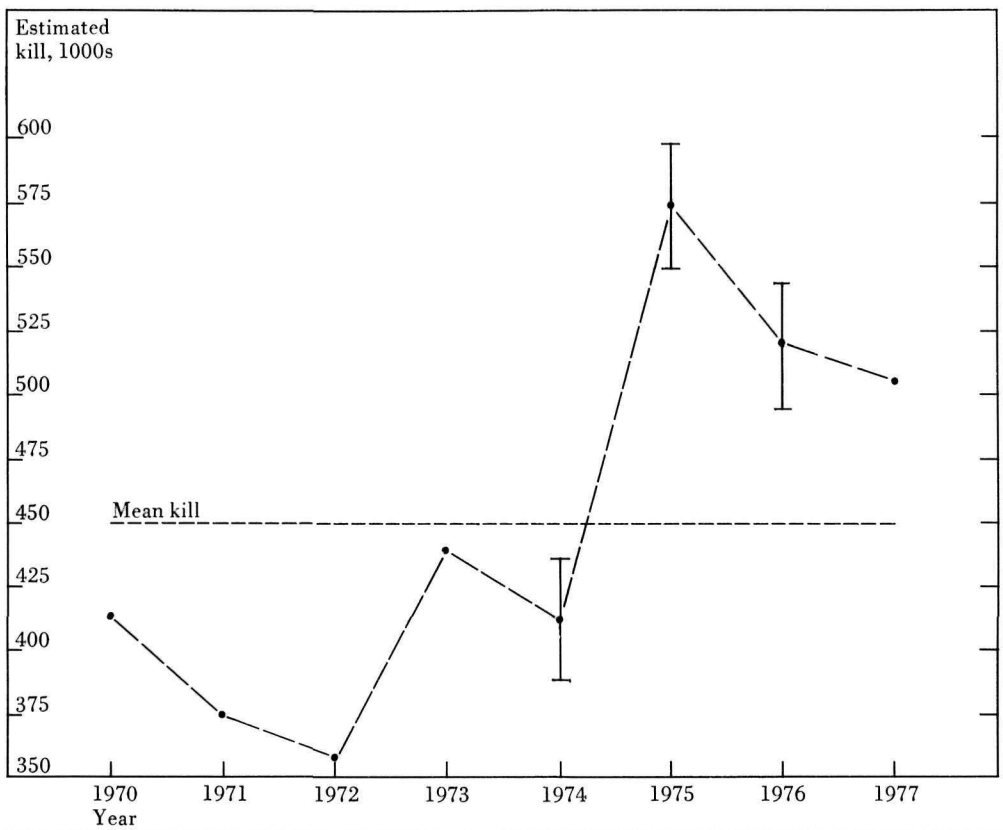
7.2.3. Other species

Only about 15% of the hunters responding to the NHS report hunting migratory game birds other than waterfowl. As a result, estimates of kill for those species have wider confidence intervals. For example, in 1976 the estimated duck kill in Canada was 4 210 000 with a 90% confidence interval of ±2% whereas the estimated American Woodcock kill was 159 000 with an accuracy of ±13% (Table 16). The confidence intervals of estimated kill for other species routinely analyzed in the NHS were as high as ±51% (Band-tailed Pigeon).

Woodcock are the most commonly hunted non-waterfowl species of migratory birds. The average annual kill between 1970 and 1977 was 120 000 (Fig. 15). The largest harvest of woodcock occurs in Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island, in order of importance. The kill in 1970 and 1971 was low because of restrictive regulations in New Brunswick (Benson 1971*b*).

Wings from woodcock killed in Canada have been collected since 1959. Before 1970 they were collected by the U.S. Bureau of Sport Fisheries, and since then by CWS. The results of these surveys, which

Figure 14
Estimated goose kill in Canada, 1970–77 with 90% confidence intervals for the 1974–76 estimates



are used to derive productivity indices, are reported elsewhere (Dobell and Boyd 1972, Baird and Dobell, in press).

Common Snipe represent the next most frequently hunted species in Canada. The kill between 1970 and 1977 averaged 99 000 and no trend was evident (Fig. 16). Quebec is consistently the province with the greatest snipe kill and the noticeable decline in Canadian kill in 1977 can be mostly attributed to a decline in the kill there. All other provinces report some snipe kill, Newfoundland and Ontario being the most important. CWS routinely undertakes a special Common Snipe survey. Dobell and Cooch (1976) give the results for the 1974 and 1975 seasons.

Figure 17 shows the kill of American Coot from 1972 to 1977. The NHS kill estimates for coot are not reliable prior to 1972 because they included "Sea Coots" (i.e. scoters) from the Atlantic Coast. The average estimated kill since 1972 was about 41 000. The reduction in coot harvest in 1977 is associated with the poor waterfowl production that year.

Estimates of Sandhill Crane kill in Canada are routinely calculated from the NHS. A Sandhill Crane survey conducted by CWS following the special crane season in southern Saskatchewan, where the majority of kill occurs, showed that the NHS results were acceptable within the stated confidence limits. These confidence limits are large, however, because the Sandhill Crane is hunted by only a small proportion of Canadian hunters (Cooch and Smith 1978). The NHS estimates of Mourning Dove and Band-tailed Pigeon kill in British Columbia are also imprecise for similar reasons. Accurate estimates of the kill of these species can only be obtained through more intensive local surveys.

7.3. Dissemination

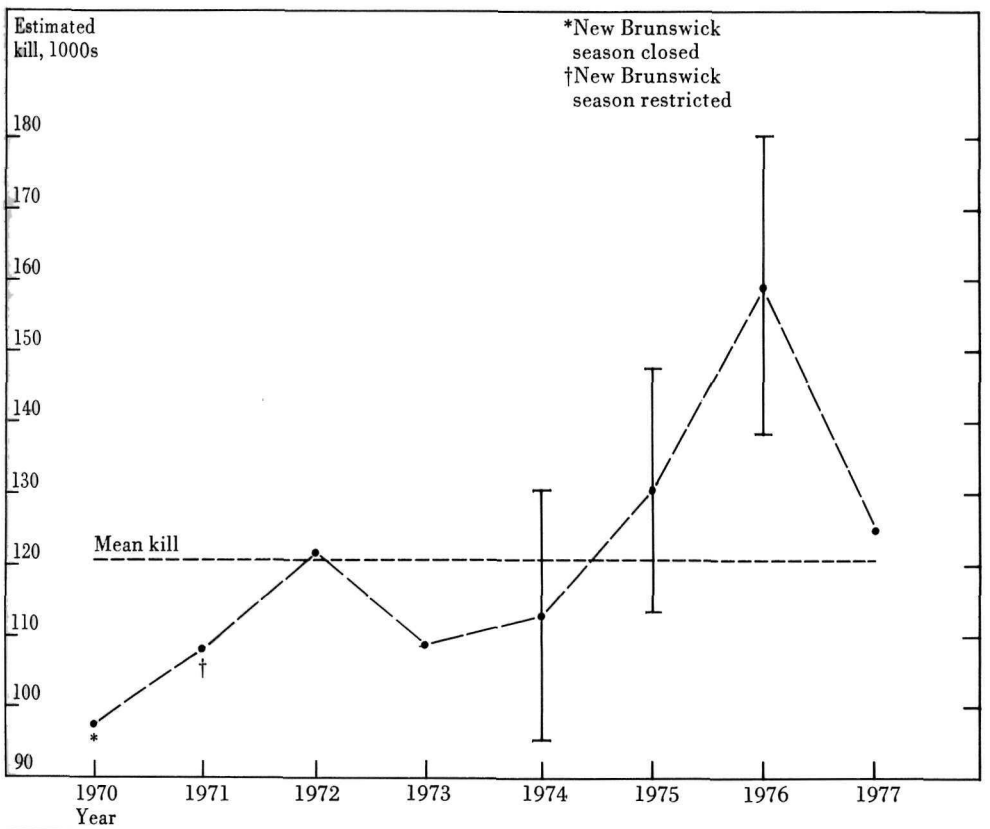
Results from each year's surveys are compiled and published as CWS progress notes. The data presented in this way are summarized by zone since the NHS has been designed to minimize the standard errors of the estimates at this level.

Typically, the progress notes present permit sales by province, estimates of total kill, kill per hunter for the species groups on the NHS questionnaire (section 4.1.), kill estimates by species (section 4.2.), estimates of age and sex ratios of the birds killed, and a few other statistics.

Appendix 2 lists the progress notes which give the fresh data each year. To allow comparison subsequent progress notes generally present data for earlier years. When changes in calculation techniques were introduced (e.g. the temporal adjustment) results from previous surveys were recalculated (e.g. Cooch, Kaiser, and Wight 1973). For this reason data from several years are most directly comparable when taken from a single progress note.

Researchers using published data from the surveys should be aware of changes in the survey which are described in various progress notes. Some earlier progress notes tabulate some statistics which are no longer published. These are shown in Appendix 2. The 1967 NHS asked two questions which were not repeated in later surveys: the distance travelled from the hunter's residence to his hunting location, and the number of shells used in hunting. The results of these questions are summarized in Benson (1971*a*). The most important alterations took place in 1972 with the addition of NHS sample A and the temporal adjustment. For this reason careful interpretation is needed when comparing results published before 1972 with those published later.

Figure 15
Estimated kill of American Woodcock in Canada, 1970–77 with 90% confidence intervals for the 1974–76 estimates



Computer records are kept of past permit sale and survey data. Appendix 3 shows the data which are available. The retrieval files can be used to locate information which may be applicable to a specific project but which does not routinely appear in the progress notes. For example, one could calculate the total kill of snipe by non-residents in New Brunswick by creating a sub-file with the record of snipe kill by these hunters and their associated extrapolation factors. Multiplying reported kill by the extrapolation factor and summing the products yield the required result. General data management programs are available which make these calculations relatively routine. More complex analyses may require development of special computer programs.

Some examples of detailed analyses using the NHS and SCS results are given in companion papers. Examples of papers using primarily published results are those by Boyd, Newell, and Smith (1978) and Cooch (1978*a*, *b*). Newell and Boyd (1978) and Freemark and Cooch (1978) made use of specialized programs.

8. Acknowledgements

Although D. A. Benson and F. G. Cooch have had functional responsibility for the development and operation of Canada's national surveys of migratory birds, the high quality of today's survey results owes much to the calibre of their associates both in and out of Ottawa. Recognition must be given to the early co-operation and assistance received from the USFWS Migratory Bird Populations Station, Patuxent Wildlife Research Center, Laurel, Maryland. That group made available samples of systems documentation, forms, envelopes, analysis, and manuals which allowed CWS to avoid many of the pitfalls which the older U.S. surveys had experienced. G. Sherstone, Canada Post Office was instrumental in establishing today's network of permit vendors.

A characteristic of the teams assembled to develop and operate these systems since 1966 has been the freedom enjoyed by members to criticize existing systems and to propose changes and improvements. It would be a serious omission not to acknowledge the contributions over the years of R. Baroni and H. Delcorde (program managers), F. Filion (forms design), G. Kaiser, K. L. Newell, and L. Wight (research biologists), H. Raible (systems analyst), H. Beznaczuk, L. Couling, S. Sellars, and A. R. Sen (biometricians), V. Benish, I. Brown, J. Cocks, E. Hutcheson, S. Quinn, and L. Teevens (auditors), D. Brown, O. Duquette, G. Fontaine, R. Guibord, D. Johnston, B. Joly, M. MacArthur, B. Nagpal, J. Rodgers, T. Seal, V. Thomas, and J. Weibe (systems analysts and programmers), G. Brownrigg and I. Stephen (data capture), C. B. Baker, B. Cabana, M. Gratton, and A. Legere (operations and maintenance).

The contributions to these national survey systems made by CWS regional and provincial biologists must not be overlooked. It was they who in several cases first attempted to provide national estimates from the survey data, and who as a result detected many of the shortcomings of the early surveys. Identification of wings and tail-fans to species, age and sex is done entirely by CWS regional staff and by biologists and technicians from universities, provincial governments, and private foundations who annually volunteer their services.

Figure 16
Estimated kill of Common Snipe in Canada, 1970–77 with 90% confidence intervals for the 1974–76 estimates

Figure 16

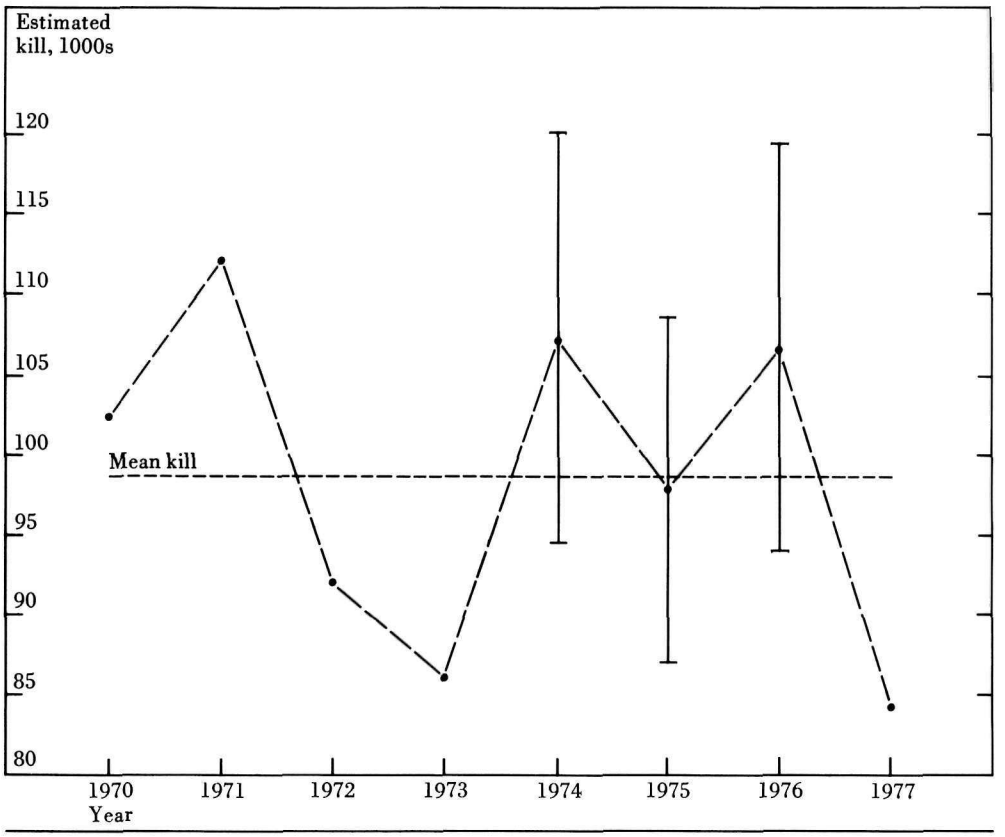


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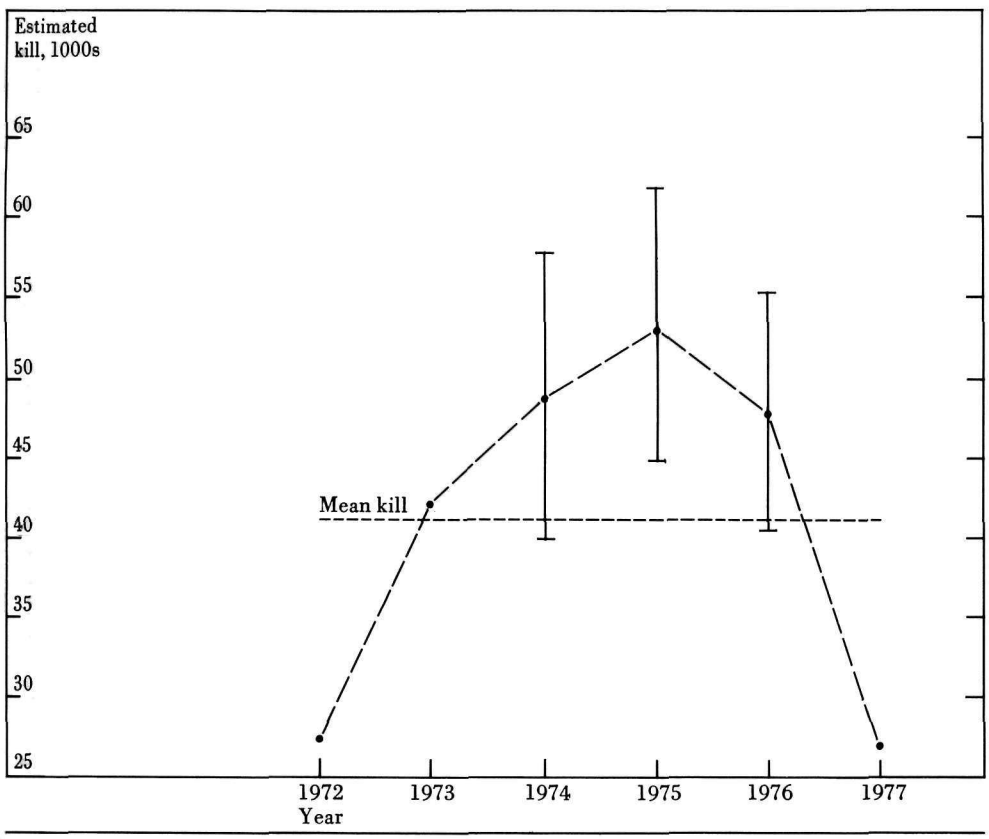
Figure 17
Estimated kill of American Coot in Canada, 1972–77 with 90% confidence intervals for the 1974–76 estimates

Figure 17



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Appendix 1
Adjustment of adult: immature ratios to allow for differential vulnerability

- Let I_B = number of immatures banded
  A_B = number of adults banded
  and the respective recovery rates of bands be I_r and A_r.
- Suppose that among the wings forwarded to the SCS I_s are from immatures and A_s from adults.
- Then the probability of an immature being shot is

$$P_I = c\,\frac{I_r}{I_B}$$

where c = the reporting rate

Similarly

$$P_A = c\,\frac{A_r}{A_B}$$

assuming that the reporting rates for adults and immatures are equal.

- If I and A are the true number of birds in the population and k is the reporting rate to the SCS then

$$I_s = kP_I I$$

$$= kc\,\frac{I_r}{I_B}\,I$$

and $$A_s = kc\,\frac{A_r}{A_B}\,A$$

Dividing and regrouping terms yields

$$\frac{I}{A} = \frac{I_s}{A_s}\,\frac{I_b}{A_B} \cdot \frac{A_r}{I_r}$$

Therefore the computed age ratio from the SCS must be multiplied by

$$\frac{I_B}{A_B} \cdot \frac{A_r}{I_k}$$

to account for vulnerability.

This calculation assumes geographic and temporal homogeneity.

Appendix 2
Publications in the Canadian Wildlife Service progress note series dealing with
a) survey results, 1966–76, and
b) additional results not given in recent publications. Also including bibliographic information for progress notes

	Year of survey										
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
a)											
Permit sales	2*	4*	9*	16	22	28	34	41	51	70	81
Waterfowl harvest	–	5*	10	16	22	28	34	41	51	70	81
Species composition	–	7*	12*	19	25	29	37	42	57	71	—
Age & sex ratios	–	7*	14*	19	25	29	37	42	57	71	—
Other species	–	5*, 27	10, 27	16, 27	22, 27	28	34	41	52	68, 69	83
b)											
Hunter age	2*	4*	–	–	–						
Hunter sex	2*	–	–	–	–						
Hunter residence	–	4*	9*	16	22						
Distribution of season bag	–	5*	10	–	–						
Distance travelled	–	5*	–	–	–						
No. shells used	–	5*	–	–	–						

–Not produced.
*Out of print.

c) Bibliographic information for progress notes

CWS progress note no.	Author, date of publication, title
2	Benson, D. A. 1967. Report on sales of the Canada Migratory Game Bird Hunting Permit 1966–67.
4	Benson, D. A. 1968. Report on sales of the Canada Migratory Game Bird Hunting Permit 1967–68.
5	Benson, D. A. 1968. Waterfowl harvest and hunter activity in Canada during the 1967–68 hunting season.
7	Anonymous. 1968. Species of waterfowl killed in Canada during the 1967–68 hunting season.
9	Benson, D. A. 1969. Report on sales of the Canada Migratory Game Bird Hunting Permit 1968–69.
10	Benson, D. A. 1969. Waterfowl harvest and hunter activity in Canada during the 1968–69 hunting season.
12	Benson, D. A. 1970. Species of waterfowl taken in Canada during the 1968–69 hunting season.
14	Benson, D. A. 1970. Age and sex ratios of ducks harvested during the 1968–69 hunting season.
16	Benson, D. A. 1970. Report on sales of the Canada Migratory Game Bird Hunting Permit and waterfowl harvest and hunter activity, 1969–70.
19	Benson, D. A. 1971. Species of waterfowl and age and sex ratios of ducks harvested in Canada during the 1969–70 season.
22	Benson, D. A. 1971. Report on the sales of the Canada Migratory Game Bird Hunting Permit and waterfowl harvest and hunter activity, 1970.
25	Cooch, F. G., and G. W. Kaiser. 1972. Species of waterfowl and age and sex ratios of ducks harvested in Canada during the 1970 season.
27	Dobell, J. V., and H. Boyd. 1972. Report on Woodcock harvests in Canada 1967–1970, and composition of the kill in 1970.
28	Cooch, F. G., G. W. Kaiser, and L. Wight. 1972. Report on sales of the Canada Migratory Game Bird Hunting permit, migratory game bird harvest and hunter activity, 1971.
29	Cooch, F. G., G. W. Kaiser, and L. Wight. 1972. Species of waterfowl and age and sex ratios of ducks harvested in Canada during the 1971 season.
34	Cooch, F. G., G.W. Kaiser, and L. Wight. 1973. Report on 1972 sales of Canada Migratory Game Bird Hunting Permit, migratory game bird harvest and hunter activity.
37	Cooch, F. G., G. W. Kaiser, and L. Wight. 1973. Species of waterfowl and age and sex ratios of ducks harvested in Canada during the 1972 season.
41	Cooch, F. G., G. W. Kaiser, and L. Wight. 1974. Report on 1973 sales of the Canada Migratory Game Bird Hunting Permit, migratory game bird harvest and hunter activity.
42	Cooch, F. G., G. W. Kaiser, and L. Wight. 1974. Species of waterfowl and age and sex ratios of ducks harvested in Canada during the 1973 season.
51	Cooch, F. G., and H. A. Raible. 1975. Report on 1974 sales of the Canada Migratory Game Bird Hunting Permit, waterfowl harvest and hunter activity.

cont'd. page 38

Appendix 2 *cont'd*

CWS progress note no.	Author, date of publication, title
52	Cooch, F. G., and H. A. Raible. 1975. Harvest of migratory game birds other than waterfowl in Canada, 1974.
57	Cooch, F. G., K. Newell, and H. Raible. 1975. Species of waterfowl and age and sex ratios of ducks harvested in Canada during the 1974 season.
68	Cooch, F. G., 1976. Kill of migratory game birds other than waterfowl by hunters in Canada 1975.
69	Dobell, J. V., and F. G. Cooch. 1976. Report on the first Common Snipe wing surveys in Canada, 1974 and 1975, and results of some recent harvest surveys.
70	Cooch, F. G. 1976. Report on 1975 sales of the Canada Migratory Game Bird Hunting Permit, waterfowl harvest and hunter activity.
71	Cooch, F. G., and K. L. Newell. 1977. Species of waterfowl and age and sex ratios of ducks and geese harvested in Canada during the 1975 season.
81	Cooch, F. G., K. Newell, and S. Wendt. 1978. Report on 1976 sales of Canada Migratory Game Bird Hunting Permit, waterfowl harvest and hunter activity.
83	Cooch, F. G., K. Newell, and S. Wendt. 1978. The 1976 kill of migratory game birds other than waterfowl by hunters in Canada.

Appendix 3
Data stored in retrieval files

Condensed permit record
1966 to present

year of sale
permit number
date of sale
province of residence
residency code*
age of hunter
renewal code*
active last year*
post office number
province of sale
latitude of sale[1]
longitude of sale[1]

Sales record
1966 to present

year of sale
province of sale
zone of sale
post office number
latitude of sale[1]
longitude of sale[1]
total sales
sales to renewal residents
sales to renewal non-residents
sales to non-renewal residents
sales to non-renewal non-residents
sales to residents from the same province
sales to residents from another province

Harvest survey record
1969 to present[2]

year of survey
year code[3]
label permit number
province of hunt
zone of hunt
latitude of hunt[1]
longitude of hunt[1]
sample code
mailing code
potential hunter*
active hunter*
active waterfowl hunter*
active hunter of other birds*
successful hunter*
successful hunter of other birds*
days hunted for waterfowl
days hunted for other birds
total duck kill[4]
sport duck kill[4]
sea duck kill[4]
total goose kill
Canada Goose kill
other goose kill
snipe kill
woodcock kill

Harvest survey record *cont'd*

dove kill
Band-tailed Pigeon kill
coot kill
gallinule kill[5]
Sandhill Crane kill
number of banded ducks killed[6]
number of banded Canada geese killed[6]
number of banded other geese killed[6]
number of banded coots killed[6]
number of banded other birds killed[6]
hunted 2 years ago*
hunted last year*
province of sample
zone of sample
prior permit number
current permit number
province of sale
zone of sale
province of residence
residency code*
renewal code*
age
sex[7]
date of sale
post office number
latitude of sale[1]
longitude of sale[1]
extrapolation factor
duck bag reported on calendar
days active indicated on duck calendar
days successful from duck calendar
goose bag from goose questionnaire
days active from goose calendar
days successful from goose calendar
latitude and longitude of hunt from goose questionnaire
province and zone of hunt from goose questionnaire

Species record – wings and tail-fans
1968 to present

year of survey
province of kill
zone of kill
AOU number[8]
year code[9]
date shot
time shot

Species record – wings and tail-fans *cont'd*

latitude of kill[1]
longitude of kill[1]
age of bird[10]
sex of bird[11]
banded code*
sample code
current permit number
province of sale
zone of sale
post office number
latitude of sale[1]
longitude of sale[1]
residency code*
renewal code*
age of hunter
W-factor
province of residence

Parts record

one for each hunter who submits wings or tails[12]
1968 to present

year of survey
province of kill
zone of kill
number of parts submitted
sample code
current permit number
province of sale
zone of sale
post office number
latitude of sale
longitude of sale
residency code*
renewal code*
age of hunter
province of residence

Duck and goose calendar files

duck 1969 to present, goose 1973, 1975, 1976

year of survey
year code[3]
label permit number
province of hunt
zone of hunt
latitude of hunt[1]
longitude of hunt[1]
sample code
mailing code
total kill from questionnaire
bag reported on the calendar
days active, from the calendar
days successful, from the calendar

also, for each day of reported hunting,
date
kill

[1]Latitude and longitude are stored to the nearest minute.
[2]Because of changes in the survey, not all years are directly comparable.
[3]Year code in the NHS is 1 for samples B and D, and 2 for samples A and E.
[4]A separate question for sea ducks was asked on 1969–73 forms. From 1974 on they only asked about total ducks.
[5]A gallinule question was used from 1969 to 1972.
[6]The questions about banded birds have specified the following categories:
(from 1969 to 1971) ducks, Canada geese, other geese, coots, other birds
(from 1972 to the present) ducks, Canada geese, other geese, other birds
[7]Hunter's sex available 1969 to 1972.
[8]AOU numbers for ducks range from 1290 to 1670, for geese from 1690 to 1740.
[9]Year code in the SCS is 1 for kills before December 31 and 2 for kills in January.
[10]Age codes are A = adult, I = immature
[11]Sex codes are M = male, F = female
[12]Only hunters who provide current permit numbers are included in the Parts File.

*All dichotomous variables have a Y for yes and an N for no.

Part 2
Migratory game bird hunters

Demographic and socio-economic characteristics of holders of Canada Migratory Game Bird Hunting Permits

by F. L. Filion

1. Abstract

This comparison of the socio-economic and demographic characteristics of holders of Canada Migratory Game Bird Hunting Permits with those of the Canadian population in five administrative regions reveals that benefits of migratory game bird hunting accrue to a broad representative cross-section of Canadian males. Information on the Canadian population was obtained from Statistics Canada; data for migratory game bird hunters were based on a pilot mail survey, with a response rate of 92%, conducted among a stratified sample of about 2000 permit purchasers during 1975. The marital status and median income of hunters and Canadian males were very similar. Hunters tended to be younger and better educated than the total male population. Hunters over-represented blue-collar occupational groups and residents in rural and small urban centres. Significant differences were observed among regions for most of the variables. A better understanding of the characteristics of game bird hunters and their population dynamics contributes to more effective resource management.

2. Introduction

This paper is concerned with the social impact of recreational hunting in Canada. It addresses itself specifically to the question of who benefits from migratory game bird hunting by comparing the socio-economic and demographic characteristics of Canada Migratory Game Bird Hunting Permit holders with those of the entire Canadian population.

3. Information sources

Information on the Canadian population was obtained from the Statistics Canada 1971 census and estimates or results of their special surveys in 1975. Socio-demographic data for permit holders were based on the results of a national pilot survey on the sociological characteristics of permit purchasers in 1975. The survey was conducted by the Canadian Wildlife Service (CWS) to examine methodological issues, study hunter characteristics, and explore related social and economic values.

Table 1
Sample selection for study of hunters of migratory game birds in 1975–76

Administrative region	Province	Zone	1975 Permit File (Non-permittees in 1974) (A) Canadian residents	(B) Non-residents	1974 Permit File (B) Non-permittee in 1973	(D) Permittee in 1973	Total
Atlantic	Nfld.	1	59	—	42	98	199
		2	5	—	4	13	22
	N.S.	1	36	—	28	92	156
		2	20	—	14	31	65
	N.B.	1	44	—	32	84	160
		2	18	—	13	31	62
	Regional total						664
Quebec		1	38	—	30	109	177
		2	12	—	8	23	43
	Regional total						220
Ontario		1	11	24	10	42	87
		2	19	—	16	83	118
		3	8	88	8	18	122
	Regional total						327
Prairies	Man.	1	23	85	23	153	284
		2	3	15	3	12	33
	Alta.	1	24	—	17	44	85
		2	40	—	28	68	136
	Regional total						538
British Columbia		1	27	—	19	53	99
		2	20	—	17	84	121
	Regional total						220
Canada Total			407	212	312	1038	1969

3.1. Sample design

G. E. J. Smith, Biometrics Division, CWS, designed the sample. A national sample totaling 1969 names was selected systematically from the Permit Files for 1974 and 1975. For optimal representation the sample was stratified by country of residence, previous hunting experience, and zone of permit purchase. Prince Edward Island and Saskatchewan were excluded from the sample to reduce the response burden on permit buyers, who were heavily canvassed in recent years. Table 1 summarizes the sample design. Sample sizes among provinces varied between 220 and 327.

Because of the stratified design, the responses to the questionnaires were weighted to make them representative of the 1975 permit universe. The weighting factors were adapted from a procedure derived by Smith (1975) and are a function of number of permits sold, number of questionnaires returned, province and zone of permit sale, previous permit purchase, hunting experience, and country of residence.

3.2. Questionnaire design

Most questions could be answered using check marks. The schedule was

divided into five parts and 64 questions. Parts 1 and 2 asked about game bird hunting behaviour, including hunting activity and expenditures in 1975; part 3 dealt with the enjoyment, satisfactions, and problems of bird hunters; part 4 asked about outdoor recreation activities other than bird hunting; and part 5 looked at the demographic and socio-economic characteristics of the respondents and was the source of the data used in the following comparisons. (The results that were obtained from other parts of the questionnaire will be analyzed and published at a later date elsewhere.)

3.3. Survey procedures

For convenience and economy the questionnaire was mailed between 1 February and 31 March 1976, with three follow-up mailings to non-respondents. Completed questionnaires were edited and coded manually. The data were then keypunched, machine edited, and transferred to magnetic tape for analysis using version 7 of the Statistical Package for the Social Sciences (Nie *et al.* 1975).

4. Results

4.1. Survey response

Of 1969 questionnaires sent, 181 were returned undelivered and 1642 were completed, for a final response rate of 91.8%. There was no significant difference in response between regions. Item response was lowest (84%) for the question on family income.

4.2. Comparative profile

Permit holders were compared to the Canadian population with respect to socio-economic and demographic variables within five administrative regions: British Columbia, the Prairie Provinces, Ontario, Quebec, and the Atlantic Provinces (Table 1). When possible, age and sex differences were controlled to maximize the validity of the comparisons. In view of the exploratory nature of the study, results which were statistically significant at the 0.10 confidence level are reported.

4.2.1. Sex composition

The great majority (98.5%) of respondents were males. There was a significant difference in the number of female hunters between the five regions ($X^2 = 9.4$, $d.f. = 4$; $P < .10$). The sample, however, was not sufficiently large to register any females in the Quebec or British Columbia regions. There were more female hunters in Ontario and the prairies than elsewhere. Because of the preponderance of males, all subsequent comparisons of characteristics of permit purchasers were made with those of the male population, rather than with the entire population of Canada.

4.2.2. Age composition

The age of the respondents, obtained from the computer file, varied from 12 to 77 years. Figure 1 compares the data with those for all Canadian males aged 10 years or more.

Respondents had a mean age of 31.5 years and were most common in the 20–39 age group. The mean age was similar in most regions (30.4–32.7 years) but was significantly higher[1] in British Columbia (36.6 years), where hunters in the 50–59 age group were as common as those between 20–29 years. With the exception of British Columbia, permittees within the 20–29 age group were clearly predominant throughout the country, especially in Ontario. The youngest age group (10–19) was most highly represented in the Atlantic and Prairie provinces. The oldest age group (60 +) was most highly represented in the prairies and British Columbia.

The mean age of the respondents by region was about 4 years below that of the Canadian male population,[2] except in British Columbia, where the means were identical. Except in the 10–19 age group,

[1]Overall one-way analysis of variance for significant differences among regional means for permittees: $F = 4.8$, $d.f. = 4, 1192$; $P < 0.01$.

[2]From Statistics Canada, 1975*a*. Mean age computed using midpoints of age groups.

Figure 1
Percentage distribution among age groups of holders of Canada Migratory Game Bird Hunting Permits and of the Canadian male population (10 years and older), by region, 1975

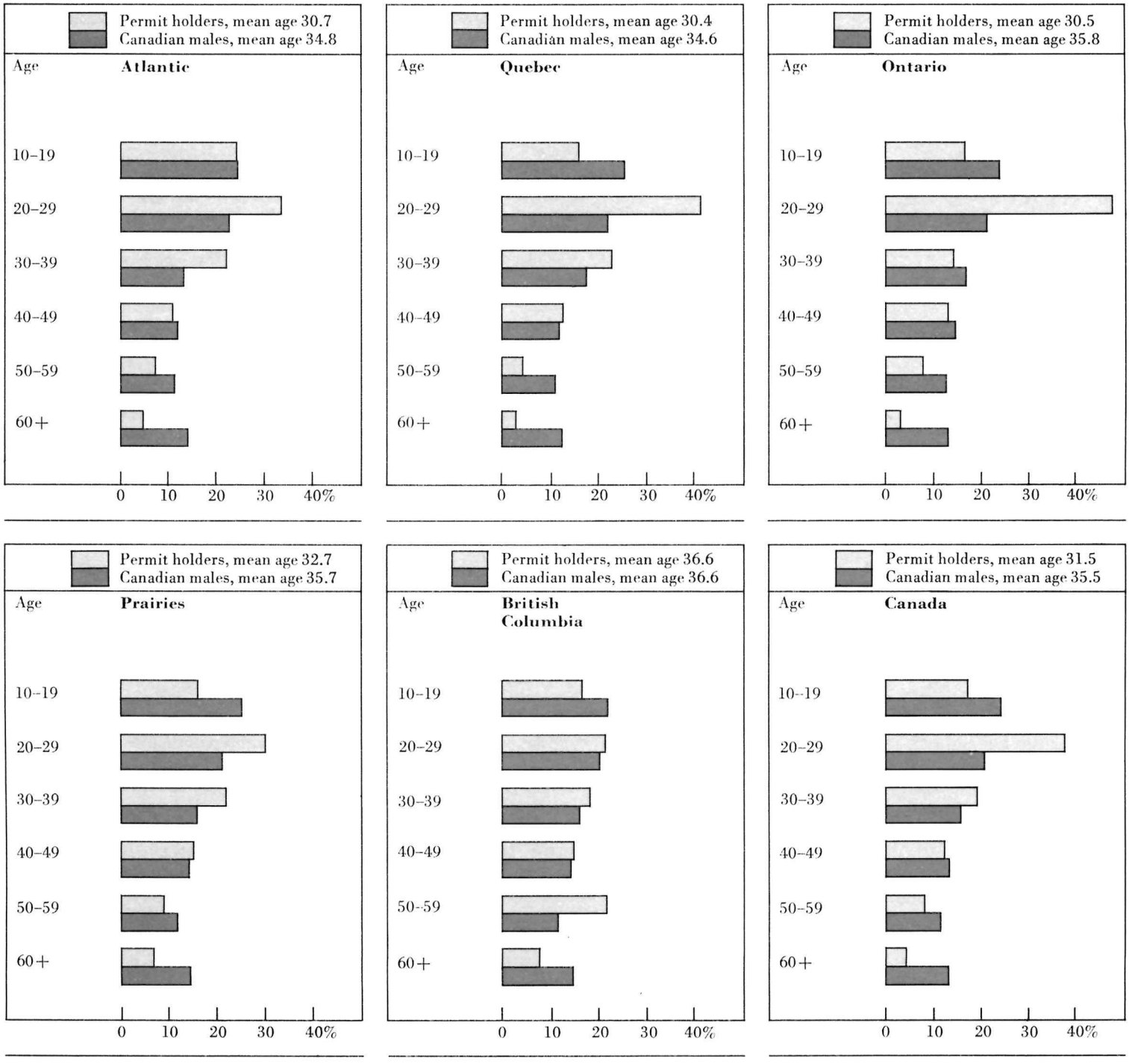
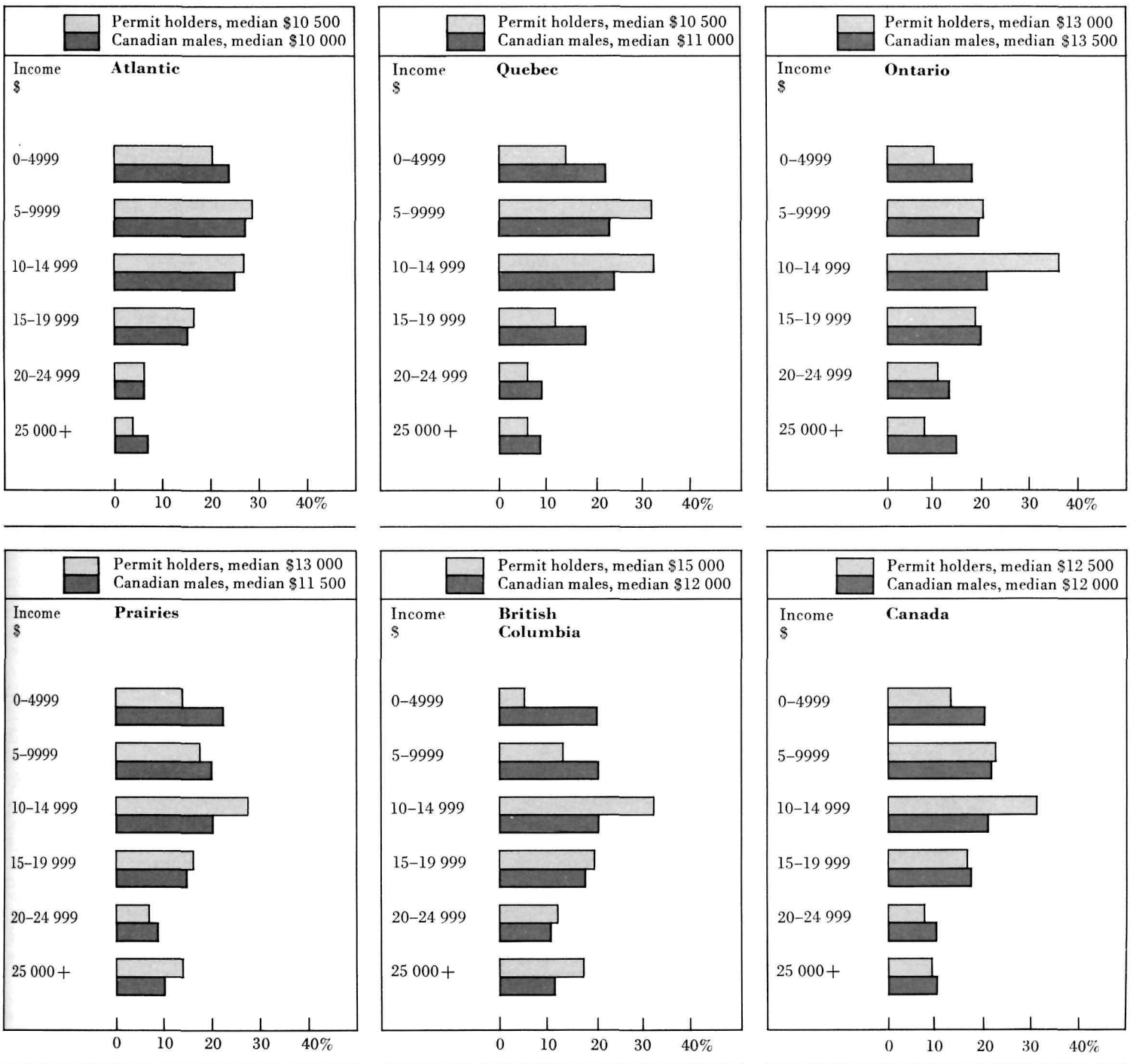


Figure 2
Percentage distribution of family incomes of holders of Canada Migratory Game Bird Hunting Permits and of the Canadian male population, by region, 1975

Figure 2



the ratio of permittees to Canadian males generally decreased as age increased and was close to 1 for the 40–49 age group. This trend was strongest in the Ontario, Quebec, and Atlantic regions. In British Columbia the ratio for the 50–59 age group was exceptionally high. The low percentage of permittees in the age group 10–19 years relative to the Canadian male population may be exaggerated because few boys in the sub-group 10–15 years purchase permits. That sub-group could not be separated out because of the small sample size.

4.2.3. Income distribution

Figure 2 summarizes information on total family income. Nearly one-third of the respondents reported a family income of $10 000 – 14 999. The median was $12 500. It was highest in B.C. and lowest in the Atlantic and Quebec regions.[3]

Respondents had about the same median income as the general population (Statistics Canada 1975*b*). Incomes for Prince Edward Island and Saskatchewan are included in the general population estimate as they could not be isolated from the data. In most regions, the ratio of permittees to Canadians is lowest for the extreme income categories.

4.2.4. Formal education

Table 2 shows that most respondents (68.6%) had some secondary or college training, only 10.3% had some university education, and 21.1% had only elementary schooling. This pattern is similar throughout the country but levels of formal schooling are significantly lower for the Atlantic region.

Respondents reported a higher level of schooling[4] than the Canadian male population. The proportion with university education was close to that of the entire population. Those with secondary and college education were highly over-represented while those with elementary education were highly under-represented.

Table 2
Education profiles of holders of Canada Migratory Game Bird Hunting Permits (1975) and Canadian male population 5 years and older (1971) by region

Level of schooling	Permit holders by region, %* (Canadian males)†					
	Atlantic	Quebec	Ontario	Prairies	B.C.	Canada
Less than grade 9‡	33.5 (57.1)	20.0 (54.5)	14.8 (45.1)	24.2 (46.2)	16.8 (41.2)	21.1 (48.7)
Secondary§	58.9 (35.3)	69.5 (35.9)	76.8 (44.1)	62.2 (43.3)	71.4 (47.2)	68.6 (41.1)
University‖	7.5 (7.6)	10.5 (9.5)	8.3 (10.8)	13.6 (10.4)	11.8 (11.6)	10.3 (10.2)
Total	100	100	100	100	100	100

*Overall Chi-square test for differences among permittees: $X^2 = 37.0$, $d.f. = 8$, $P < 0.01$.
†Statistic Canada 1971, Table 36.
‡Includes no schooling.
§Includes partial and complete secondary, college, or technical schooling.
‖Includes partial and complete university schooling.

Table 3
Labour profiles of holders of Canada Migratory Game Bird Hunting Permits and Canadian male population aged 15 years or older by region, 1975

Status	Permit holders by region, %* (Canadian males)†					
	Atlantic	Quebec	Ontario	Prairies	B.C.	Canada
In labour force‡	85.2 (70.2)	84.2 (77.7)	88.4 (80.5)	79.5 (81.0)	83.5 (76.7)	84.5 (78.5)
Not in labour force§	14.8 (29.8)	15.8 (22.3)	11.6 (19.5)	20.5 (19.0)	16.5 (22.3)	15.5 (21.5)
Total	100	100	100	100	100	100

*Overall Chi-square test for differences among permittees: $X^2 = 11.4$, $d.f. = 4$; $P < 0.05$.
†Statistics Canada 1976, Table 39.
‡Includes employed and unemployed Canadians.
§Includes students and retired.

4.2.5. Labour force participation and occupations.

The majority of respondents were employed (80.5%), 11.2% were students and 4.0% were unemployed. According to Statistics Canada (1976, Table 39) Canadian males above 15 years in 1975 had an employment rate of 73.6% and an unemployment rate of 4.9%.

Table 3 indicates that except in the Prairie Provinces members of the labour force (employed plus unemployed) were more likely to be sport hunters of migratory game birds.

[3]Overall Chi-square test for significant differences among permittees: $X^2 = 60.8$, $d.f. = 20$; $P < 0.01$.
[4]Since data for the Canadian male population includes the 5–9 age group and dates back to 1971, the two populations are not strictly comparable. About 10–11% of the Canadian males aged 5 years or more fall in the 5–9 age group; of course, they are not eligible to hunt migratory game birds and are for the most part enrolled in elementary school. Their presence has the effect of inflating the "less than grade nine" category for Canadian males by a couple of percentage points and consequently underestimating the remaining categories slightly.

The occupation profiles in Figure 3 show that respondents occurred in every major occupational category as defined in Appendix 1. The most common occupations were (*a*) processing (21.8%), (*b*) clerical, sales, and service (19.9%), (*c*) managerial, administrative, and professional (19.1%) and (*d*) construction (18.2%) categories. The occupations of respondents varied significantly[5] among regions. The proportion in managerial, administrative, and professional categories was about twice as high in the Prairie region (25.6%) as in the Atlantic Provinces (12.0%). The proportion in British Columbia in occupations related to primary resources (18.8%) was about four times that in Ontario (4.8%). The proportion in the construction trade in the Prairie Provinces (10.6%) is only half that in Ontario (25.3%).

The ratio of respondents to Canadian males of 15 years or older (Statistics Canada 1976, Table 46) was generally highest for blue-collar categories and was due mainly to construction and occupations related to primary resources. The Prairie region was exceptional with a high ratio in the managerial, administrative, and professional category.

Table 4
Marital status of holders of Canada Migratory Game Bird Hunting Permits (1975) and Canadian male population 15 years and older (1972) by region.

	Permit holders by region, %* (Canadian males)†					
Marital status	Atlantic	Quebec	Ontario	Prairies	B.C.	Canada
Single	33.9 (33.6)	31.2 (35.0)	29.8 (29.4)	30.5 (30.9)	19.0 (29.3)	30.1 (31.6)
Married and other	66.1 (66.4)	68.8 (65.0)	70.2 (70.6)	69.5 (69.1)	81.0 (70.7)	69.9 (68.4)
Total	100	100	100	100	100	100

*Overall Chi-square test for differences among permittees: $X^2 = 5.7$, $d.f. = 4$; $P < 0.25$.
†Statistics Canada 1972*a*.

Table 5
Proportion of holders of Canada Migratory Game Bird Hunting Permits (1975) and Canadian families (1972) having children living at home.

	Permit holders by region, %* (Canadian males)†					
Children	Atlantic	Quebec	Ontario	Prairies	B.C.	Canada
Yes	83.0 (73.2)	70.6 (72.2)	73.5 (69.0)	78.9 (68.8)	61.4 (68.0)	75.0 (70.0)
No	17.0 (26.8)	29.4 (27.8)	26.5 (31.0)	21.1 (31.2)	38.6 (32.0)	25.0 (30.0)
Total	100	100	100	100	100	100

*Overall Chi-square test for differences among permittees: $X^2 = 13.4$, $d.f. = 4$; $P < 0.01$.
†Statistics Canada 1972*b*.

4.2.6. Marital status

Most respondents were married (67.4%). The marital status of respondents did not vary significantly among regions (Table 4). Generally, the proportions of single, married or other Canadian males 15 years or older and those of permittees were very similar. In British Columbia single men were clearly under-represented (19.0% of permit holders vs 29.3% of all males).

4.2.7. Children

Table 5 compares the proportion of non-single permit holders and Canadian families having children at home. Proportions varied significantly among regions. Respondents generally had a slightly greater probability than the norm for Canadians of having children (75% vs 70%). This was most marked in the Atlantic and Prairie regions and least in British Columbia.

4.2.8. Rural–urban residence

Figure 4 summarizes data on current residence of permittees. Nationally, a greater proportion of permittees resided in urban areas[6] than in rural areas (66.3% vs 33.7%). Respondents were most highly urbanized in the prairies (72.5%) and least in the Atlantic region (56.1%); differences between regions were highly significant.[7]

By contrast to the Canadian male population (Statistics Canada 1972*c*, Table 2) permittees over-represented rural residents (33.7% vs 23.5%). This was most apparent in Ontario (36.5% vs 18.3%) and least in the Atlantic and Prairie regions. Canadian males residing in cities of 100 000 or more inhabitants were consistently under-represented. In the most highly populated provinces, permittees consistently over-represented people living in either small cities or towns.

5. Summary and implications

Although the characteristics of permit purchasers vary significantly by administrative region, the results of the socio-demographic and economic comparison imply that the benefits of migratory game bird hunting accrue to a broad representative cross-section of Canadian males.

Permit holders are predominantly male (98.5%), have a mean age of 31.5 years, and are usually married. They usually

[5]Overall Chi-square test for significant differences among permittees: $X^2 = 71.1$, $d.f. = 24$; $P < 0.01$.
[6]Population centres of 1000 persons or more.
[7]Overall Chi-square test for significant differences among permittees: $X^2 = 156.7$, $d.f. = 16$; $P < 0.01$.

Figure 3
Percentage distribution among major occupational categories of holders of Canada Migratory Game Bird Hunting Permits and of the Canadian male population, by region, 1975

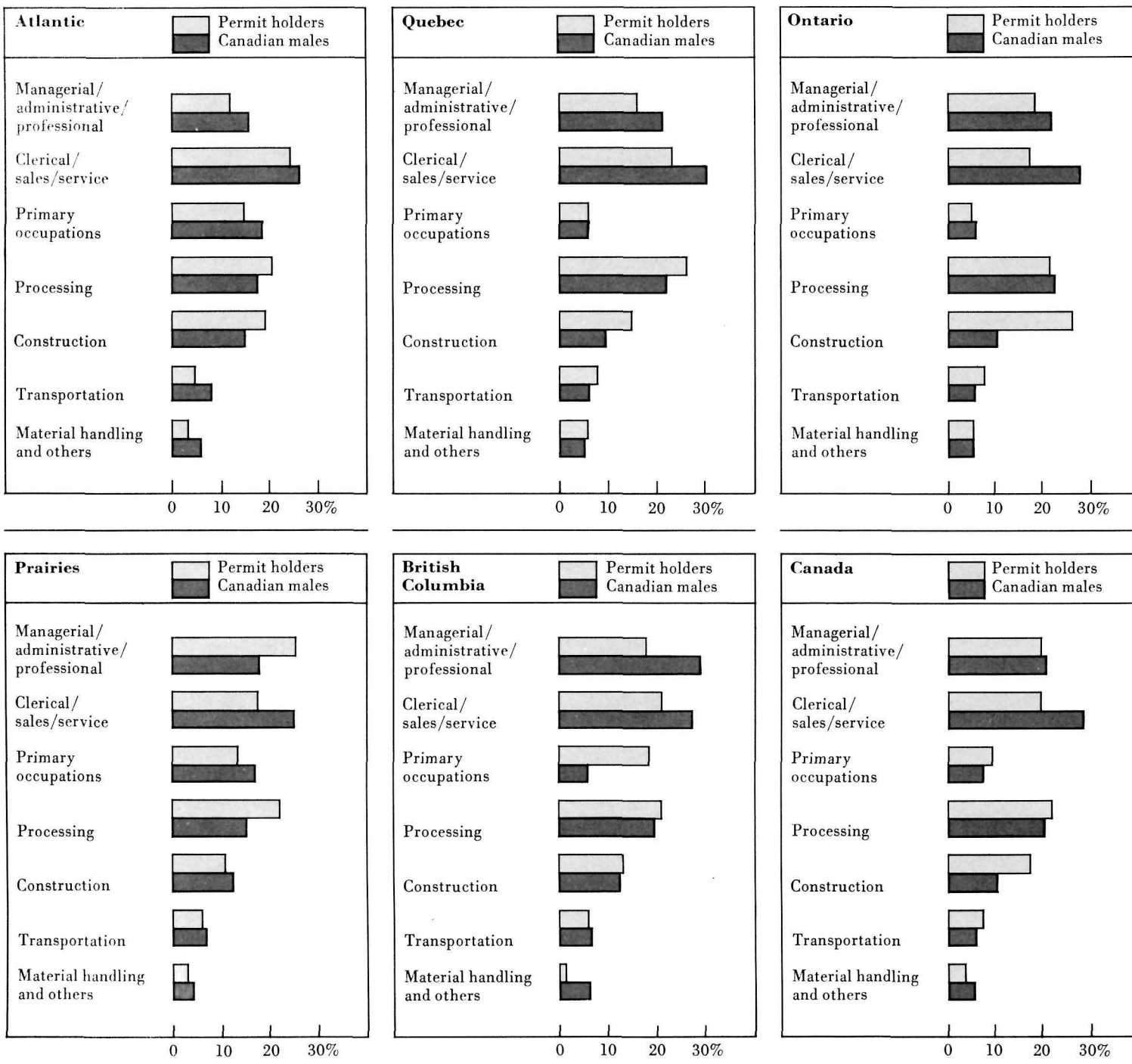
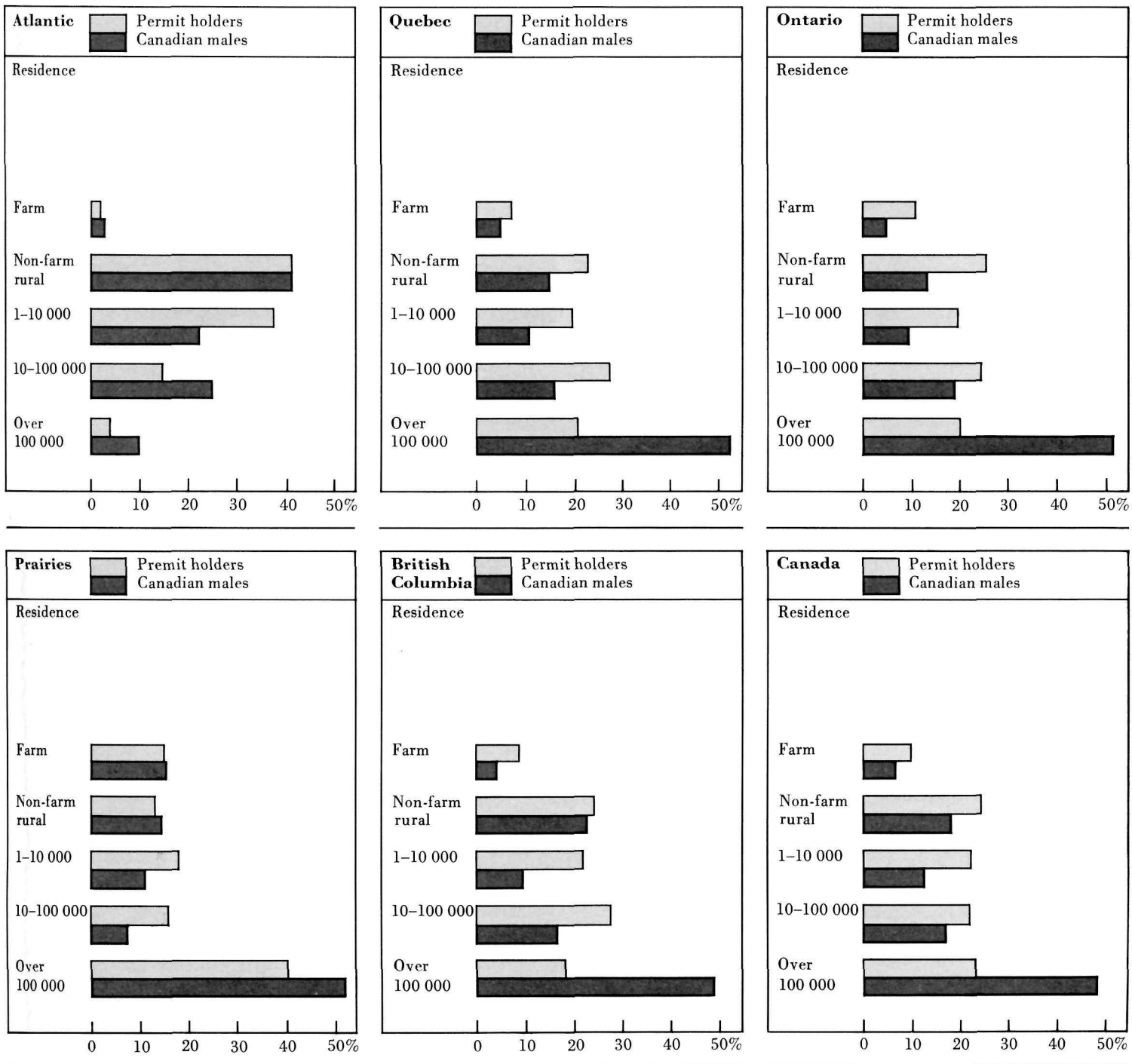


Figure 4
Percentage distribution in rural and urban areas of holders of Canada Migratory Game Bird Hunting Permits and of the Canadian male population, by region, 1971

Figure 4



have secondary, technical, or college education (68.6%), are involved in blue collar occupations (61.0%) and reside in urban areas (66.3%). The reported median family income is about $12 500.

Waterfowl hunting continues to be a male-dominated activity, as it has been traditionally. In 1966 when the purchase of a permit became necessary for would-be hunters of migratory game birds, males bought 98.8% of permits. Between 1966 and 1971, the last year in which applicants were asked to indicate their sex, the proportion of male buyers remained virtually unchanged. All age, education, income, and occupation groups in the Canadian male population are well represented among permit holders; however, they are on the average younger than the norm for Canadian males and over-represent the 20–39 year age group. Survey respondents tended to be more educated than most Canadian males. The median family income of permit holders approximates that of Canadians but intermediate income groups ($10 000 – 15 000) tend to be over-represented. Migratory game bird hunting tends to appeal more to those in construction, processing, and occupations related to primary resources than to those in white-collar occupations. A higher proportion of married permit holders report having children than do Canadians as a whole.

Permit holders over-represent people living in rural areas (farm, non-farm) and in small urban areas (1000 – 100 000) but very much under-represent those in urban areas exceeding 100 000 persons.

British Columbia, and to some extent the prairies, are distinguished from other administrative regions by a higher proportion of older and wealthier permit holders and have the highest representation in the white-collar occupations. Although British Columbia shows the highest proportion of married permit holders, they have the lowest reported rate for children. The largest proportion of permit holders residing in rural areas is in the Atlantic region while the smallest is on the prairies.

The national data were in general accordance with several surveys conducted in the United States (Peterle 1967, Hendee and Potter 1976). Data for the Ontario region are very similar to results regarding waterfowl hunters from the comprehensive Ontario Recreation Survey conducted in 1974 (Ross and Buckley 1977).

As agricultural expansion, urbanization, and industrialization increase, wildlife populations, their habitats, and hunting opportunities are threatened. The annual rate of increase in permit sales has exceeded population growth for several years and established a record high in 1977–78 (Cooch *et al.* 1978). Although such trends cannot continue indefinitely they do make current migratory game bird management more complex. Data from studies such as this shed light on a changing hunter population. The age structure and rural-urban distribution of permittees help us understand recruitment and desertion patterns in migratory game bird hunting. Since recruitment generally takes place before age 20, trend data on the participation rates of youth are very important for future management. Under-representation of Canadian youth among permit holders could be a reflection of the social constraints imposed by the family, education, and career development or be a reflection of changing attitudes towards hunting. Further attention must be devoted to this age group. Under-representation among advanced age groups is presumably an indication of their lower physical abilities and declining interest in a strenuous activity. Although most hunters now live in urban areas, they were introduced to the sport when they resided in rural areas. The decline in rural influence may trigger a decrease in activities associated with rural lifestyles and traditional preferences such as hunting. However, this process may be slow, since permit holders are predominant in small and middle urban areas rather than large ones.

An awareness and better understanding of the characteristics of migratory game bird hunters and their population dynamics will contribute to more effective resource management. Socio-economic and demographic data are helpful in comparing migratory bird hunters to hunters of other game, or to non-consumptive wildlife-based recreationists. The data can be used to arrive at resource-management decisions and to communicate more effectively with target groups.

6. Acknowledgements

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Appendix 1
Definitions of occupational categories

Operational categories used in this survey	Occupations listed in Canadian Census Occupational Classification Manual (1971)*
Managerial, administrative, and professional	Managerial, administrative, and related
	Natural sciences, engineering ,and mathematics
	Social sciences and related fields
	Teaching and related
	Medicine and health
	Artistic, literary, recreational, and related
Clerical, sales, and service	Clerical and related
	Sales
	Service
Primary occupations	Farming, horticultural, and animal husbandry
	Fishing, hunting, trapping, and related
	Forestry and logging
	Mining and quarrying, including oil and gas field
Processing	Processing
	Machining and related
	Product fabricating, assembling, and repairing
Construction	Construction, trades
Transportation	Transport equipment operation
Materials handling and other crafts	Materials handling and related occupations not classified elsewhere
	Other crafts and equipment operating
	Occupations not classified elsewhere

* Vol. 1, Cat. No. 12-536.

The kill of migratory game birds in Canada by non-resident sport hunters

by F. G. Cooch

1. Abstract

Between 14 500 and 20 000 Canada Migratory Game Bird Hunting Permits have been sold annually to non-resident hunters since permits were introduced in 1966. An expanded survey of non-residents in 1976 made feasible a more complete measure of the impact of non-residents. In 1976 non-residents bought 4.1% of the permits sold and shot 6.2% of the ducks and 8.9% of the geese killed in Canada. Because of a tendency to aggregate, non-residents constitute up to 20% of the hunters and take up to 30% of the ducks and 39% of the geese in some zones. In some smaller areas, non-residents exceed 80% of the active hunters. This tendency to aggregate has important implications for migratory bird management programs.

2. Discussion

The number of Canadian residents buying Canada Migratory Game Bird Hunting Permits increased from approximately 365 000 in 1966 to in excess of 464 000 in 1976. Sales to non-residents have risen less, from an average of 15 500 in the three seasons 1966–68 to 17 600 in 1974–76, a gain of 13.4%, but without regular annual increments (Table 1). Most non-residents are from the United States.

Non-resident hunters in Canada tend to hunt in specific areas. Nationally, non-residents make up only 3.6–4.6% of the migratory game bird sport hunters in Canada each year. The proportion in some provinces is much greater (Table 1). Table 2 shows sales to non-residents in 1976 by zone of purchase. Permit sales to non-residents were insignificant in Newfoundland, Prince Edward Island, Nova Scotia, southern and coastal British Columbia (zone 2), the Northwest Territories and the Yukon Territory. The percentage of non-resident permit holders exceeded the national average in Manitoba, Saskatchewan, and Ontario and was highest in northern Ontario (zone 3, 19.2%).

The province and zone of purchase does not necessarily represent the ultimate destination of a non-resident hunter. For example, a person may purchase a permit upon entering Canada at Emerson, Manitoba, but eventually hunt in Saskatchewan. In 1976, 5000 non-resident hunters were estimated to have been active in Saskatchewan whereas only 4700 permits were sold there to non-residents. The number of active sport hunters in any area of Canada can be estimated from results obtained from the National Harvest Survey (NHS) questionnaires. Each permit holder is asked to indicate where he did the majority of his hunting. Figure 1 presents the percentage of all active hunters in a degree block who were non-resident for degree blocks with a substantial duck or goose kill in 1976. These data are not available for years before 1976. Data concerning the distribution of active, intermittent non-resident sport hunters were first available from the NHS in 1973 when a separate sampling strata for non-resident hunters (the E sample) was established (see Cooch *et al.* 1978). A further modification in 1976, when

Table 1
Sales of permits in Canada to non-residents of Canada, 1966–76

Province or territory	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Nfld.	23	40	49	26	44	36	56	105	57	45	52
P.E.I.	14	15	9	13	20	11	17	13	15	10	38
N.S.	60	54	67	70	89	48	43	58	39	35	66
N.B.	251	251	301	289	156	252	259	279	300	330	258
Que.	625	542	680	692	907	885	1107	1239	1242	968	639
Ont.	8172	8022	9281	9081	7789	7770	6893	7783	7690	7957	8718
Man.	1544	1591	1757	2170	2318	2665	1943	2643	2049	2588	3915
Sask.	2744	3006	3163	3863	3540	4888	3936	2879	3393	3815	4734
Alta.	733	926	936	878	879	821	634	833	845	1036	1148
B.C.	500	576	592	644	598	547	336	419	276	245	240
Yukon*									7	6	9
N.W.T.*									2	2	3
Unknown		47	8	33	47	44	1				
Total non-resident	14 666	15 070	16 843	17 759	16 387	17 967	15 225	16 251	15 915	17 037	19 847
Total resident	365 393	365 557	366 542	367 847	386 650	395 622	406 452	436 489	418 247	454 283	464 924
% non-resident	3.9	4.0	4.4	4.6	4.1	4.3	3.6	3.6	3.7	3.6	4.1

*Permits not sold before 1974.

Table 2
Permit sales to residents and non-residents, 1976

Prov. or territory	Survey zone	Total permit sales			
		Total	Residents	Non-residents	% non-residents
Nfld.	01	27 227	27 182	45	*
	02	2 394	2 387	7	*
	Total	29 621	29 569	52	*
P.E.I.	Total	5 756	5 718	38	*
N.S.	01	8 112	8 056	56	*
	02	5 214	5 204	10	*
	Total	13 326	13 260	66	*
N.B.	01	9 411	9 227	184	2.0
	02	4 332	4 231	101	2.3
	Total	13 743	13 458	285	2.1
Que.	01	52 090	51 659	431	0.8
	02	14 363	14 155	208	1.5
	Total	66 453	65 814	639	1.0
Ont.	01	41 441	38 319	3 122	7.5
	02	77 109	76 367	742	1.0
	03	25 266	20 412	4 854	19.2
	Total	143 816	135 098	8 718	6.1
Man.	01	38 355	35 192	3 163	8.3
	02	8 326	7 574	752	9.0
	Total	46 681	42 766	3 915	8.4
Sask.	01	23 986	22 278	1 708	7.1
	02	10 967	10 580	387	3.5
	03	26 716	24 077	2 639	9.9
	Total	61 669	56 935	4 734	7.7
Alta.	01	30 920	30 125	795	2.6
	02	44 819	44 466	353	0.8
	Total	75 739	74 591	1 148	1.5
B.C.	01	12 257	12 058	199	1.6
	02	14 304	14 263	41	*
	Total	26 561	26 321	240	0.9
N.W.T.	Total	893	890	3	*
Yukon	Total	513	504	9	1.8
Canada		484 771	464 924	19 847	4.1

*Trace.

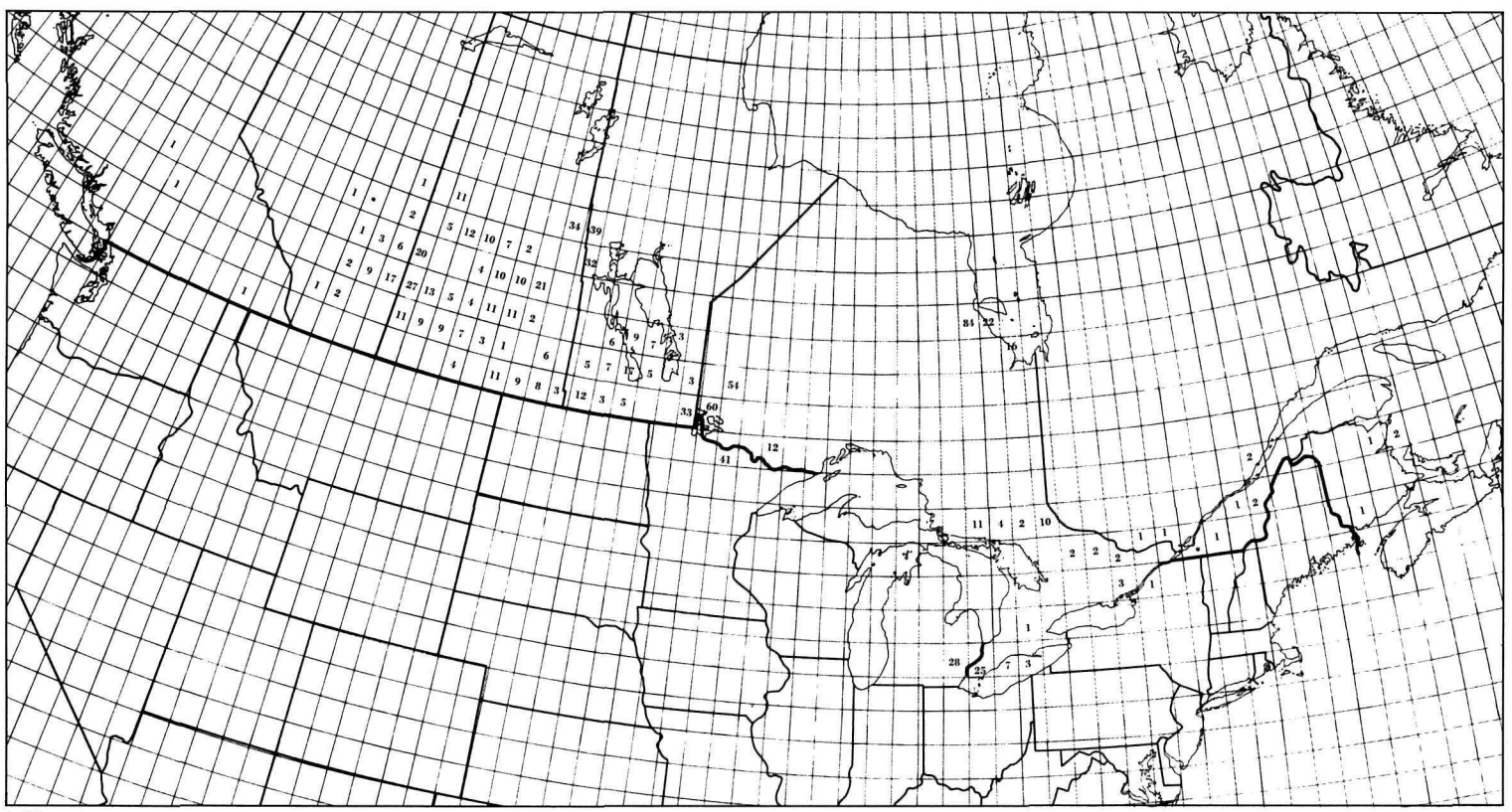
all non-residents regardless of status were sampled, resulted in an expansion of coverage from 6 to 14 hunting zones which accounted for nearly 96% of all non-resident hunters.

The tendency of non-resident hunters to aggregate in areas of easy access is evident from Figure 1. A comparison of non-resident hunter distribution with the distribution of total duck and goose kill (Freemark and Cooch 1978, Figs. 1–4) shows that non-residents select high kill areas. Only in southern Manitoba and Saskatchewan do these factors lead to widespread dispersion of hunting activity.

Table 3 gives the total kill by 19 847 non-residents in Canada in 1976. Non-residents bought 4.1% of the permits (Table 2) and harvested 6.2% of ducks, 8.9% of geese, and 2.6% of the woodcock.

Figure 1
Percentage of active hunters of migratory birds in Canada who are non-resident, 1976

Figure 1



* Trace

Table 3
The total estimated harvest of migratory game birds in Canada by non-resident sport hunters, 1976

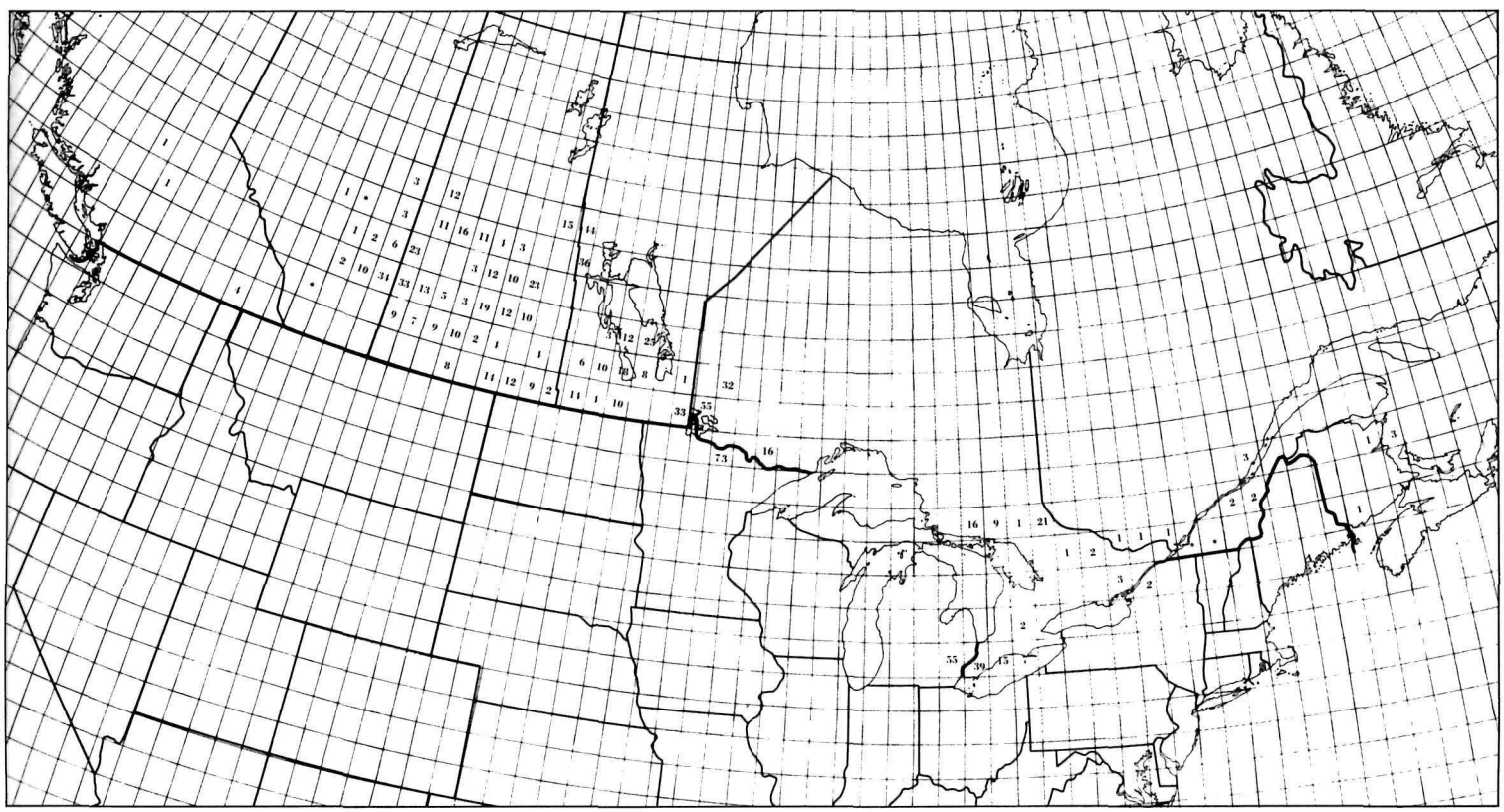
Species group	Total harvest	Non-resident harvest	% non-resident
Ducks	4 212 600	260 200	6.2
Geese	520 400	46 400	8.9
Snipe	107 000	2 200	2.1
Woodcock	160 100	4 100	2.6
Doves	3 800	200	5.3
Coots	48 000	2 000	4.2

The proportion of ducks, geese, and woodcock killed by non-residents is presented by hunting zone in Table 4. Data are available only in those zones where the number of non-residents was large enough to merit the establishment of sample E. The proportion of waterfowl killed by non-residents was highest in northern Ontario (zone 3), where they accounted for 19.2% of permit sales and took an estimated 30.5% of 165 900 ducks and 38.9% of the estimated goose harvest of 18 300. The non-resident hunting success was also substantial in southern Ontario (zone 1), where non-residents represented 7.5% of permit sales but took 21.9% of 302 300 ducks and 27.7% of an estimated 15 500 geese.

Waterfowl biologists and administrators have suspected that the proportion of waterfowl kill accounted for by non-resident hunters was highest in the Prairie Provinces. In 1976 maximum values in this region were obtained in northern Manitoba (zone 2) where non-residents

Figure 2
Percentage of ducks shot by non-residents, 1976

Figure 2



* Trace

took 17.7% of the total duck harvest of 107 700, and in southwestern Saskatchewan (zone 1) where non-residents took 14.5% of the total goose harvest of 95 900. Permit sales amounted to only 9.0 and 7.1% of the total in these two zones respectively. The proportion of duck kill accounted for by non-resident hunters exceeded the national average (6.9%) in all zones of Manitoba and Saskatchewan but was quite low in Alberta. The goose kill was greater than the national average (10.0%) in Manitoba zone 2, Saskatchewan zones 1 and 2, and southern Alberta zone 1. Although non-resident duck kill was substantial in the three Prairie Provinces combined (132 600), it only exceeded that in Ontario by approximately 10 000.

Waterfowl kill by non-residents was not estimated to be greater than 2000 birds in any other zone of Canada. In New Brunswick, however, non-residents who bought 2.1% of the permits shot 21.5% of the woodcock. Their relative importance was high in both zones (southern, 19.0%; northern, 27.4%).

Figures 2 and 3 present the distribution of kill of ducks and geese by non-residents (represented as a proportion of total kill) for degree blocks with significant duck or goose kill.

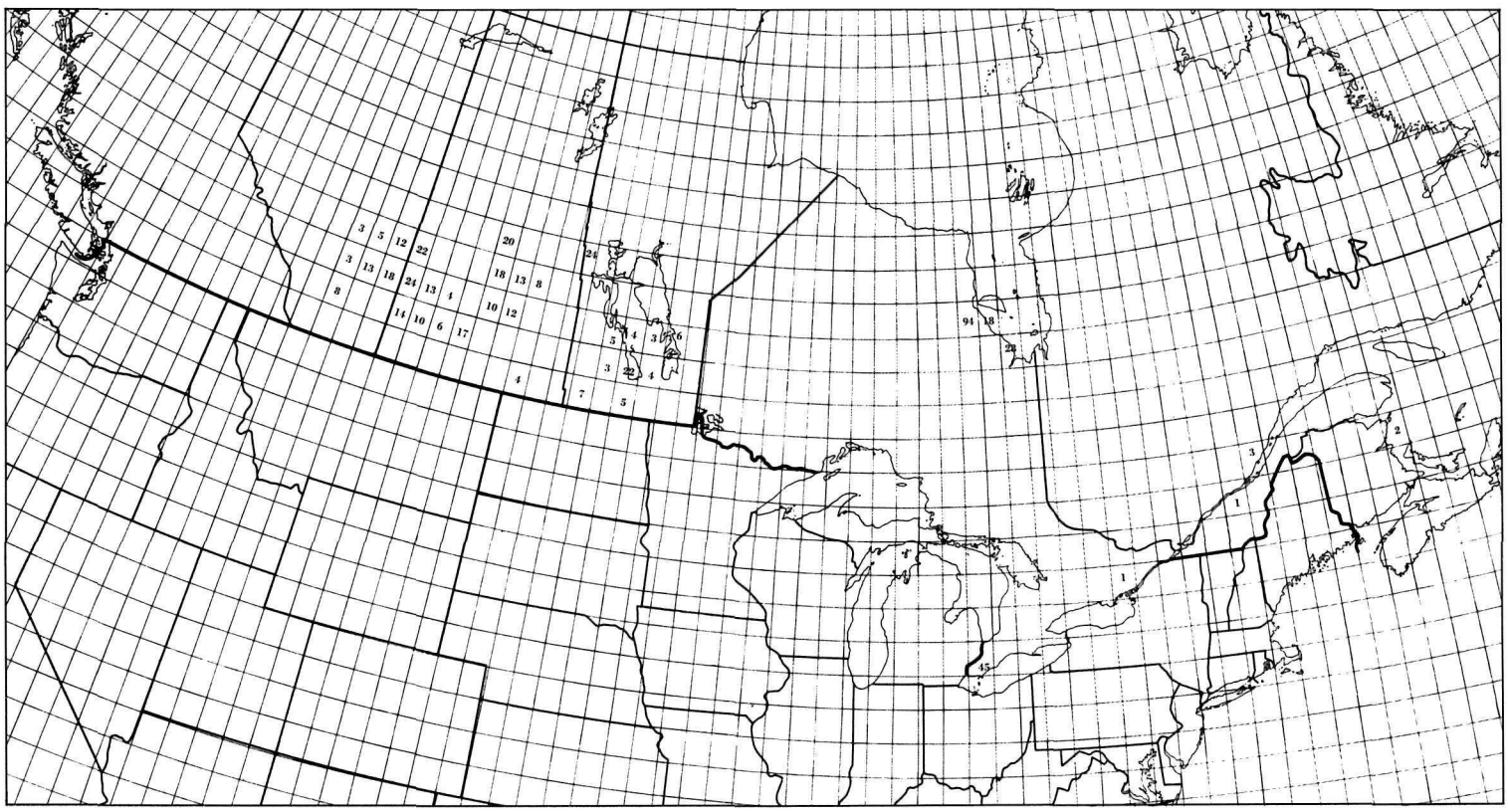
Duck harvest by non-residents was most substantial in the vicinity of Kindersley and the Quill Lakes, Saskatchewan; Flin Flon, Manitoba; Rainy River and Windsor, Ontario (Fig. 2). The goose harvest by non-residents in Ontario was concentrated largely in the Windsor region and along the southwest coast of James Bay; in Manitoba in the Interlake region, and in Saskatchewan and Alberta along the border between the two provinces (Fig. 3).

On average, non-residents have a higher success rate: they hunt fewer days but kill more birds per day than do resident hunters. Table 5 shows the relative success and effort of members of the four subsamples of the 1976 NHS.

The relatively high proportion of non-resident hunters (93% in 1976) who are active can be attributed to the fact that they generally enter the country for the express purpose of hunting migratory birds, whereas residents tend to be more oppor-

Figure 3
Percentage of geese shot by non-residents, 1976

Figure 3



tunistic. Their high success rate reflects their experience and dedication. They spend more hours hunting per day and choose good hunting areas (Figs. 2 and 3).

Non-resident hunters concentrate in relatively limited areas of Canada where their hunting success is disproportionately high. As a result, their impact on local migratory bird populations may be substantial.

An alternate way of studying the impact of non-resident hunters is to look at residency in terms of provincial rather than international boundaries. Some provinces attract large numbers of migratory bird hunters from other provinces. Probably the most dramatic single case is that of British Columbia residents who hunt in Alberta. In 1976, 1540 British Columbia residents bought permits in Alberta compared to the 1150 permits sold to non-residents of Canada. At present, we have no quantitative measure of the appreciable number of hunters who bought permits in British Columbia but did the majority of their hunting in Alberta. Saskatchewan is also a province which attracts large numbers of out-of-province migratory bird hunters.

At present, the impact of out-of-province hunters on local waterfowl resources is poorly documented. A study is being planned using data obtained from the NHS which will provide some quantification of the importance of these hunters.

Migratory game bird hunting regulations are set by CWS at the provincial level. Knowledge of the characteristics of hunters who are involved is a useful technical tool. The development of an effective survey of the kill of migratory birds by non-residents of Canada has been a major advance in contributing to our understanding of hunting pressure in Canada.

3. References

Cooch, F. G., S. Wendt, G. E. J. Smith, and G. Butler. 1978. The Canada Migratory Game Bird Hunting Permit and associated surveys. This publ.

Freemark, K. E., and F. G. Cooch. 1978. Geographical analysis of waterfowl kill in Canada. This publ.

Table 4
Harvest of ducks, geese, and woodcock by residents and non-residents within hunting zones, 1976, only including zones where number of non-residents large enough to merit establishment of sample E.

		No. of ducks harvested			No. of geese harvested			No. of woodcock harvested		
Prov.	Zone	Res.	Non-res.	% non-res.	Res.	Non-res.	% non-res.	Res.	Non-res.	% non-res.
N.B.	01	47 170	200	0.4	2 500	0	0	7 951	1 860	19.0
	02	20 937	286	1.4	3 966	72	1.8	3 064	1 157	27.4
	Total	68 107	486	0.7	6 466	72	1.1	11 015	3 018	21.5
Que.	01	486 678	3 017	0.6	38 062	631	1.6	48 059	400	0.8
	02	112 548	658	0.6	13 626	918	6.3	7 544	109	1.4
	Total	599 226	3 675	0.6	51 688	1 549	2.9	55 603	509	0.9
Ont.	01	236 204	66 075	21.9	11 187	4 291	27.7	22 629	290	1.3
	02	502 388	5 900	1.2	16 654	25	0.2	45 635	27	0.1
	03	115 328	50 524	30.5	11 160	7 089	38.9	5 970	246	3.9
	Total	853 920	122 499	12.6	39 001	11 405	22.6	74 234	563	0.8
Man.	01	217 674	26 984	11.0	65 079	6 052	8.5	—	—	—
	02	88 586	19 089	17.7	24 544	2 830	10.3	—	—	—
	Total	306 260	46 082	13.1	89 623	8 882	9.0	—	—	—
Sask.	01	255 266	28 673	10.1	82 033	13 885	14.5	—	—	—
	02	156 369	13 417	7.9	11 725	1 337	10.2	—	—	—
	03	322 452	31 666	8.9	35 933	3 071	7.9	—	—	—
	Total	734 087	73 756	9.1	129 691	18 293	12.4	—	—	—
Alta.	01	254 547	8 751	3.3	65 785	5 751	8.0	—	—	—
	02	619 212	4 042	0.7	40 795	341	0.8	—	—	—
	Total	*873 759*	*12 793*	1.4	*106 580*	6 092	5.4	—	—	—
B.C.	01	*81 142*	*857*	1.0	5 664	*84*	1.5	—	—	—
Canada		3 516 501	260 148	6.9	428 785	46 377	9.8	140 852	4 090	2.8

Table 5
Effort and success of duck hunters by subsample data estimated from NHS respondents, 1976

Sample*	Contacts	Total respondents	Current permit holders	Response rate	Active hunters	% active†	Successful duck hunters	% successful‡	Days hunted/ active hunter	Ducks/ active hunter day
A	6309	3004	3004	47.6	2152	71.6	1608	74.7	7.3	0.88
B	5643	2667	1413	47.3	1140	80.7	924	81.1	8.1	1.00
D	29117	13902	10488	47.8	8748	83.4	7748	88.6	8.6	1.46
E	1388	824	824	59.4	765	92.8	719	94.0	5.7	2.39
Total	42 457	20397	15729	48.0	12 805	81.4	10999	85.9	8.2	1.37

*For explanation of letters, refer to Cooch *et al.* (1978:3.2.).
†Calculated as a % of respondents who had purchased a permit.
‡Calculated as a % of active hunters.

Opinions of hunters in Nova Scotia on regulations under the Migratory Birds Convention Act

by F. L. Filion and F. J. Payne[1]

1. Abstract

In fall 1976, 72% of a stratified sample of 3496 purchasers of a Canada Migratory Game Bird Hunting Permit in Nova Scotia responded to a mail questionnaire which solicited their opinions of the hunting regulations and their perceptions of major hunting problems. About 85% of respondents were satisfied or partly satisfied with existing season dates and 95% with existing bag limits. Respondents were more concerned about increasing legitimate hunting opportunities than increasing daily bag limits. Less than half supported changes in daily hunting hours or legalized Sunday hunting. Respondents perceived insufficient law enforcement as the most serious problem requiring government attention. Significant relationships existed between age, experience, and success of respondents and their preferences. Studies such as this help managers to gain a better understanding of the hunting clientele and to design management practices which optimize hunters' satisfaction and compliance with hunting regulations.

2. Introduction

In summer 1976, at the request of the Wildlife Division, Nova Scotia Department of Lands and Forests, the Canadian Wildlife Service (CWS) agreed to conduct an exploratory study of hunters' opinions towards the migratory game bird hunting regulations in the province. The objectives of the co-operative study were (*a*) to determine hunters' satisfaction and preferences regarding season dates and bag limits by species and place of hunting, (*b*) to assess hunters' opinions of possible changes in hunting regulations, and (*c*) to study hunters' perceptions of the most common and most serious migratory game bird hunting problems.

The Nova Scotia Department of Lands and Forests has conducted two previous waterfowl hunter opinion surveys, in 1964 and 1970. These surveys, although based on smaller samples, have assisted the department in making recommendations to CWS regarding regulatory waterfowl management in Nova Scotia. Because of differences in sampling universes and questionnaire design, however, results of these surveys are not directly comparable to the survey results described here.

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3. Methods

3.1. Survey Design

3.1.1. Questionnaire design

The study was conducted using a mail questionnaire related to the 1975–76 migratory game bird hunting season. Most of the 36 questions were directly related to the objectives but several concerned hunters' characteristics such as age, activity, success, and place of hunting. Appendix 1 is a reset version of the questionnaire and includes response data.

3.1.2. Sample design

A total of 3496 names was systematically selected from the 13 990 names in the 1975 Canada Migratory Game Bird Hunting Permit computer file for Nova Scotia. The sample was stratified by county of permit purchase to ensure maximum geographic representation. Details for counties within zones are presented in Appendix 2. The overall sampling intensity was 0.25 but was as high as 0.66 for counties with relatively low sales. In several counties it was judged undesirable to select larger samples because of concurrent intensive canvassing for the National Harvest and Species Composition surveys.

3.1.3. Survey procedures

The questionnaires were mailed by the Nova Scotia Department of Lands and Forests between October 1976 and February 1977 in three waves. Following provincial tabulations and analyses, the completed questionnaires were shipped to CWS in Ottawa where they were manually edited, coded, and stored on magnetic tape.

3.2. Analyses

Analyses were done using version 7 of Nie *et al.* (1975). The major part of the analysis consisted of cross-tabulations of explanatory and dependent variables. The explanatory variables comprised four groups: success variables (Question 4), activity variables (Q. 1 and 3), place variables (Q. 2) and sociological variables (Q. 5, 16, and 17). The dependent variables were grouped in three categories: satisfaction and preferences (Q. 8, 9, 10, 11, and 12), opinions on changes (Q. 6, 7, and 15) and perceptions of problems (Q. 14).

Due to the exploratory nature of the study, statistical significance was assumed at the 10% confidence level. Data were weighted to compensate for disproportionate sampling in various counties. The weights are defined and listed in column F of Appendix 2.

4. Results

4.1. Response rates

Of the 3496 questionnaires sent out, 167 were returned undelivered and 2410 were completed. The usable response rate was 72%, and a large majority of questions had a response rate exceeding 90%.

4.2. Characteristics of respondents

Nearly half the responding permit holders (49.3%) were in the 20–39 age group (Q. 17). They had an average of 16.6 years of hunting experience (Q. 16a). Surprisingly few (15.5%) belonged to sportsmen's, hunters' or conservation organizations (Q. 16b). Rather more than half of them (53.4%) hunted in a party (Q. 5). The great majority (91.1%) hunted in 1975 (Q. 1a) and spent most of their time hunting sea ducks (18.7%) and other ducks (67.2%) (Q. 3b). Most respondents purchased their permits in zone 2 (68.9%) and hunted primarily (60.4%) in that zone (Q. 2), where 66.3% of the male population of the province lived in 1976 (Statistics Canada, unpubl. data from 1976 census). Effort averaged 18.5 days per hunter and decreased as the season advanced (Q. 3a).

A very high proportion of the responding hunters (87.9%) were successful (Q. 4a). Their seasonal kills were highest for Black Ducks (8.6) and sea ducks (7.2), and averaged 24.1 birds per successful respondent (Q. 4b).

4.3. Satisfaction and preferences

A large majority of respondents were satisfied or partially satisfied with the hunting season dates. The proportion of dissatisfied permittees ranged from 9 to 16% and was highest among hunters seeking both ducks and geese (Q. 12). About half of the respondents were satisfied with the existing dates while about 38% wanted a season that opened and closed later (Q. 9 and 11c).

Satisfaction with current daily bag limits was high: 95% of respondents felt bag limits are high enough to allow them to enjoy hunting (Q. 10a). Existing bag limits could be cut by almost half and still provide enjoyable hunting; 75% of the respondents would be satisfied with a bag limit of six sea ducks while 80% would accept a limit of four for other ducks (Q. 10b).

Respondents were more concerned with the length of the hunting season than with daily bag limits. If the supply of migratory game birds were to increase, 67% of the hunters would favour a longer season over higher bag limits; if population decreased, 62% would prefer a smaller bag limit to a shorter season (Q. 9a–b).

No particular day of the week emerged as a favourite for the season opening. For a given number of respondents preferring a particular day, about an equal number showed their dislike for that day (Q. 8a–b). There is a notable exception for Saturday: those against (53.9%) outnumbered those in favour (14.2%) by almost 4 to 1. However, many respondents (62.6%) replied they would "probably" or "definitely" go hunting on opening day if it occured on a Wednesday.

Several significant interrelationships were observed between the characteristics of permit holders and their responses. Those most satisfied with the regulations hunted primarily in the zone having fewest hunters (zone 1) and were found among the youngest and oldest age groups. They also had less previous hunting experience and smaller harvests, and hunted fewer days than dissatisfied respondents. Respondents favouring a change to a longer season with reduced bag limits were found mostly among sea duck and goose hunters, hunters in zone 2, permittees in the younger age groups, and those hunting the greatest number of days or reporting the highest harvests.

Opponents to a Saturday season opening were found mostly among older and experienced permittees, hunters in zone 2, and those hunting the greatest number of days or having large harvests.

4.4. Opinions on possible changes

There was little support for major changes in daily hunting hours or the legalization of Sunday hunting. Most respondents (68.0%) disapproved of banning hunting before sunrise; nearly half (45.4%) supported a suggested ban on hunting after sunset (Q. 7). Despite the fact that over half of the migratory game bird hunting in the Maritimes occurs on Saturdays, most respondents (64.8%) dislike the idea of legalizing Sunday hunting (Q. 6).

Only 30.6% of the respondents were very unfavourable to an increase in the cost of the migratory bird permit from $3.50 to $5.00 (Q. 15). In 1974 the cost was raised from $2.00 to $3.50, and total permit sales in Nova Scotia dropped by 8.5% to 13 791, from 15 071 in 1973, the most sold in any year. During 1975 and 1976, permit sales in the province averaged 13 658 and were up to 15 744 in 1977. In view of the apparent stability in sales, a marginal increase in price would probably have a smaller impact than the increase in 1974.

Several permittee characteristics were significantly related to their responses. Permittees in favour of restricted daily hunting hours were less active than the rest. Supporters of legalized Sunday hunting were younger and less experienced than opponents. Members of sportsmen's, hunters' or conservation organizations were more likely to favour an increase in the cost of the permit.

4.5. Problems affecting hunting

"Insufficient law enforcement" in general and "hunting out of season" in particular were perceived as the most common problems requiring government attention (Q. 14b). Deep concern about "going over bag limits" was ranked fifth preceded by concern with "hunting out of season" (ranked second), "sky busting" (third), and "not enough land for public hunting" (fourth).

"Insufficient law enforcement" and "hunting out of season" were identified as serious problems most often by those belonging to a sportsmen's, hunters' or conservation organization. Those hunting 40 days or more and hunters with large harvests perceived hunting out of season as a major problem more often than others.

5. Conclusions

This co-operative study was undertaken to obtain a better understanding of the opinions of holders of permits towards the existing hunting regulations in Nova Scotia and possible changes in them, and to study the permit holders' perceptions of the most serious problems affecting hunting. Resources permitting, a better understanding of the clientele will help management to optimize hunters' satisfactions. This should lead to better compliance with hunting regulations and more effective enforcement.

Any changes in the current regulations will please some hunters and offend others. Our results should be used as a guide to minimize dissatisfaction among hunters without endangering current migratory game bird populations. They also indicate how hunters' preferences may alter as their age composition, participation in organizations, activity, and success also change.

Although satisfaction with the current regulations is very high, there is some discontent among highly active and successful hunters and those in the zone having the highest density of hunters. Young permittees are most favourable to change. The perceptions of the major problems affecting hunting as well as the reported preferences indicate that respondents are generally more concerned with legitimate hunting opportunities than the harvesting of game. Increased fines as well as more intensive surveillance should help reduce concern over law enforcement. Problems which are not directly related to law enforcement ("sky busting" and the lack of information on hunting regulations) can perhaps be handled best by increasing or refining existing information and education programs.

6. Acknowledgements

The authors acknowledge the valuable assistance of F. G. Cooch (Migratory Birds Branch, CWS), Gail Eagen (Computer and Applied Statistics Directorate, Environment Canada), staff of the Nova Scotia Wildlife Division (Kentville), and Donna Eastwood (Department of Geography, University of Ottawa) during the gathering, processing, and analysis of the data.

7. References

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences, 2nd ed. McGraw Hill Book Company, Toronto. 675 pp.

Appendix 1
Reset version of questionnaire on migratory game bird hunting regulations in Nova Scotia and statistical summary of responses.

Notes:
i) For each question the following data are presented:
the number of usable responses (n), percentage responding (%), or the mean response value. The response data are in italics.

ii) The weighted total number of returns was 2408. This was the analytical base for all questions except for questions 1b, 2a, 2b, 3a, 3b, 4a, and 5 for which the maximum number of usable returns was 2194, and question 4b for which the base was 1917.

Opinion Survey on 1976
Migratory Game Bird Hunting Regulations

Purpose
The provincial and federal wildlife agencies would like to know how you feel about migratory game bird hunting season dates, bag limits, and other problems which may affect your hunting enjoyment. Your answers will help us modify hunting regulations to suit your needs whenever game bird populations permit.

Instructions
Please answer each question as best you can (guess if necessary) and return the questionnaire in the enclosed self-addressed envelope as soon as possible. Most questions can be answered quickly by placing a simple check mark (√) in the small boxes.

All answers are stricly confidential.

1 a. Did you hunt migratory game birds in Nova Scotia last season (in 1975)? (check one) (n = *2408*)

Yes *91.1%* No *8.9%*

b. If *Yes* what birds did you hunt? (check as many as you hunted) (n = *2184*)

Ducks *91.4%* (Black, Teal, Whistlers, Bluebills, etc.)	Sea Ducks *43.3%* (Scoter, Eider, Old Squaw, Mergansers)
Geese *45.0%*	Woodcock or Snipe *22.0%*

2 a. In what counties did you hunt migratory birds in 1975? (n = *2184*) (Place a check mark in box behind each county in which you hunted)

(zone)			
1	Annapolis	*5.2%*	*(2.2%)*[1]
1	Antigonish	*5.6%*	*(2.1%)*
2	Cape Breton	*9.1%*	*(5.6%)*
1	Colchester	*10.7%*	*(5.3%)*
1	Cumberland	*13.1%*	*(9.6%)*
2	Digby	*5.2%*	*(2.2%)*
2	Guysborough	*8.0%*	*(4.6%)*
2	Halifax	*21.7%*	*(16.1%)*
1	Hants	*10.6%*	*(4.1%)*
1	Inverness	*5.0%*	*(1.6%)*[1]
1	Kings	*10.4%*	*(7.3%)*
2	Lunenburg	*6.5%*	*(3.7%)*
1	Pictou	*5.2%*	*(3.9%)*
2	Queens	*7.6%*	*(3.8%)*
2	Richmond	*6.3%*	*(2.2%)*
2	Shelbourne	*15.0%*	*(12.2%)*
1	Victoria	*4.1%*	*(3.6%)*
2	Yarmouth	*12.7%*	*(10.0%)*

b. Please underline the one county where you spent most time hunting, (underline one of the above) *See data in brackets in 2 (a)*. (n = *2149*)

3 a. On about how many separate DAYS did you hunt migratory game birds in each month last season? (n = *1805*)

October	*6.1*	December	*4.3*
November	*5.3*	January	*2.8*

b. Which migratory game birds did you spend most of your time hunting last season? (n = *2178*)

Ducks	*67.2%*	Geese	*8.2%*
Sea ducks	*18.7%*	Other	*5.9%*

4 a. Did you kill and retrieve any migratory game birds last year? (n = *2181*)

Yes *87.9%* No *12.1%*

b. If *Yes* please indicate about how many of the following you bagged? (n = *1893*)

Sea ducks	*7.2*	Woodcock or	
Geese	*1.0*	Snipe	*2.3*
Black ducks	*8.6*	Other ducks	5.0

5. Last season did you hunt migratory game birds mostly? (n = *2177*)

Alone? *46.6%* With a party? *53.4%*

[1]Data in brackets are for question 2b.

6. As you know, it is unlawful to hunt on Sundays in Nova Scotia. Would you like to see Sunday hunting legalized? (n = *2359*)

Yes *32.7%* No *64.8%* Don't know *2.5%*

7. At present, it is permitted to hunt migratory game birds from one-half hour *before* sunrise to one-half hour *after* sunset. In order to help reduce crippling losses and the shooting of protected birds, would you approve the following changes in daily hunting hours?

a. Would you approve banning hunting before sunrise? (n = *2326*)

Yes *32.0%* No *68.0%*

b. Would you approve banning hunting after sunset? (n = *2332*)

Yes *45.4%* No *54.6%*

c. Would you approve banning hunting before sunrise *and* after sunset? (n = *2279*)

Yes *32.5%* No *67.5%*

8 a. On which day do you best like the migratory game bird hunting season to open? (check one) (n = *2342*)

Monday	*22.1%*	*(21.1%)*[2]
Tuesday	*2.9%*	*(2.5%)*
Wednesday	*3.0%*	*(8.3%)*
Thursday	*1.5%*	*(2.3%)*
Friday	*6.4%*	*(6.2%)*
Saturday	*14.2%*	*(53.9%)*
No preference	*49.9%*	*(5.6%)*

b. In 8 a. above please *underline* the opening day which you dislike most of all. (underline one) *See data in brackets in 8a.* (n = *1927*)

c. If the 1977 season opened on a Wednesday do you think you would be able to go hunting that day? (check one) (n = *2338*)

Yes definitely *24.1%* Probably not *26.0%*
Yes probably *38.5%* Definitely not *11.4%*

[2]Data in brackets are in response to 8 b.
[3]Mean values computed from responses to Q. 10 b.

9 a. Suppose that the future supply of migratory game birds becomes *greater* than it is now. Would you rather have: (check one) (n = *2270*)

A longer season? *66.8%* Or a higher daily bag limit? *33.2%*

b. Suppose that in the future the supply of migratory game birds becomes *lower* than it is now. Would you rather have: (check one) (n = *2329*)

A shorter season? *38.1%* Or a lower daily bag limit? *61.9%*

c. Suppose that in the future the supply of migratory birds remains the *same* as it is now. Would you rather have: (check one) (n = *2336*)

- the same season length and daily bag limit as we have now? *53.8%*
- a longer season with a lower daily bag limit? *37.3%*
- a shorter season with a higher daily bag limit? *8.9%*

10. The present maximum *daily bag* limits for migratory game birds are shown in the table.

Sea Ducks and Mergansers	(n = *1343*) 10 birds *(5.7)*[3]
Other ducks	(n = *1503*) 6 birds *(3.8)*
Geese	(n = *1466*) 5 birds *(2.6)*
Snipe	(n = *1170*) 10 birds *(5.6)*
Woodcock	(n = *1202*) 8 birds *(4.6)*

a. Do you feel that the daily bag limits are high enough to let you enjoy hunting? (n = *2359*)

Yes *94.6%* No *5.4%*

If *No* please explain why: (specify).....

b. If daily bag limits had to be reduced to protect bird populations, what is the lowest possible daily bag limit you would need to have an enjoyable day of hunting? Enter your numbers for each bird category in the blank space at the bottom of the above table. (*See data in brackets in table above*). (n = *1503*)

11. Suppose that in the future the length of the migratory bird hunting season is the same as it is now, but changing the time of the season is being considered. Would you rather have: (check one) (n = *2341*)

- a season that opens and closes earlier? *18.4%*
- a season that opens and closes later? *37.6%*
- no change in the dates we have now? *44.0%*

12. The hunting seasons for ducks, geese and sea ducks are summarized on the *calendar on the back of the questionnaire*. Each month of the season is divided into five weeks. Sundays appear in the shaded areas.

a. In general, are you satisfied with the *duck and goose* hunting season dates in your *home county?* (n = *2316*)

Satisfied *58.0%*
Partly satisfied *26.0%*
Dissatisfied *16.1%*

b. In general, are you satisfied with the *sea duck* hunting season dates in your *home county?* (n = *2231*)

Satisfied *78.0%*
Partly satisfied *12.5%*
Dissatisfied *9.5%*

c. In general, are you satisfied with the *duck and goose* hunting season dates in the county where you spend *most time* hunting? (n = *2324*)

Satisfied *59.3%*
Partly satisfied *24.7%*
Dissatisfied *16.1%*

d. In general, are you satisfied with the *sea duck* hunting season dates in the county where you spend *most time* hunting? (n = *2212*)

Satisfied *77.4%*
Partly satisfied *13.4%*
Dissatisfied *9.2%*

e. If you have answered *Partly Satisfied* or *Dissatisfied* to any of the above could you tell us why?

No comments *58.2%*
Comments *41.8%*

13. If you are *not satisfied* with the 1975–76 hunting season shown in the calendar we would like to know the weeks when you would like to hunt migratory game birds. (The weeks for October, November, December and January are clearly shown in the calendar on the back of the questionnaire). Please check √ the boxes in the table below to show the weeks in which you would like to hunt migratory game birds.

a. For *waterfowl hunting in your home county* do not check more than 11 boxes.

b. For *sea duck* hunting in your *home county* do not check more than 25 boxes.

c. For *waterfowl* hunting *outside home county* do not check more than 11 boxes.

d. For *sea duck* hunting *outside home county* do not check more than 25 boxes.

Places	Home county										Outside home county									
Birds	Waterfowl					Sea ducks					Waterfowl					Sea ducks				
Weeks	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
September																				
October																				
November																				
December																				
January																				
February																				

(n = *2408*)

(*Data available from Nova Scotia Department of Lands and Forests, Wildlife Division*)

Name county.....

14 a. The following is a list of some serious problems that may exist in migratory game bird hunting. Which of the problems do you feel are most common in Nova Scotia? (check as many as you like) (n = *2313*)

hunting migratory game birds without a licence	*35.6%*	(*4.7%*)[4]
shooting migratory game birds before or after hours	*39.5%*	(*3.7%*)
baiting	*15.1%*	(*0.7%*)
going over bag limit	*54.8%*	(*8.4%*)
filling out someone else's bag limit in group hunting	*25.5%*	(*1.4%*)
hunters not going after birds that are shot	*50.9%*	(*6.7%*)
sky busting: shooting when waterfowl are out of range	*71.5%*	(*9.3%*)
hunting waterfowl out of season	*50.5%*	(*16.0%*)
not being able to identify birds before shooting	*36.9%*	(*2.8%*)
shooting kinds of birds that are protected	*32.1%*	(*3.3%*)
insufficient law enforcement	*41.6%*	(*19.0%*)
fines for violating regulations are too low	*34.9%*	(*7.0%*)
regulations are too hard to understand	*13.2%*	(*2.0%*)
not enough information on bird hunting regulations	*23.7%*	(*3.4%*)
not enough land for public hunting	*26.6%*	(*9.0%*)
other (specify)	*6.5%*	(*2.5%*)

[4]Data in brackets are for question 14 b.

b. In question 14 above please *underline* the one most serious problem which you feel requires government attention (*underline one* only). *See data in brackets in 14 a.* (n = *2011*)

15. The cost of the Canada Migratory Game Bird Hunting Permit is $3.50. Some of this money is used to purchase habitat, protect birds and enforce hunting regulations. If in 1977 the cost of the permit was raised to $5.00 how would you feel? (n = *2313*)

Very favourable	*15.1%*	Unfavourable	*23.0%*
Favourable	*31.3%*	Very unfavourable	*30.6%*

16 a. For about how many years have you been hunting migratory game birds? (n = *2305*)

About *16.6* years

b. Do you belong to a sportsman's, hunter's or conservation organization? (n = *2302*)

Yes *15.5%* No *84.5%*

17. How old are you? (n = *2354*)

Less than 20	*10.6%*	40's	*15.8%*
20's	*27.0%*	50's	*12.9%*
30's	*22.3%*	60's and over	*11.4%*

Thank you very much for your co-operation

We welcome any additional comments you might like to make on hunting regulations and law enforcement in Nova Scotia. (n = *2408*)

No comments *47.7%*
Comments *52.3%*

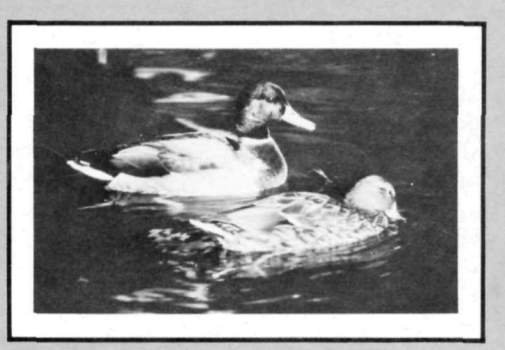
Please return the questionnaire today using the special postage paid envelope.

Appendix 2
Sample selections and analytic weights by county

A County	Zone	B Permit sales	C Sample selection	D Sampling ratio	E Questionnaires returned	F Weights*
Annapolis	1	257	152	0.59	108	0.410
Antigonish	1	209	123	0.59	68	0.529
Colchester	1	605	151	0.25	107	0.974
Cumberland	1	898	224	0.25	167	0.926
Hants	1	502	121	0.24	88	0.983
Inverness	1	191	110	0.58	69	0.477
Kings	1	962	239	0.25	165	1.004
Pictou	1	598	150	0.25	111	0.928
Victoria	1	133	84	0.63	48	0.477
Cape Breton	2	1030	257	0.25	178	0.997
Digby	2	190	125	0.66	89	0.368
Guysborough	2	549	137	0.25	97	0.975
Halifax	2	3247	640	0.20	437	1.280
Lunenburg	2	500	125	0.25	96	0.897
Queens	2	484	121	0.25	82	1.017
Richmond	2	477	117	0.24	70	1.174
Shelbourne	2	1678	334	0.20	217	1.332
Yarmouth	2	1480	286	0.19	213	1.197
Total		13 990	3496	0.25	2410	1.000

* (Ei/Bi) (2410/13990).

Part 3
Distribution of waterfowl kill



Geographical analysis of waterfowl kill in Canada

by K. E. Freemark and F. G. Cooch

1. Abstract

Results of the 1969, 1970, 1974, and 1975 National Harvest and Species Composition surveys are used to produce maps showing the level (estimated kill per square kilometre averaged over two years) and the distribution by degree block of the national kill of some waterfowl species.

Maps of the national duck and goose kill show that the highest duck kill areas were in southeastern Quebec, central Alberta, and southwestern British Columbia in 1969–70 and 1974–75, and in southern Manitoba and southern and eastern Ontario in 1969–70 but not 1974–75. Highest goose kills occurred in Saskatchewan in 1969–70 and 1974–75, and near Lake Manitoba in 1974–75. A tenfold increase in kill of Lesser Snow Geese was also evident around southern Lake Manitoba. These changes reflect, in part, changes in hunter numbers and waterfowl hunting regulations, fall abundance of ducks and geese, and a redirection of hunting effort.

The application of the mapping technique to a specific migratory game bird problem is illustrated using the harvest of Black Ducks and Mallards in Ontario and Quebec in 1969–70 and 1974–75. The changes in the combined harvest of these species were paralleled by similar changes in the number of active hunters. The increase in the proportion of Mallards and the decrease in the proportion of Black Ducks in Ontario from 1969–70 to 1974–75, however, reflected changes in the breeding populations of these species indicated by breeding pair surveys in 1951 and 1971. The limited breeding pair surveys for Quebec do not show whether the increased kill of Mallards in this province in 1974–75 reflected population changes.

Maps such as these provide a useful index of waterfowl kill on a temporal and geographical basis for waterfowl managers.

2. Introduction

The National Harvest Survey (NHS) and the Species Composition Survey (SCS) were designed to give reliable estimates of annual kill at the national, provincial, and zonal levels (Cooch *et al.* 1978). However, because all data are recorded by latitude and longitude to the minute it is possible to delineate annual waterfowl kill by degree block. Analysis by degree block is useful in identifying waterfowl species and areas exposed to intensive local hunting pressure, although generally the smaller the analysis unit, the greater the standard error of the estimate. This report illustrates a mapping technique for presenting the distribution of the national kill of some waterfowl game species by degree block. The usefulness of this method in providing a temporal and geographical index of waterfowl kill is here demonstrated by (*a*) analyzing changes in the distribution and levels of duck and goose kill in Canada, and (*b*) examining the changes in the levels and proportional composition of the Black Duck plus Mallard harvest in Ontario and Quebec.

3. Methods

The waterfowl kill data were estimated from the results of the NHS and SCS for the 1969, 1970, 1974, and 1975 hunting seasons. Data were combined for the two pairs of consecutive years in order to compensate for gaps and other irregularities resulting mainly from small sample sizes incurred by a degree block analysis.

The kill of all species of duck for each degree block was averaged for 1969 and 1970 (1969–70) and for 1974 and 1975 (1974–75). The averages for each pair of years were divided by the area of each degree block (km^2).[1] No adjustment was made for differences in the proportion of land and water between degree blocks. The average estimated kill per square kilometre of all ducks by degree block was then represented pictorially on maps of Canada.

A similar procedure was used to obtain the distribution of kill for all species of geese. The kill of Lesser Snow Geese in the Prairie Provinces was analyzed to help explain changes in harvest distribution of goose species in that region.

Changes in the distribution of Black Duck and Mallard kill in Ontario and Quebec between 1969–70 and 1974–75 were examined by computing the relative proportion of each species by degree block. Where the total number of wings of these two species received from a degree block in Ontario or Quebec in the SCS for each period was 20 or more, a proportion was calculated and illustrated on a regional map by a pie diagram. We chose the sample size of 20 in an attempt both to maximize geographical coverage and to minimize the variability associated with small sample sizes. The sample size required to provide estimates within 10% of the true value with 90% confidence (Walpole 1968) approaches 65 in some zones (depending on zonal proportions), a number attainable only in the most southerly regions of each province. In degree blocks where proportions were calculated, estimated average total kill for the two species was obtained from the NHS computer files and mapped.

4. Results and discussion

4.1. Total duck and goose harvest

In 1969–70 the areas of maximum duck kill included southeastern Quebec, southern and eastern Ontario, southern Manitoba, central Alberta, and southwestern British Columbia (Fig. 1). The kill in the seven degree blocks with the greatest reported harvest (more than eight ducks per square kilometre) ranged from 8.7 to 13.1. By 1974–75 (Fig. 2) southern Manitoba was no longer a maximum duck kill zone. A less striking reduction in duck kill occurred in southern and eastern Ontario. The areas of highest kill were in southeastern Quebec, central Alberta, and southwestern British Columbia, with 8.5 to 13.1 ducks killed per square kilometre in nine degree blocks. Overall, the estimated duck kill had increased substantially in Alberta, Saskatchewan, and southeastern Quebec.

[1]Degree block areas provided by the Computations and Adjustment Section of the Department of Energy, Mines and Resources.

Figure 1
The distribution of average kill (per km²) of all duck species in Canada, 1969–70

Figure 1

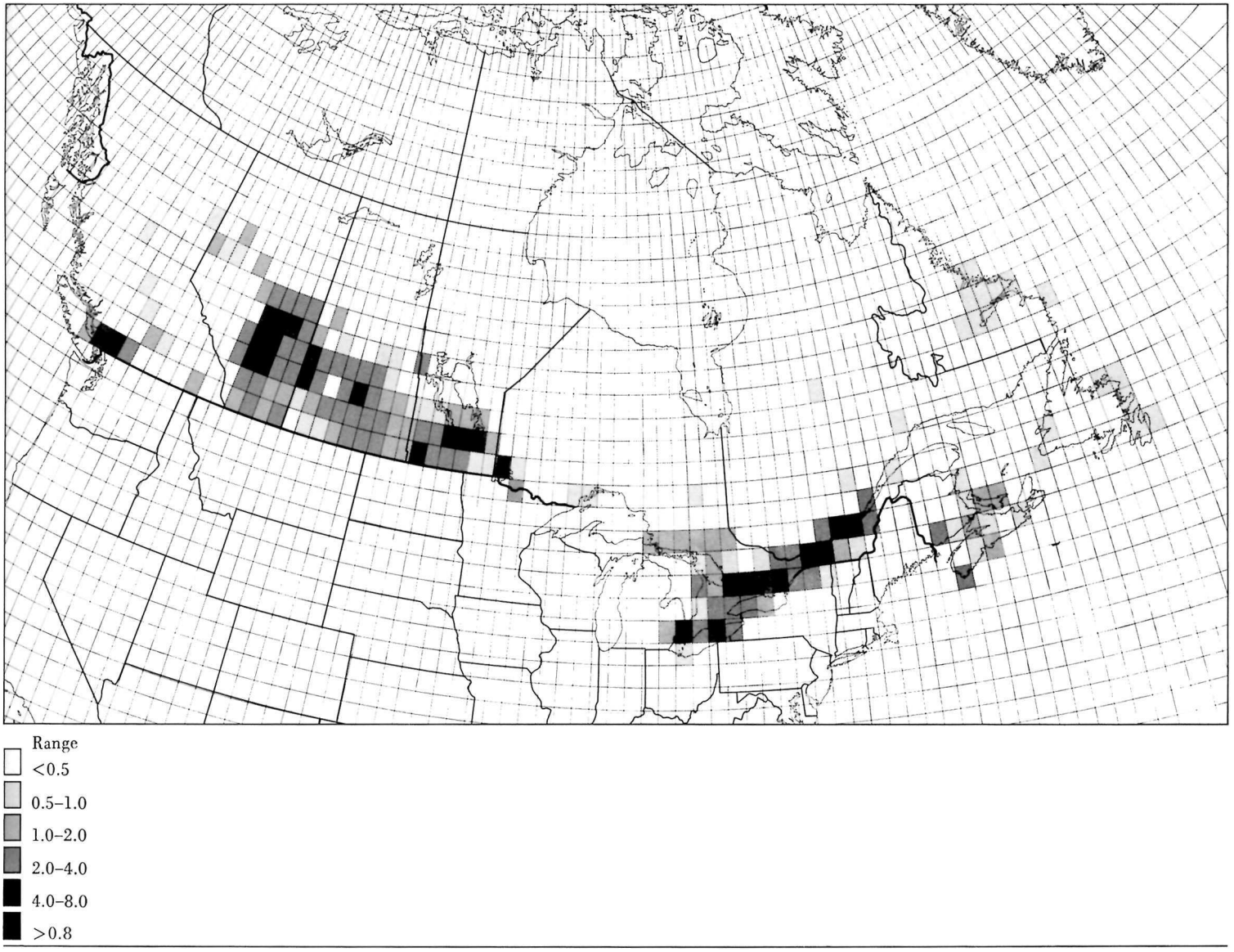


Figure 2
The distribution of average kill (per km²) of all duck species in Canada, 1974–75

Figure 2

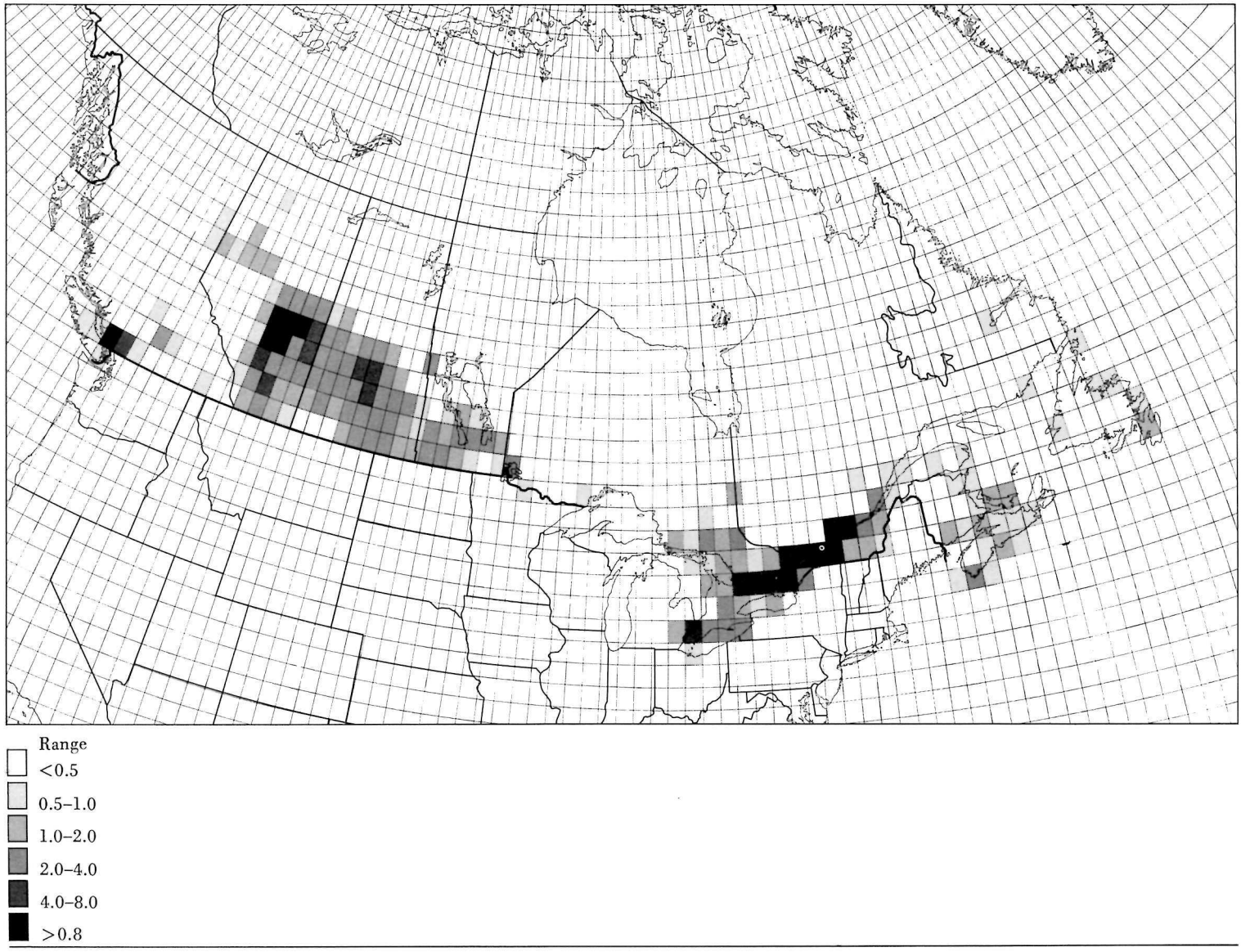


Figure 3
The distribution of average kill (per km²) of all goose species in Canada, 1969–70

Figure 3

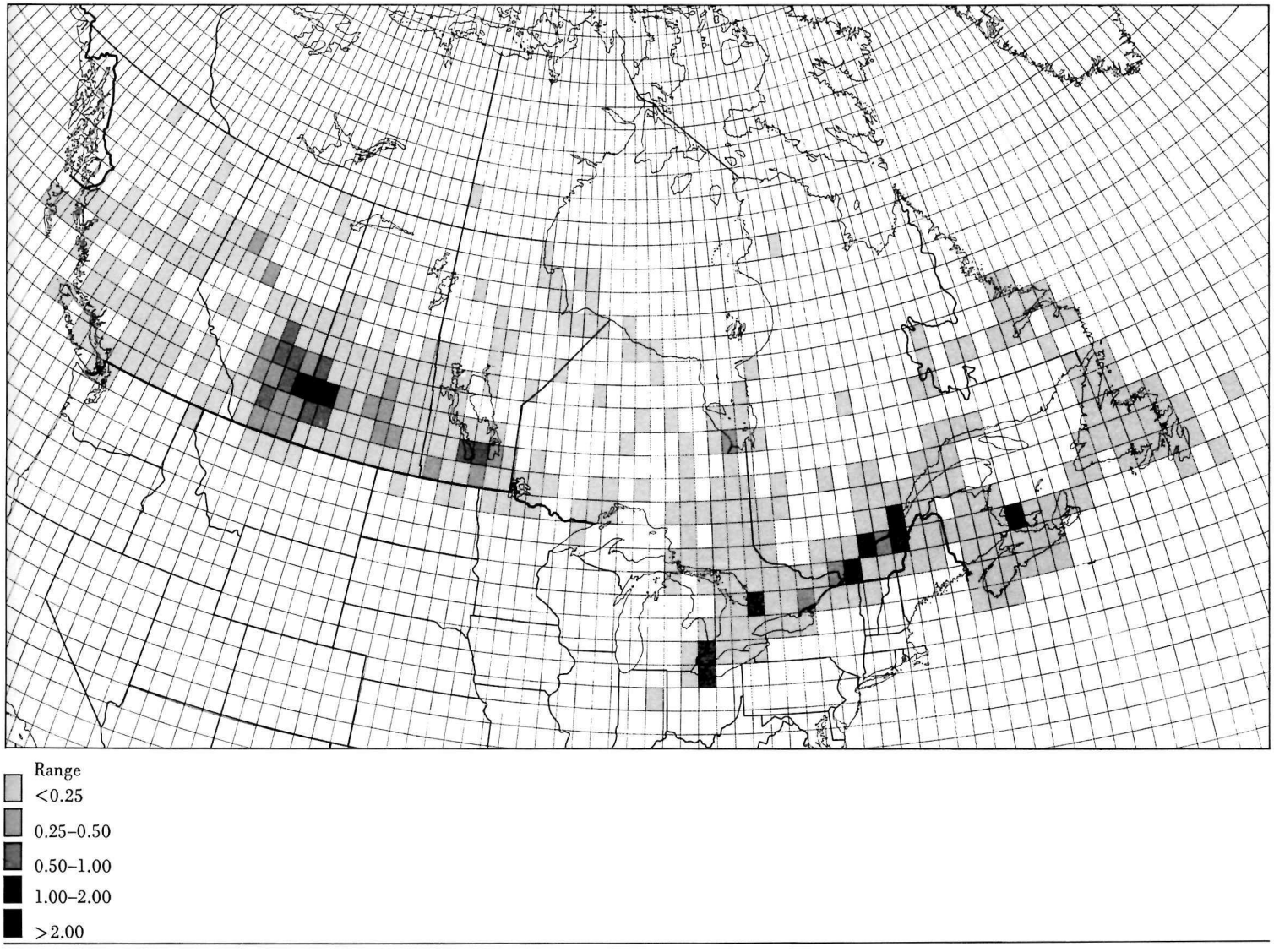


Figure 4
The distribution of average kill (per km²) of all goose species in Canada, 1974–75

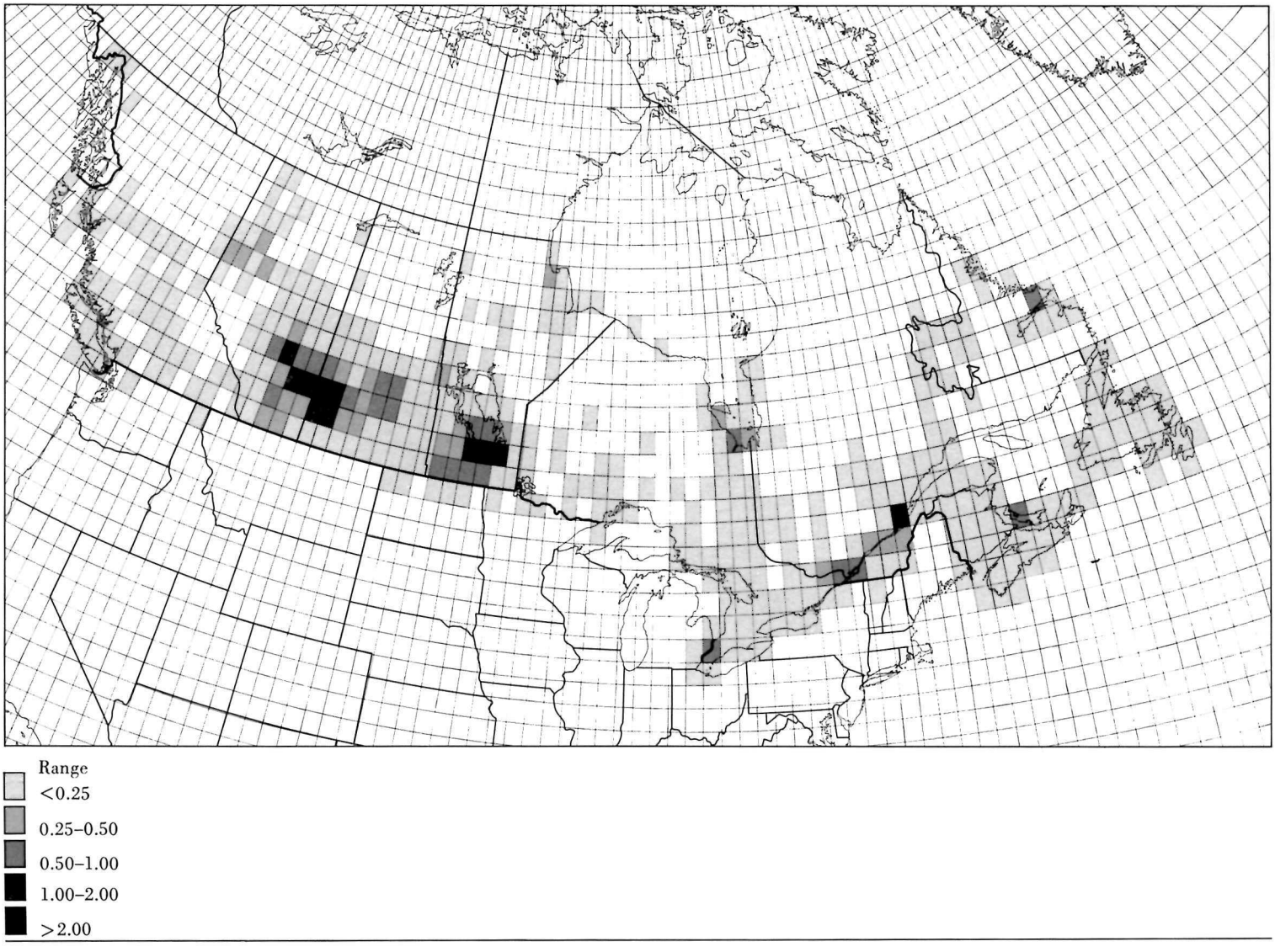


Table 1
Estimated harvest of Black Ducks and Mallards, and number of active hunters in central Ontario, southern Ontario, and southern Quebec for the 1969–70 and 1974–75 hunting seasons

	Central Ontario			Southern Ontario			Southern Quebec		
	1969–70	1974–75	% change	1969–70	1974–75	% change	1969–70	1974–75	% change
Mallard harvest	220 226*	291 968	+32.6†	158 447	177 125	+11.8	76 960	122 927	+59.7
Black Dust harvest	128 509	96 816	−24.7	50 819	31 003	−39.0	169 074	157 855	−6.6
Mallard + Black Duck harvest	348 775	388 784	+11.5	209 266	208 128	−0.5	246 034	280 782	+14.1
Estimated active hunters	122 611‡	128 550	+4.8	55 170	53 059	−3.8	61 646	81 631	+32.4

*Totals for the 2 years (from Cooch and Kaiser 1973, Cooch and Newell 1977).
†The sign denotes the direction of the change: + means an increase, − signals a decrease.
‡Totals for the 2 years.

Between 1969–70 and 1974–75 the harvest surveys showed a general increase in the number of degree blocks where ducks were killed. This was particularly evident in northern British Columbia, Alberta, central Quebec, and Labrador (cf. Figs. 1 and 2).

Figure 3 shows the goose kill in 1969–70. More than 2.0 geese per square kilometre were killed only in the block incorporating Kindersley, Saskatchewan (51°N 109°W), where the kill was 2.9 geese per square kilometre.

In 1974–75 (Fig. 4) the greatest goose kill occurred near Lake Manitoba (50°N 97–98°W) and, again, near Kindersley, Saskatchewan. The kill in these three degree blocks ranged from 2.5 to 3.7 geese per square kilometre.

An increased goose kill was also evident in southwestern Saskatchewan and southeastern Alberta in 1974–75. Except for parts of the Prairie Provinces and along the shores of the St. Lawrence River and southern James Bay, the goose kill in both hunting periods was generally small.

The increased kill of ducks and geese in some degree blocks of Alberta and Saskatchewan between 1969–70 and 1974–75 reflected, in part, an increase in permit sales in these provinces (Alberta, 19.1%; Saskatchewan, 17.4%; Cooch 1976). An increase in the number of active hunters in southeastern Quebec probably accounted for the increased total duck kill there in 1974–75 (see section 4.2.).

Although permit sales in southern Manitoba declined by 6.8% between 1969–70 and 1974–75 (Benson 1970, 1971; Cooch and Raible 1975; Cooch 1976), the decrease was not enough to account for the dramatic decline in the total duck kill. By 1974–75, the duck breeding population had declined by 8% from the 1969–70 level; there was also a higher relative proportion of early migrating species such as Blue-winged Teal and Pintail (Benning 1977). In 1969–70, Mallards comprised an average of 60% of the total ducks estimated killed in southern Manitoba (Cooch and Kaiser 1972). By 1974–75 the Mallard breeding population had diminished by 18% from the 1969–70 level (Benning 1977) and the proportion of Mallards in the bag had decreased to 50% (Cooch and Newell 1977). These declines were generally attributed to a combination of overshooting of Mallards, lowered production of young ducks due to a decrease in suitable breeding habitat through intensified agricultural practices (e.g. draining and cultivation of potholes and/or burning of emergent vegetation) and increased predation by mammals. Restrictive duck hunting regulations established in 1974, which delayed the season opening and severely limited the permitted daily bag of Mallards, further affected the number of ducks killed in the 1974–75 seasons.

Meanwhile, by 1974–75 the breeding population of Canada Geese in southern Manitoba had increased 450% from 1969–70 levels (Benning 1977). A general increase in the number of geese from northern breeding areas staging in southern Manitoba was believed to be, at least partly, a result of provincial habitat management programs. In 1973 a waterfowl habitat construction program was initiated at the Oak Hammock Marsh located 23 km north of Winnipeg, Manitoba. Just prior to development, fall staging geese numbered less than 1200 and remained only until the waterfowl season opened (Oak Hammock Marsh Wildlife Management Area Advisory Committee 1974). By 1976, 130 000 geese were utilizing the 3360 ha refuge from late August to mid October (Graham 1976). A similar project at Grant's Lake, southwest of Oak Hammock Marsh, has also proved effective in increasing the numbers of geese remaining in autumn (W.K. Brace, pers. comm.). Figures 5 and 6 illustrate the effect which these projects have had on the Snow Goose harvest in the Prairie Provinces. An increase in harvest area as well as a dramatic increase in the magnitude of Snow Goose kill per square kilometre in 1974–75 is evident. Around southern Lake Manitoba (50°N 98°W) the number of Snow Geese killed per square kilometre increased from an average of 0.1 in 1969–70 to 1.1 in 1974–75.

Figure 5
The distribution of average kill (per km²) of Snow Geese in the Prairie Provinces, 1969–70

In conjunction with this increased availability of geese in southern Manitoba, the changes in hunting regulations in 1974, which opened the goose season before the duck season and restricted the permitted daily bag of Mallards, resulted in many hunters redirecting their hunting effort from ducks to geese.

4.2. Black Ducks and Mallards

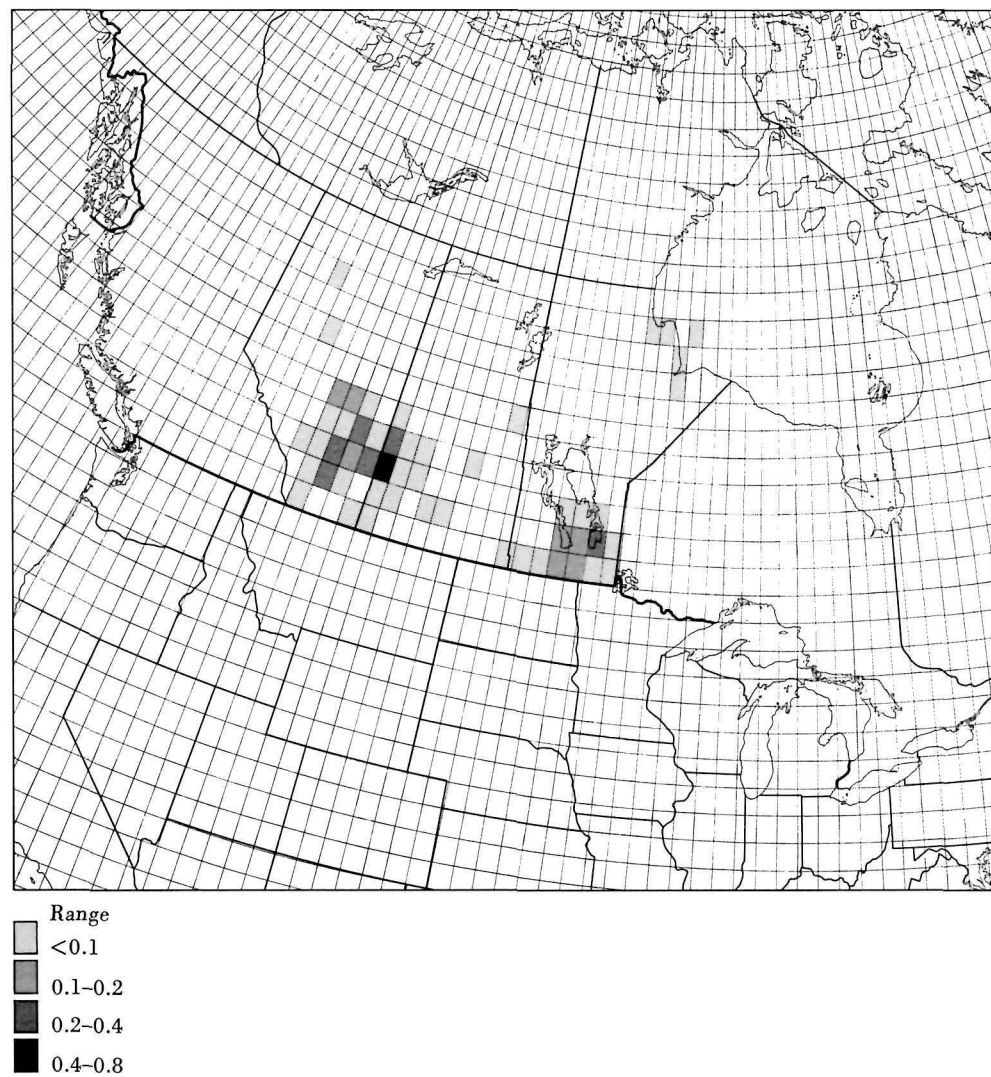
In comparing the 1969–70 and 1974–75 kill of Black Ducks and Mallards in Ontario and Quebec, a substantial change in the magnitude (Figs. 7 and 8) and the distribution (Figs. 9 and 10) of the kill is evident. The proportion of Black Ducks killed decreased in most parts of the provinces between 1969–70 and 1974–75. This trend is particularly striking when coupled with a general increase in the total numbers of Black Ducks and Mallards harvested during this period (see Figs. 7–10).

Table 1 shows the percentage change in the harvest of Black Ducks and Mallards between 1969–70 and 1974–75 hunting seasons, and the change in the number of active hunters in the same period, for central and southern Ontario and southern Quebec.

While the changes in the combined Black Duck and Mallard kill in Ontario can generally be attributed to parallel changes in the number of active hunters, the increased Mallard and decreased Black Duck harvests reflect changes in the breeding populations of these two species. Breeding pair surveys in central and southern Ontario showed a significant decline in the number of Black Duck pairs and a sixfold increase in the number of nesting Mallards between 1951 and 1971 (Dennis 1974, Collins 1974).

In southern Quebec, an increased number of hunters shot substantially more Mallards but essentially the same number of Black Ducks in 1974–75 compared to 1969–70. The limited breeding pair surveys available for Quebec during this period do not confirm that this reflects population changes (Reed 1975).

Figure 5

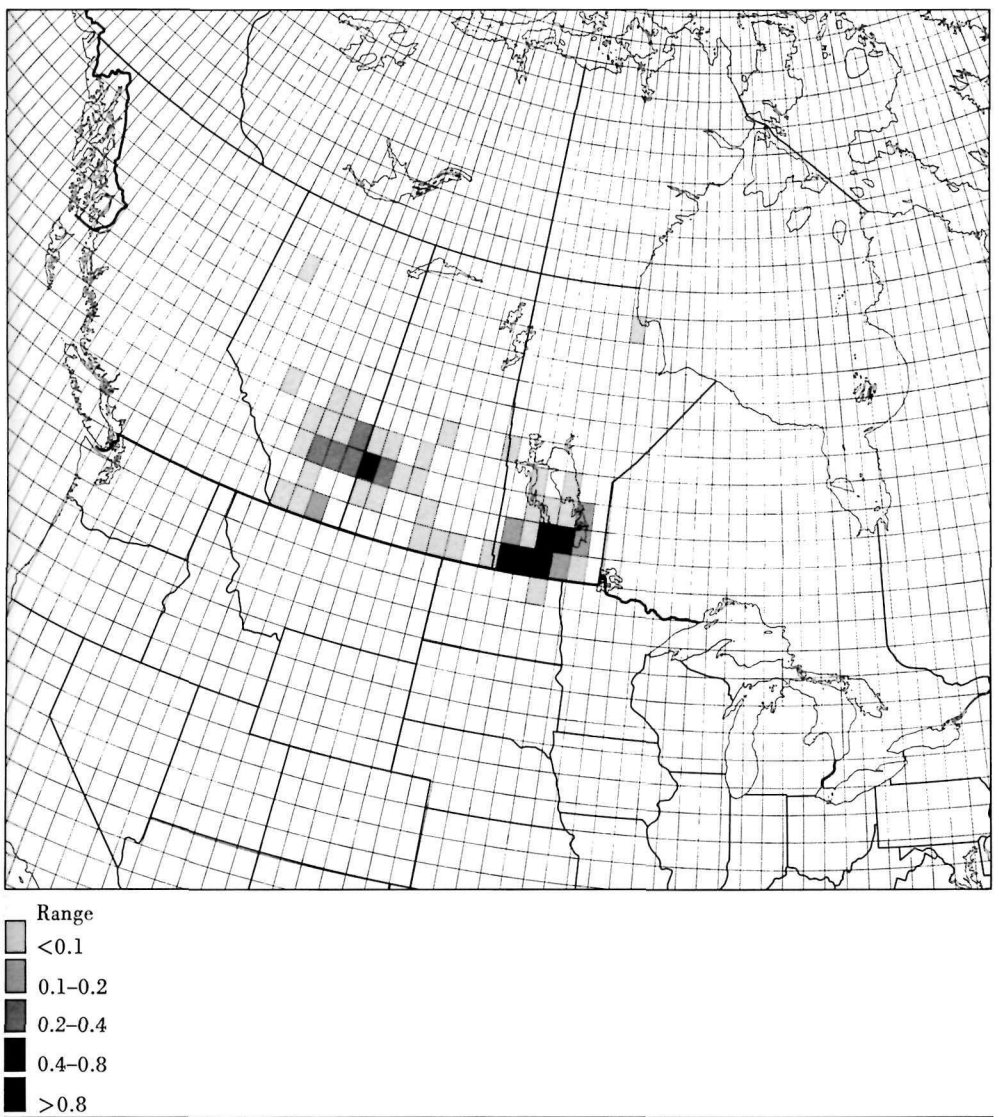


A more detailed discussion of changes in Black Duck harvest in eastern Canada is presented by Newell and Boyd (1978).

5. Conclusions

The use of the NHS and SCS to generate kill estimates within degree blocks represents a useful tool to waterfowl managers. An atlas of waterfowl kill, which illustrates the degree block information, can be generated in any year for any species or species group which is substantially harvested in Canada. The technique thus has the advantage of being comprehensive (for major species) and useful in identifying (1) specific management problems (e.g., Black Ducks in Ontario), (2) areas where special hunting surveys may be necessary, (3) areas where special regulations or additional enforcement may be required,

Figure 6
The distribution of average kill (per km²) of Snow Geese in the Prairie Provinces, 1974–75



and (4) important areas for habitat acquisition.

Because neither of the parent surveys was designed to provide precise results at the degree block level, under-estimation of the waterfowl kill in a degree block may occur due to a patchy distribution or return of harvest questionnaires (NHS) and wing envelopes (SCS). Inability to assign some records to a degree block has also resulted in under-estimation of the waterfowl kill particularly in the 1969–70 seasons.

The vectoring problem discussed by Cooch *et al.* (1978) in relation to automated calculation of hunting location is evident in Figures 1–4. Hunting locations near zonal, provincial, or international boundaries may be assigned to neighbouring zones or to the United States. There were fewer outliers in 1974–75 than in 1969–70 (cf. 48°N 49°W, 61°N 101°W, in Figs. 1 and 2), owing to improved operational procedures. The magnitude of the vectoring error can be appreciated from those records which have been misassigned to the United States. The error never resulted in waterfowl kill estimates exceeding the lowest harvest levels.

Other errors which are inherent in these analyses can be attributed to the parent surveys. For example, the NHS obtains estimates of only the retrieved waterfowl kill by people purchasing Canada Migratory Game Bird Hunting Permits. The actual kill is somewhat higher but very difficult to estimate. Biases in wing returns which plague the SCS will also have an effect on the degree block results.

This mapping technique does provide, however, a useful index of waterfowl kill on a temporal and geographical basis. Since the numbers generated at the degree block level lack robustness, the data cannot be used as more than indicators of the true situation. In the production of the maps we have used a large scale to dampen some of the effects of small samples, and thus the relative importance of one degree block to another is likely to be accurate for the most part. If the harvest levels in degree blocks differ by more than one unit of scale, a real difference is highly probable.

Figure 7
Average harvest, 1969–70, of Black Ducks and Mallards for degree blocks in Ontario and Quebec, from which a total of 20 or more Black Duck and Mallard wings were returned

Figure 7

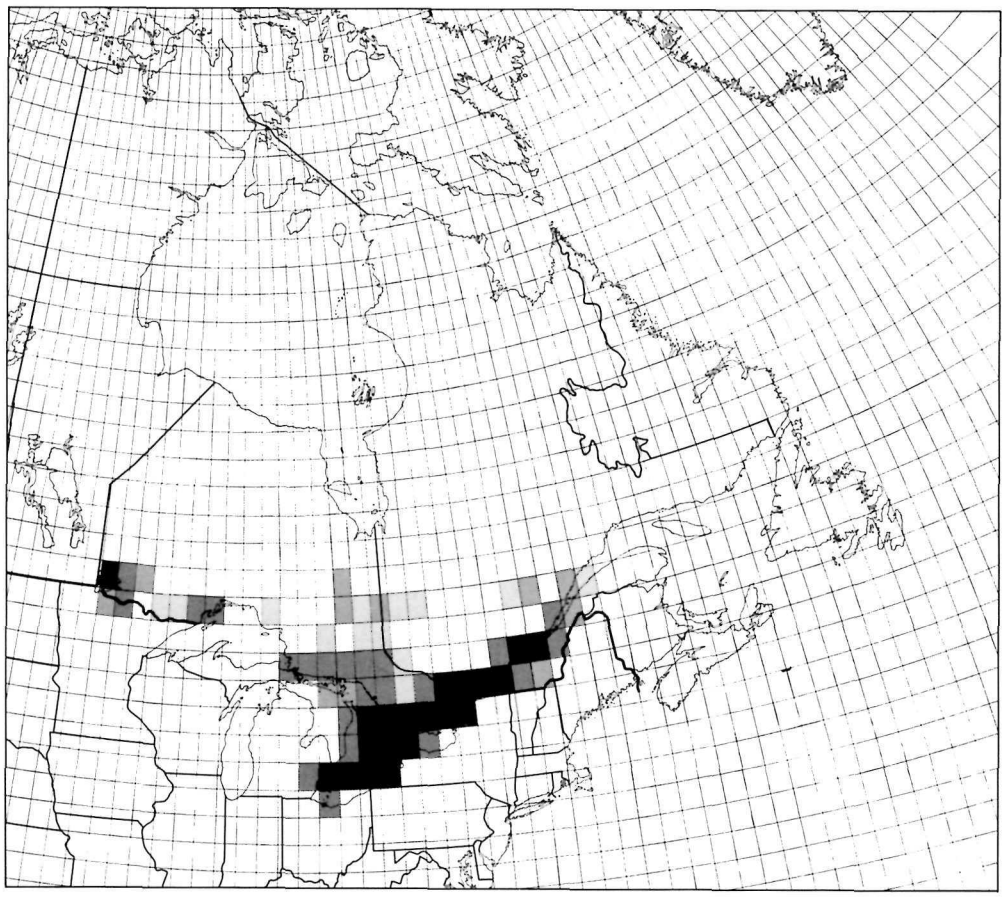


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Figure 8
Average harvest, 1974–75, of Black Ducks and Mallards for degree blocks in Ontario and Quebec, from which a total of 20 or more Black Duck and Mallard wings were returned

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Figure 8

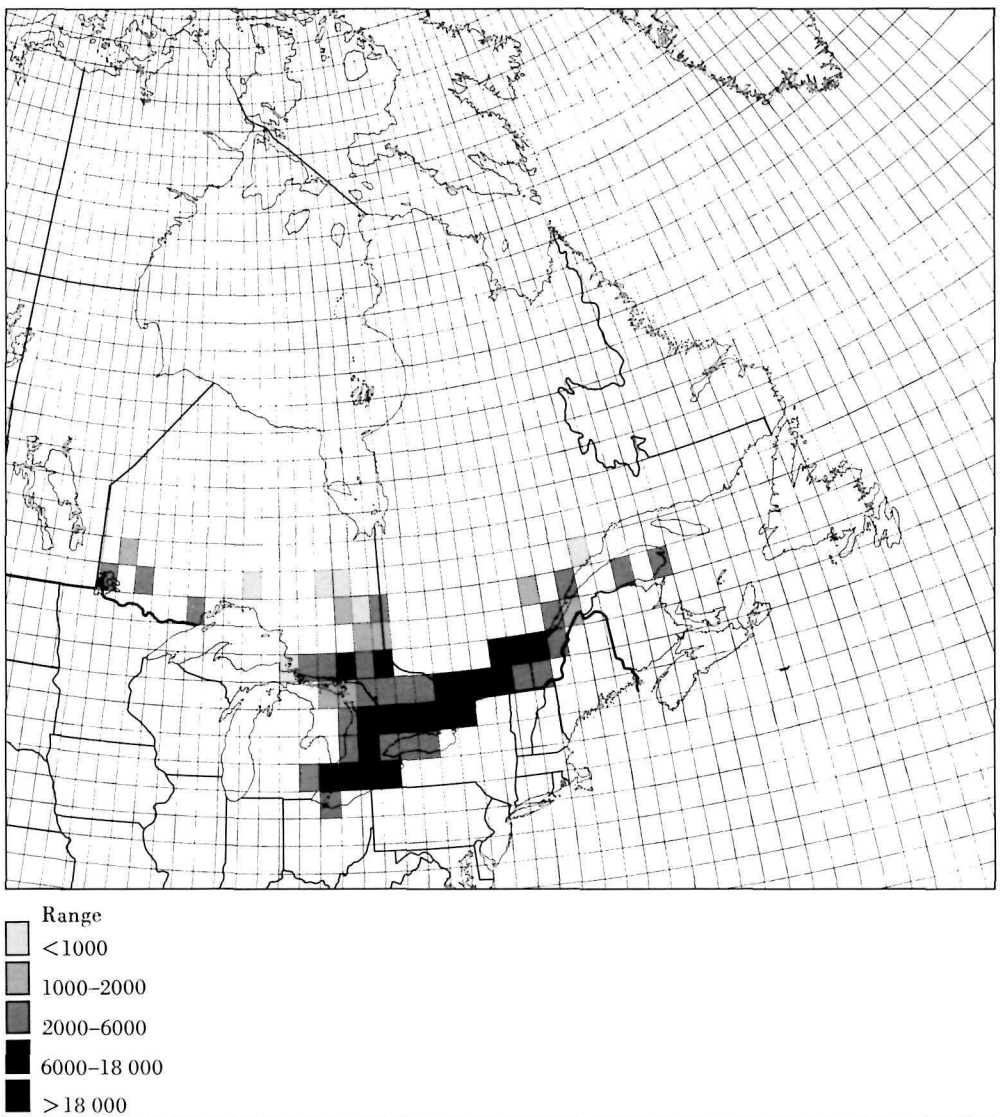
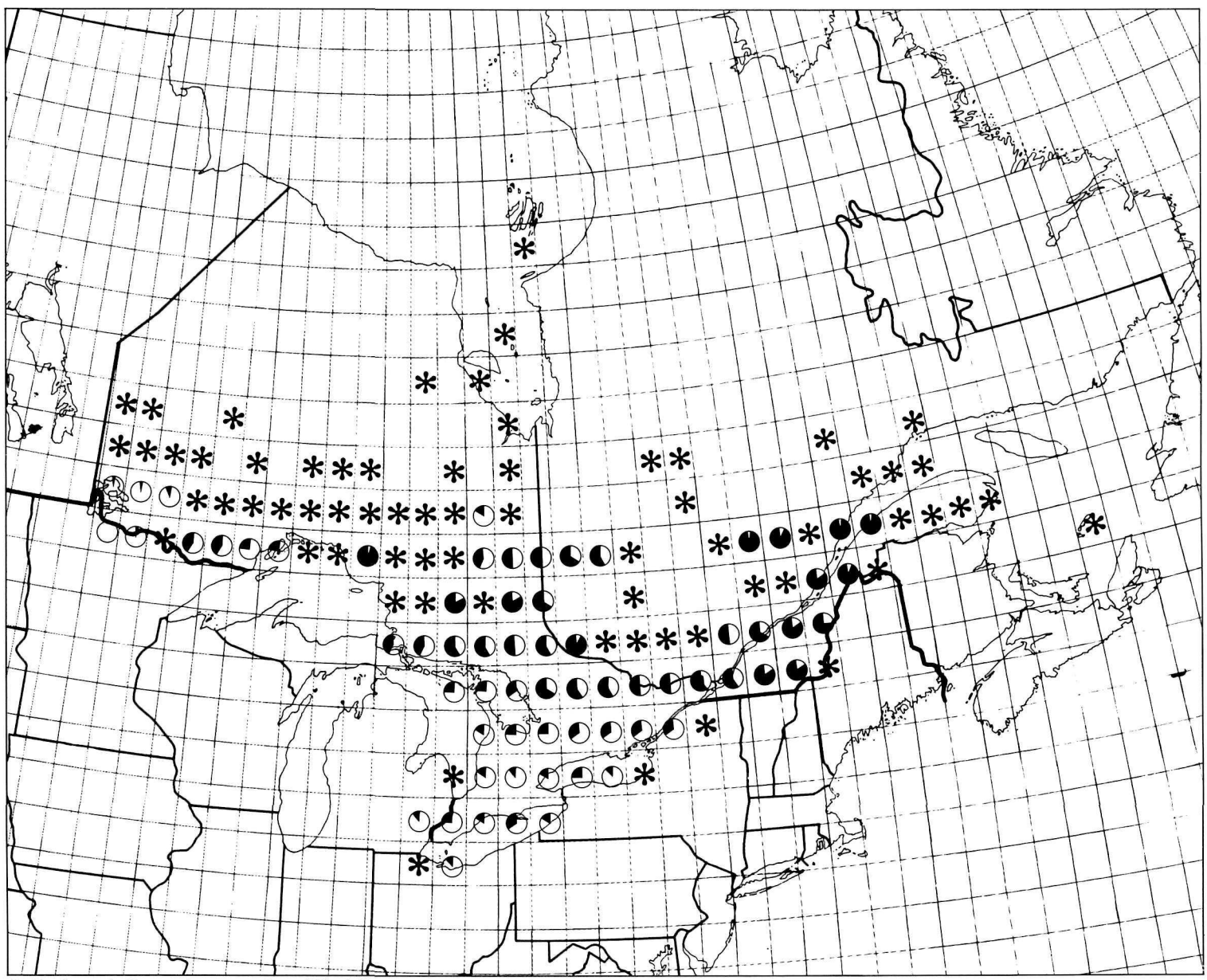


Figure 9
The proportion of Mallards and Black Ducks killed for degree blocks in Ontario and Quebec, 1969–70

Figure 9

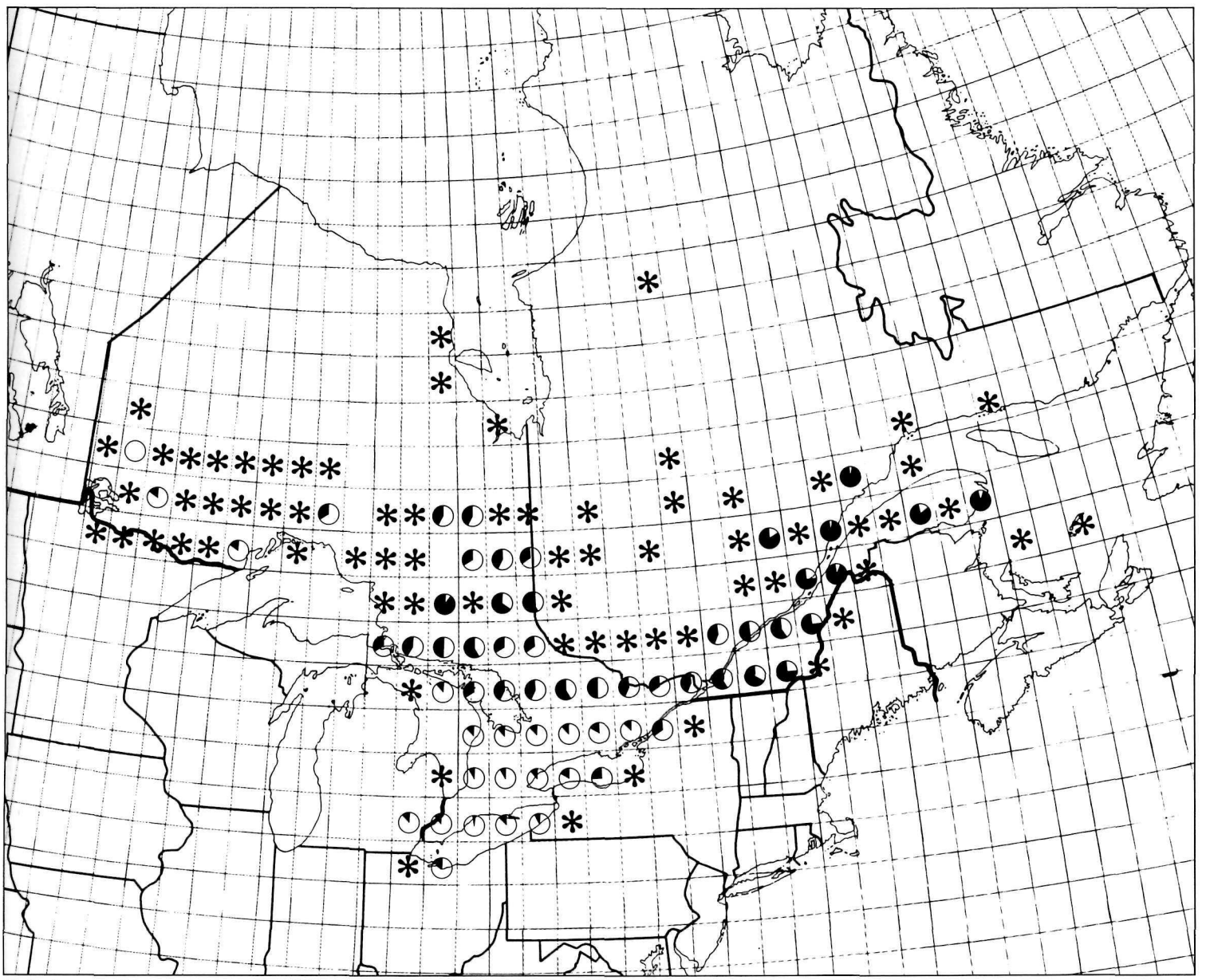


◐ Dark area indicates the proportion of Black Duck wings in total number of Black Duck and Mallard wings received from hunters.
White area indicates the proportion of Mallard wings in total number of Black Duck and Mallard wings received from hunters.

✱ < 20 Black Duck and Mallard wings in total received from hunters.

Figure 10
The proportion of Mallards and Black Ducks killed for degree blocks in Ontario and Quebec, 1974–75

Figure 10



◐ Dark area indicates the proportion of Black Duck wings in total number of Black Duck and Mallard wings received from hunters.
White area indicates the proportion of Mallard wings in total number of Black Duck and Mallard wings received from hunters.

✱ < 20 Black Duck and Mallard wings in total received from hunters.

Distribution between Canada and the United States of the retrieved waterfowl kill by sport hunters

by F. G. Cooch

1. Abstract

Between 1967–69 and 1976 the retrieved kill of ducks by sport hunters in North America increased from 14.0 million to 19.4 million, the kill of geese from 1.6 to 2.1 million, and the number of hunters from 2.3 to 2.6 million. Canadians represent about 17.5% of the continent's sport hunters and they account for about 22% of the continental kill of both ducks and geese.

Canadian kill is concentrated on late migrating species, and because of legislative restrictions on the timing of hunting seasons, Canadians cannot increase their portion of the continental kill of ducks. An increased harvest of geese by Canadians is probable as fall staging in Canada becomes more widespread.

2. Introduction

Geis and Cooch (1972) described the relative distribution between Canada and the United States of the sport kill of dabbling and diving ducks during 1967, 1968, and 1969. Increased sport hunting of ducks and geese by North Americans since then, and claims by native peoples for continuing and greater access to the resource, make it more and more important to know where the kill of various species occurs. Canada has not yet allocated quotas for the kill of geese and other species as has occurred in some flyways in the United States; however, the need to allocate quotas among different groups of users within Canada and between the two countries is a distinct possibility, if it should happen that the numbers and activities of hunters continue to increase as they have in the past decade.

This report presents estimates of the distribution of the kill between the United States and Canada for 1973–75 and 1976, based on National Harvest Survey (NHS) questionnaires and Species Composition Survey (SCS) data. The 1973–75 analyses include geese and sea ducks, as well as the dabbling and diving ducks on which Geis and Cooch (1972) concentrated.

Table 1
Average distribution between Canada and the United States of the retrieved kill of species of ducks and geese during the 1973, 1974, and 1975 hunting seasons

	Average retrieved kill 1973–75					% of total kill		
Species	Canada	%	U.S.	%	Total	Canada	U.S.	Continental
Ducks								
a) Dabblers								
Mallard	1 672 900	27.2	4 483 800	72.8	6 156 700	43.3	34.4	36.8
Black Duck	310 300	45.6	370 600	54.4	680 900	8.4	2.8	4.1
Gadwall	118 700	15.5	648 200	84.5	766 900	3.2	5.0	4.6
American Wigeon	137 000	14.6	801 900	85.4	938 900	3.7	3.6	5.6
Green-winged Teal	193 200	11.9	1 425 200	88.1	1 618 400	5.3	10.9	9.7
Blue-winged Teal	144 700	14.5	849 800	85.5	944 500	3.9	6.5	5.9
Shoveler	63 200	12.6	439 800	87.4	503 000	1.7	3.4	3.0
Pintail	233 500	14.7	1 294 400	85.3	1 517 900	6.1	9.9	9.1
Wood Duck	92 900	8.7	973 100	91.3	1 158 900	2.5	7.5	6.9
b) Divers								
Redhead	44 000	23.1	146 100	76.9	190 100	1.2	1.1	1.1
Canvasback	31 400	30.6	71 200	69.4	102 600	0.9	tr.	0.6
Greater Scaup	76 900	46.5	88 400	53.5	165 300	2.1	tr.	1.0
Lesser Scaup	133 600	20.7	511 300	79.3	644 900	3.6	3.9	3.9
Ring-necked Duck	104 500	18.7	455 100	81.3	559 600	2.8	3.5	3.4
Goldeneye	115 500	59.5	78 500	40.5	194 000	3.1	tr.	1.2
Bufflehead	65 000	34.3	124 500	65.7	189 500	1.8	1.0	1.1
Ruddy Duck	4 300	5.8	68 900	94.2	73 200	tr.*	tr.	0.4
Hooded Merganser	32 300	39.1	50 300	60.9	82 600	0.9	tr.	0.5
Other Mergansers	24 500	39.5	37 400	60.5	61 900	0.7	tr.	0.4
c) Sea ducks								
Oldsquaw	22 600	58.2	16 200	41.8	38 800	0.6	tr.	0.2
Eiders	24 800	57.9	18 000	42.1	42 800	0.7	tr.	0.3
Scoters	61 300	44.4	76 700	55.6	138 000	1.7	tr.	0.8
Total ducks	3 696 700	22.1	13 029 600	77.9	16 723 600	100	100	100
Geese								
White-fronted Goose	60 800	34.9	113 600	65.1	174 400	12.8	6.9	8.3
Snow Goose	99 700	15.7	534 000	84.3	633 700	21.0	32.6	30.0
Ross' Goose	5 800	46.4	6 700	53.6	12 500	1.2	0.4	0.6
Canada Goose	308 300	24.2	967 300	75.8	1 273 600	64.9	59.1	60.4
Brant	800	5.1	14 500	94.9	15 300	tr.	0.9	0.7
Total Geese	475 400	22.5	1 636 100	77.5	2 111 500	100	100	100
Total waterfowl	4 172 100	22.1	14 665 700	77.9	18 837 800	—	—	—
Permit holders	452 100	17.5	2 138 400	82.5	2 590 500			

*Trace.

Table 2
Retrieved kill of ducks and geese in 1967–69, 1973–75, and 1976, Canada – United States

	Canada		U.S.		
	No. ('000)	%	No. ('000)	%	Total ('000)
Permit/stamp sales					
1967–69	385.3	16.7	1928.1	83.3	2313.4
1973–75	425.1	17.5	2138.6	82.5	2590.7
1976	484.8	18.6	2118.4	81.4	2603.2
Kill of ducks					
1967–69	3037	21.7	10 945	78.3	13 982
1973–75	3697	22.1	13 030	77.9	16 727
1976	4158	21.4	15 242	78.6	19 400
Kill of geese					
1967–69	228	14.2	1378	85.8	1606
1973–75	475	22.5	1637	77.5	2112
1976	507	23.9	1609	71.1	2116

Table 3
Changes in the number of legal waterfowl hunters and total retrieved kill expressed as per cent of mean values for 1967–69

	Canada*		U.S.		Total	
	1973–75	1976	1973–75	1976	1973–75	1976
Permit/stamp sales	+ 17.3	+ 25.8	+ 10.9	+ 9.9	+ 12.0	+ 12.5
Kill of ducks	+ 21.7	+ 36.9	+ 19.1	+ 39.3	+ 19.6	+ 38.8
Kill of geese	+108.3	+122.4	+ 18.8	+ 16.8	+ 31.5	+ 31.8

*Adjusted waterfowl kill estimates take into account changes in survey procedures in 1972.

3. Results

Table 1 summarizes the average kill of ducks and geese which occurred in both countries in 1973–75. Canada's proportion of the retrieved kill varies strikingly among species. Canadian hunters are dependent on a relatively small number of late-migrating species, whereas many more species are available to American hunters. Only in the case of Goldeneye, Oldsquaw, and Eiders do Canadians take more than 50% of the continental kill of a particular species of duck. The kill of these three species represents only 1.7% of the continental kill of ducks. The Mallard (27.2%) and the Black Duck (45.6%) are the only two dabblers for which the Canadian proportion of the continental kill greatly exceeds 15%.

Canada is the principal breeding ground for most of North America's waterfowl. Yet the Canadian portion of the kill for most species is lower than the proportion of Canadian hunters in North America. In Canada, Black Ducks plus Mallards represent 53.7% of the harvest, and in the United States, 37.3%. Green-winged and Blue-winged teal constitute 9.1% of the Canadian harvest and 17.5% of that in the United States. That difference was increased as a result of the "experimental early teal seasons" introduced in parts of the United States in the mid 1960s, most of which are still continuing.

Changes in the distribution of estimated retrieved sport kill between 1967–69 and 1973–75 cannot be obtained directly by comparing the data in Table 1 with those presented by Geis and Cooch (1972). The estimates of the legal sport kill in Canada prior to 1972 on which they drew were too high because intermittent hunters were not included (Cooch *et al.* 1978). When intermittent hunters (representing 20% of permit holders) were incorporated into the NHS in 1972, results were calculated with and without the intermittent sample to determine the effect of the improved sampling scheme. Inclusion of intermittent hunters resulted in a reduction of the estimated duck and goose kill by 10.2 and 12.5%, respectively. For the purposes of this paper, the previously published average kills of ducks for 1967–69 have been adjusted using those correction factors.

Between 1969 and 1976 the reported retrieved kill by sport hunters of waterfowl in North America increased from 14.0 million to 19.4 million ducks (+38.8%) and from 1.6 million to 2.1 million geese (+31.8%) (Tables 2 and 3). Comparing the adjusted figures with those for 1973–75, the proportion of the continental kill of ducks taken by Canadians (22%) has not changed noticeably, whereas the kill of geese taken by Canadians has increased from 14.2 to 22.5% (Table 2). In the case of geese, much of the increase resulted from increased use of staging areas and the subsequent harvest in Manitoba, southern Quebec, and Prince Edward Island.

There was a 17.3% increase in Canadian permit holders, compared with a 10.9% increase in sales of duck stamps in the United States between 1967–69 and 1973–75 (Table 3). The estimated continental retrieved kill of ducks and geese in 1973–75 had increased by 18.8 and 31.5% respectively from 1967–69. The duck kill in Canada increased by 22%, whereas the kill in the United States increased by 19%.

In 1973–75, Canadians retrieved an average of 8.2 ducks per potential hunter per season, compared to an average of 6.1 for American hunters. The seasonal kill per potential hunter increased by 0.43 ducks per season over the 1967–69 average in the United States but by only 0.30 in Canada.

The Canadian kill of geese increased from 0.46 birds to 1.05 per potential hunter per season, whereas the U.S. kill increased by only 0.05 to 0.77. The kill of geese per potential hunter in Canada now exceeds that in the United States, reversing the relative positions of 1967–69.

In 1972 the Canadian SCS was modified, so that thereafter waterfowl part receipts were generally analyzed on a weekly, rather than a seasonal basis (see Cooch *et al.* 1978). This modification results in a reduction of the estimated kill of early migrant species such as Wood Duck and Blue-winged Teal, and an increase in the estimates of late migrants such as Scaup, Goldeneye, Canvasback, and Redhead. The new estimates more accurately reflect the true species composition of the harvest but do not affect our estimates of total duck and goose kill. Unfortunately, it is not possible to re-analyze the species composition of the Canadian kill for the interval 1967–69 using the temporal adjustment presently employed.

4. Discussion

Both the Canadian and U.S. harvest surveys only provide estimates of the legal kill by sport hunters. No adjustment is made to allow for birds killed as a result of crop depredation prevention programs in prairie Canada, nor do these estimates incorporate the kill by native people of northern Canada and Alaska. Data related to the impact of illegal hunters, crop depredation programs, and native people on waterfowl populations are fragmentary. Data acquired as a result of the James Bay Agreement (Boyd 1977), although not valid for all Canadian native people, suggest that if estimates of native kill were added to this study, the estimated proportion of harvest occurring in Canada might increase significantly.

In addition, the U.S. harvest estimates are adjusted downwards to account for reporting bias (Atwood 1956). No similar adjustment is made in the Canadian surveys. Other substantial differences exist in the two surveys, especially in the sampling scheme. Canadian hunters are selected for the survey on a stratified and randomized basis. In the United States, mailing addresses are obtained by soliciting cooperators at predetermined post offices. Both surveys provide only an index of actual waterfowl kill in the two countries, and comparisons between countries are doubtless less reliable than are comparisons between years within a country.

The Migratory Birds Convention (1916) does not permit a season to open before 1 September or remain open after 10 March. No season can run more than 109 days. Few seasons in Canada exceed 40 days: hunting ceases at freeze-up. Therefore, the full length of the legal season cannot be utilized. Many species of waterfowl, dabbling ducks in particular, migrate early and by the opening of the hunting season much of the fall flight has left Canada. Two examples of the effects of this early emigration may be cited. In 1974 the co-operative waterfowl breeding ground survey indicated a breeding population of 2 264 000 Pintail in southern Alberta. A conservative estimate is that a population of that magnitude would yield a fall flight of 4 million. The harvest of Pintails in Alberta in 1974 was estimated to be 99 000 or 2.5% of the fall flight emanating from that province.

Another case is that of the Blue-winged Teal, which is increasing in Manitoba while breeding Mallards are declining. In order to protect breeding Mallards and Canvasbacks, the opening of the duck season was delayed in 1974 until 7 October. On the basis of the co-operative waterfowl breeding ground survey, 596 000 Blue-winged Teal were present in May in southern Manitoba and would have produced a fall flight of at least 1 million birds. Manitoba hunters were able to take only 8000 or 0.08% of the fall flight because of the delayed opening of the season.

These are extreme examples but they indicate the dilemma facing Canadian waterfowl managers. It is an accepted principle that birds are most vulnerable to shooting near their natal marshes. If seasons are opened in southern Canada at the earliest legal date (1 September) in order to increase the harvest of early migrants such as teal and Pintail, the dangers to local populations, late migrants, or more slowly developing species such as diving ducks and the larger forms of dabbling ducks are exacerbated.

This dichotomy of migration pattern has important implications for Canadians. Table 1 shows two things clearly: the pressure of the Mallard as the principal North American quarry species of duck and the exaggerated importance of Mallards and other late migrants to Canadian hunters. Unless pressure on Mallards and Black Ducks is reduced in the United States and other more abundant species are substituted, the species primarily available to Canadian hunters must gradually decline in numbers.

The situation in southern Manitoba is a classic example of what might come to pass without close international co-operation in setting hunting regulations. Whereas the population of ducks as a group has remained relatively constant, Mallards have declined from their pre-eminence in the 1950s, to be replaced by early migrants such as Blue-winged Teal and Pintail. This benefits the American hunter but it does little good for Canadians, whose country provides most of the breeding areas. As hunting pressure by Canadians increases, the importance of late migrants to Canadians will increase.

Too little data are available from 1967 to 1976 to detect many changes in the distribution of kill of waterfowl either within a country or between countries. At present, Canada, which produces 90% of the continent's ducks and perhaps 95% of its geese, takes 22% of the continental harvest of both groups. The ability of Canadians to increase their portion of the continental kill of ducks is restricted by the 1 September opening and the desire not to overharvest local breeding stocks of avail-

able target species such as geese, Mallards, Black Ducks, and diving ducks.

This paper does not address the problem of harvest by population and sub-population or the geographic distribution of harvest throughout North America, as was attempted in a limited way by Geis and Cooch (1972) and specifically for Mallards by Geis (1971), Pospahala, Anderson, and Henny (1974) and Martin and Carney (1977). Such studies and analyses are essential when decisions are made as to the allocation of the migratory bird resources between Canada and the United States.

The number of waterfowl hunters is growing more rapidly in Canada than in the United States. In 1977, permit sales to Canadians exceeded 500 000 for the first time. Despite that increase, if the continental pressure on late migrants continues to increase over the long term, the Canadian share of the continental kill of ducks will remain static or more probably decline from its present level of 22% as the numbers of late migrants are replaced by those less hardy. The kill of geese will slowly rise as fall staging in Canada becomes more widespread.

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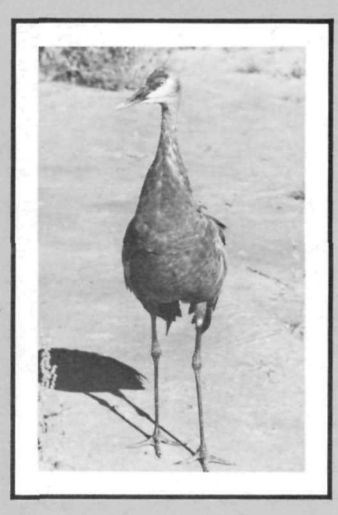
Part 4
Specific studies



The sport kill of Black Ducks in Canada, 1968-76

by K. L. Newell and H. Boyd

1. Abstract

Direct measurement of population size and productivity is impracticable over much of the breeding range of the Black Duck in Canada. Population status of this species is examined through study of the composition of the retrieved sport hunting kill provided by the national harvest surveys. The discussion covers measures of hunting effort, kill in relation to hunting effort, age ratios, and age and sex composition of the kill. Temporal distributions of kill and hunting effort are presented. This report also summarizes season length, opening dates, and bag limits applicable to Black Ducks from 1968–76, and relates the kill to changes in regulations. Trends in the Black Duck kill, numbers of hunters in eastern Canada, and hunting effort are projected on the basis of linear regressions.

2. Introduction

The Black Duck is a subject of controversy in eastern North America, because its numbers have decreased noticeably in parts of its range and because an anti-hunting organization in the United States has proposed that an effective way to restore its abundance would be to impose a moratorium on the hunting of Black Ducks in the eastern United States and Canada (USFWS 1976). To be effective in several eastern provinces where the Black Duck is the principal game duck, a moratorium would require the total closure of duck hunting. Before so drastic a step could be taken, it would be necessary to establish clearly both that the hunting of Black Ducks in Canada is having a seriously depressing effect on the population, and that a cessation of, or massive reduction in, duck hunting in eastern Canada would be likely to have an immediate and lasting beneficial effect on the number of Black Ducks.

Two of the great difficulties about monitoring the welfare of the Black Duck population, even in the settled and cleared southern parts of its breeding range, are measuring either the size of the breeding population or its annual productivity. In the larger part of its breeding range — the eastern boreal forest — the Black Duck is generally inaccessible and almost impossible to count (Chamberlain and Kaczynski 1965). Given the impracticability of direct population measurement, one indirect approach to monitoring the population productivity is through study of the composition of the Black Duck kill and its relationship to hunting effort.

The work reported here is an assembly and discussion of the evidence obtained since 1968 by means of the National Harvest Survey (NHS) and Species Composition Survey (SCS) based on sales of the Canada Migratory Game Bird Hunting Permit. Since 1966, would-be hunters of waterfowl and other migratory game birds in Canada have been obliged by law to buy a permit[1] each year, in addition to whatever hunting and weapon licences may be required in each province. Permit sales give direct information on the number of hunters of migratory game birds and provide a sampling framework of names and addresses of hunters, some of whom are asked, by means of mail questionnaires, how often they hunt and how many birds they kill. In addition, another sample of permit purchasers are asked to send in the wings from the ducks they kill, so that biologists can determine the relative abundance of different species in the bag, and the proportions of males and females, and of first-winter and older birds, in the sample of each species. More complete accounts of the national surveys can be found in Benson (1971) and in a companion paper in this publication by Cooch *et al* (1978).

There are no well-founded estimates of the number of people who hunt ducks in Canada without a permit. Indians and other native peoples are not required to hold permits, and therefore their legal kill is not measured by the surveys discussed in this report. In northern Ontario and northern Quebec the kill of Black Ducks by Indians is substantial, though few detailed surveys have yet been made. The number of illegal hunters in eastern Canada and their kill of Black Ducks are treated here as insignificant, though that assumption may be a mistake (Cooch *et al* 1978).

In this report the geographical distribution of hunting and kill is described in terms of provinces and zones within the larger provinces, because the regulations governing opening and closing dates of the hunting season, the number of ducks that may be taken in one day, and the possession limits are set with reference to those zones (with a few additional complications in some provinces where hunting and survey zones encompass different areas).

The zonal groupings are irrelevant to the ecology of the Black Duck. Further preparatory work on the distribution of this species in relation to habitat types in the hunting season is needed before geographical analyses using biological rather than political boundaries can profitably be made. It seems more useful to extract as much as possible from the existing material than to defer analysis until ecological data are available.

The kill of Black Ducks in the United States, many of them originating in Canada, is about 125% of that in Canada. While it is obviously necessary to include this kill in any assessment of the total impact of hunting on Black Ducks, the present study is deliberately restricted to the impact of the kill reported by permit holders in Canada.

3. Methods

Estimates of Black Duck kill and hunting effort in Canada are made from the NHS and SCS. The design and conduct of those surveys are described elsewhere in this publication (Cooch *et al.* 1978). A few comments on technical changes over the years are found in this text and in notes to the tables and figures.

The record of permit sales is the most accurate information used here, although we have made some minor changes in the seasonal figures published initially to in-

[1]Unless otherwise indicated, "permit" refers to the Canada Migratory Game Bird Hunting Permit.

Table 1
Estimated retrieved kill of Black Ducks in eastern Canada by province, 1968–76

Season	Newfoundland			P.E.I.	N.S.	N.B.	Atlantic Provs.	Quebec	Ontario				Total E. Can.
	Island	Labr.	Total						South	Central	North	Total	
1968	14 394	407	14 801	4 628	24 003	23 890	67 322	87 780	22 414	75 379	21 079	118 872	273 974
1969	19 765	4 754	24 519	9 273	30 371	25 410	89 573	85 519	22 156	62 023	22 520	106 699	281 791
1970	21 629	1 324	22 953	8 841	30 324	22 941	85 059	104 605	28 663	66 486	21 362	116 511	306 175
1971	14 327	3 503	17 830	16 366	42 980	22 418	99 594	113 045	22 318	50 197	25 082	97 597	310 236
1972	18 582	4 268	22 850	9 731	35 658	17 805	86 044	103 300	24 422	53 146	23 208	100 776	290 120
1973	16 619	3 154	19 773	6 898	52 323	22 345	101 339	120 816	19 312	54 854	20 363	94 529	316 684
1974	28 065	2 313	30 378	16 392	44 407	22 829	114 006	110 554	17 229	47 871	18 961	84 061	308 621
1975	28 416	4 513	32 929	14 149	58 114	22 880	128 072	91 426	13 774	48 945	21 463	84 182	303 680
1976	20 714	2 302	23 016	22 123	59 020	26 348	130 507	118 498	22 822	53 523	20 035	96 380	345 385
Mean 1972–76	22 479	3 310	25 789	13 859	49 904	22 441	111 994	108 919	19 512	51 668	20 806	91 986	312 898

clude additional reports submitted after completion of the preliminary reports on sales. A strike by postal workers during part of the hunting season in 1975 had produced some departures from the typical pattern of sales. It was much more serious for wing samples in the SCS, cutting down markedly the numbers sent in from mid October, particularly in Ontario.

All the data other than permit sales are derived from sample surveys and hence are estimates, subject to biases, reporting errors and chance variations. Some of the biases are known and have been, or in principle could be, allowed for either by adjustment of the data or by associating estimates of variance with the statistics themselves. Now that results for several years are available, including the effects of several variations in sampling procedures, it is becoming possible to explore the accuracy and precision of the statistics. In nearly all analyses that follow, it is not yet practicable to measure the reliability of estimates, apart from standard errors for duck kill by zones and provinces.

The reported number of days spent hunting waterfowl and an average number of days spent hunting per active hunter provide measures of hunting effort, and are tabulated for comparable seasons 1972–76. Waterfowl hunter-days were calculated from the product of the total number of active hunters and the average number of days on which those hunters were active.

Kill in relation to hunting effort was measured as Black Ducks killed per successful duck hunter and as Black Duck kill per 1000 waterfowl hunter-days. Within-season changes in kill per unit effort were measured by the average number of Black Ducks killed per hunter-day for weekly periods throughout the hunting season. Both days spent duck hunting and Black Duck kill were calculated for the same seven-day periods.

Age ratios of Black Ducks calculated from wing samples collected in the SCS were examined for significant differences between years and were tabulated as proportions of immature wings in the total yearly samples. In some areas, yearly wing samples are small and age ratios subject to bias. Following the calculation of age ratios and tests for significant year-to-year variation, an adjustment was made to reduce the exaggerated proportion of immatures in the wing sample due to their greater vulnerability to the gun (Hanson and Smith 1950); age ratios without this adjustment are not likely to be representative of the age composition in the population present during the hunting season.

Banding and recovery data for Black Ducks banded before the hunting season in eastern Canada were selected from the North American Bird Banding retrieval files for 1968–76. We considered direct recovery rates within Canada to be the only relevant data for adjusting age ratios from wing samples in the SCS. Because of the restrictive selection criteria for recoveries, yearly samples were generally very small and recovery rates varied considerably from year to year. Much of the annual variation was thought to be due to the small sample sizes, rather than to an increase or decrease in the rate at which Black Duck bands were recovered. Application of a method of partitioning χ^2 (Maxwell 1961) identified years in which the recovery rate differed substantially from the period mean, and also showed those sequences of years for which a pooled rate provides the best estimates.

After we had identified the significantly different years or combinations thereof, the ratio of the recovery rates for immatures and adults provided the relative recovery rates. Age ratios from wing samples were then divided by relative recovery rates to produce adjusted age ratios.

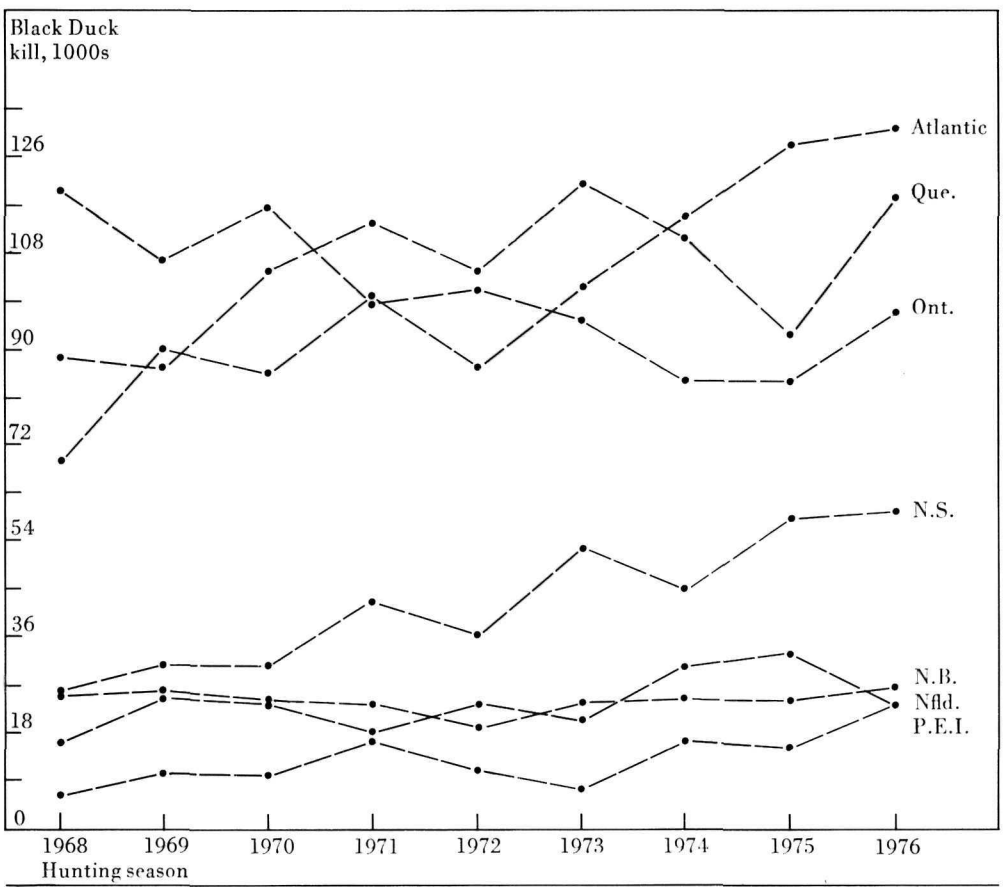
4. Results

4.1. Estimated kill of Black Ducks

Estimates of the kill by recreational hunters in each province and in zones of Newfoundland and Ontario in the nine seasons 1968–69 to 1976–77 are given in Table 1, and their variations are illustrated

Figure 1
Estimated retrieved kill of Black Ducks by hunters in eastern Canada by province, 1968–76

Figure 1



in Figure 1. A few hundred Black Ducks are also shot in Manitoba each year, but as they form an insignificant part of the total Canadian kill of this species and of the duck kill in that province, they were excluded from these analyses. Some under-estimation of the kill has occurred in those parts of the Atlantic region where hunting seasons extend beyond December 31 because, until 1978, wings sent in after the end of December were not used in partitioning the kill by species. The numbers of Black Ducks taken in January are probably not large in relation to those that are killed earlier in the season. (We plan to verify the size of the late kill by making some modifications to the survey in 1977–78 and thereafter.)

Collectively, the estimated kill in eastern Canada has remained close to an average of just over 300 000 each season, the range of seasonal values being between 274 000 and 346 000. This is a remarkable result. If the annual kill is related to population size and to the recruitment of young (with their greater vulnerability to the gun), a much wider range of values might have been expected.

4.2. Hunting effort

The numbers of permits purchased in eastern Canada (Table 2) provide a reliable measure of the number of potential waterfowl hunters. But some of the purchasers are inactive, and many who do

Table 2
Number of purchasers of Migratory Game Bird Hunting Permits in eastern Canada by province, 1968–76

	Newfoundland						Atlantic		Ontario				Total
Season	Island	Labr.	Total	P.E.I.	N.S.	N.B.	Provs.	Quebec	South	Central	North	Total	E. Can.
1968	15 557	1 828	17 645	3 649	9 022	9 558	39 874	37 110	44 390	71 441	22 842	139 182	216 166
1969	17 137	1 984	19 121	3 800	8 863	10 127	41 911	39 543	42 088	69 554	22 618	134 260	215 714
1970	19 192	2 188	21 380	3 932	9 941	10 309	45 562	46 081	41 040	70 679	23 723	135 442	227 085
1971	20 905	2 300	23 460	4 513	11 381	11 146	50 500	50 276	38 927	69 196	23 401	133 563	234 339
1972	21 449	2 233	23 682	4 492	12 158	11 366	51 698	53 082	38 787	69 207	23 433	131 427	236 207
1973	25 251	2 668	27 919	4 972	15 071	12 869	60 831	57 247	40 689	74 558	26 030	141 277	259 355
1974	22 626	2 501	25 127	5 038	13 791	11 916	55 872	58 345	39 460	73 230	23 779	136 469	250 686
1975	27 207	2 908	30 115	4 963	13 990	12 930	61 998	63 768	42 077	77 914	28 679	148 670	274 436
1976	27 227	2 394	29 621	5 756	13 326	13 743	62 446	66 453	41 441	77 109	25 266	143 816	272 715
Mean 1972–76	24 752	2 541	27 293	5 044	13 667	12 565	58 569	59 779	40 491	74 404	25 437	140 332	258 680

Table 3
Estimated number of waterfowl hunter-days in eastern Canada by province, 1972–76*

	Newfoundland						Atlantic		Ontario				Total
Season	Island	Labr.	Total	P.E.I.	N.S.	N.B.	Provs.	Quebec	South	Central	North	Total	E. Can.
1972	144 708	12 398	157 106	38 891	94 958	65 535	356 490	381 763	223 776	395 073	128 663	747 512	1 485 765
1973	169 620	18 356	187 976	36 788	110 152	67 227	402 143	421 665	207 027	449 963	159 538	816 528	1 640 336
1974	172 491	21 226	193 717	51 920	108 788	67 027	421 452	485 908	201 318	413 747	140 841	755 906	1 663 266
1975	196 993	22 318	219 311	44 562	123 801	62 579	450 253	447 848	239 774	463 071	176 046	878 891	1 776 992
1976	184 201	19 853	204 054	59 326	120 329	70 993	454 702	480 793	244 479	420 011	136 941	801 431	1 736 926
Mean	173 603	18 830	192 433	46 297	111 606	66 672	417 008	443 595	223 275	428 373	148 406	800 054	1 660 657

* Waterfowl hunter-days calculated from the product of the number of active hunters and the average number of days on which those hunters were active.

Table 4
Estimated retrieved kill of Black Ducks in eastern Canada by province, 1972–76, expressed as kill per 1000 waterfowl hunter-days*

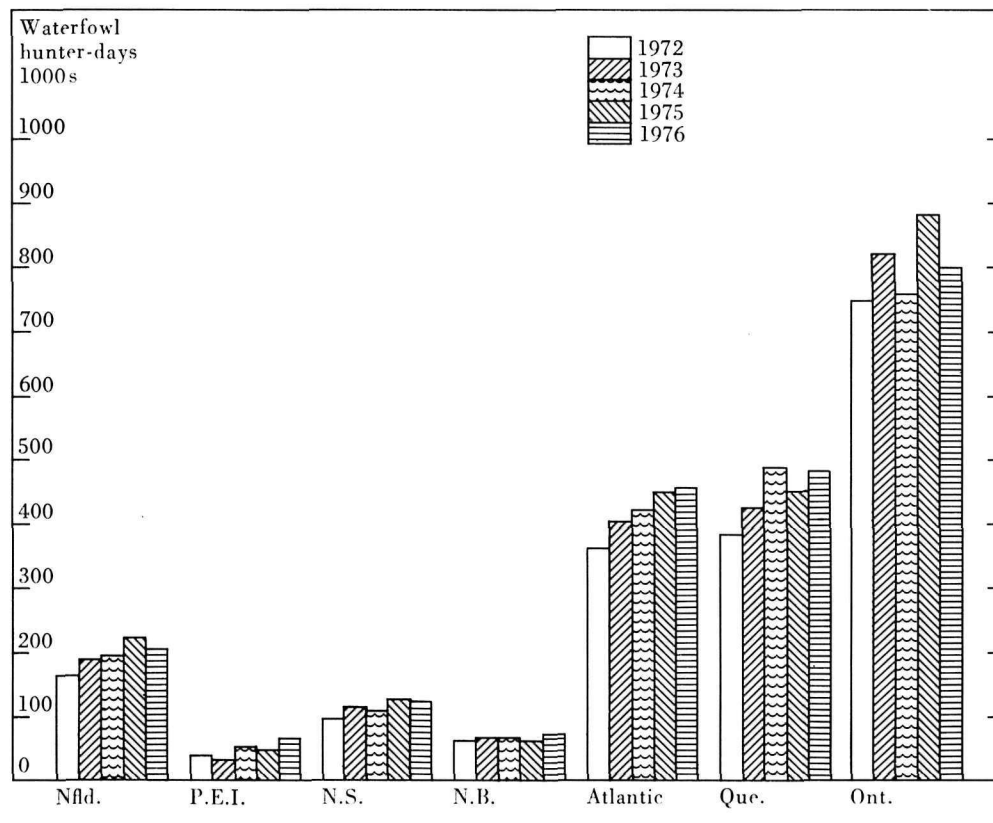
	Newfoundland						Atlantic		Ontario				Total
Season	Island	Labr.	Total	P.E.I.	N.S.	N.B.	Provs.	Quebec	South	Central	North	Total	E. Can.
1972	128.4	344.2	145.4	250.2	375.5	271.7	241.4	270.6	109.1	134.5	180.4	134.8	195.3
1973	98.0	171.8	105.2	187.5	475.0	332.4	252.0	286.5	93.3	121.9	127.6	115.8	193.1
1974	162.7	109.0	156.8	315.7	408.2	340.6	270.5	227.5	85.6	115.7	134.6	111.2	185.6
1975	144.2	202.2	150.1	317.5	469.4	365.6	284.4	204.1	57.4	105.7	121.9	95.8	170.9
1976	112.5	116.0	112.8	372.9	490.5	371.1	287.0	246.5	93.3	127.4	146.3	120.3	198.8
Weighted mean†	129.5	175.8	134.0	299.3	447.1	336.6	268.6	245.5	87.4	120.6	140.2	115.0	188.4

* Expressed as kill per 1000 waterfowl hunter-days to avoid small decimal numbers.

† Weighted mean calculated as $\frac{\Sigma x_i}{\Sigma y_i}$ where x_i = Black Duck kill and y_i = waterfowl hunter days in year i.

Figure 2
Estimated number of waterfowl hunter-days in eastern Canada, 1972–76

Figure 2



go hunting are unsuccessful. The national surveys provide estimates of the number of active waterfowl hunters and of successful duck hunters, but there is no measure of the effort directed specifically at Black Ducks.

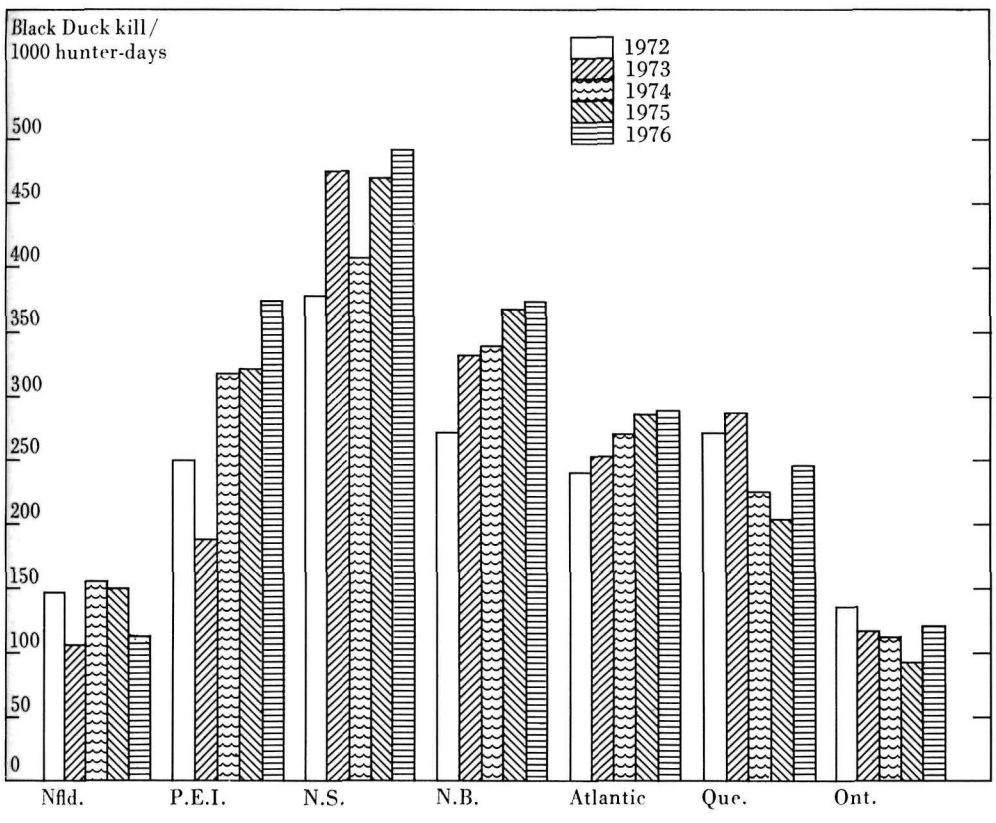
4.3. Black Duck kill in relation to hunting effort

The Black Duck population resembles that of marine fish in being hard or impossible to count at any time of year. In fisheries management it has become general practice to relate statistics on landings of marketable fish to some measure of catching effort and to treat a decline in catch per unit effort as an indication of over-fishing. It is possible to apply the same approach to the Black Duck kill, using the estimated numbers of active waterfowl hunters multiplied by the mean number of days hunted, as reported by them, to obtain provincial indices of waterfowl hunting effort (Table 3, Fig. 2). That done, an index of Black Duck kill per unit of effort can be calculated by dividing the kill by the number of hunter days (Table 4, Fig. 3).

As noted earlier, estimates of the kill per unit effort are available for only five seasons (1972 to 1976), a short period for detecting trends. Yet, in general, the picture they give resembles that of the kill estimates over the nine-year period shown in Figure 1. Despite increases in hunter activity, the Black Duck kill per 1000 hunter-days has recently increased in the Atlantic Provinces, though fluctuating widely in Labrador and insular Newfound-

Figure 3
Estimated number of Black Ducks killed and retrieved per 1000 waterfowl hunter-days in eastern Canada, 1972–76

Figure 3



land. In Quebec and Ontario the success rate against Black Ducks has fallen. The net result has been little change in rate for eastern Canada as a whole.

An alternative way of relating Black Duck kill to effort is to compute the average Black Duck kill per successful hunter. This was done for all nine seasons for which estimates of specific kill are available (Table 5).

Most of the results relating Black Duck kill to the number of successful hunters are consistent with those shown by the hunting effort approach: "success" has increased in Nova Scotia and Prince Edward Island, and decreased in Quebec and Ontario, and for eastern Canada as a whole. There is an anomaly in New Brunswick, where this measure of success was higher in the first three years than subsequently, without the steady increase shown by the ratio of kill to active hunter-days. For all provinces, the values for 1968–71 are probably biased upward in relation to the values obtained since 1972, because in the earlier years the hunters surveyed were drawn only from previous purchasers of the permit, thereby eliminating the performance of irregular hunters and novices, whose success is relatively low.

4.4. Composition of kill by age and sex

The Black Duck wings sent in by participants in the SCS can be classed by sex and as "first-winter" or "adult" (more than a year old); although it was not until 1971 that a reliable technique for distinguishing first-winter males from females came into use. This classification is of interest in two ways. First, it is important to be sure that hunters are not taking dangerously large numbers of any one class, particularly those of the highest reproductive value, the adult females. Second, variations in the proportion of first-winter wings may serve as an index of the relative abundance of flying young and hence of breeding success.

Ducks are particularly vulnerable to hunters in their first year of life. This results in disproportionately small numbers of adult wings in the samples and in overestimation of breeding success. It is possible to adjust the age ratios for first-winter vulnerability by means of the relative direct-recovery rates of banded birds, but recovery-rate adjustment of the sex ratio is prevented by the small size of the samples of banded adults and a marked sex bias in the "catchability" of adults for banding.

The unadjusted and unweighted sex ratios show that in most provincial samples there are significant departures from a 1:1 ratio of males and females. Amongst adults there are exceptionally large numbers of males in Nova Scotia and Prince Edward Island, while males are in a minority in Ontario, and especially in New Brunswick (Table 6). What is perhaps more remarkable is that the disparities in the much larger first-winter samples (Table 7) are almost as great, though not all in the same direction: marked excesses of males in Ontario, Prince Edward Island, and Quebec, and of females in New Brunswick. These differences do not conform with those found earlier in the northeastern United States. (Geis, Smith, and Rogers 1971) nor can they be related to any simple hypotheses about differences between males and females in the timing of migratory movements or in the choice of staging and wintering areas. It will be necessary to employ more reliable devices than provincial wing-samples to account for the anomalies. However, the internal consistency of the annual provincial samples suggests that the results are unlikely to be due to chance

Table 5
Estimated average number of Black Ducks killed and retrieved per successful duck hunter in eastern Canada by province, 1968–76*

Season	Newfoundland						Atlantic		Ontario				Total
	Island	Labr.	Total	P.E.I.	N.S.	N.B.	Provs.	Quebec	South	Central	North	Total	E. Can.
1968	—	—	2.18	2.15	5.01	3.95	3.41	3.57	—	—	—	1.47	2.18
1969	2.70	5.64	3.01	4.01	6.31	3.93	4.12	2.84	1.08	1.13	1.76	1.21	2.01
1970	2.81	1.69	2.71	3.36	5.53	3.49	3.67	3.23	1.52	1.31	1.56	1.40	2.21
1971	1.91	2.83	2.04	5.41	7.22	3.21	4.03	3.31	1.09	1.27	1.50	1.27	2.29
1972	2.46	3.92	2.65	3.81	5.59	2.70	3.56	3.19	1.25	1.17	1.76	1.29	2.15
1973	1.79	2.45	1.87	2.80	6.37	3.38	3.64	3.45	1.03	1.07	1.42	1.12	2.15
1974	2.73	1.44	2.55	5.28	5.42	3.18	3.75	2.57	0.90	0.95	1.34	1.01	1.97
1975	2.53	3.10	2.59	4.65	6.82	3.13	4.05	2.17	0.63	0.93	1.38	0.94	1.86
1976	2.06	1.61	2.01	6.18	6.85	3.52	4.19	2.63	1.00	1.07	1.41	1.11	2.12
Mean 1972–76	2.32	2.41	2.33	4.70	6.25	3.19	3.86	2.76	0.96	1.03	1.46	1.09	2.04

* 1968 estimates not available by zone.

Table 6
Number of female wings in seasonal samples of adult Black Duck wings, by province, 1968–76

	Season	Nfld.	P.E.I.	N.S.	N.B.	Atlantic	Quebec	Ontario	Total
a) as *x* adult female: *y* total adult sample	1968	14: 20	6: 14	17: 27	34: 59	71: 120	39: 65	49: 113	159: 298
	1969	11: 21	4: 13	15: 38	46: 93	76: 165	44: 96	74: 141	194: 402
	1970	6: 19	8: 20	33: 96	58:108	105: 243	57: 103	78: 145	240: 491
	1971	4: 17	32: 82	100: 249	101:176	237: 524	61: 147	94: 157	392: 828
	Sum 1968–71	35: 77	50:129	165: 410	239:436	489:1052	201: 411	295: 556	985:2019
	1972	6: 25	45: 98	77: 191	72:117	200: 431	109: 240	116: 247	425: 918
	1973	8: 14	13: 28	65: 177	64:103	150: 322	82: 155	116: 212	348: 689
	1974	10: 18	13: 42	63: 139	48: 92	134: 291	73: 168	98: 193	305: 652
	1975	5: 8	18: 35	33: 105	24: 44	80: 192	36: 68	18: 40	134: 300
	1976	11: 18	10: 32	31: 96	17: 39	69: 185	34: 71	49: 109	152: 365
	Sum 1972–76	40: 83	99:235	269: 708	225:395	633:1421	334: 702	397: 801	1364:2924
	Sum 1968–76	75:160	149:364	434:1118	464:831	1122:2473	535:1113	692:1357	2349:4943
b) adult females as % of total	1968	70.0	42.9	63.0	57.6	59.2	60.0	43.4	53.4
	1969	52.4	30.8	39.5	49.5	46.1	45.8	52.5	48.3
	1970	31.6	40.0	34.4	53.7	43.2	55.3	53.8	48.9
	1971	23.5	39.0	40.2	57.4	45.2	41.5	59.9	47.3
	Mean 1968–71	45.5	38.8	40.2	54.8	46.5	48.9	53.1	48.8
	1972	24.0	45.9	40.3	61.5	46.4	45.4	47.0	46.3
	1973	57.1	46.4	36.7	62.1	46.6	52.9	54.7	50.5
	1974	55.6	31.0	45.3	52.2	46.1	43.4	50.8	46.8
	1975	62.5	51.4	31.4	54.6	41.7	52.9	45.0	44.7
	1976	61.1	31.3	32.3	43.6	37.3	47.9	45.0	41.6
	Mean 1972–76	48.2	42.1	38.0	57.0	44.6	47.6	49.6	46.7
	Mean 1968–76	46.9	40.9	38.8	55.8	45.4	48.1	51.0	47.5

Table 7
Number of female wings in seasonal samples of immature Black Duck wings, by province, 1971–76

	Season	Nfld.	P.E.I.	N.S.	N.B.	Atlantic	Quebec	Ontario	Total
a) as *x* immature female: *y* total immature sample	1971	11: 20	127: 327	347: 765	333: 707	818:1819	366: 848	—	1184: 2667
	1972	71:136	104: 202	446: 827	295: 530	916:1695	380: 823	429: 994	1725: 3512
	1973	32: 70	47: 92	409: 844	323: 604	811:1610	495:1064	469:1113	1775: 3787
	1974	29: 66	84: 167	292: 587	257: 493	662:1313	429: 907	326: 852	1417: 3072
	1975	34: 78	53: 119	226: 444	180: 346	493: 987	210: 437	210: 435	913: 1859
	1976	41: 88	83: 184	276: 563	133: 297	533:1132	235: 542	256: 542	1024: 2216
	Sum 1972–76	218:458	498:1091	1996:4030	1521:2977	4233:8556	2115:4621	1690:3956	8038:17113
b) immature females as % of total	1971	55.0	38.8	45.4	47.1	45.0	43.2	—	44.4 *
	1972	52.2	51.5	53.9	55.7	54.0	46.2	43.2	49.1
	1973	45.7	51.1	48.5	53.5	50.4	46.5	42.1	46.9
	1974	43.9	50.3	49.7	52.1	40.5	47.3	38.3	46.1
	1975	43.6	44.5	50.9	52.0	49.9	48.1	48.3	49.1
	1976	46.6	54.1	49.0	44.8	47.1	43.4	47.2	46.2
	Sum 1972–76	47.6	45.6	49.5	51.1	49.5	45.8	42.9	47.0 *

* Immature sample in 1971 in Ontario not classified by sex.

Table 8
Numbers of first-winter wings in seasonal samples of Black Duck wings, by province, 1968 to 1976

	Season	Nfld.	P.E.I.	N.S.	N.B.	Atlantic	Quebec	Ontario	Total
a) as *x* 1st winter: *y* total sample	1968	84:104	47: 61	125: 152	282: 341	538: 658	600: 670	723: 837	1861: 2165
	1969	73: 91	89: 102	164: 203	432: 527	755: 923	703: 798	781: 915	2242: 2636
	1970	146:165	75: 95	268: 358	490: 596	986: 1218	735: 835	798: 950	2519: 3003
	1971	21: 28	352: 439	775:1025	724: 904	1872: 2396	860:1011	861:1021	3593: 4428
	Sum 1968–71	331:392	563: 697	1332:1738	1928:2368	4154: 5195	2898:3314	3163:3723	10 215:12 232
	1972	127:149	189: 256	736: 901	493: 606	1545: 1912	794:1027	968:1211	3307: 4150
	1973	70: 84	92: 120	844:1021	604: 707	1610: 1932	1064:1219	1113:1325	3787: 4476
	1974	66: 84	167: 209	587: 726	493: 585	1313: 1604	907:1075	852:1045	3072: 3724
	1975	78: 86	119: 154	444: 549	346: 390	987: 1179	437: 505	435: 475	1859: 2159
	1976	90:109	184: 216	564: 660	298: 337	1136: 1322	545: 616	547: 656	2228: 2594
	Sum 1972–76	431:512	751: 955	3175:3857	2234:2625	6591: 7949	3747:4442	3915:4712	14 253:17 103
	Sum 1968–76	762:904	1314:1652	4507:5595	4162:4993	10 745:13 144	6645:7756	7078:8435	24 468:29 335
b) 1st winter as % of total	1968	80.8	77.0	82.2	81.7	81.8	89.6	86.4	86.0
	1969	80.2	87.2	80.8	82.0	82.1	88.1	85.4	85.0
	1970	90.5	78.9	74.9	82.2	81.0	88.0	84.0	83.9
	1971	75.0	80.2	75.6	80.1	78.1	85.1	84.3	81.1
	Mean 1968–71	84.4	80.8	76.6	81.4	80.0	87.4	85.0	83.5
	1972	85.2	73.8	81.7	81.4	80.8	77.3	79.9	79.7
	1973	94.6	76.7	82.7	85.4	83.3	87.3	84.0	84.6
	1974	78.4	79.9	80.9	84.3	81.9	84.4	81.5	82.5
	1975	90.7	77.3	80.9	88.7	83.7	86.5	91.4	86.1
	1976	82.6	85.2	85.5	88.4	85.9	88.5	83.4	85.9
	Mean 1972–76	84.2	78.6	82.3	85.1	82.9	84.4	83.1	83.3
	Mean 1968–76	84.3	79.5	80.6	83.4	81.7	85.7	83.9	83.4

and that there are some persistent geographical differences in the killing of males and females, in addition to the general tendency for the bag to contain an excess of males.

The unadjusted age ratios (Table 8) also show persistent geographical patterns, with some marked changes over time in addition. It is more instructive to concentrate upon the age ratios after adjustment for vulnerability by the use of recovery rates. (The adjustment factors and the method of calculation are given in Appendix 1.) A comparison of the adjusted and unadjusted ratios, presented in Appendix 2, uses the ratio in the form number of first-winter birds per adult, which is that used in USFWS reports and analyses (Geis *et al.* 1971).

The alternative form—first-winter as a percentage of total—is used in Table 9. This is more practical because it is restricted and fluctuates much less, making similarities easier to see. The provincial nine-year means are closely similar, ranging from 65.7% first-winter in Prince Edward Island to 72.1% in Ontario. The annual values for each province vary from 46.5% (Prince Edward Island, 1972) to 87.5% (Ontario, 1975). In testing for statistical significance in numbers arrived at in so indirect a way, it seems best to use ranking methods. Using Kendall's coefficient of concordance, W, as a measure of overall correlation, we find in ranking the seasons for each province ($n = 9$, $k = 5$) that $W = 0.463$, which is significant at the 1% level, indicating that yearly trends in age ratios are similar from province to province.

A similar ranking of provinces for each season shows no sustained trends in 1968–76. Nor could significant correlations be found between the annual ratings of any pairs of provinces, whether adjacent or remote. It appears that age ratios are not persistently higher or lower in any part of the Canadian range. As it is not at all clear how far the regional samples are drawn from "open" or "closed" stocks of birds, it is not surprising that the age ratio as an index of breeding success is not very discriminating. What seems to emerge is that even in a year such as 1972, when the spring was cold and wet throughout eastern Canada, many female Black Ducks must have bred successfully. (Proportions of young averaged 60.5% in the fall of 1972.) Apparently it would take an exceptionally bad spring and summer to bring about general failure to raise young.

Table 9
Proportions (%) of first-winter Black Ducks in the hunting-season populations of different regions of eastern Canada, 1968–1976, obtained by adjusting age ratios in the SCS (from Table 8) by relative recovery rates (Appendix 1)

Year	P.E.I.	N.S.	N.B.	Que.	Ont.
1968	71.3	75.9	66.1	72.2	75.7
1969	73.7	74.3	65.1	69.3	74.1
1970	72.2	66.9	65.4	75.2	67.9
1971	64.4	59.6	62.2	70.1	72.0
1972	46.5	68.0	64.1	58.4	65.5
1973	74.3	69.4	65.6	73.9	71.5
1974	69.0	75.3	74.2	82.9	74.0
1975	65.5	75.4	80.8	73.5	87.5
1976	60.6	72.1	80.4	68.6	76.4
Weighted mean	65.7	70.6	67.8	71.9	72.1

After the vulnerability adjustment, the nine-year mean age ratios of wing samples ranged from 1.91 to 2.58 young per adult, with adult males and females roughly equal in number, corresponding to a ratio of about 1.0–1.3 flying young to each adult female. This seems plausible when we recall that Reed (1975) found relatively large numbers of females that reared no flying young in the comparatively clement region of the St. Lawrence estuary.

4.5. Black Duck hunting seasons and bag limits, and their effects on reported kill

In 1974, when the price of the permit was increased from $2.00 to $3.50, there was a marked drop in the number of permits sold in most zones of eastern Canada, which was more than offset in 1975 and later. By comparison, reductions in season length and changes in opening date intended to reduce hunting opportunities have not had clearly perceptible effects on the general trend toward more hunters spending more time hunting.

Table 10 provides a summary of opening dates and season length applicable to Black Ducks in eastern Canada from 1968 to 1976. Except in Prince Edward Island and Ontario, the daily bag limit for ducks was six throughout the region during that period, and there were no special restrictions relating to Black Duck kill. In Prince Edward Island, although the daily limit on ducks was six, no more than four Black Ducks could be taken. In Ontario the daily limit for ducks was five, all of which could be Black Ducks. Although the choice of opening date differs substantially between provinces and zones, there have been few zonal changes, apart from minor adjustments to fit the calendar and a tendency for the opening date to be advanced gradually during the period.

We have been able to analyze the effects of such changes on the kill of Black Ducks in only four zones (Table 10). Given the coarseness of the measuring devices available, it is perhaps encouraging to find that the recorded consequences of change

Table 10
Effects of regulation changes on the retrieved kill of Black Ducks in those parts of eastern Canada where appreciable changes were made, 1968–76

	Season	Opening date	Season length (days)	Black Duck kill	Permit sales	Black Duck kill: Per permit	Black Duck kill: Per 1000 legal hunter-days	Black Duck kill: Per 1000 hunter-days	Black Duck kill: % change from previous year	Expected effect of regul. change†
a) Insular Newfoundland	1968	Sep 9	76	14 394	15 557	0.93	12.2	—	—	0
	1969	8	76	19 765	17 137	1.15	15.2	—	+37.3	0
	1970	7	76	21 629	19 192	1.13	14.8	—	+9.4	0
	1971	1	76	14 327	20 905	0.69	9.0	—	−33.8	+
	1972	18	70	18 582	21 449	0.87	12.4	128.4	+29.7	− −
	1973	22	70	16 619	25 251	0.66	9.4	98.0	−10.6	0
	1974	9/23′*	83/69′*	28 065	22 626	1.24	14.9	162.7	+68.9	+/0
	1975	8/20′	83/71′	28 416	27 207	1.04	12.6	144.2	+1.3	0/0
	1976	11/18′	81/74′	20 714	27 227	0.76	9.4	112.5	−27.1	0/0
b) Prince Edward Island	1968	Oct 14	62	4 628	3649	1.27	20.5	—	—	0
	1969	13	62	9 273	3800	2.44	39.4	—	+100.4	0
	1970	14	60	8 841	3932	2.25	37.5	—	−4.7	0
	1971	4	69	16 366	4513	3.63	52.6	—	+85.1	++
	1972	11	75	9 731	4492	2.17	28.9	250.2	−40.5	−
	1973	15	55	6 898	4972	1.39	25.2	187.5	−29.1	−
	1974	7	62	16 392	5038	3.25	52.5	319.0	+137.6	++
	1975	6	62	14 149	4963	2.85	46.0	317.5	−13.7	0
	1976	7	65	22 123	5756	3.84	59.1	372.9	+56.4	+
c) Southern Nova Scotia	1968	Oct 23	49	17 717	6693	2.65	54.0	—	—	0
	1969	15	70	23 577	6723	3.51	50.1	—	+33.1	+
	1970	15	70	21 677	7502	2.89	41.3	—	−8.1	0
	1971	9	75	27 550	8473	3.25	43.4	—	+27.1	+
	1972	2	73	22 279	8870	2.51	34.4	356.7	−19.1	+
	1973	1	83	24 170	10 547	2.29	27.6	462.1	+8.5	+
	1974	1	81	23 641	9699	2.44	30.1	408.0	−2.2	0
	1975	1	81	34 463	8349	4.13	51.0	464.3	+45.8	0
	1976	1	79	38 485	8112	4.35	60.1	488.8	+11.7	0
d) Southern Ontario	1968	Oct 5	70.5	22 414	44 390	0.50	7.2	—	—	0
	1969	4	72.5	22 156	42 088	0.53	7.3	—	−1.1	0
	1970	3	73.5	28 663	41 040	0.70	9.5	—	+29.4	0
	1971	2	74.5	22 318	38 927	0.57	7.7	—	−22.1	0
	1972	Sep 30	76.5	24 422	38 787	0.63	8.2	109.1	+9.4	0
	1973	Oct 6	70.5	19 312	40 689	0.47	6.7	93.3	−20.9	−
	1974	Sep 28	78	17 229	39 460	0.44	5.6	85.6	−10.8	+
	1975	27	78	13 774	42 077	0.33	4.2	57.4	−20.0	0
	1976	25	82	22 822	41 441	0.55	6.7	93.3	+65.7	+

*Later opening in Avalon Peninsula shown after/′
0 indicates no change
+indicates increase
− indicates decrease
++ indicates strong increase
− − indicates strong decrease
+/0 notation indicates split in season

Table 11
Observed effects of regulation changes in insular Newfoundland, Prince Edward Island, southern Nova Scotia, and southern Ontario compared with their expected effects on numbers of Black Ducks killed: summary of data from Table 10

	Expected effects of reg. change*			
Observed effects	Decr. kill	None	Incr. kill	Total
Decreased kill	3	4	3	10
None ($\lesssim \pm 10\%$)	0	8	1	9
Increased kill	1	5	7	13
Total	4	17	11	32

*Of 15 changes expected to lead to marked differences, 10 resulted in the intended direction and four in the opposite direction, and one produced no detectable effect.

have been in the intended direction in 10 of 15 cases where a clear response would be expected (Table 11). That 17 of 32 changes were unlikely to lead to measurable effects raises questions about managerial strategy and tactics (see section 5.2.).

It has recently become practicable to combine the information on dates of hunting reported in the NHS with the kill of ducks whose wings have been sent in to the SCS, so as to construct profiles of the distribution of the kill by species throughout the hunting season. There are technical limitations, such as the bias resulting from highly successful hunters running short of wing envelopes in the middle of the season, and the samples are very small in relation to the total kill (see Cooch *et al.* 1978). Grouping of the data into seven-day periods, rather than day-by-day tabulation, is necessary for nearly all species in most parts of the country. Weekly periods are arbitrarily started on the last Wednesday in August, so that the opening day or weekend will be wholly contained in one week.

The bar graphs of Figure 4, based on the results of the 1976 season, illustrate the spread of the duck kill through the open season in different zones of eastern Canada. A marked peak in Black Duck kill may be found in or around the opening week in all areas except Labrador and southern Ontario. In Ontario, the Black Duck kill was spread fairly evenly over 11 weeks starting at the end of September. Elsewhere, 17–43% of the entire reported kill was concentrated into the first week, and more than half the kill occurred in two or three weeks of a legal open season rarely less than eight weeks long. Only in Prince Edward Island (47.8%), southern Nova Scotia (60.4%), northern Nova Scotia (37.6%), southern Ontario (54.1%), and central Ontario (28.6%) do the numbers reported taken after the beginning of November (in weeks 11–22) amount to more than 20% of the seasonal kill. In most areas the largest kill of Black Ducks occurred in the opening week, while in Labrador, southern Nova Scotia, and northern Quebec the peak was delayed.

The weekly distribution of hunting effort expended by duck hunters in 1976 is shown in Figure 5. A peak in hunting activity occurred in weeks 4 to 8 in most areas, a pattern similar to that of the kill. In southern Nova Scotia, Prince Edward Island, and New Brunswick the increase in hunting which occurred after week 9 was presumably due to extended seasons and the continued availability of ducks, many of which winter in the Maritime Provinces though relatively few do so elsewhere in eastern Canada.

A comparison of kill (Fig. 4) and hunting activity (Fig. 5) in 1976 provides some interesting findings. In the Atlantic Provinces the temporal patterns of Black Duck kill and effort are very similar, possibly due to the comparatively high success rates there, and because the Black Duck is the main quarry, whereas those for Ontario and Quebec show much less similarity. Black Duck kill in Ontario, particularly in the southern zone, was low in relation to hunting effort throughout the 1976 season.

In areas where a marked opening peak was shown, the Black Duck kill per unit effort was highest in opening week and declined steadily during the remainder of the season, whereas in those Atlantic zones where a late season kill occurred, the success rates actually increased at the end of the season. In Newfoundland, the highest Black Duck kill per unit effort occurred near the end of the season.

5. Discussion

5.1. Projection of hunting effort and Black Duck kill, 1977–85.

By extrapolating from the results presented so far we can see how, if the trends of the last few years persist, the impact of hunting in Canada in 1980 and beyond may differ from that in the early 1970's. We adopt the simplest possible procedure for this purpose, extrapolating the linear regression equations of permit sales and of hunter-days on years to provide alternative estimates of future hunter activity, and also the regressions of kill and of kill per unit effort on years to estimate future success. Even if the measures of past performance are reliable, any projections based on them may well cease to be so within three or four years, even in the absence of any imposed perturbation, such as a major change in hunting regulations or substantial changes in population size or recruitment.

Despite these disclaimers, we can identify some trends with reasonable confidence (Tables 12, 13) and assert that, if they persist, by 1985 the number of permits sold and the numbers of hunter-days in the Atlantic Provinces and in Quebec may be about half as many again as in 1976, with the number of successful hunters having increased by just under one-half. The projections for Ontario indicate a minor increase from recent levels of activity.

If the nine-year run of Black Duck kill estimates is used, the projected kill in the Atlantic Provinces will be nearly 50% higher in 1985 than the kill in 1976; but if only the data from 1972–76 are used, the projected kill in 1985 might be as much as 83% greater than the 1976 kill. No confident projections of change can be made for the kill in Quebec. In Ontario the Black Duck kill in 1985 may have fallen further, perhaps to only one-third of its 1976 level.

Table 12
Summary of regional predictions of permit sales, number of successful hunters, and hunter-days for 1980 and 1985.*

	Permit sales†			Successful hunters†			Waterfowl hunter-days‡		
Region	1980	1985	$\frac{1985}{1976}$%	1980	1985	$\frac{1985}{1976}$%	1980	1985	$\frac{1985}{1976}$%
Atlantic	76.5	91.6	+46.8	38.4	46.1	+47.8	563.7	686.0	+50.9
Quebec	82.0	100.4	+51.0	54.1	65.8	+46.2	(578.1)	(690.3)	(+43.6)
Ontario	(159.6)	(175.7)	(+22.2)	(88.6)	(91.8)	(+5.4)	(902.2)	(987.3)	(+23.2)
E. Canada	306.2	345.8	+26.8	181.1	203.6	+24.7	2044.0	2363.5	+36.1

*Numbers are in thousands. Estimates in parentheses derived from regressions showing no significant departure from zero slope. Predictions of Ontario permit sales on the basis of data from 1972–76.
†Projections from 1968–76 data
‡Projections from 1972–76 data.

Table 13
Summary of regional predictions of retrieved Black Duck kill in 1980 and 1985. Numbers in thousands of ducks. Estimates in parentheses derived from regressions showing no significant departure from zero slope

	Projected from 1968–76 data			Projected from 1972–76 data		
Region	1980	1985	$\frac{1985}{1976}$%	1980	1985	$\frac{1985}{1976}$%
Atlantic	157.2	192.9	+47.8	181.4	239.2	+83.3
Quebec	(125.3)	(138.7)	(+17.1)	(109.5)	(110.0)	(−7.2)
Ontario	69.9	51.1	−88.6	(80.5)	(70.9)	(−36.0)
E. Canada	352.4	382.6	+10.8	371.4	420.2	+21.7

Looking at the kill per unit effort, we may predict a further increase in the Atlantic Provinces to as much as 400 per 1000 hunter-days by 1985. In Quebec and Ontario continuing reduction in the yield seems likely, by perhaps as much as 50% of the 1976 levels by 1985 (down to 103 in Quebec and only 62 in Ontario), although these projections are much less reliable than those relating to the Atlantic Provinces.

In sum, if present trends continue in the Atlantic Provinces, more hunters will be taking a lot more Black Ducks in the next decade. In Quebec the number of hunters will increase but their take of Black Ducks may not do so. In Ontario, where hunting effort may remain relatively unaltered, the kill of Black Ducks is likely to continue to decline.

5.2. Management strategy and tactics

In the United States there has been a good deal of public debate about the declining numbers of the Black Duck and the need to combat that decline by restricting hunting, as well as by habitat preservation and re-creation or enhancement. This led to the preparation of an environmental assessment statement (USFWS 1976) accompanied by a negative declaration from the director of USFWS stating *inter alia* that he had "determined that the proposed action to allow for the improved management of Black Ducks, particularly continued sport hunting at restrictive levels designed to protect the resource base, is not a major federal action which could significantly affect the quality of the human environment. . .". There has been no comparable public pressure within Canada for restrictive action, although the organizers of the 1975 campaign in the United States also wrote in the same terms to the director-general of CWS seeking "an immediate moratorium on hunting black ducks...", and making six more proposals for other remedial actions and for additional research (I. Andersen *et al.*, letter to A. G. Loughrey, 6 June 1975). CWS concurred in the judgment of USFWS that an immediate cessation of hunting of Black Ducks was not justified. Both agencies and the interested provinces and states have intensified their studies of the situation. This paper is the product of part of the CWS investigation.

The story presented in the preceding sections suggests that even within the limited scope of a review of the impact of Canadian sport hunting, ignoring all ecological considerations, there is not a single "Black Duck problem". Along the Atlantic seaboard of Canada it appears that, despite a marked increase in "hunting pressure", as measured by permit sales and waterfowl hunter-days, the hunting of Black Ducks has not yet reached an intensity sufficient to reduce significantly the kill per unit effort, the latter being considered proportional to the stock present (Fig. 6). That seems to be true for each of the four provinces separately, although the yields per unit effort (Tables 4 and 5) are very different in Nova Scotia, where the Black Duck constitutes about 53% of the total duck kill, and in Newfoundland, only 34%. In Quebec there is some indication (Fig. 6) that further increases in hunting may be rewarded with lower yields.

In Ontario, where the take of Black Ducks is low in relation to effort, it seems to be continuing to fall. This does not show that Canadian hunting is responsible for the decline of the Black Duck in Ontario, but it suggests that attempts to reduce the kill of Black Ducks in Ontario should be considered among possible ways of reversing or slowing down a decline that has been evident for many years in the US Mississippi Flyway and those parts of the

Figure 4
Total duck and Black Duck kill by weekly periods during 1976 hunting season by province in eastern Canada

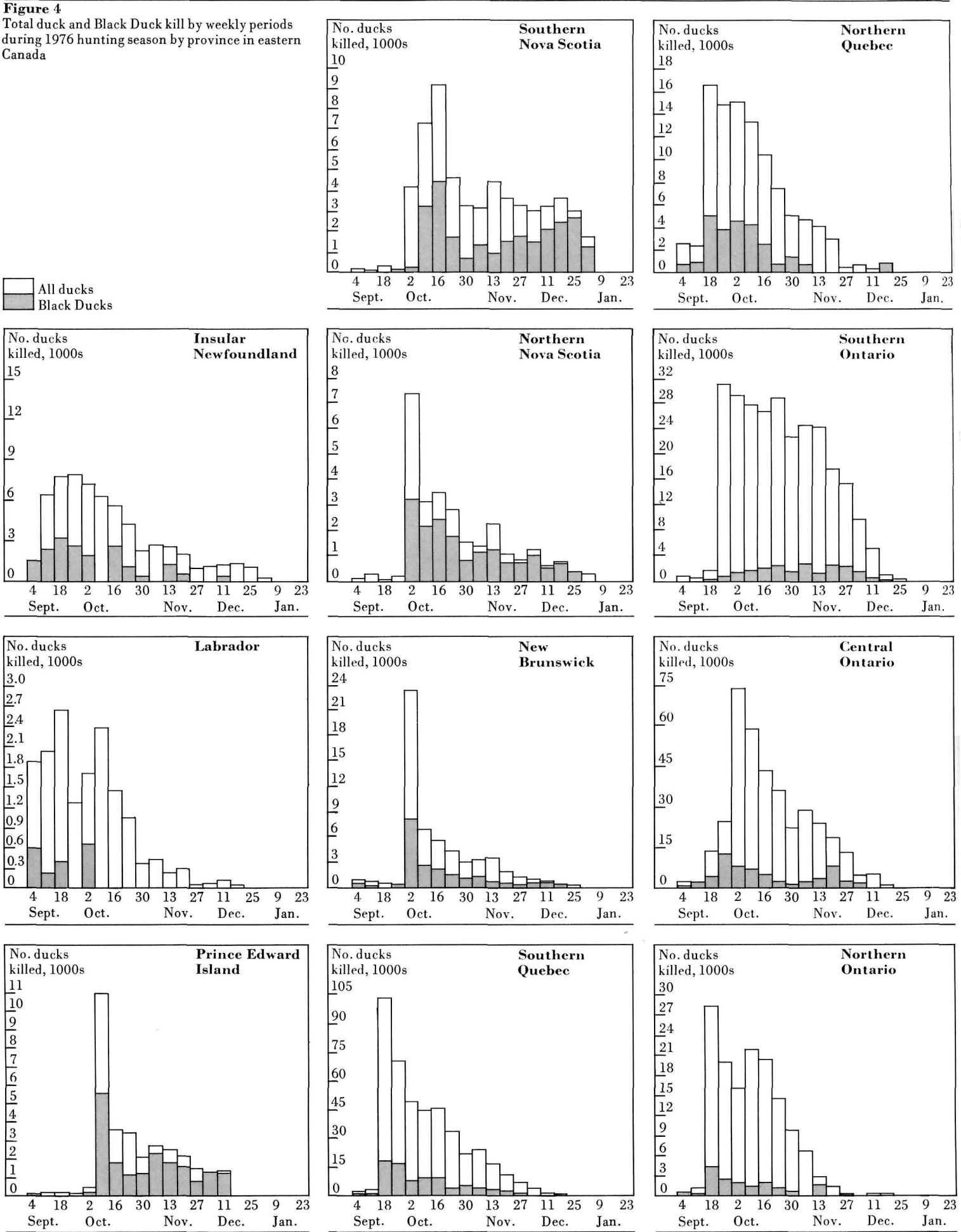
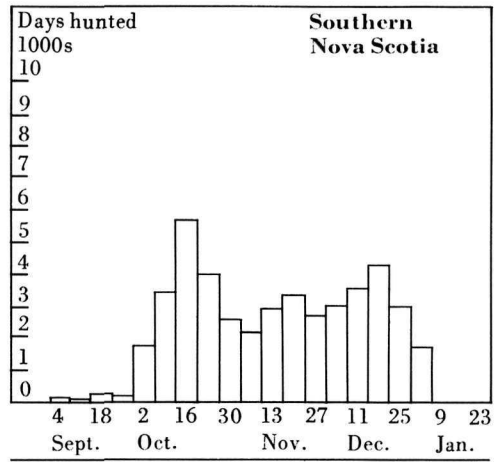
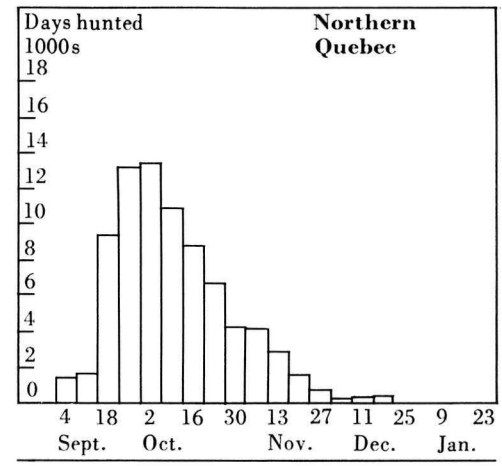
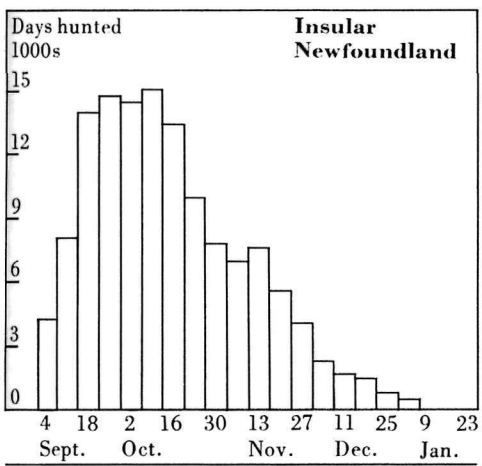
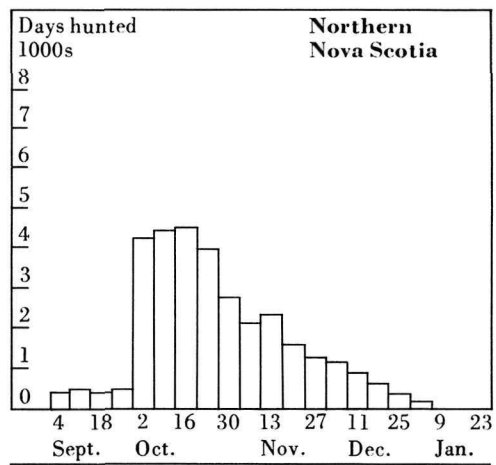


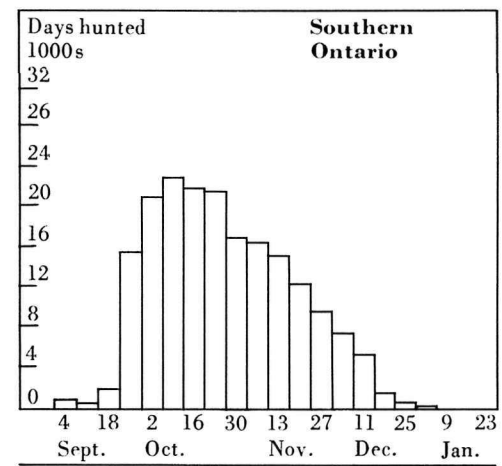
Figure 5
Waterfowl hunter-days by weekly periods during the 1976 hunting season by province in eastern Canada

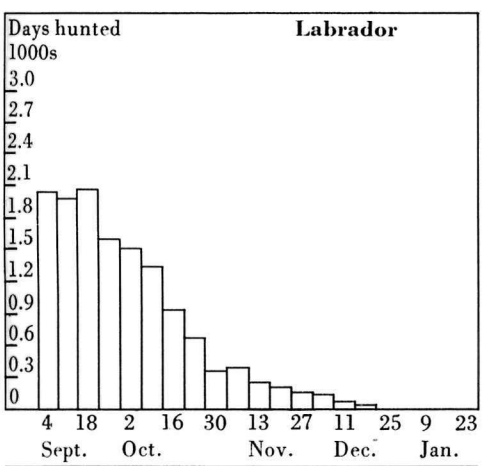


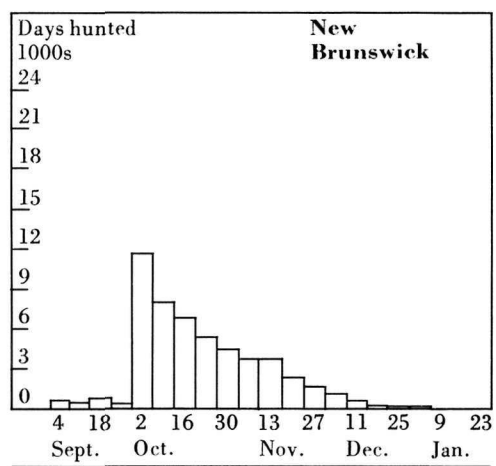


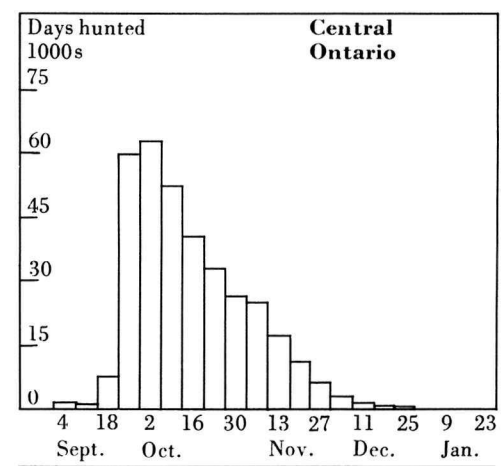


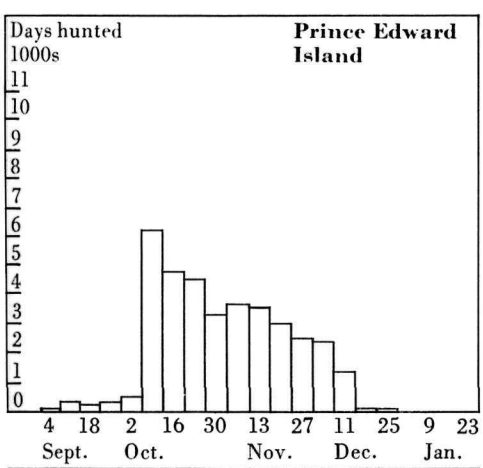


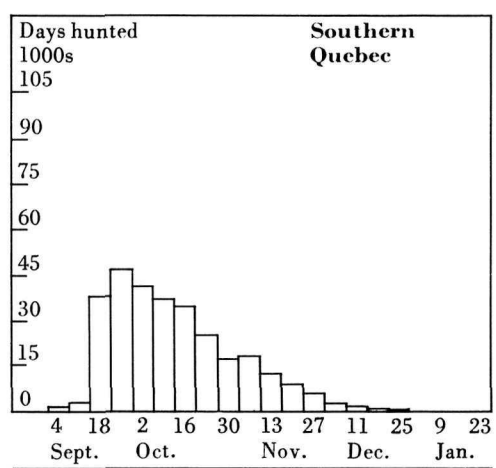












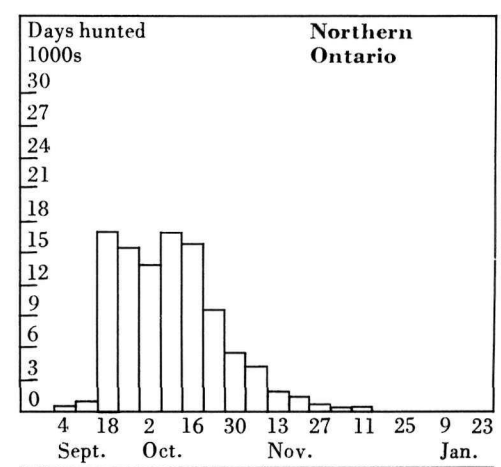
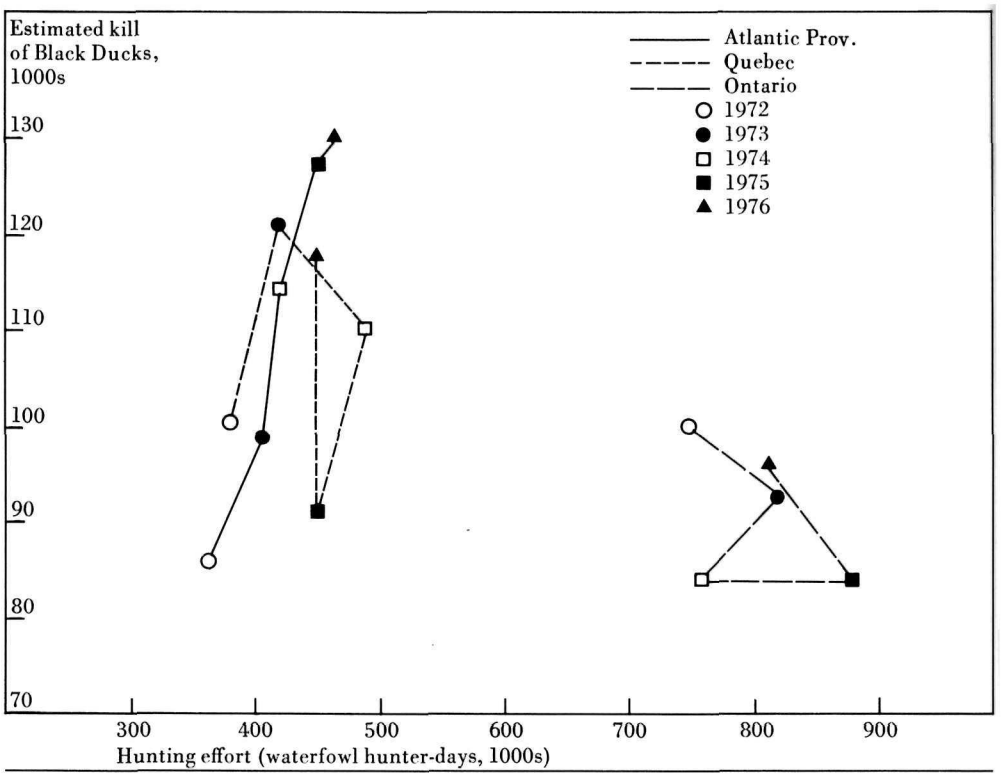


Figure 6
Retrieved Black Duck kill as a function of waterfowl hunter-days for Ontario, Quebec, and Atlantic Provinces, 1972–76

Atlantic Flyway partly supplied by birds from Ontario (USFWS 1975), as well as in breeding surveys in the settled parts of the province itself (Collins 1974, Dennis 1974*a* and *b*). However, when the feasibility of cutting back the Black Duck kill in Ontario is considered, some formidable practical difficulties become apparent. The most serious is that the Black Duck closely resembles the Mallard, particularly when both are in first autumn plumage, as are the great majority of the ducks that are shot each year. Hunters cannot be expected to distinguish between them before shooting, or even when they pick up the ducks they have shot. If it were to be made illegal to shoot Black Ducks while it remained legal to shoot Mallards, no magistrate could be expected to convict a hunter charged with illegally taking a Black Duck if the hunter claimed that he believed it to be a Mallard. No amount of training of hunters in duck identification is likely to remove this difficulty. A reduction in general bag limit for ducks would be useless, because only a small proportion of hunters obtain the present limit of five ducks a day (Reed and Boyd 1974); also a specific restriction on the permissible daily take of Black Ducks such as that used in Prince Edward Island, "six ducks, of which only four may be Black Ducks", could not be enforced where Mallards are abundant. That being so, the only regulatory means available to reduce the Black Duck kill are to change the opening date or the season length.

From the bar graphs of Figure 4, it looks as if a delay of two weeks in opening the season in northern and central Ontario might appreciably reduce the Black Duck kill. Such a change would be fiercely resisted by duck hunters, because it would also deprive them of their best opportunities to hunt most of the other quarry species. The remaining alternative, closing certain areas to hunting for all or part of the season, is also difficult to apply efficiently and reasonably to help the Black Duck, for it does not segregate itself in large masses away from other ducks. Indeed,

Figure 6



more than most ducks, this species occurs singly or in very small groups dispersed amongst small ponds and along rivers. The proposal to close off a large tract of country would be both unpopular and unenforceable.

In such circumstances, it seems unwise to use restrictive regulations to ease the pressure on the Black Duck, but it may well be worth seeking the voluntary cooperation of knowledgeable hunters by asking them to leave the species alone as much as possible. The hunters most likely to shoot several ducks a day are those most likely to know where to hunt Black Ducks. If hunters were prepared to forego an opportunity now in the interest of more later, further reductions in the population might be averted. The effectiveness of such voluntary restraints will never be easy to "sell" or to demonstrate, but the effort may be worth making, if it is also possible to encourage a similar restraint in the relevant parts of the United States and, most important, if it seems practicable to attempt to retain a substantial breeding stock in Ontario.

At present, with the growth of the Mallard population and its extension north and east through the St. Lawrence Basin, the case for Black Duck restoration-for-hunting is a weak one. As an edible target the Mallard is no less desirable, and it is providing itself in large numbers without special measures by Canadian management agencies (though earlier stocking programs in some of the Great Lakes states may possibly have contributed to its spread). Nor is the "Ontario Black Duck" yet sufficiently scarce to warrant special care as a threatened form while, because of the readiness with which Black Ducks and Mallards hybridize and produce fertile offspring,

there is in any event no way of maintaining a population of "pure" Black Ducks in regions where the two species overlap.

In the Maritimes it seems safe to treat the Black Duck stocks as being in robust condition, especially those wintering in Prince Edward Island and Nova Scotia, though their numbers are small in relation to the total wintering population of the Atlantic coast. Because the Atlantic Flyway Council has agreed with the USFWS to freeze hunting regulations relating to Black Ducks for three years, while various investigations of habitat needs and survival are being conducted, it would be inappropriate for Canada to engage in experimental manipulation of regulations in the immediate future. But serious thought should be given to making changes designed to provide better information on the "elasticity" of the Black Duck population in response to varying hunting pressures, as well as to allow hunters as many recreational opportunities as they wish and can have without depleting the stock. If changes in regulations in Canada are to be made at the end of the experimental period, they should be substantial ones, intended to produce measurable changes in kill, and their effects should be monitored adequately. Timid tinkering may occasionally have local political benefits, but it does nothing to improve the craft of waterfowl management, still a very primitive and a very conservative business.

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Appendix 1
Relative recovery rates* from preseason Black Duck banding in eastern Canada†, 1968–76

Year	Area of banding				
	P.E.I.	N.S.	N.B.	Que.	Ont.
1968	1.347				
				3.295	2.037
1969	2.445	1.470			
1970	1.447		2.443		2.484
1971					
	2.243			2.428	
1972		2.103			2.092
1973	1.137		3.070		
1974				1.111	
	1.792	1.384			
1975			1.866	2.317	1.553
1976	3.741	2.277		3.514	
Mean	1.933	1.749	2.408	2.410	2.058

*Relative recovery rate is the ratio of the immature recovery rate to the adult recovery rate.

†Chi-square 2 x 2 contingency tests were used to determine significantly different years in both adult and young banding and recovery data. The yearly recovery rates were compared with adjacent years starting with 1976 working back to 1968. If the values were not found to be significantly different from one year to the next, they were combined until a difference was found. The bars in the table represent the combinations of years made, with the period mean for the interval shown in the centre.

Appendix 2
Black Duck age ratios from the SCS (Table 8 data) adjusted by relative recovery rates of immatures to adults (from Appendix 1)*

Year	P.E.I.		N.S.		N.B.		Que.		Ont.	
	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.
1968	3.35	2.49	4.62	3.14	4.77	1.95	8.57	2.61	6.34	3.11
1969	6.84	2.80	4.25	2.89	4.55	1.86	7.43	2.26	5.82	2.88
1970	3.75	2.59	2.97	2.02	4.62	1.89	7.35	3.03	5.25	2.11
1971	4.05	1.81	3.10	1.47	4.02	1.65	5.70	2.35	5.38	2.57
1972	1.95	0.87	4.46	2.12	4.36	1.79	3.41	1.40	3.98	1.90
1973	3.29	2.89	4.77	2.27	5.86	1.91	6.87	2.83	5.25	2.51
1974	3.98	2.22	4.22	3.05	5.36	2.87	5.40	4.86	4.42	2.85
1975	3.40	1.90	4.23	3.06	7.86	4.21	6.43	2.78	10.88	7.01
1976	5.75	1.54	5.88	2.58	7.64	4.09	7.68	2.19	5.02	3.23
Weighted Mean 1968–76	3.89	1.91	4.14	2.40	5.01	2.11	5.98	2.56	5.22	2.58

*Age ratios are adjusted for relative vulnerability as in Hanson and Smith (1950).

Sport hunting of Gadwall and American Wigeon in Canada and the United States, 1968-76, and its relationships to population changes

by H. Boyd, K. L. Newell and G. E. J. Smith

1. Abstract

Data on breeding numbers from aerial surveys are combined with estimates of numbers of fledged young and of total sport kill, derived from harvest surveys, to determine population changes and the relationship of hunting kill to total annual losses. Both species declined, probably from reduced recruitment. Attempts to draw inferences from the Canadian kill statistics about the size of the breeding population in the preceding summer and to predict the size of the population in the following year were unsuccessful.

2. Introduction

Understanding the role of hunting in the dynamics of duck populations is necessary to any attempt at the rational exploitation of waterfowl. Until now, interest in and arguments about the management of duck hunting in North America have been largely related to the Mallard, the most abundant and most popular game duck, and to the Black Duck and Canvasback, two other highly prized species.

In this paper, we broaden the discussion by looking at the impact of sport hunting on two other wide-ranging dabbling ducks, the Gadwall and American Wigeon. We also use the data for these species to test the feasibility of deriving information about the welfare of breeding populations from analyses of the Canadian kill.

The Gadwall is a holarctic species, remarkable for the great recent extensions of its breeding range eastward in North America (Bellrose 1976, Henny and Holgersen 1973, Palmer 1976) and northwestward in Eurasia (Bauer and Glutz 1968). Its North American stronghold remains in the former prairie grasslands of southern Alberta and Saskatchewan, and in North Dakota, a region now very largely devoted to the production of wheat and other agricultural crops. Its principal wintering haunts are in the states bordering the Gulf of Mexico, south to 18°N, with much smaller numbers near the Pacific and Atlantic coasts of the United States.

The American Wigeon (hereafter referred to as Wigeon) is confined to North America. It breeds principally in the parklands of the Prairie Provinces, somewhat to the north of the areas most densely populated by Gadwall, but also breeds in large parts of Alaska, British Columbia, the Yukon Territory, and the Mackenzie District of the Northwest Territories, and eastward to the Atlantic coast, although it is not plentiful east of Manitoba. The winter distribution is also very wide: in the east from the coast of New England to Cuba and the Gulf of Mexico, and along the Pacific coast from the estuaries of British Columbia to Baja California, with some major concentrations in parts of inland California.

Thus the distributions of Gadwall and Wigeon overlap substantially at all times of year, but diverge sufficiently to bring about different geographical patterns of hunting kill in Canada and the United States.

Because little is known of other causes of mortality or of the factors influencing breeding distribution and success, we concentrate here on the available facts about the breeding populations of the two species in recent years, and the possible influence of hunting kill upon those numbers. We consider four chief questions: (*a*) how have the recorded numbers of Gadwall and Wigeon varied in recent years? (*b*) what has been the relative importance of recruitment and of mortality in producing the observed changes in numbers? (*c*) how large a role has hunting in Canada and the United States played in annual losses? and (*d*) can Canadian kill survey data alone be used to monitor and predict the condition of the breeding populations?

We use data mainly from the routine annual surveys of (*a*) breeding populations conducted by the U.S. Fish and Wildlife Service (USFWS) assisted by the Canadian Wildlife Service (CWS) and (*b*) sport hunting kill surveyed in Canada by CWS (see Cooch *et al.* 1978) and in the United States by USFWS (Greenwalt 1975). The data are known to vary greatly in completeness and reliability. Much work still needs to be done to verify the accuracy and precision of past estimates, and to improve field identification and recording of ducks, and the sample surveys of hunting activity and bag composition. For the exploratory purposes of this paper, we largely ignore questions of reliability, although the analyses help to demonstrate some of the weaknesses of the existing system of collecting information.

We analyze data from 1968–76, the years during which waterfowl hunting activity and bag composition have been surveyed in Canada, and therefore of special concern to CWS. Similar surveys had begun earlier in the United States. Most of the period 1968–76 was climatically favourable for breeding ducks, with water relatively abundant in most of the heartland areas of these two species.

3. Results

3.1. Populations in May

Estimates provided by USFWS of the numbers of Gadwall and Wigeon in late May (B_t) are given in Table 1. These are derived from systematic aerial surveys in the principal breeding areas, supplemented by less regular surveys elsewhere. The term "Canadian" as used here includes Alaska, parts of the western N.W.T. and southern Yukon, and the Prairie Provinces. "American" refers principally to the states immediately south of 49°N.

The estimated numbers of Gadwall were highest in 1968 (2.1 million) and least in 1973 (1.2 million, an exceptionally low figure), averaging nearly 1.7 million and tending to fall fairly steadily throughout the period. There was no clear trend in the Canadian sampling area, but a marked decline in the American area, i.e., in the south of the breeding range, which nevertheless held about one-third of the population.

The average number of Wigeon (3.2 million) was almost twice that of Gadwall. The variations about the mean were greater, from a peak of 3.75 million in 1970 to a low of about 2.7 million in 1976 and 1977. The American population of Wigeon was proportionately much smaller

Table 1
Breeding populations of Gadwall and Wigeon, 1968–76, and estimates of flying young and of fall flight (in thousands)

		Breeding population			Flying young		Fall flight	
	Breeding year t	Can. B_{tc}	U.S. B_{tu}	Total B_t	Can. Y_{tc}	U.S. Y_{tu}	Can. N_{tc}*	U.S. N_{tu}†
Gadwall	1968	1406	692	2098	574	1142	1980	3219
	1969	1124	713	1837	1746	2026	2870	3852
	1970	1020	678	1696	684	1072	1734	2747
	1971	1117	616	1733	1007	1340	2124	3058
	1972	1205	571	1776	564	1034	1769	2787
	1973	794	404	1198	454	730	1248	1908
	1974	1221	341	1562	1014	1327	2235	2870
	1975	1141	531	1672	810	1430	1951	3073
	1976	1174	304	1478	598	897	1772	2343
	1977	1202	344	1546				
	Mean	1134	538	1672	828	1222	1961	2873
Wigeon	1968	1945	838	2783	1767	1818	3712	4573
	1969	2722	470	3192	6052	3909	8774	7087
	1970	3328	424	3752	2423	3496	5751	7215
	1971	3107	318	3425	4519	3342	7626	6752
	1972	2749	679	3428	2066	2688	4815	6090
	1973	3174	491	3665	1904	3090	5078	6725
	1974	2725	277	3002	2307	3663	5032	6641
	1975	2387	475	2862	1979	3794	4366	6625
	1976	2190	509	2699	1773	3070	3963	5740
	1977	2436	242	2678				
	Mean	2703	498	3201	2754	3208	5457	6383

*$N_{tc} = B_{tc} + Y_{tc}$
†$N_{tu} = (B_t - K_{td}) + Y_{tu}$
K_{td} = estimated number of adults killed by Canadian hunters $= K_{tc} \cdot \frac{1}{1 + W_{tc}}$ where W_{tc} is the Canadian immature–adult ratio in the kill as measured from the Canadian parts survey, and K_{tc} = kill by Canadian hunters (Table 3).

than that of Gadwall, but of much the same absolute magnitude (average 0.5 million). The variations in the Canadian and American numbers of Wigeon were markedly out of phase.

In the preceding 13 years, 1955–67, the annual population for Gadwall averaged 1.3 million, highest in 1966 at nearly 2 million, and lowest in 1958 and 1959 at 0.7 million. During that period the Wigeon averaged 3.0 million and ranged from 3.8 million in 1959 to 2.2 million in 1963. Although the variations observed in 1968–77 were well within the range of those recorded in 1955–67, there was a significant downward trend in total breeding population for both species: Gadwall, 1968–77, average decline of 1.76% per year; Wigeon, 1970–77, average decline of 4.74% per year.

3.2. Estimates of numbers of flying young and of fall flight

We estimate the number of flying young, Y_t, and hence of the fall flight, N_t, indirectly because the July brood surveys conducted by the USFWS give no reliable guide to the breeding success of such species as Gadwall and Wigeon. We use the

Table 2
Immature–adult ratios (W_t) in samples of wings in Canadian and U.S. parts surveys, 1968–76, and *population age ratios (R_t) obtained from W_t* by use of relative vulnerability (V)* of adult and immature ducks, as determined from bandings and recoveries, 1968–76†

		Canada		United States	
	Breeding year	In parts survey W_{tc}	In population R_{tc}	In parts survey W_{tu}	In population R_{tu}
Gadwall	1968	2.48	0.41	1.19	0.55
	1969	9.48	1.55	2.41	1.11
	1970	4.07	0.67	1.40	0.64
	1971	5.47	0.90	1.69	0.78
	1972	2.84	0.47	1.29	0.59
	1973	3.47	0.57	1.35	0.62
	1974	5.04	0.83	1.87	0.86
	1975	4.21	0.71	1.89	0.87
	1976	3.09	0.51	1.36	0.62
	Mean	4.46	0.74	1.61	0.74
Wigeon	1968	4.68	0.91	1.05	0.66
	1969	11.45	2.22	1.95	1.23
	1970	8.75	0.73	1.49	0.94
	1971	7.49	1.45	1.56	0.98
	1972	3.87	0.75	1.26	0.79
	1973	3.09	0.60	1.35	0.85
	1974	4.36	0.85	1.95	1.23
	1975	4.27	0.83	2.13	1.34
	1976	4.17	0.81	1.83	1.15
	Mean	5.79	1.02	1.62	1.02

* Mean vulnerability quotients:

	Can.	U.S.
Gadwall	6.07	2.18
Wigeon	5.15	1.59

The U.S. relative vulnerability V_u is obtained from banding data of the years 1968–76 using direct recoveries in the U.S. of birds banded in either Canada or the U.S. As Canadian recoveries are too few for reliable calculation of V_c, it was obtained indirectly from $V_c = V_u W_c / W_u$ where W_c (W_u) is the average immature-adult ratio, over the years 1968–76, in the Canadian (U.S.) kill from the Canadian (U.S.) parts survey.

† The immature-adult ratio in the fall flight over Canada in year t, R_{tc} is estimated from $R_{tc} = W_{tc}/V_c$ where W_{tc} is the Canadian immature–adult ratio in the kill as measured from Canadian parts survey and V_c is the relative vulnerability in the fall flight over Canada. Similarly the U.S. age ratio in the fall flight is $R_{tu} = W_{tu}/V_u$, where W_{tu} is the U.S. age ratio in the kill and V_u the relative vulnerability in the fall flight over the U.S.

wings contributed to the CWS and USFWS Species Composition Surveys (SCS) to estimate the number of Gadwall and Wigeon killed and the ratios of immature to adult wings, W_t, to indicate the relative abundance of flying young (Tables 2, 3, 4). The Canadian wing samples are very strongly biased in favour of immatures. We adjust for this by means of the relative vulnerability quotient, V, as used in Hanson and Smith (1950).

Because of the scarcity of Canadian band recovery data for adults of both species, direct estimates of Canadian vulnerability would not be reliable. It seems reasonable that the immature–adult ratio in the fall flight over Canada should be appreciably higher than that over the United States, since the majority of each species breed in Canada, and the Canadian kill is relatively small compared to the breeding population and hence the fall flight. Because immature–adult ratios are much higher in the Canadian parts survey than those in the U.S. survey, one might be led to believe that immatures are much more vulnerable in Canada than in the United States. An indirect estimate of Canadian relative vulnerability is described in the footnotes to Table 2. The procedure implicitly assumes that the average immature–adult ratio in the fall migration between 1968 and 1976 is the same over Canada as over the United States. While this assumption is open to criticism, it appears the most reasonable one in view of the lack of some alternative information.

We note that the estimate of fall flight is obtained in different ways for Canada and the United States (Table 1, N_{tc} and N_{tu}) to reflect the fact that the ducks at risk in the United States include both emigrating survivors from Canada and U.S.-bred birds.

Although there is no simple relationship between the two estimates of flying young, there is a striking similarity in the annual fluctuations of the numbers over Canada and the United States (Table 1, Y_{tc} and Y_{tu} 6; Fig. 1). The higher numbers in the United States do not reflect higher productivity. The resemblance between the numbers presumably follows from the dominating output of the much larger breeding population in Canada, and from a tendency for production in the south of the range to vary from year to year in much the same way as further north. Note that the adjusted age ratios (Table 2, columns 2 and 4) are well below 1.0 in all years except 1969.

The estimated annual numbers of flying young Wigeon (Table 1, columns 5 and 6; Fig. 2) vary in a very different way from those of Gadwall, although both peaked in 1969. That year and again in 1971 the numbers of flying young over Canada are estimated to have been substantially

Table 3
Estimates of retrieved sport hunting kill of Gadwall and Wigeon in Canada, 1968–76* (in thousands)

	Season	Atl.	Que.	Ont.	Man.	Sask.	Alta.	BC	NWT	YT	Canada K_{tc}
Gadwall	1968	X‡	X	X	14.3	20.5	39.6	X	X	X	76.6 (74.4)†
	1969	–‡	0.4	3.1	21.5	40.5	52.5	1.1	X	X	119.1
	1970	–	0.4	2.7	13.0	50.0	50.2	1.3	X	X	117.6
	1971	–	1.5	2.0	11.8	28.3	54.3	2.3	X	X	100.1
	1972	–	2.2	3.5	10.3	24.8	48.2	1.2	X	X	90.2
	1973	0.1	1.9	2.6	9.8	25.7	47.9	1.3	X	X	89.2
	1974	0.3	3.6	3.9	11.3	33.3	58.9	2.7	X	X	113.9
	1975	0.2	3.8	10.1	16.3	58.0	60.7	3.7	–	–	152.7
	1976	–	6.3	6.6	10.3	42.0	62.7	1.3	–	–	129.2
	Mean	0.1	2.4	4.3	13.2	35.9	52.8	1.9	X	X	109.6
Wigeon	1968	X	X	X	19.2	27.3	39.3	74.4	X	X	186.3 (160.2)†
	1969	0.1	6.1	16.5	14.8	38.2	57.1	43.5	X	X	176.8
	1970	1.1	6.7	16.3	19.7	33.1	35.5	44.1	X	X	156.4
	1971	0.6	6.1	12.0	11.3	22.1	36.8	35.4	X	X	124.3
	1972	1.0	4.6	12.2	11.6	16.8	39.7	40.4	X	X	126.3
	1973	1.9	6.4	9.5	12.3	16.9	32.9	42.8	X	X	122.7
	1974	1.6	9.4	11.9	10.0	21.9	35.3	35.9	X	X	126.1
	1975	2.4	6.1	17.4	13.4	29.8	50.4	40.7	1.4	0.7	162.3
	1976	2.9	11.5	22.9	11.3	27.5	38.6	29.7	5.6	1.0	151.0
	Mean	1.9	7.1	14.8	13.1	25.8	40.8	29.1	X	X	142.6

*Data from CWS, NHS and SCS: species composition in eastern provinces not available 1968; surveys not conducted in N.W.T. and Yukon until 1975.
†Estimates for 1968 increased to 74.4 for Gadwall and 160.2 for Wigeon, to allow for omissions from eastern Canada, using pro-rating factors, from 1969 and 1970, of 1.029 for Gadwall and 1.163 for Wigeon.
‡X = no estimate available, – = estimate less than 50.

greater than those reaching and produced in the United States. From 1972 onward the Canadian estimates behave in a less erratic way. It seems likely that the early wildness of the estimates is due more to oddities in the wing samples than to any biological phenomenon.

The adjusted age ratios for Wigeon (Table 2, columns 2 and 4) are just over 1.0.

3.3. Annual losses suffered by Canadian populations

Using the estimated fall flight, N_{tc}, and the breeding population in the following year, $B_{(t+1)c}$, it is possible to obtain a crude index of losses from September to May for the Canadian population (Table 5). This suggests an average rate of loss of Gadwall of about 43%. There is one absurdly low value, for 1973, presumably due either to an under-estimate of the fall flight that year or an over-estimate of the breeding population in 1974, but otherwise the consistency and plausibility of the estimates is remarkable, given the crudity of the data and the method of calculation. The Canadian kill appears to account for no more than 20% of the fall and winter losses.

The estimates of fall, winter, and spring losses of Wigeon are even more consistent than those for Gadwall, averaging 50%, and ranging from about 27% to 64%. The kill in Canada seems to have represented less than 8% of the losses, except in 1968–69, a year in which the estimated total losses were unusually small.

We defer further examination of these results until the relative hunting kill in Canada and the United States, and the age and sex composition of the kill, have been described.

3.4. Sport hunting kill in Canada

The estimates of the retrieved kill by sport hunters in Canada obtained from the CWS National Harvest Survey (NHS) and the SCS are summarized in Table 3. Errors in estimates of hunter kill are discussed further in a companion paper by Cooch *et al.* (1978). Birds knocked down but not bagged are not included in these estimates; nor are those killed by native people or others not required to purchase a Canada Migratory Game Bird Hunting Permit, and are therefore not included in the sampling universe. We have virtually no information on the possible extent, scale, and timing of such additional hunting losses.

The reported kill of Gadwall in the Atlantic Provinces is negligible. It increases by province westward from Quebec to a maximum in Alberta, dropping again to a low number in British Columbia. Few Gadwall are taken north of 60°N. The national total has fluctuated quite widely about the nine-year mean of 110 000 (range 89 000–153 000), with no steady trend nationally (Table 3).

Wigeon are much more frequently taken in the Atlantic Provinces than Gadwall, but the general pattern of kill by province is similar, increasing from the Maritimes to western Alberta. The kill in British Columbia is large, and that in the territories (not sampled before 1975) far from negligible. The mean kill in 1969–76, 143 000, is greater than that of Gadwall, with smaller variations from year to year (range 123 000–177 000); the estimates for four successive seasons in the period 1971–74 lie between 123 000 and 126 000.

Table 4
Retrieved hunting kill of Gadwall and Wigeon in the United States, 1968–76* (in thousands)

	Season	Atlantic Flyway	Miss. Flyway	Central Flyway	Pacific Flyway	Alaska	USA K_{tu}
Gadwall	1968	18.7	90.0	105.3	96.1	0.6	310.8
	1969	33.8	185.0	332.6	114.9	0.6	667.0
	1970	24.4	336.7	304.2	115.4	0.5	781.2
	1971	16.9	287.7	316.4	134.1	0.6	755.6
	1972	24.6	304.3	330.7	107.7	0.5	767.8
	1973	19.5	185.6	184.0	84.0	0.4	473.4
	1974	27.5	257.7	250.7	127.1	0.5	663.5
	1975	36.4	360.6	285.8	128.8	0.4	812.1
	1976	40.8	415.7	315.4	99.2	1.0	872.1
	Mean	27.0	269.3	269.4	111.9	0.6	678.2
Wigeon	1968	41.6	124.9	79.9	426.5	9.7	682.5
	1969	82.3	209.1	109.6	481.5	8.5	951.0
	1970	79.2	260.2	222.9	293.7	9.0	1065.0
	1971	48.1	191.9	184.7	478.7	13.8	917.4
	1972	66.1	231.1	175.6	412.9	14.8	900.4
	1973	38.0	179.4	135.1	298.6	14.7	665.8
	1974	67.8	195.8	154.4	334.5	11.3	763.8
	1975	88.4	242.1	183.7	424.2	12.5	950.9
	1976	99.1	225.2	178.8	549.8	15.1	1067.9
	Mean	67.8	206.6	158.3	411.1	12.2	885.0

* Data from USFWS harvest surveys, with adjustments for exaggerated success, effects of hunter age, and crippling loss, as described by Chamberlain, Martinson, and Clark (1971) and Martin and Carney (1977).

3.5. Sport hunting kill in the United States

Estimates of the retrieved hunting kill of Gadwall and Wigeon in the United States are listed in Table 4. As in Canada, the kill of Gadwall is largest in the middle of the country and least toward the Atlantic coast. There have been wide fluctuations in total U.S. kill (mean 678 000, range 310 000–872 000).

As in Canada, the U.S. kill of Wigeon is greater than that of Gadwall, but has shown proportionately smaller annual fluctuations (mean 885 000, range 666 000–1 068 000).

3.6. Total sport hunting kill

For Gadwall and Wigeon combined the Canadian kill has represented only about 14% of the total hunting kill, and has shown no tendency to alter proportionately (range 11%–19%). In other respects the impact of hunting on the two species is markedly different. The average kill of Wigeon, at about 1 million, is about 30% above that of Gadwall (790 000). Yet the proportionate kill is markedly higher for Gadwall than for Wigeon, both as a proportion of the fall flight and as a proportion of the total losses. The total annual kill of Gadwall, and the kill as a proportion of the fall flight and of the total losses, have all shown a clear tendency to increase during the period. The total kill of Wigeon has shown no trend, but the kill has increased both in relation to the size of the fall flight and to total losses, though the trends are less strong than in the case of Gadwall.

Figure 1
Breeding population, fledged young and annual losses of Canadian populations of Gadwall, 1968-76

3.7. Use of Gadwall and Wigeon by Canadian hunters

On the evidence presented so far, it appears that the impact of Canadian hunters on Gadwall and Wigeon is insufficient to constitute a threat to the well-being of either species, although the total impact of hunting on Gadwall may be approaching a critical level. This finding raises the question whether it would be profitable for Canadian hunters to direct more effort toward these species.

Since 1972 it has been possible, by means of the national harvest surveys, to estimate the amount of activity each year by waterfowl hunters in different regions, and the number of hunters who succeeded in killing at least one duck (see Cooch *et al.* 1978). Combining that information with the estimates of kill, we can see (Tables 6 and 7) that Gadwall and Wigeon are of minor concern to waterfowl hunters over most of the country, although the Wigeon is important to hunters in British Columbia, and both species are actively pursued by hunters in the Prairie Provinces. On the assumption that hunters are not deliberately refraining from shooting these species when the opportunity to do so is offered, the data make the rather inconvenient point that intensification of effort against them is likely to be rewarding to hunters only in those provinces where the existing effort is relatively high. If each successful hunter in western Canada were to add one more Gadwall and Wigeon to his season's bag, the Canadian kill of each would be nearly doubled. Given the relative stability of waterfowl hunting effort in Alberta in 1972–76, it seems as if the most likely way to increase the kill of Wigeon would be by a substantial number of hunters changing their hunting tactics, so as to increase the frequency of their encounters with Gadwall or Wigeon. In British Columbia, where waterfowl hunting activity is apparently declining, there is no indication that the pursuit of either of these species by the remaining hunters is being intensified.

Figure 1

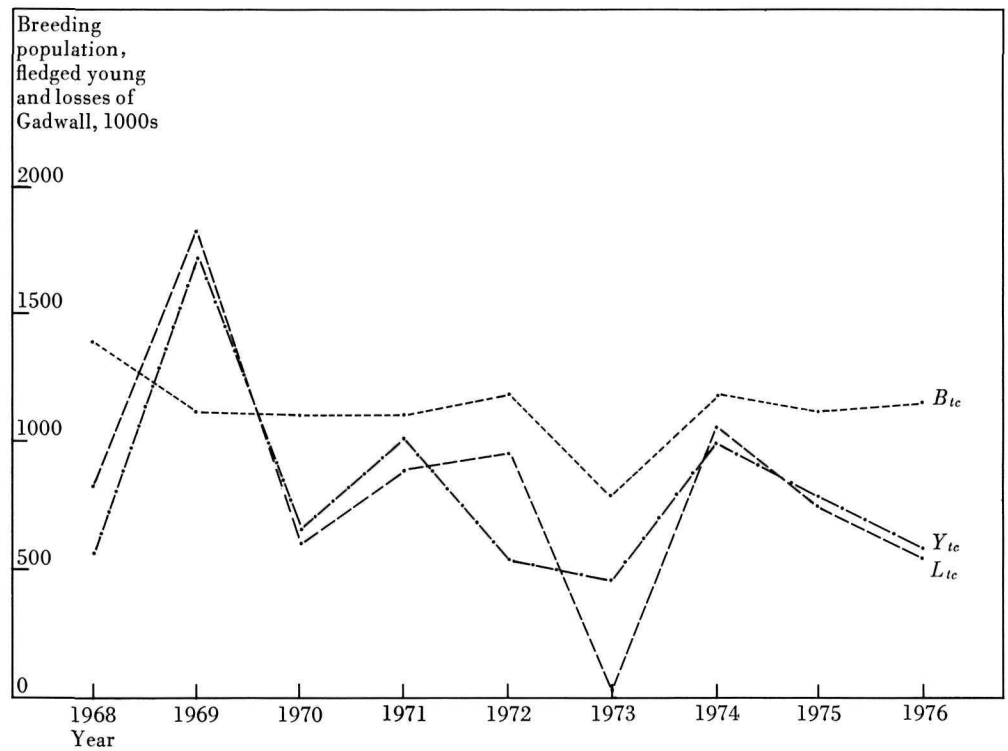
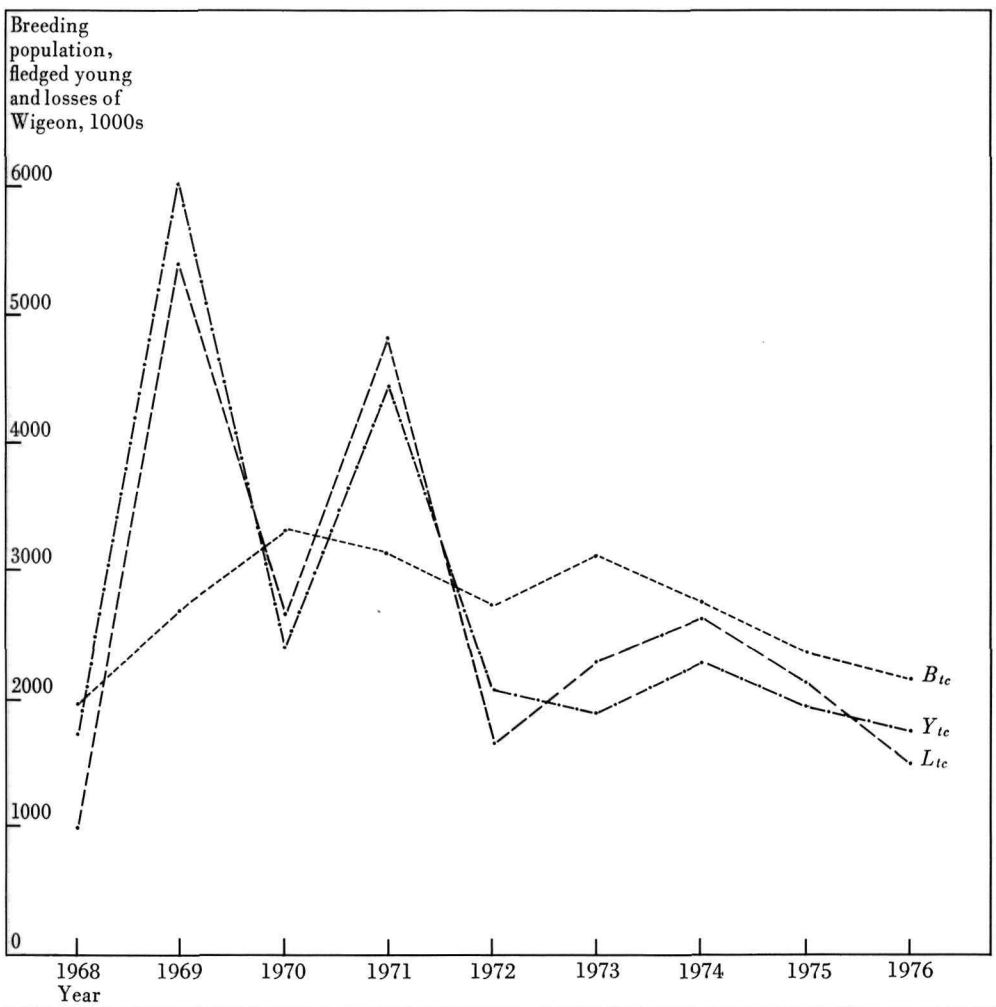


Table 5
Apparent annual losses suffered by Canadian populations of Gadwall and Wigeon, 1968–76* (in thousands)

	Gadwall			Wigeon		
Breeding year t	Loss L_{tc}	% loss M_{tc}	Can. kill as % of loss	Loss L_{tc}	% loss M_{tc}	Can. kill as % of loss
1968	856	43.2	8.9	990	26.7	18.8
1969	1850	64.5	6.4	5446	62.1	3.2
1970	617	34.4	20.0	2644	46.0	5.9
1971	919	43.3	10.9	4877	64.0	2.5
1972	975	55.1	9.3	1641	34.1	7.7
1973	27	2.2	(330.4)	2353	46.3	5.2
1974	1094	48.9	10.4	2645	52.1	4.8
1975	777	39.8	19.7	2176	42.9	7.5
1976	570	32.2	22.7	1527	38.5	9.9
Mean	850	43.3	12.9	2699	49.5	5.3

*Calculated from relation $L_{tc} = N_{tc} - B_{(t+1)c}$; rates of loss, M_{tc}, from $M_{tc} = L_{tc}/N_{tc}$; and Canadian kill as proportion of total losses, K_{tc}/L_{tc} (data from Table 1).

Figure 2
Breeding population, fledged young and annual losses of Canadian populations of Wigeon, 1968-76



3.8. Possible relationships of kill to stock size, recruitment, and losses

We have described the annual changes in estimated breeding populations and production of flying young and related them to the reported kill in Canada and the United States. To examine the impact of hunting on the populations of Gadwall and Wigeon it is necessary to measure the associations and interactions between the available statistics — most simply through correlation and regression. The regressions of kill on time show no significant trends.

The association between estimates of kill and changes in population statistics are shown by the Pearson correlation coefficients (Table 8). For Gadwall there appear to be significant correlations between B_{tu} and Y_{tu} (0.49), Y_{tu} and Y_{tc} (0.95). However, these are spurious due to the fact that the variables are calculated from common data. The correlation between K_{tc} and K_{tu} (0.73) is significant.

For Wigeon there is a significant negative correlation between B_{tc} and B_{tu} (-0.59). There is a significant negative correlation (perhaps spurious) between B_{tu} and Y_{tu} (-0.83) though none between B_{tc} and Y_{tc}. There is a positive correlation between Y_{tu} and Y_{tc}. The Canadian and U.S. kills are much less highly correlated (0.39) than for the Gadwall (0.73). The United States kill, K_{tu}, is positively correlated with the numbers of young, Y_{tu}, but the Canadian kill (K_{tc}) is not significantly correlated with B_{tc} or Y_{tc}; the correlation with B_t is negative (-0.49), a curious result were it significant.

The use of multiple linear regression adds nothing to the indications provided by the correlation coefficients, apart from confirming the lack of any appreciable association between K_{tc} and B_{t+1} or $B_{(t+1)c}$. That is, the existing evidence fails to show that sport hunting in Canada in 1968–76 had any significant effect on the size of the breeding population of either species in the following year.

Another important aspect of these results, though again leading to a verdict of "not proven", is that recourse to Canadian kill data, without drawing on the breeding season surveys, does not permit reliable inferences to be drawn about the size of the breeding population or of the numbers of flying young immediately prior to the hunting season, or predictions about the size of the breeding population in the next season.

4. Conclusions

It may seem both paradoxical and irresponsible to suggest that, despite evidence that the North American populations of Gadwall and Wigeon have diminished in recent years, the Canadian kill of both might be increased without accelerating their decline. Yet effective management of waterfowl stocks can only be accomplished by managers prepared to base decisions on the data available to them, rather than on general impressions and native caution. It is, of course, true that the data are incomplete and of doubtful reliability, and that to treat the entire North American stock of each species as if it were made up

Table 6
Canadian sport hunting kill of Gadwall and Wigeon, 1972–76, per 1000 waterfowl hunter-days of activity. Results calculated from CWS Progress Notes

	Season	Atl.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Total
Gadwall	1972	—	5.8	4.7	42.5	76.0	111.8	5.9	38.7
	1973	0.2	4.4	3.1	39.9	81.6	100.0	7.0	36.2
	1974	0.6	7.3	5.2	45.3	91.1	115.9	16.7	45.1
	1975	0.3	8.5	11.6	54.5	136.9	133.9	23.4	57.4
	1976	—	13.2	8.2	34.1	97.5	130.6	8.6	48.8
	Mean	0.3	8.0	6.7	43.4	97.8	118.4	11.9	45.6
Wigeon	1972	2.9	12.0	16.2	47.8	51.6	92.1	202.9	47.0
	1973	4.9	15.1	11.7	50.0	53.7	68.6	228.0	42.8
	1974	3.7	19.4	15.8	40.4	59.8	69.5	220.6	42.8
	1975	5.3	13.7	19.9	44.6	70.3	111.1	254.2	52.0
	1976	6.4	24.1	28.5	37.5	63.8	80.5	196.8	48.5
	Mean	4.7	17.2	18.5	43.8	60.7	83.7	220.2	46.7

Table 7
Canadian sport hunting kill of Gadwall and Wigeon, 1972–76, per successful duck hunter. Results calculated from CWS Progress Notes

	Season	Atl.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Total
Gadwall	1972	—	0.06	0.04	0.38	0.61	0.96	0.07	0.36
	1973	0.002	0.05	0.03	0.35	0.70	0.90	0.07	0.34
	1974	0.009	0.08	0.05	0.45	0.76	1.03	0.19	0.43
	1975	0.005	0.09	0.11	0.59	1.16	1.18	0.26	0.56
	1976	—	0.14	0.08	0.33	0.82	1.14	0.09	0.46
	Weighted mean	0.004	0.09	0.06	0.42	0.83	1.04	0.13	0.42
Wigeon	1972	0.03	0.13	0.15	0.42	0.41	0.79	2.26	0.45
	1973	0.05	0.16	0.11	0.44	0.46	0.62	2.24	0.41
	1974	0.05	0.22	0.14	0.40	0.50	0.62	2.52	0.42
	1975	0.08	0.15	0.19	0.49	0.60	0.98	2.81	0.53
	1976	0.09	0.26	0.26	0.36	0.54	0.70	2.13	0.48
	Weighted mean	0.06	0.19	0.17	0.42	0.51	0.74	2.38	0.46

only of Canadian and United States components is an over-simplification. The crucial questions are: (*a*) how dangerous are these inadequacies? and (*b*) would it be worth attempting to obtain much more and much better information?

A clue to the answers to those questions may be obtained by comparing the results we have been discussing with those emerging from the major series of studies of the Mallard by the USFWS, culminating in the discussion of the effect of exploitation on survival by Anderson and Burnham (1976). Obviously much more is known about the population dynamics and ecology of the Mallard than of Gadwall and Wigeon, though at a vastly greater cost. In this study we have made little use of the results of banding, because an initial scrutiny revealed that the extent of banding was wholly insufficient to enable us to identify sub-populations within the total stocks of the species, or to estimate regional differences in survivals as have been done for the Mallard. It would be very expensive to set up extensive banding programs aimed at those species and would take a long time to obtain results, which might well turn out to be as inconclusive as in the case of the Mallard.

We suggest that the most economical approach to management of Gadwall and Wigeon at present is to assume that the principles of exploitation elucidated by Anderson and Burnham (1976) for Mallards apply to these closely related species.

Table 8
Pearson correlation matrices for Gadwall and Wigeon population variables: B_t and B_{t+1} breeding populations in years t and $t+1$; B_{tc} and B_{tu} breeding populations in Canada and in United States; Y_{tc} and Y_{tu} indices of flying young over Canada and United States in fall; K_{tc} and K_{tu} kill in Canada and in United States

		B_{tc}	B_{tu}	Y_{tc}	Y_{tu}	K_{tc}	K_{tu}
Gadwall	B_{tu}	0.216					
	Y_{tc}	0.097*	0.354				
	Y_{tu}	0.275*	0.492*†	0.947*‖			
	K_{tc}	−0.111	−0.235	0.305	0.353*		
	K_{tu}	−0.124	−0.229	0.150	0.122	0.728§	
	B_{t+1}	0.129	−0.321	0.311	0.261	−0.147	−0.421
Wigeon	B_{tu}	−0.589‡					
	Y_{tc}	0.292*	−0.355				
	Y_{tu}	0.463*	−0.835*‖	0.481*‡			
	K_{tc}	−0.429	0.276	0.290	0.137*		
	K_{tu}	0.108	−0.282	0.230	0.465†	0.386	
	B_{t+1}	0.399	0.163	0.631‡	−0.049	0.084	0.100

*Correlation may be spurious due to common data used to calculate the variables.
†$0.1 < P < 0.2$.
‡$0.05 < P < 0.1$.
§$0.01 < P < 0.05$.
‖$P < 0.01$.

Specifically, we suggest that at the present rates of exploitation in both Canada and the United States hunting losses are being sufficiently compensated for by decreased natural mortality. Perhaps the most useful next step will be to focus on some parts of the population of one or both species which are under relatively great stress, to see if we can establish where the threshold lies beyond which it is no longer possible for increased hunting mortality to be offset by reduced natural losses. An obvious candidate group in Canada is the Wigeon population wintering in British Columbia.

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Experimental Sandhill Crane survey 1974-76

by G. E. J. Smith and F. G. Cooch

1. Abstract

An experimental survey was conducted in 1974, 1975, and 1976 to obtain improved estimates of the numbers of Sandhill Cranes killed in Saskatchewan during the special crane season in the first week of September. Questionnaires were mailed to a large sample of resident Saskatchewan hunters drawn from those who purchased a Migratory Game Bird Hunting Permit before the close of the special crane season. The sampling for the survey was much more intensive than that for the National Harvest Survey (NHS). The resulting annual estimates were consistently lower than those obtained from the yearly NHS and from surveys of hunters conducted by the Saskatchewan government.

2. Introduction

The requirement for better data on the harvest of Sandhill Cranes in Saskatchewan developed as a result of two opposing pressures. First, Miller, Hochbaum, and Botkin (1972), Miller and Botkin (1974) and Miller (1974) expressed concern about the ability of the species to withstand what appeared to be excessive hunting pressure, because it has a low annual reproductive output and does not breed before its fourth year. Miller and his co-authors predicted the extinction of the Central Flyway population in less than two decades if hunting mortality continued at the rate indicated by national harvest surveys in Canada and the United States.

Second, there were increasing demands from the Government of Saskatchewan, the Saskatchewan Wildlife Federation, Sandhill Crane hunters, and farmers to open more areas to Sandhill Crane hunting and to lengthen the very brief season which, by agreement, had been limited to the first week or so of September, preceding the start of the waterfowl hunting season (Migratory Birds Convention Act 1976). Their objective was to limit crop depredation and increase recreational hunting.

The Canadian Wildlife Service (CWS), the U.S. Fish and Wildlife Service and the Saskatchewan Fish and Wildlife Branch agreed that more precise data were required for management purposes and to check the validity of the models developed by Miller and co-workers. The National Harvest Survey (NHS) was not designed to provide precise data on the kill of species which are not harvested in large numbers. In 1976, the special Sandhill Crane season was restricted to about one-eighth of the province and to one week in early September. Thus, although there were approximately 2500 responses from Saskatchewan hunters to the NHS that year (Cooch, Newell, and Wendt 1978) very few of them were from Sandhill Crane hunters and the estimate of Sandhill Crane kill lacked precision. In 1976 the 95% confidence limits of the crane kill were ±53% of the estimate.

The hunter and game population surveys conducted by the Saskatchewan Department of Tourism and Renewable Resources (Ross 1976 and Government of Saskatchewan 1977) suffered from similar problems but were potentially more precise as 5300 responses were received in 1976.

Table 1
Sample sizes and responses for the Sandhill Crane survey, 1974 – 76

Year	Zone of purchase/ sample	Hunters			Responses			
					Active§		Inactive	
		Available*	Selected†	Contacted‡	Wave 1	Wave 2 #	Wave 1	Wave 2 #
1974	1A	1299		260	33		131	
	1B	1508		275	14		167	
	1C	140		28	3		15	
	1D	257		47	0		28	
	3A	1336		270	83		98	
	3B	1486		311	25		188	
	3C	152		31	7		10	
	3D	211		28	3		16	
1975	1A	1302	653	634	74	10	334	107
	1B	1877	375	371	16	6	201	79
	1C	153	50	49	6	3	18	10
	1D	234	50	48	1	1	19	12
	2A	1458	292	283	4	1	126	56
	2B	1532	153	152	0	0	66	41
	2C	212	50	46	0	0	18	14
	2D	432	50	49	0	0	18	15
	3A	1740	1740	1712	432	129	594	191
	3B	1929	772	762	44	21	417	153
	3C	197	131	128	15	15	43	19
	3D	339	50	50	3	2	19	10
1976	1A	851	426	409	36	6	237	66
	1B	1134	227	219	9	1	127	35
	1C	81	81	74	4	0	39	15
	1D	135	135	127	7	3	74	27
	3A	1494	1494	1442	275	72	654	178
	3B	1565	783	767	47	12	374	164
	3C	142	142	136	20	6	60	22
	3D	215	215	207	14	8	90	33

*Hunters available for sampling are those who purchased their permit on or before the last day of the special crane season.
†Hunters were selected based on the proportion in their zone and sample group expected to hunt Sandhill Crane. These proportions could not be calculated in 1974.
‡Those contacted are those selected for sampling less undeliverables.
§Active hunters are those who reported hunting Sandhill Cranes during the special season.
#No follow-up (wave 2) was done in 1974.

Table 2
Sandhill Crane survey estimates by stratum, 1974–76

Year	Permit data: Zone	Permit data: Sample*	Number responding	Potential hunters†	e-factor‡	Survey estimates: Active hunters Est.§	Active hunters S.E.‖	Successful hunters Est.	Successful hunters S.E.	Kill/potential hunter Est.	Kill/potential hunter S.E.	Kill/active hunter Est.	Kill/active hunter S.E.	Kill/successful hunter Est.	Kill/successful hunter S.E.	Total kill Est.	Total kill S.E.
1974	1	A	164	1299	7.9207	261	38	150	30	0.329	0.086	1.64	0.38	2.84	0.51	428	112
	1	B	181	1508	8.3315	117	28	92	25	0.105	0.036	1.36	0.36	1.73	0.38	158	54
	1	C	18	140	7.7778	23	12	8	7	0.056	0.052	0.33	0.33	1.00	**	8	7
	1	D	28	257	9.1786	0	—#	0	—	0.000	—	**	**	**	**	0	—
	3	A	181	1336	7.3812	613	46	487	45	1.486	0.189	3.24	0.35	4.08	0.38	1986	253
	3	B	213	1486	6.9735	174	30	119	26	0.258	0.069	2.20	0.49	3.24	0.57	384	103
	3	C	17	152	8.9412	63	18	54	17	1.176	0.452	2.86	0.81	3.33	0.79	179	69
	3	D	19	271	14.2632	43	22	0	—	0.000	—	0.00	—	**	**	0	—
1975	1	A	525	1414	2.6933	226	18	143	15	0.286	0.036	1.79	0.18	2.83	0.21	404	51
	1	B	302	1920	6.3576	140	26	70	19	0.096	0.031	1.32	0.36	2.63	0.50	184	60
	1	C	37	195	5.2703	47	13	21	9	0.216	0.128	0.89	0.51	2.00	0.99	42	25
	1	D	33	283	7.2121	14	9	14	9	0.091	0.063	1.50	**	1.50	**	22	15
	2	A	187	1489	7.9626	40	17	16	11	0.053	0.045	2.00	1.78	5.00	**	80	68
	2	B	107	1597	14.9252	0	—	0	—	0.000	—	**	**	**	**	0	—
	2	C	32	228	7.1250	0	—	0	—	0.000	—	**	**	**	**	0	—
	2	D	33	441	13.3636	0	—	0	—	0.000	—	**	**	**	**	0	—
	3	A	1346	1826	1.3566	761	13	526	12	0.954	0.031	2.29	0.07	3.31	0.08	1742	57
	3	B	635	1957	3.0819	200	19	129	16	0.227	0.037	2.22	0.29	3.43	0.37	444	72
	3	C	92	236	2.5652	77	9	38	7	0.293	0.072	0.90	0.20	1.80	0.30	69	17
	3	D	34	348	10.2353	51	21	10	10	0.176	0.170	1.20	1.24	6.00	**	61	59
1976	1	A	345	1070	3.1014	130	16	90	13	0.180	0.031	1.48	0.19	2.14	0.20	192	33
	1	B	172	2622	15.2442	152	45	30	21	0.029	0.020	0.50	0.35	2.50	**	76	53
	1	C	58	185	3.1897	13	5	13	5	0.276	0.134	4.00	1.32	4.00	1.32	51	25
	1	D	111	285	2.5676	26	6	5	3	0.018	0.010	0.20	0.11	1.00	**	5	3
	3	A	1179	1648	1.3978	485	12	313	10	0.623	0.024	2.12	0.06	3.28	0.07	1026	39
	3	B	597	2856	4.7839	282	31	144	23	0.106	0.019	1.07	0.15	2.10	0.19	301	54
	3	C	108	200	1.8519	48	6	26	4	0.287	0.067	1.19	0.25	2.21	0.37	57	13
	3	D	145	432	2.9793	66	11	27	7	0.110	0.032	0.73	0.18	1.78	0.23	48	14

*Samples A, B, C, and D are defined in section 3.1.
†Number who purchased Canada Migratory Game Bird Hunting Permits.
‡Extrapolation factor.
§Estimate.
‖Standard error of the estimate.
#Indicates a calculated standard error of zero.
**Estimated ratio could not be calculated since no hunters were in category, or standard error of estimate was based on less than three observations.

3. Methods

3.1 Survey design

A survey of Sandhill Crane hunting activity in September 1974 was mailed in March of 1975 as a pilot project, although we realized that, due to the late date, hunters would have some difficulty in recalling details. No follow-up mailing was attempted.

The questionnaire (Appendix 1) asked whether the recipient had hunted during the special season, how many Sandhill Cranes he had killed in each provincial game management zone, and for how many years he had hunted cranes during the special seasons.

In 1975, both the questionnaire design (Appendix 2) and mailing procedure were revised. The new questionnaire asked for kill by day as well as by game management zone. It also contained a map showing major geographic features, which improved the data on the location of kill. The first set of questionnaires was mailed in December 1975, the follow-up in January 1976. The initial mailing was delayed as a result of a postal strike during October and November 1975. In 1976, the survey retained the 1975 questionnaire design (Appendix 3) but in the absence of a postal strike the mailing date was 30 days earlier.

The special Sandhill Crane season takes place in several provincial Game Management Zones (GMZ) within NHS zones 1 and 3. In 1975 the provincial GMZ's were rearranged. Thus the hunting area in 1975 and 1976 differed slightly from that in 1974 (Appendices 1–3), resulting in the opening of a small portion of NHS zone 2 to crane hunters.

In 1974 the sample of hunters was chosen from Canada Migratory Game Bird Hunting Permit[1] holders who purchased their permits (*a*) on or before the last day of the Sandhill Crane season and (*b*) in NHS zones 1 or 3 of Saskatchewan (Appendix 1).

In 1975, hunters purchasing a permit in Saskatchewan zone 2 were also sampled. Only five of the respondents indicated participation (the estimated number of participants was 11) and only two reported killing cranes (estimated crane kill was 80). Sampling from this zone was not repeated in 1976. Only residents of Saskatchewan could legally purchase a provincial hunting licence before late September and thus non-residents were not sampled. In addition, Saskatchewan residents who purchased their permits outside Saskatchewan were also omitted.

The sampling universe (defined by *a* and *b* above) was stratified using the following criteria: zone of purchase,[2] permit purchased or not purchased in the previous year, and month of purchase (August or September).

The following notation is used to identify strata within each NHS zone of purchase.

Sample	Purchased permit in previous year	Month of purchase for current year's permit
A	Yes	August
B	Yes	September
C	No	August
D	No	September

Thus eight strata were formed (12 in 1975). In 1974 approximately one-fifth of the hunters were systematically sampled. In the succeeding years a statistical procedure called Neyman Allocation (Cochran 1963) was used to distribute the sample among the strata in the most efficient manner.[3]

Generally it is necessary to have higher sampling intensity where the kill by

Table 3
Sandhill Crane survey estimates by date of hunting, 1975 and 1976

Date of hunting	Active hunters		Successful hunters		Kill/ active hunter		Kill/ successful hunter		Total kill		% of total kill
	Est.*	S.E.†	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.	
1975											
Sept. 1	1059	35	529	24	0.94	0.04	1.89	0.04	1001	46	32.8
Sept. 2	394	26	131	14	0.63	0.05	1.91	0.08	249	36	8.2
Sept. 3	381	26	131	13	0.65	0.06	1.89	0.10	246	26	8.1
Sept. 4	442	31	195	20	0.84	0.09	1.91	0.07	373	41	12.2
Sept. 5	438	30	163	18	0.89	0.08	2.40	0.08	390	52	12.8
Sept. 6	743	36	382	27	1.06	0.06	2.06	0.08	789	60	25.9
1976											
Sept. 1	853	44	440	28	1.19	0.06	2.30	0.06	1013	62	57.7
Sept. 2	451	37	177	15	0.87	0.06	2.22	0.09	392	34	22.3
Sept. 3	286	30	86	13	0.57	0.08	1.88	0.16	163	26	9.3
Sept. 4	290	38	88	19	0.52	0.17	1.72	0.05	152	47	8.7
Sept. 6	116	15	23	8	0.26	0.08	1.33	0.21	31	11	1.7
Sept. 7	89	13	6	3	0.08	0.03	1.24	0.14	7	3	0.4

*Estimate.
†Standard error of the estimate.

Table 4
Sandhill Crane survey estimates by provincial game management zone, 1975 and 1976

Year	GMZ	Active hunters		Successful hunters		Kill/ active hunter		Kill/ successful hunter		Total kill		% of total kill
		Est.*	S.E.†	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.	
1975	10	812	33	485	25	1.98	0.15	3.31	0.18	1606	120	52.7
	11	503	27	301	17	1.82	0.09	3.04	0.13	915	61	30.0
	12	174	24	98	18	1.54	0.26	2.71	0.34	267	55	8.8
	13	167	26	77	17	1.16	0.26	2.53	0.43	194	47	6.4
	19	37	10	13	4	0.62	0.15	1.76	0.26	23	7	0.8
	21	37	11	16	5	1.15	0.58	2.73	1.32	43	21	1.4
1976	10	636	35	331	23	1.44	0.08	2.77	0.09	918	65	52.2
	11	372	29	206	15	1.64	0.08	2.96	0.10	609	43	34.7
	12	98	24	25	7	0.59	0.16	2.34	0.50	57	18	3.2
	13	164	37	56	22	0.68	0.32	1.97	0.32	111	54	6.3
	19	61	12	24	8	0.54	0.17	1.39	0.20	33	12	1.9
	21	36	19	14	6	0.80	0.37	2.10	0.75	29	14	1.7

*Estimate.
†Standard error of the estimate.

[1]Unless otherwise indicated, permit refers to a Canada Migratory Game Bird Hunting Permit in this paper.
[2]Zone 2 was sampled only in the 1975 survey.
[3]In 1975, Neyman Allocation was used for zones 1 and 3. Zone 2 was arbitrarily sampled as follows: sample A, 1/5; sample B, 1/10; samples C and D, 50 hunters were selected in each because the sampling universes were small.

Table 5
Sandhill Crane survey response rates by zone and mailing wave

Year	Zone	Contacted	Response		Response rates, %		
			Wave 1	Wave 2	Wave 1	Wave 2	Waves 1 and 2
1974	1	610	391	—*	64.1	—*	64.1
	3	640	430	—*	67.2	—*	67.2
	Total	1250	821	—*	65.7	—*	65.7
1975	1	1102	669	228	60.7	20.7	81.4
	2	530	232	127	43.8	24.0	67.7
	3	2652	1567	540	59.1	20.4	79.4
	Total	4284	2468	895	57.6	20.9	78.5
1976	1	829	533	153	64.3	18.5	82.8
	3	2552	1534	495	60.1	19.4	79.5
	Total	3381	2067	648	61.1	19.2	80.3

*No follow-up was mailed.

individual hunters varies more, which usually occurs in strata where the kill is large. The single-wave 1974 survey showed that those who purchased a hunting permit in August and had purchased permits in previous years were more successful than those who purchased in September or had not purchased previously. Those who purchased in zone 3 were more successful than those who purchased in zone 1. These factors are reflected in the sampling intensities within each stratum (Table 1). For example, the sample sizes for zone 3 were generally larger than for zone 1. The sample sizes for those who purchased a permit in the previous year were larger than the sample sizes for those who did not.

Estimates by stratum of the numbers of active and successful hunters, the total kill, and the kill per potential, active, and successful hunter were produced along with their standard errors (Table 2). The mathematical formulae are given in Appendix 4. For 1975 and 1976 the results were also computed by date of hunting and provincial game management zone (Tables 3 and 4).

3.2 Processing of the data

The incoming questionnaires were checked manually for completeness and the data coded for computer input. A series of programs were written in BASIC and run on an HP9830. These programs (*a*) transferred the data to tape, (*b*) located and printed any hunter records that violated specified edit criteria so that corrections could be made (e.g. the sum of the harvest by date must equal the sum of the harvest by game management zone), (*c*) calculated estimates and standard errors, and (*d*) printed tables.

4. Results

4.1 Response rate

The 1974 survey had the lowest response rate of the three surveys (1974, 65.7%; 1975, 78.5%; 1976, 80.3%). The response rate to the first mailing was comparable in three years (Table 5) and the lower final rate in 1974 was apparently due to a lack of a second mailing. The response rate from zone 2 was significantly lower than that for both zone 1 ($\chi^2 = 36.9$, $d.f. = 1$, $P < 0.001$) and zone 3 ($\chi^2 = 34.1$, $d.f. = 1$, $P < 0.001$).

Response rates in zones 1 and 3 did not differ significantly ($\chi^2 = 1.73$, $d.f. = 1$, $P > 0.10$). Probably the response rate of zone 2 is depressed because hunters in that zone are not near the area where crane hunting is permitted during the special season.

4.2 Temporal distribution of the kill

In 1975, the greatest harvest was taken on opening day, when about 1000

Table 6
Frequency distribution of successful crane hunters

Kill of Sandhill Cranes	Number of responding hunters					
	1974		1975		1976	
	Sandhill*	National†	Sandhill	National	Sandhill	National
1	30	7	160	21	72	6
2	23	4	103	12	85	8
3	23	3	84	7	51	3
4	14	5	61	5	61	2
5	6	0	24	0	17	1
6	8	0	26	2	11	0
7	5	0	12	1	5	0
8	9	4	16	3	10	1
9	0	0	3	0	0	0
10	1	1	4	0	0	0
11	0	0	3	0	0	0
12	0	0	4	0	2	0
13	0	0	1	0	0	0
14	0	0	1	1	0	0
15	0	0	2	0	0	0
16	0	0	1	0	0	0
20	0	1	0	0	0	0
22	1	0	0	0	0	0
23	0	0	2	0	0	0
24	0	0	1	0	0	0
36	0	1	0	0	0	0
64	0	0	0	1	0	0
Sample kill	418	142	1641	207	929	52
Successful hunters in sample	120	26	508	53	314	21

*Sandhill Crane Survey.
†National Harvest Survey.

birds were killed (Table 3). The estimated harvest dropped to 249 on the second day, increased slowly to 390 on the fifth day, and then jumped to 789 on the last day.

In 1976, the kill was also greatest on opening day, when an estimated 1013 cranes were killed. On the second day, this dropped to 392, which was substantially higher than on the second day of 1975. The crane season was then terminated because of the presence of several Whooping Cranes. Some cranes were reported killed after the season was legally closed but the number of birds reported dropped dramatically. In the last two days of the season an estimated 38 birds were killed, compared with 1179 in 1975. The estimated seasonal kill decreased from 3048 in 1975 to 1758 in 1976.

4.3 Geographical distribution of kill

Provincial game management zone 10 is the principal crane hunting area (Table 4). Each year about one-half of the cranes were killed within its boundaries and about one-third in GMZ 11. The remaining one-sixth of the kill was concentrated in GMZ's 12 and 13 with very little kill reported in zones 19 and 21. Last Mountain Lake and its associated National Wildlife Area and Prairie Farm Rehabilitation Administration community pastures are the major staging areas for Sandhill Cranes in Saskatchewan (Stephen 1967). Our results emphasize that most cranes are killed there.

5. Comparison of surveys

The experimental Sandhill Crane survey sampled crane hunters with much higher frequency than did either the NHS or Saskatchewan surveys. In 1975, 38% of hunters buying permits before and during the special crane seasons were contacted. In 1976, when zone 2 hunters were omitted from the sample because they killed few cranes, the sampling intensity in zones 1 and 3 was much higher (60%). The Saskatchewan government surveys contacted approximately 30% of all game bird hunters, including crane hunters, while the NHS was much lower at only 9% (5474 questionnaires delivered out of 61 669 permits sold). The NHS resulted in extrapolation factors ranging from about 25 to 50, depending on the stratum. The experimental Sandhill Crane survey, because of more intense sampling and high response rate, had extrapolation factors of 1.5 to 3 for strata in which the kill was high.

A small sample of hunters will provide a less accurate estimate of total kill than a larger sample. The problem is increased if the distribution of kill is skewed, that is to say if a few hunters have very large kills. For example, if a respondent to the Sandhill Crane survey reported killing 20 cranes and had an extrapolation factor of 3, he

alone would contribute 60 cranes to the total. In the NHS, the same hunter might have an extrapolation factor of 50, and would contribute 1000 cranes to the kill estimate. As only a few crane hunters would be in the NHS sample, such outliers would likely result in a large over-estimate of the crane kill. For example, in 1975 out of 53 hunters who reported killing cranes, one reported killing 64 (Table 6), which accounted for 31% of the total reported kill.

The response rate of the experimental survey, which was approximately 66% in 1974, and 80% in both 1975 and 1976, was much higher than that achieved in either the Saskatchewan government survey which was 25% in 1975 (Ross 1976) and 22% in 1976 (Government of Saskatchewan 1977), or in the NHS in Saskatchewan which was 53% (Cooch 1976) and 46% in 1976 (Cooch, Newell, and Wendt 1978).

Low response rates from hunter surveys generally result in over-estimates of harvest because non-respondents tend to be less active and less successful hunters than respondents (Sen 1970, Filion 1974, 1975–76). The addition of a follow-up questionnaire in this experimental crane survey reduced the estimate of total kill by 3% in 1975 and 6% in 1976 (Table 7). Estimates of the numbers of active and successful hunters were also reduced. Non-response bias was also reduced by the use of a stratified rather than random sampling scheme.

If the sample had been chosen randomly from the three zones, there would have been an upward bias in the total kill of about 4% (Table 8). If, in addition, there had been no second mailing, the upward bias would have been approximately 10% (Tables 9, 10). Sampling biases and non-response biases in the NHS and Saskatchewan government survey were likely greater than in the experimental crane survey since sampling intensities and response rates were lower and the stratification of the sample less detailed.

Response bias will exist in a harvest survey if respondents supply erroneous

Table 7
Effect of a second mailing (wave) of questionnaires on estimates from the special Sandhill Crane survey

	1975		1976	
	Est.	S.E.	Est.	S.E.
Kill of Sandhill Cranes				
a) based on wave 1	3130	188	1870	127
b) based on wave 2	2690	370	1383*	194
c) based on both waves	3048	154	1757	97
% decreased from a to c	2.6		6.0	
Number of active hunters				
a) based on wave 1	1571	64	1271	75
b) based on wave 2	1473	109	987*	111
c) based on both waves	1557	51	1202	61
% decreased from a to c	0.9		5.4	
Number of successful hunters				
a) based on wave 1	999	47	684	47
b) based on wave 2	859	82	522*	65
c) based on both waves	969	37	648	36
% decreased from a to c	3.0		5.3	

*The estimate based on wave 2 was significantly less ($P < 0.05$) than that based on wave 1.

Table 8
Estimates of total kill of Sandhill Cranes assuming the absence of zonal stratification (i.e. random over zones, sampling fraction = 1/p)*

	From actual survey			Assuming a random sample	
Zone	No. potential hunters	Estimated kill	Response rate	No. respondents†	Kill reported by respondents ‡
1	3767	653	0.814	3066/p	532/p
2	3755	80	0.677	2542/p	54/p
3	4367	2316	0.794	3467/p	1839/p
Total	11 889	3048		9075/p	2425/p

$$\text{Kill} = \frac{2425/p}{9075/p} \times 11\,899 = 3177$$

*Data obtained from Tables 2 and 5.

†No. of respondents = $\frac{\text{no. of potential hunters} \times \text{response rate}}{\text{proportion of hunters sampled}}$

‡Kill reported by respondents = $\frac{\text{response rate} \times \text{estimated kill}}{\text{proportion of hunters sampled}}$

information either deliberately or because of misinterpretation of the questions or memory failure. As with most surveys, it was not possible to measure response bias in the Sandhill Crane survey since this requires a knowledge of the true situation. However, the replies of hunters who reported killing at least one crane in the NHS and who also responded to the Sandhill Crane survey were compared. Of the 19 hunters in 1975 whose responses were compared, only three did not give the same answer to both surveys. The 19 hunters reported killing 64 cranes in the NHS and 67 in the Sandhill Crane survey. In 1976, seven successful crane hunters responded to both surveys. Of these, four responded differently. The sum of their reported kill was 20 in the Sandhill Crane survey and 24 in the NHS. Neither difference was statistically significant, (t-test for paired comparison, $P > 0.05$). There is reason to expect that people will report more cranes in the NHS since the time period is not restricted to the special crane season. For example, in 1974, 8% of the total estimated kill for Saskatchewan was reported by hunters who purchased their permit after the close of the special season. In 1975 this figure climbed to 11%. In addition, hunters may report cranes killed under a crop depredation permit in the NHS. The Saskatchewan government survey should also have slightly higher estimates since it also is not restricted to the special season.

The estimates of the Sandhill Crane kill obtained from the NHS, the Sandhill Crane survey, and the Saskatchewan government survey differ greatly (Table 11). The standard errors of the estimates obtained from the Sandhill Crane survey were much less than those of the NHS in each year. The Sandhill Crane survey estimates are thus more precise. No standard errors were presented for the Saskatchewan government surveys (Ross 1976, Government of Saskatchewan 1977) and it is therefore impossible to assess their statistical precision. In 1974 and 1975 the estimates of the kill obtained from the Sandhill Crane survey were approximately half of those of the NHS (Table 11). In 1974 the Saskatchewan government survey estimate of 2900 cranes killed approximated the value obtained from the Sandhill Crane survey. In 1975 the Saskatchewan government estimate of 3703 was about 700 higher than the Sandhill Crane survey. In 1976 the NHS had the lowest estimate (1426). The Saskatchewan government survey estimate was nearly double this value (2734) while the Sandhill Crane survey estimate was 1757.

Estimates of the Sandhill Crane kill in each game management zone as determined by the Sandhill Crane survey and the Saskatchewan government survey in 1975 and 1976 are compared in Table 12.

Table 9
Estimates of total kill of Sandhill Cranes assuming the absence of zonal stratification and the second wave of questionnaires (sampling fraction = 1/p) *

	From 1st wave of actual survey			Assuming a random sample	
Zone	No. potential hunters	Estimated kill	Response rate	No. respondents †	Kill reported by respondents ‡
1	3767	727	.607	2287/p	441/p
2	3755	115	.438	1645/p	50/p
3	4367	2289	.591	2581/p	1353/p
Total	11 889	3130		6513/p	1844/p

$$\text{Kill} = \frac{1844/p}{6513/p} \times 11\,889 = 3366$$

*Data obtained from Tables 2, 5, and 8.

†No. of respondents = $\frac{\text{no. of potential hunters} \times \text{response rate}}{\text{proportion of hunters sampled}}$

‡Kill reported by respondents = $\frac{\text{response rate} \times \text{estimated kill}}{\text{proportion of hunters sampled}}$

Table 10
Non-response biases inherent in simpler designs of the Sandhill Crane survey (using 1975 data) (summarizes Tables 8 and 9).

Follow-up	Stratification by zone of purchase	Estimate of kill *	Bias, % †
no	no	3366	10.4
yes	no	3177	4.2
no	yes	3130	2.7
yes	yes	3048	0

* Estimates assume simpler designs.

† Biases are measured relative to the implemented design. Since the response rate was not 100%, the true biases will be somewhat larger.

Both surveys showed GMZ 10 to be the area of highest kill with GMZ 11 being second in importance. The Sandhill Crane survey showed that there was some kill in zones 19 and 21 which was not reported by the Saskatchewan government survey.

6. Conclusions and implications

The Sandhill Crane harvests during the Saskatchewan special crane seasons in 1974, 1975, and 1976 are most accurately represented by the Sandhill Crane survey. Clearly in 1974 and 1975 the NHS seriously over-estimated the crane kill, yielding results almost twice those of the experimental survey. The results of Saskatchewan government surveys were higher than those for the Sandhill Crane survey in both 1975 and 1976, but were approximately the same in 1974.

Reliable estimates of harvest become critical in the case of a species such as the Sandhill Crane which has a low reproductive potential, a long migration route, and for which we have poor estimates of the population size and annual recruitment rate. In 1975 both Canada and the United States (Sorensen and Reeves 1976) conducted special Sandhill Crane surveys, using different sampling frames. The pooled results indicate a harvest of the Central Flyway populations of approximately 12 600 birds, substantially lower than the

Table 11
Comparison of Sandhill Crane, National Harvest and Saskatchewan surveys

		Successful crane hunters				Crane harvest					Kill/successful hunter			
		Sandhill†		National‡	Sask.§	Sandhill		National		Sask.	Sandhill		National	Sask.
Year	Zone*	Est.	S.E.	Est.	Est.	Est.	S.E.	Est.	S.E.	Est.	Est.	S.E.	Est.	Est.
1974	1	250	40	231		594	124	918	440		2.38	0.34	3.97	
	2‖	—	—	50		—	—	115	151		—	—	3.00	
	3	659	54	900		2548	281	5571	2133		3.86	0.31	6.19	
	Total	909	67	1181	1000	3142	308	6641	2183	2900	3.46	0.24	5.62	2.9
1975	1	248	27	419		652	84	1045	335		2.63	0.21	2.49	
	2	16	11	0		80	68	0	—		5.00	#	—	
	3	705	23	1158		2316	110	4955	2008		3.29	0.09	4.28	
	Total	969	37	1578	1424	3048	154	6000	2035	3703	3.15	0.11	3.80	2.6
1976	1	138	25	126		325	67	270	156		2.35	0.22	2.23	
	2‖	—	—	55		—	—	53	41		—	—	1.00	
	3	509	26	461		1432	70	1102	340		2.81	0.07	2.51	
	Total	648	36	643	804	1757	97	1426	376	2734	2.71	0.07	2.33	3.4

*The zones are the geographic divisions for sampling purposes of the National Harvest and Sandhill Crane surveys. Hence, they have no relevance to the Saskatchewan government survey.
†Sandhill Crane survey.
‡National Harvest Survey.
§Saskatchewan government survey.
‖Zone 2 was not sampled for the Sandhill Crane survey.
#Standard errors based on fewer than 3 observations are not given for the Sandhill Crane survey.

estimate of 17 600 given by the sum of the estimates from the U.S. and Canadian national harvest surveys. In 1976 special surveys indicated a harvest of about 9000, again lower than that of 9700 estimated from the national surveys. (The estimates for the U.S. surveys are given by Sorensen 1977.) Whether these reductions in estimates of kill eliminate the need for anxiety about the impact of hunting on crane survival is a question that can only be resolved with the help of much additional information on population size and recruitment. Similarly, until such information is available, it would be rash to encourage any great increase in crane hunting in Saskatchewan.

Table 12
Comparison of geographic distribution of kill in 1975 and 1976, as measured by the Sandhill Crane survey and the Saskatchewan government survey

		Sandhill Crane survey			Sask. govt. survey	
Year	GMZ	Est.*	S.E.†	%	Est.	%
1975	10	1606	120	52.7	2139	57.7
	11	915	61	30.0	1149	31.0
	12	267	55	8.8	287	7.8
	13	194	47	6.4	128	3.5
	19	23	7	0.8	0	0.0
	21	43	21	1.4	0	0.0
	Total	3048	154	100.0	3703	100.0
1976	10	918	65	52.2	1273	46.5
	11	609	43	34.7	1169	42.8
	12	57	18	3.2	188	6.9
	13	111	54	6.3	104	3.8
	19	33	12	1.9	0	0.0
	21	29	14	1.7	0	0.0
	Total	1757	97	100.0	2734	100.0

*Estimate.
†Standard error of the estimate.

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Appendix 1
Text of the Special Saskatchewan Sandhill Crane Survey for the 1974 season mailed by CWS to Saskatchewan residents who purchased a Canada Migratory Game Bird Hunting Permit before the close of the Sandhill Crane season

Special Saskatchewan Sandhill Crane Survey 1974 Season

Please complete and mail this short questionnaire even if you did not hunt cranes in 1974.

1. Did you hunt Sandhill Cranes during the special open season for that species, September 2–7, 1974?

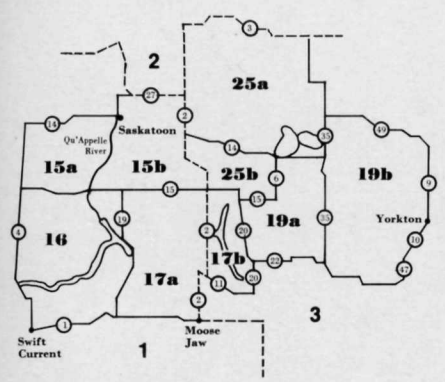
yes ☐ no ☐

2a. If "yes", refer to the map below. Please circle the number of the Provincial Game Management Zone(s) in which you hunted, and

b. please write in the number of Sandhill Cranes which you shot in each zone in which you hunted.

3. For how many years have you hunted cranes during the special season?

1 year ☐ 3 years ☐
2 years ☐ More than 3 years ☐



① Highway no. 0 NHS Zone
00 Game Management Zone.

Appendix 2
Text of the Special Saskatchewan Sandhill Crane Survey for the 1975 season mailed by CWS to Saskatchewan residents who purchased a Canada Migratory Game Bird Hunting Permit before the close of the Sandhill Crane season

Special Saskatchewan Sandhill Crane Survey 1975 Season

Please complete and mail this short questionnaire. If you did not hunt cranes in 1975, please answer the first question and mail the questionnaire.

1. Did you hunt Sandhill Cranes during the special open season September 1–6, 1975?

yes ☐ no ☐

2. Please write the number of cranes you killed and retrieved each day you hunted in the spaces below. Please put a check (√) for a day when you hunted but killed nothing.

Sandhill Crane Season

Mon. Sept. 1	Tue. Sept. 2	Wed. Sept. 3	Thurs. Sept. 4	Fri. Sept. 5	Sat. Sept. 6

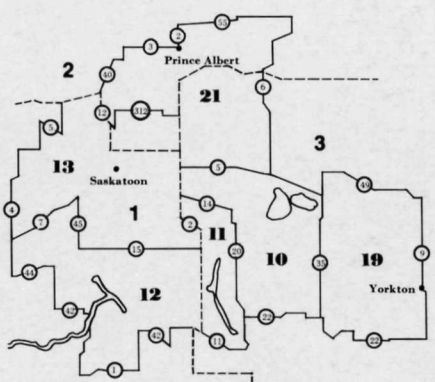
3. Please indicate the number of cranes you killed and retrieved in each Game Management Zone (GMZ) in the spaces below. Please put a check (√) for a zone where you hunted but killed nothing. (For your convenience the map shows where the zones are.)

Sandhill Crane Hunting Zones

GMZ 10	GMZ 11	GMZ 12	GMZ 13	GMZ 19	GMZ 21

4. In which years did you hunt cranes?

1974 ☐ 1971 ☐
1973 ☐ Earlier ☐
1972 ☐



① Highway no. 0 NHS Zone
00 Game Management Zone.

Appendix 3
Text of the Special Saskatchewan Sandhill Crane Survey for the 1976 season mailed by CWS to Saskatchewan residents who purchased a Canada Migratory Game Bird Hunting Permit before the close of the Sandhill Crane season

Special Saskatchewan Sandhill Crane Survey 1976 Season

Please complete and mail this short questionnaire. Even if you did not hunt cranes in 1976, please answer the first question and mail the questionnaire.

1. Did you hunt Sandhill Cranes during the special open season September 1–7, 1976?

yes ☐ no ☐

2. Please write the number of cranes you killed and retrieved each day you hunted in the spaces below. Please put a check (√) for a day when you hunted but killed nothing.

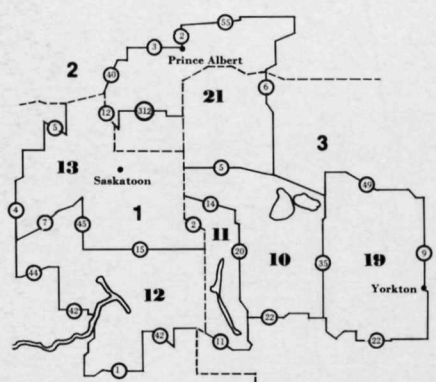
Sandhill Crane Season

Wed. Sept. 1	Thurs. Sept. 2	Fri. Sept. 3	Sat. Sept. 4	Mon. Sept. 6	Tues. Sept. 7

3. Please indicate the number of cranes you killed and retrieved in each Game Management Zone (GMZ) in the spaces below. Please put a check (√) for a zone where you hunted but killed nothing. (For your convenience the map shows where the zones are.)

Sandhill Crane Hunting Zones

GMZ 10	GMZ 11	GMZ 12	GMZ 13	GMZ 19	GMZ 21



① Highway no. 0 NHS Zone
00 Game Management Zone.

Appendix 4
Formulas used for estimates and standard errors

The formulas used to calculate the estimates and their standard errors follow. The derivations are given in Smith (In press).

Let i = stratum (combination of month and zone of purchase, and renewal status)
N_i = permit sales in stratum i
n_i = no. survey respondents in stratum i
m_i = no. responding hunters in stratum i who were active
t_i = no. responding hunters in stratum i who were successful
x_{ij} = no. cranes killed by the j^{th} responding hunter in stratum i
$x_{i\cdot} = \sum_j x_{ij}$

The extrapolation factor, i.e. the number of hunters represented by each respondent, for stratum i is $e_i = N_i/n_i$

1. Estimation of totals

The estimator of the total for any variable is formed by adding the products of the extrapolation factor and the value of the variable for each hunter. The estimator of total kill, X, is

$$\hat{X} = \sum_i \sum_j e_i x_{ij}$$

of the number of active hunters is

$$\hat{M} = \sum_i e_i m_i$$

and of the number of successful hunters is

$$\hat{T} = \sum_i e_i t_i.$$

The variances of these quantities are estimated respectively by

$$\text{var } \hat{X} = \sum_i f_i n_i e_i^2 (s_i - x_{i\cdot}^2/n_i)/(n_i - 1)$$

where $s_i = \sum_j x_{ij}^2$

and $f_i = 1 - n_i/N_i$ is the finite population correction;

$$\text{var } \hat{M} = \sum_i f_i e_i^2 m_i (n_i - m_i)/(n_i - 1)$$

and $$\text{var } \hat{T} = \sum_i f_i e_i^2 t_i (n_i - t_i)/(n_i - 1)$$

Finally, the number of potential hunters is known exactly from the permit sales. It is $N = \sum_i N_i$ or alternatively, $N = \sum_i e_i n_i$. Its variance is zero.

2. Estimation of means

The estimator of kill per potential hunter is $\hat{X}/N$ with a variance estimated by

$$\text{var } (\hat{X}/N) = N^{-2} \text{ var } \hat{X}$$

The estimators for kill per active hunter and kill per successful hunter are respectively $\hat{X}/\hat{M}$ and $\hat{X}/\hat{T}$. The expressions for the variances of these quantities are more complex than for $\hat{X}/N$, since the denominators are now random variables instead of being known exactly. This results in the following estimators:

$$\text{var } (\hat{X}/\hat{M}) =$$

$$\hat{M}^{-2} \sum_i \frac{e_i^2}{m_i} f_i \left[1 + \frac{f_i}{m_i}\left(1 - \frac{m_i}{n_i}\right)\right] \frac{s_i - x_i^2/m_i}{m_i - 1}$$

$$\frac{s_i - x_i^{-2}/m_i}{m_i - 1}$$

var $(\hat{X}/\hat{T})$ is given by the above expression but with $\hat{M}$ and m_i replaced by $\hat{T}$ and t_i respectively.

3. Estimation for subpopulations

Estimators and their variances for subpopulations such as GMZ's or dates of hunting may be readily obtained by modifying the definitions of m_i, t_i, and x_{ij} to refer only to the subpopulation of interest. For example, if this subpopulation is those who hunted in GMZ 10, then

m_i = no. responding hunters in stratum i who were active in GMZ 10
t_i = no. responding hunters in stratum i who were successful in GMZ 10
x_{ij} = no. cranes killed in GMZ 10 by the j^{th} hunter in stratum i.

s_i will be changed accordingly. Then the above formulas for estimators and variances apply. The standard error is simply the square root of the variance.

Conclusion

The role of harvest surveys in managing the exploitation of waterfowl in Canada

by H. Boyd

Perhaps the greatest merit of the waterfowl harvest surveys now being carried out in the United States and Canada is that they tell us more about hunters than about waterfowl. By "us" I mean initially, though not most importantly, public servants such as myself who have some responsibility as managers but who suffer from the ineradicable weaknesses of being interested in birds and having been trained as biologists. As recently as seven years ago, when the Government of Canada, following the fashion of the day, created a Department of the Environment, it was possible for us to think that the day of the biologist had arrived. We should have known better. "The age of chivalry is gone. That of sophisters, economists and calculators has succeeded." That remark by Edmund Burke, made about 1792, has gained fresh currency in the 1970's as environmental concerns have been pushed aside by economic upheavals. The changed emphasis in government now requires us to look on waterfowl and other forms of wildlife primarily as renewable resources to be exploited, that is as components of economic, rather than ecological, systems. We are ill-prepared to do so, partly because until very recently one of the characteristics of waterfowl management was that it dealt with a resource of little apparent cash value. Not being propelled by market considerations, waterfowl management has been very slow to develop, in theory even more than in practice, a leisurely field for people with a fondness for outdoor life. We have been toying with adopting the concepts of fisheries management and were recently startled to read "An epitaph for the concept of maximum sustained yield" (Larkin 1977). I suppose we would have turned next to some adaptation of predator-prey theory, in belated pursuit of the pioneering exercises by Holling (1965) and Watt (1968). Now we are required to find some economic or sociological apparatus to give our work "relevance".

By serendipity what we have been doing with the harvest surveys since 1976 provides some splendid raw material for this necessary descent into non-science. As some of the earlier papers in this volume record, we already have a lot of data on who is doing what to whom, where, and how often. What we now have to do is to see whether this cottage industry can be modernized and identified as a significant contributor, if not to gross national product, at least to some other fashionable economic indicator. Given the emphasis being put on "contracting out" research from government to industry wherever possible (and our own preference for biology), it may be prudent to farm out that aspect of our commerce with birds to appropriate specialists in identifying bucks, following their movements, and stimulating their circulation.

Meanwhile the waterfowl harvest surveys also feed the population biologists with facts, albeit fewer and much less precise than they would like to have, in order to monitor the ebbs and flows of the stocks of those species commonly shot by hunters. About the species infrequently taken the surveys have little to say, so that information about the welfare of scarce species must be sought in other ways.

The harvest survey results that have received most attention deal with the major quarry species. The U.S. Fish and Wildlife Service has recently devoted intensive research to the population ecology of the Mallard, including identifying subpopulations; differentiating their breeding, staging, and wintering areas; and measuring their productivity (Anderson and Henny 1972; Pospahala, Anderson, and Henny 1974); describing hunter activity (Martin and Carney 1977); estimating survival and harvest rates (Anderson 1975); and exploring in detail various hypotheses about the effects of exploitation on survival (Anderson and Burnham 1976). That massive investigation has led to important advances in understanding but it is very discouraging about the amounts of data required to provide reliable estimates of some key parameters in the models being used. A study based on 400 000 recoveries from 3 million banded birds, which concludes (Anderson 1975) that for most necessary purposes not enough banding has yet been done in most areas, must go a long way to quench enthusiasm for banding as a tool for research or monitoring. Great technical advances have been made in the use of stochastic methods of estimating survival (Brownie *et al.* 1978). Earlier deterministic models and methods (e.g. those of Bellrose and Chase 1950 and Hickey 1952) have been discredited as seriously biased and inefficient. Yet the estimators that are proposed to replace them, though more intellectually respectable, seem to be no more useful. For example, a precise estimate of mean survival over five years is of little help if (*a*) it requires the expensive banding of tens of thousands of birds a year to provide sufficient recoveries or if (*b*) adult survival is liable to vary widely and erratically from year to year or to be much affected by the age structure of the stock, as seems to be the case for several northern-nesting geese.

It will not be possible for more than one or two intensive large-scale investigations to be pursued by the Canadian Wildlife Service (CWS) at any one time in the foreseeable future, because of scarcity of funds and manpower. This makes it important to be careful in selecting those problems to be studied in expensive ways. It also makes it essential to develop approaches to research and monitoring for management purposes that require few resources. The harvest surveys are of special interest in that respect, as they provide geographically broad information relatively cheaply. It is a little discouraging that some of the investigations reported earlier in this volume (e.g. those on the Gadwall and American Wigeon, and on the Black Duck) which were, in part, intended to see whether the Species Composition Survey could provide useful indices of population size and annual productivity, have so far yielded largely negative results in those directions. It is, of course, far too

early to abandon such attempts, both because the run of years is still very short and because the methods of analyzing the data are still in their infancy. We intend to pursue many more investigations in the next few years, if the resources to continue the surveys are sustained at the necessary level.

One of the reasons why the analytical results have so far been largely inconclusive is, very probably, because the existing approach to limiting waterfowl hunting by regulations is a very conservative one. It is true that season lengths and bag limits are nearly all much less than they were 40 or 50 years ago. It may perhaps be true that this restraint has helped to maintain waterfowl stocks. But it is hard to be sure of that, while the changes that are being made are so minor that their effects are unlikely to be clearly distinguishable from the effects of the many other factors that are likely to affect the size of the kill from year to year and place to place.

We are entering a period in which managers, both in Canada and the United States, intend to make as few changes as possible in waterfowl hunting regulations, while the biologists in both countries try to learn more about causes of population change other than sport hunting, and while administrators try to reach agreement on management objectives and goals, nationally and for North America as a whole. It should not be assumed that this emphasis on stabilizing regulations diminishes the importance of squeezing as much information as possible from the data contributed by hunters responding to the national harvest surveys. The opposite is true: by reducing the variation in one of the few factors under some human control, steady regulations should improve our understanding of the impact of other factors.

What CWS has to do in the next few years, in collaboration with the provinces and with the federal and state governments of the United States and Mexico, is to learn how to manage, with very meagre resources, the simultaneous exploitation of a lot of species over a whole continent. Such a task is far more demanding than "single-species" management. Fortunately, the birds themselves are for the most part sufficiently adaptable to be able to cope with changes in hunting intensity without irreversible harm, even if the responsible agencies make mistakes, as they certainly will continue to do. What is much less certain is whether waterfowl can continue to cope with the deterioration of their environment, whether by the intensification of agriculture on the Canadian prairies or the further degradation of coastal marshes and river systems. To help them in that battle requires of the harvest surveys that they yield information not about hunting but about breeding numbers and success. To extract relevant "signals" from the "noise" of hunting surveys will be an exciting challenge indeed.

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Glossary

Scientific names of species mentioned in text. The order of listing follows the American Ornithological Union Check-list.

PELECANIFORMES
Double-crested Cormorant, *Phalacrocorax auritus*

ANSERIFORMES
Whistling Swan, *Olor columbianus*
Canada Goose, *Branta canadensis*
Brant, *Branta bernicla*
White-fronted Goose, *Anser albifrons*
Snow Goose (includes Blue Goose), *Anser caerulescens*
Ross' Goose, *Anser rossii*
Mallard, *Anas platyrhynchos*
American Black Duck, *Anas rubripes*
Gadwall, *Anas strepera*
American Wigeon, *Anas americana*
Common Pintail, *Anas acuta*
Green-winged Teal, *Anas crecca*
Blue-winged Teal, *Anas discors*
Northern Shoveler, *Anas clypeata*
Wood Duck, *Aix sponsa*
Redhead, *Aythya americana*
Ring-necked Duck, *Aythya collaris*
Canvasback, *Aythya valisineria*
Greater Scaup, *Aythya marila*
Lesser Scaup, *Aythya affinis*
Common Goldeneye, *Bucephala clangula*
Barrow's Goldeneye, *Bucephala islandica*
Bufflehead, *Bucephala albeola*
Oldsquaw, *Clangula hyemalis*
Common Eider, *Somateria mollissima*
White-winged Scoter, *Melanitta deglandi*
Surf Scoter, *Melanitta perspicillata*
Black Scoter, *Melanitta nigra*
Hooded Merganser, *Lophodytes cucullatus*
Common Merganser, *Mergus merganser*
Red-breasted Merganser, *Mergus serrator*

GRUIFORMES
Whooping Crane, *Grus americana*
Sandhill Crane, *Grus canadensis*
Common Gallinule, *Gallinula chloropus*
American Coot, *Fulica americana*

CHARADRIIFORMES
Greater Yellowlegs, *Tringa melanoleuca*
Lesser Yellowlegs, *Tringa flavipes*
American Woodcock, *Philohela minor*
Common Snipe, *Capella gallinago*

COLUMBIFORMES
Band-tailed Pigeon, *Columba fasciata*
Rock Dove, *Columba livia*
Mourning Dove, *Zenaida macroura*

PASSERIFORMES
Snow Bunting, *Plectrophenax nivalis*

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