Edited by
Anthony J. Erskine

Waterfowl breeding population surveys, Atlantic Provinces

Occasional Paper
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Erratum

Page 37, Figure 1. The following line was omitted from the key :

▲ Sample sites during 1978 and 1979 surveys

Environment Canada | Environnement Canada
Canadian Wildlife Service | Service canadien de la faune

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Dedication

I dedicate this compendium to the memories of *the late George F. Boyer (1916–60)* and *the late Charles O. Bartlett (1922–77)*, whose work as biologists with the Canadian Wildlife Service in the Atlantic Region has been an enduring stimulus for those of us who followed later.

Note on reviewing

The entire manuscript was read in draft by CWS editors and by Jerry Longcore, United States Fish and Wildlife Service, whose comments guided the preparation of the final version.

Contents

Introduction

Surveys of waterfowl breeding in the Atlantic Region extend over 50 years, but the amount of information actually published to date is regrettably small. The earliest work was largely exploratory, and was carried out by the Bureau of Biological Survey — renamed the United States Fish and Wildlife Service (USFWS) in 1940 — which became concerned over the decrease in the number of prairie ducks during the droughts of the 1930s. Their work was mainly concerned with finding new sources of ducks. Biologists from the United States visited the Maritimes, and later Newfoundland, every year starting in 1935 to examine and discuss with local people the waterfowl situation in those areas. After World War II, duck numbers appeared to decrease again while hunting increased. Concern over this situation progressed to the point where surveys were mounted to monitor year-to-year changes in waterfowl populations. Methodology crystallized very slowly, and was seldom spelled out explicitly, so results were rarely comparable or reproducible. Disillusionment with monitoring efforts spread, as did efforts towards obtaining actual population estimates, but the latter were hampered by lack of a region-wide basis for extrapolation. The Canada Land Inventory (CLI) provided a rating of wetland capability for waterfowl production, but it was unacceptably weak in classifying coastal wetlands, and it did not receive general acceptance even for the purposes for which it was better suited. In the late 1970s pressure for waterfowl population estimates was renewed; development of a waterfowl management plan required a clearer picture of the resources to be managed. For the first time in this Region, and possibly Canada, the need for such a picture was matched by a usable (though imperfect) data base and the willingness to extrapolate from it. As expected, the results provoked more questions than they provided answers, but nonetheless fully justified the effort.

The purpose of this compilation of papers is to set out some of the more comprehensive waterfowl survey results which contributed to the regional population estimates. Some of these papers have circulated in unpublished form for years while others arose from recently completed studies. To round out the picture, I have provided one or more paragraphs to introduce some of the papers and place them in context. Some of these commentaries, the first in particular, are brief historical summaries showing how the Canadian Wildlife Service (CWS) and waterfowl surveys in the Region developed together. Perspectives change with time, and I hope that it is possible to be critical of the thinking behind some of the early work without disparaging its quality. I have built on past work wherever possible, and can only regret that so much of the work escaped unrecorded and unanalysed. This publication should help both to record what was done and to plan future work.

The early period

Reconnaissance, 1935–47

From its establishment in 1919 until 1932, the work of the Migratory Bird Protection Section of National Parks Branch (Canada) was largely devoted to enforcement and education, and any surveys that were made were exploratory. The annual visits by biologists or technicians of the USFWS focused mainly on areas of waterfowl concentration, although other game and water birds received attention in the unpublished reports by Hotchkiss and Brackett, Boswell and Atkinson, and Harold S. Peters in particular. Peters visited the Atlantic Region, often including Newfoundland (*cf.* Peters and Burleigh 1951), every year from 1937 through 1947, and surveyed many of the same areas each year. His reports contained many statements about populations having increased or decreased between years, but it is clear that such conclusions were based largely on impressions. No data exist to indicate that his waterfowl surveys were standardized as to date, method, or intensity of coverage, or that reconnaissance was widespread. Most fieldwork was carried out in the St. John River marshes, the coastal marshes near Tabusintac, the NS–NB border marshes, scattered wetlands in central PEI, marshes around the Minas Basin, and wetlands near Halifax, these being the areas known to be promising for waterfowl hunting. That early period ended in 1947, the year in which the Canadian Wildlife Service (originally called Dominion Wildlife Service) was formally established. In that year, Peters made his last trip to the northeast, and Robie Tufts, Chief Migratory Birds Officer for the Maritimes since 1919, retired, so the next period began with new people and new objectives.

Exploratory surveys and monitoring, 1948–63

Late in 1947, the newly appointed Wildlife Management Biologist, the late George F. (Joe) Boyer, set up his office in Sackville, NB, centrally located within the Maritimes and adjacent to the extensive NS–NB border marshes. Pressure of inter-provincial jealousy led to the establishment of a second CWS office in Truro, NS, where Harry Webster and subsequently Brian Carter were based from 1949 to 1953. Newfoundland's union with Canada in 1949 resulted in the establishment of another office in St. John's, where Leslie Tuck was responsible for migratory birds. Meanwhile, visits by the Atlantic Flyway Biologist of the USFWS, C.E. (Ed) Addy, resumed in 1949, when the USFWS engaged aircraft for surveys and reconnaissance. The increased manpower and resources made more extensive surveys possible, and the need for standardized, comparable surveys was emphasized in the first report (Addy *et al.* 1949).

Despite those hopes, the next report expressed doubts about comparability of even those surveys that were repeated, because of variation in survey dates between years (Addy *et al.* 1950), and that difficulty persisted throughout the period. Part of the problem undoubtedly stemmed from dissatisfaction with the meagre results obtained, whether surveys had been made from the air or on the ground, because many areas were not surveyed annually. Travel even by paved roads was much slower then than in the 1970s, so time spent in reconnaissance of new areas interfered with repeating former surveys on comparable dates. Perhaps more important was the dissipation of effort because too many responsibilities were assigned to the available staff. A reconstruction of Boyer's work schedule for 1952 showed that between mid-April and late October he was in the field almost continuously, working successively on woodcock population surveys, snipe habitat, waterfowl population surveys, monitoring effects of spruce budworm sprays on bird and other vertebrate populations, waterfowl banding with retrievers and by bait-trapping, merganser banding along rivers, and hunter bag-checking, in areas scattered from the Upsalquitch River in northern NB to the Yarmouth County marshes in southern NS. Few studies, or even detailed reports, were published in that period, as in-depth study was almost impossible, and reproducible results were more of an ideal than an objective.

One fairly standardized survey was maintained through that period in the St. John River marshes of New Brunswick by the Northeastern Wildlife Station (NEWS), headed by the late Bruce S. Wright. This was set up in 1945 under sponsorship of Ducks Unlimited, and was continued by the Wildlife Management Institute (Washington, DC) from 1947, after Wright's initial findings had suggested that overhunting was responsible for observed declines in duck numbers. The initial reconnaissance conducted in 1945 extended into the St. Lawrence valley of Quebec, and in succeeding years into Ungava and Labrador, but gradually the work became concentrated in central New Brunswick. Between 1947 and 1951, duck-banding stations were operated under NEWS sponsorship at Baie Johan Beetz, Quebec; Tinker Harbour, Labrador; and Grand Codroy, Newfoundland (*cf.* Addy 1953). However, the longest series of data came from the summer waterfowl production survey in the St. John marshes, begun in 1945 and continued until the mid-1960s. In the first years, the same observers (Brian Carter and Donald Reid) were involved each year, so coverage was reasonably standardized, but this was not the case later when the survey was assigned to students who changed every year or two.

After 1954, the USFWS concluded that waterfowl numbers in the Maritimes did not warrant their time, and they redirected their efforts northward into Quebec and Labrador (*cf.* Chamberlain and Kaczynski 1965). CWS personnel continued some of the Maritimes surveys, but they realised increasingly that data from any one area could not necessarily represent the rest of the region. With this recognition came an emphasis on intensive coverage of more restricted areas, with hopes of estimating total populations and of understanding better the relationships of the birds with their environment. The first two papers in this collection arose from that stage in the evolution of waterfowl surveys.

The author of the first paper, the late C.O. (Charlie) Bartlett, came to CWS in 1956. His 1957 fieldwork included previously surveyed areas on PEI, and from that time on his work was increasingly focused there, with emphasis on population surveys and banding. The first paper is a condensed and edited version of his final report before he left the Service in 1963. At that time he expected to continue the study, with support from the provincial government, and eventual publication, but other matters intervened. He died in 1977.

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I. Black Duck populations in Prince Edward Island, 1958–62

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1. Abstract

A study of waterfowl populations on Prince Edward Island in 1958–62 showed that Black Ducks predominated in the breeding season (44% of spring adults, 46% of broods), and Blue-winged Teals were second. Most ducks were reared on the fresh and brackish portions of the short river systems characteristic of the island; two fresh ponds produced 18 broods/km^2, and a brackish tidal marsh and three barrier-beach ponds produced 5–7 broods/km^2, averaged over 3–5 years. Production varied, declining from 1958 to 1961 but with some recovery in 1962. Chronology also varied, with 50% of successful nests having been started by 15 April in 1958 but only by 23 May in 1961. Locally reared Black Ducks were hunted intensively in the breeding areas, 81% of all band recoveries being made locally during the first two weeks of the hunting season. Survivors departed in late October, migrating coastally through Nova Scotia and Massachusetts as far as Delaware. From 5000 to 9000 Black Ducks wintered on Prince Edward Island, with up to 2000 frequenting Moore's Sanctuary where over 3000 were banded in 1952–62. Band recoveries and sightings of colour-marked birds showed that the wintering population was drawn from Black Ducks summering in Labrador, east Quebec, Newfoundland, Cape Breton Island, and Prince Edward Island. Migration to wintering areas began in late October; most later recoveries were in Prince Edward Island and Nova Scotia with a few along the coast from Massachusetts to Delaware. Comparison of the summer- and winter-banded samples suggested disproportionately heavy hunting of local birds. In view of this, and with the evidence that breeding ducks seemed not to be occupying all the suitable wetlands available to them, it was recommended that a delayed opening of the hunting season on Black Ducks be implemented to relieve pressure on the local population.

2. Introduction (by A. J. Erskine)

In the late 1950s, CWS waterfowl studies were attempting to serve two masters (and occasionally more). The documenting of year-to-year changes in numbers was demanded at the annual meetings to set waterfowl hunting seasons and bag limits in the United States, which draws heavily on ducks from the Canadian prairies. It was unclear to what extent ducks from other parts of Canada contributed to the US harvest, although banding had shown that most Canadian ducks wintered largely in the USA (*cf.* Addy 1953, Aldrich *et al.* 1949). At the same time, the feeling was growing that CWS work should further Canadian as well as American ends, as we needed to have a better understanding of the biology of the various species. Several studies of breeding biology (e.g. Lemieux 1959), local productivity (Dzubin and Gollop 1972), and migration (Moisan *et al.* 1967) stemmed from that period, some of them arising from their authors' pursuit of advanced degrees. Banding objectives were also ambivalent. There was constant pressure to maintain samples adequate to assess first-year recovery rates for adjusting hunter kill estimates. Banding of flightless young ("locals") was also emphasized to verify that results obtained from bait-trapping of flying immatures were representative of those localities. Apart from these generally applicable objectives, banding also provided information on the local stocks, which were still poorly known. This report, which was never published, illustrates the use of surveys and banding in a study of a local waterfowl situation on Prince Edward Island. It therefore has a strong operational slant but it does provide basic information of permanent value.

3. The study area

3.1. Physical features, climate, and land use

Physiographically, Prince Edward Island forms the insular portion of the Gulf of St. Lawrence plain, a level to moderately undulating area underlain by carboniferous sandstones and conglomerates which also includes parts of New Brunswick and Nova Scotia. The island is about 230 km long and from 5 to 55 km wide. The rivers and streams are short, shallow and slow-flowing; the larger rivers have tidal estuaries which cut deep into the coastline. Sandy loam soils predominate; spring-fed ponds and streams are common, particularly in the eastern two-thirds of the island.

Situated between 46 and 47°N latitude in the Gulf of St. Lawrence, and sheltered from the open ocean, Prince Edward Island has a relatively moderate climate, which may be classed as humid–temperate. It is strongly influenced by the close proximity of all parts of the island to the sea. The mean annual precipitation is 1090 mm, varying from 815 to 1140 mm. The growing period is approximately 180 days or roughly from May through October. Warming in spring, however, is often delayed by floating ice in the Gulf of St.

[1]Deceased November 1977. MS was redrafted for this publication by A.J. Erskine.

Lawrence and Northumberland Strait, which in some seasons persists until the end of May. The climate, therefore, is characterized by a fairly long, cold, winter, a cool summer, and high precipitation; there is a long but late frost-free period compared with other areas in the Maritimes.

Prince Edward Island is included in the Acadian Forest Region (Rowe 1959). Most of the original mixed conifer and hardwood forest has been removed and woodlots now cover only 20–30% of the island's area (5650 km^2). Agriculture is the predominant land use, a large part of the cleared land being used to grow potatoes.

Prince Edward Island has a high proportion (about 5%, vs. 2% in NS and NB) of waterfowl hunters in its largely rural population. The increasing numbers of resident hunters and improved transportation have increased hunting in local breeding areas.

3.2. Waterfowl habitat and breeding populations

Waterfowl habitat on Prince Edward Island is made up of three broad wetland types:
a) Fresh-water streams and ponds (inland)
b) Brackish portions of streams and brackish ponds
c) Salt-water bays and estuaries (coastal).[1]
These types occur in varying proportions in all river systems. The freshwater areas are most important during spring and early summer as nesting and brood-rearing areas. Brackish-water areas are important later in the summer for brood-rearing, and as feeding and loafing areas for moulting adults. Salt-water bays and estuaries are used mainly during the fall, winter and spring months as feeding and loafing areas for migrants and wintering waterfowl; Red-breasted Mergansers are the only ducks breeding in those coastal areas. Most ducks breed in the fresh- and brackish-water wetlands. As the rivers on the island are short, all three habitat types occur on most river systems within a distance of 10 to 15 km. The diversity of habitat offers a variety of ecological conditions in a fairly small area.

Black Duck and Blue-winged Teal broods were observed in both the fresh- and brackish-water wetlands. American Wigeon and Ring-necked Ducks favoured the barrier-beach ponds although they were also observed on inland ponds. Pintail were restricted to the few large expanses of open marsh available on the island (Bartlett 1960).

[1]Editorial note: All study areas (App. 1) were classified under the Canada Land Inventory (1965–67) and the Maritimes Wetland Inventory (1981–84); these classifications are available through CWS, Atlantic Region.

4. Methods

Most methods of measuring populations changed to some extent as the study evolved so some data are missing for some years.

Breeding populations of waterfowl were assessed by ground surveys on foot or by canoe, usually with a Labrador retriever assisting in the "beat-out" of dense marsh vegetation. In 1957–60 "spring pair" counts were made in late May, and two or more brood counts in the summer; in 1961–62 the spring counts were omitted in favour of increased brood coverage. Flightless young ducks were captured with the aid of the dog and banded, whenever possible. The ages of broods were estimated as outlined by Gollop and Marshall (1954), and possible duplication between successive surveys was considered when estimating production.

Winter populations were assessed by aerial surveys covering the coasts and unfrozen inland areas. Ducks were banded from late December to early April at Moore's Sanctuary (Milltown Cross, 46°06′N, 62°38′W), where the late Harvey Moore fed wintering waterfowl every year from 1949 until his death in 1960. Through the winter of 1958–59, all birds banded were captured by Moore who walked among them and picked them up at random as they fed. In 1959, a drop-door trap that would accommodate 400–500 birds at a time was constructed. This was to eliminate the bias in the sex ratio among previously banded birds which occurred when the "pick-up" method of banding was used. The majority of the birds could be captured in 2–3 days. The white underwing feathers of 272 Black Ducks handled during February 1960 and 781 banded in January through April 1961 were colour-marked; underwings of 445 females were dyed yellow, using picric acid (Kozlik 1959), and those of 608 males were dyed red, using Rhodamine-B.

Before the introduction of the Migratory Game Bird Hunting Permit and associated surveys of hunting in 1966–67 (Cooch *et al.* 1978), less rigorously standardized questionnaire surveys had been made in Prince Edward Island. They had provided data on seasonal distribution of hunting and waterfowl kill.

Table 1
Species composition of (a) adult ducks observed in May and broods observed in May to August 1957–60 (all years combined), and (b) broods observed in June to August 1961 and 1962, on 47 study areas on Prince Edward Island

	(a) 1957–60				(b) 1961		1962	
	Spring adults		Summer broods		Summer broods		Summer broods	
Species	No.	%	No.	%	No.	%	No.	%
Green-winged Teal	31	3.7	9	2.4	4	1.4	14	5.5
Black Duck	367	44.0	172	46.3	96	34.8	101	39.5
Mallard	1	0.1	—	—	—	—	—	—
Northern Pintail	51	6.1	28	7.5	17	6.2	14	5.5
Blue-winged Teal	203	24.4	110	29.6	126	45.6	89	34.7
Northern Shoveler	1	0.1	1	0.3	—	—	—	—
American Wigeon	80	9.6	24	6.5	11	4.0	12	4.7
Ring-necked Duck	72	8.6	25	6.7	22	8.0	26	10.1
Common Goldeneye	10	1.2	1	0.3	—	—	—	—
Common Merganser	3	0.4	—	—	—	—	—	—
Red-breasted Merganser	13	1.6	1	0.3	—	—	—	—

Table 2
Waterfowl production on six Prince Edward Island study areas, 1958–62

		Black Duck brood production											
		1958			1959			1960			1961			1962		
Study area (type)	Size (ha)*	No.	%†	Dens /km^2	No.	%	Dens /km^2	No.	%	Dens /km^2	No.	%	Dens /km^2	No.	%	Dens /km^2
Murray River Pond	74	8	100		20	80		n.s.	—		8	73		13	100	
Lecco's Pond	13	n.s.‡	—		3	42		n.s.	—		1	25		2	33	
(inland fresh ponds)				11			26			—			10			17
Mount Stewart	300	6§	30		24	44		16	38		12	25		13	34	
(inland tidal marsh)				2§			8			5			4			4
Deroche Point	164	6	30		2	8		4	20		1	5		4	11	
Condon's Pond	32	4	44		9	45		6	43		4	57		8	100	
Steels' Pond	10	6	100		4	80		3	75		5	56		3	60	
(barrier-beach ponds)				8			7			6			5			7

* Including surrounding marsh.
† Percentage of total broods on area.
‡ No survey.
§ Inadequate coverage.

Table 3
Chronology of clutch initiation by Black Ducks on Prince Edward Island in 1958–61, estimated by back-dating from known-age broods

	1958			1959			1960			1961		
Period	No. of nests	%	Σ%	No. of nests	%	Σ%	No. of nests	%	Σ%	No. of nests	%	Σ%
1–7 April	—			1	0.9	0.9	—			—		
8–15	17	48.5	48.5	7	6.5	7.4	3	4.6	4.6	1	1.1	1.1
16–22	3	8.6	57.1	31	29.0	36.4	18	27.7	32.3	—	0	1.1
23–29	3	8.6	65.7	15	14.0	50.4	10	15.4	47.7	3	3.5	4.6
30 April-6 May	4	11.4	77.1	16	14.9	65.3	10	15.4	63.1	11	12.6	17.2
7-13 May	3	8.6	85.7	8	7.5	72.8	8	12.3	75.4	8	9.2	26.4
14-20	—	0	85.7	11	10.3	83.1	4	6.2	81.6	13	14.9	41.3
21-27	4	11.4	97.1	5	4.7	87.8	5	7.7	89.3	20	23.0	64.3
28 May-3 June	1	2.9	100.0	4	3.7	91.5	4	6.2	95.5	13	14.9	79.2
4–10 June	—			6	5.6	97.1	2	3.1	98.6	13	14.9	94.1
11–17	—			1	0.9	98.0	1	1.4	100.0	3	3.5	97.6
18–24	—			2	2.0	100.0	—			2	2.4	100.0
	35			107			65			87		

5. Results

5.1. Breeding populations and production

Observations during 1957–60 on adults and broods on 47 areas representing all three habitat types (Table 1) showed that Black Ducks made up 44% of the adults observed in late May, and 46% of the broods seen in May through August. Blue-winged Teal were second in abundance (30% of broods); other species with 5+ % of total broods included Northern Pintail, American Wigeon, and Ring-necked Duck. In 1961 and 1962 the proportions of Black Ducks were lower (35 and 40% of broods) and of Blue-winged Teal higher (46 and 35%) (Table 1).

The number of broods varied greatly between areas and habitat types (Table 2). Black Duck production ranged from 18 broods/km^2 (3-yr mean) for two inland fresh-water ponds to 5.4 broods/km^2 (4-yr mean) on brackish tidal marsh and 6.7 broods/km^2 (5-yr mean) on coastal barrier-beach ponds. Production on individual study areas fluctuated even more widely (Appendix 1); some ponds that produced three or four broods in 1961 produced none in 1962, and vice versa. Variations occurred even on the smaller areas where the entire river system was surveyed during each visit, so it is unlikely that movement along the river system could explain such fluctuations. Overall, numbers of Black Duck broods observed suggest that there was a decrease between 1958 and 1961, with some recovery in 1962.

The chronology of clutch initiation for Black Ducks was estimated by back-dating (after Gollop and Marshall 1954), allowing 26 days for incubation and 8 days for egg-laying (mean clutch of eight eggs and laying rate of one egg/day) (Table 3). Laying chronology varied considerably among years: 50% of the clutches had been started by the following dates; 15 April 1958, 29 April 1959, 30 April 1960, and 23 May 1961.

The success of brood rearing was assessed by comparing the mean sizes of broods of different ages, but the data collected (Table 4) gave no useful evidence of the expectable trend toward lower mean size of older broods. However, the markedly smaller number of Class III broods in 1961 may be significant (see below).

5.2. Movements and harvest patterns of locally reared Black Ducks

Ninety-three recoveries were available from 438 flightless young Black Ducks banded on Prince Edward Island during the period 1958–62. The geographical distribution of the band recoveries (birds reported dead) (Table 5) shows that 81% were birds shot by island gunners. More than two-thirds (69%) of the birds were shot in the same 10-minute block of latitude and longitude or in one of the immediately adjoining blocks, and thus had moved less than 30 km from the banding locations. Of 73 dated local recoveries (Table 6), 45% were obtained on opening day, and 74% from birds shot during the first two weeks of the hunting season. Only eight local recoveries were made after the end of October, but most foreign recoveries were from birds shot during December and January.

The 18 foreign recoveries (Fig. 1) suggested that Prince Edward Island Black Ducks have a strictly coastal migration similar to that described by Addy (1953) for Newfoundland birds. The absence of recoveries in New Brunswick and Maine is particularly striking. Recaptures of six and eight locally reared birds during winter banding at Moore's Sanctuary, PEI, in 1960 and 1961, respectively, showed that some winter on the island. An undated recovery from Harrington Harbour, Quebec, and a banding retrap at Lobstick Lake, Labrador, suggested that some PEI-reared Black Ducks later settle farther north to breed.

Table 4
Black Duck brood sizes on Prince Edward Island study areas during 1958 to 1961* (sample sizes in parentheses)

Year	Mean no. of young in broods of different age-classes					
	I		II		III	
1958	6.6	(9)	6.2	(9)	6.5	(17)
1959	6.2	(24)	6.0	(31)	6.8	(31)
1960	7.4	(14)	5.8	(9)	6.9	(15)
1961	6.5	(13)	6.5	(35)	5.1	(8)

* Some duplication in brood counts occurred within each year.

Table 5
Direct recovery rate and the geographical distribution of hunting season recoveries from 438 local Black Ducks banded on Prince Edward Island in the summers of 1958 – 62 inclusive

Year	Direct recoveries			Local recoveries			Foreign recoveries	
	No. banded	No.	%	Total recoveries	No.	% total recoveries	No.	% total recoveries
1958	3	2	66.7	2	2	100	—	—
1959	87	11	12.7	17	15	88	2	12
1960	117	23	19.7	25	19	76	6	24
1961	149	28	18.8	36	29	81	7	19
1962	82	7	8.5	13	10	77	3	23
Totals	438	71	16.7	93	75	81	18*	19

* Prince Edward Island 1 (120 km); Nova Scotia 7; Massachusetts 4; New York 1; New Jersey 4; Delaware 1.

Recovery and mortality rates for locally reared Black Ducks are shown in Tables 5 and 7, respectively. The direct recovery rate of 16.7% was half again the mean direct recovery rate for all immature Black Ducks banded in Canada and the USA in the same period (Smith and Geis 1962), and the first-year mortality rate of 77% was considerably higher than the mean of 64.7% for all immature Blacks.

5.3. Wintering habitat and populations

Prince Edward Island is near the northern limits of the Black Duck wintering range. The numbers of birds observed on the island during midwinter aerial inventories from 1950 to 1960 varied from 2800 to 8700 (Table 8). During mild winters the birds occurred all over the island, whereas during severe winters they tended to concentrate in the eastern two-thirds of the island.

Black Ducks wintering on Prince Edward Island were found normally in small flocks. During the 1960 midwinter bird count, only three flocks exceeded 200 birds; the average flock size was about 25 birds. They occurred in the numerous small open-water areas located at the headwaters of rivers, at or near highway bridges, or near the outlets of small spring-fed streams and ponds. The smaller freshwater ponds were usually frequented during the daylight hours, the birds returning in the evening to salt-water bays and estuaries where they congregated in larger flocks.

Cardigan Bay, on the eastern shore of Prince Edward Island, harboured a major concentration of wintering Black Ducks. Since 1949, when Harvey Moore began winter feeding on his pond on the Sturgeon River, Black Ducks have visited the area, coming into the pond during the daylight hours and flying the 8 km back to Cardigan Bay again at dusk. The birds were counted during their evening departure from Moore's Sanctuary. The numbers of birds visiting the area increased rather rapidly from an estimated

Figure 1
Distribution of recoveries of Black Ducks banded as flightless young ("locals") in Prince Edward Island, 1958–62

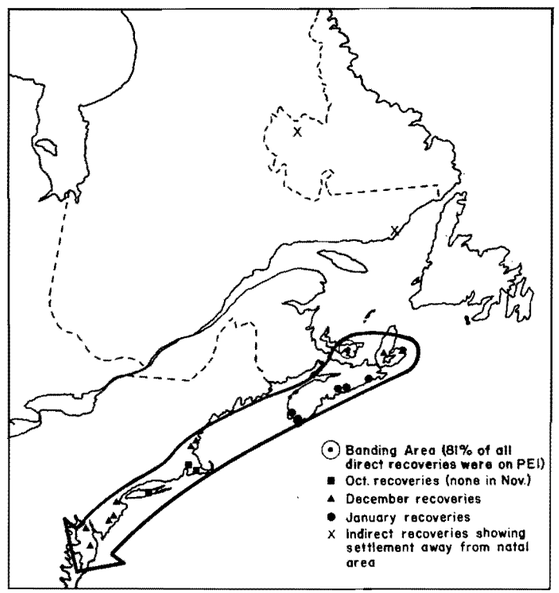


Table 6
Temporal distribution of (a) 73 local* recoveries from locally raised Black Ducks banded on Prince Edward Island in the summers from 1958 to 1962, and (b) 158 local recoveries of Black Ducks banded in Cardigan Bay, Prince Edward Island, in the winters of 1953 – 61 inclusive

Reported hunting dates	(a)		(b)	
	No. of recoveries	% of recoveries	No. of recoveries	% of recoveries
Opening day	33	45	14	9
1–15 October†	54	74	34	21
16–31 October	9	12	21	13
October‡	2	3	23	15
Total October	65	89	78	49
1–15 November	2	3	23	15
16–30 November	3	4	24	15
November‡	1	1	20	13
Total November	6	8	67	42
1–19 December	2	3	13	8
Total recoveries	73	100	158	100

* Prince Edward Island.
† Includes opening day recoveries.
‡ Exact date unknown.

Table 7
Mortality rates of 438 local Black Ducks banded on Prince Edward Island in the summers from 1958 to 1962

Summer banded	No. banded	No. reported dead by age intervals					
		0–1 yr	1–2 yr	2–3 yr	3–4 yr	>4 yr	Total
1958	3	2	—	—	—	—	2
1959	87	11	5	—	—	1 (5–6)	17
1960	117	25	2	—	—	—	27
1961	149	28	5	2	—	1 (5–6)	36
1962	82	7	2	3	1	—	13
Totals	438	73	14	5	1	2	95
		77%	64%	62%			

Table 8
Black Ducks wintering on Prince Edward Island and in the Cardigan Bay area, from midwinter aerial and ground surveys, in 1950–60, rounded to nearest 100

Year	Population		Cardigan Bay as % of total
	PEI excluding Cardigan Bay	Cardigan Bay	
1950	2800	25	1
1951	3700	60	2
1952	3000	130	4
1953	3800	300	7
1954	5400	700	11
1955	7100	1600	18
1956	5900	2000	25
1957	5500	2000	27
1958	3700	1300	26
1959	2800	2000	42
1960	4600	1500	25

Table 9
Seasonal and geographical distribution of 293 recoveries of Black Ducks banded in the Cardigan Bay area of Prince Edward Island during the winters of 1953 – 61 inclusive

Season	No. of recoveries						
	PEI	NS	NB	Nfld.	Lab.	Que.	USA
Wintering*	1	1	—	—	—	—	2
Breeding†	2	2	—	8	4	6	—
Hunting‡	208	34	2	13	3	2	5
Total	211	37	2	21	7	8	7
Percentage of total	72	13	1	7	2	3	2

* February, March.
† April to August.
‡ September to January.

25 birds in 1949–50 to about 2000 in the winter of 1955–56 (Table 8). After that year, estimates of the number of Black Ducks visiting the area fluctuated between 1300 and 2000, representing from 25 to 42% of the total winter population on Prince Edward Island.

5.4. Origins and harvest patterns of Black Ducks wintering on Prince Edward Island

Winter banding of Black Ducks at Moore's Sanctuary began in February 1953, and 3295 birds were banded through April 1961. The distribution of 22 breeding season returns (Table 9, Fig. 2) shows that the birds were breeding in Labrador, Quebec, Newfoundland, and Cape Breton Island, as well as Prince Edward Island. Observations of the birds colour-marked in 1960 and 1961 (Fig. 2) confirmed that pattern, the Cape Breton sightings (*per* A. J. Erskine) involving a pair (both marked) and a female with a brood (seen twice). The sightings in Maine may have involved birds that moved farther south to New England after having been marked; when seen (12 and 15 May 1961) they could have been migrating or breeding locally. Recoveries during September, and to a lesser extent in October, still further reinforce the pattern of breeding season returns (Fig. 2). The Black Ducks wintering in eastern Prince Edward Island are part of a population that breeds in an area that stretches from there to Cape Breton Island, east to western Newfoundland and north to the extreme eastern part of Quebec and southern Labrador, that is, mainly between 46 and 54°N and between 55 and 65°W.

Figure 2
Distribution of recoveries of Black Ducks banded in winter at Milltown Cross, PEI, 1953–62, during the months April through October, including sightings of colour-marked birds

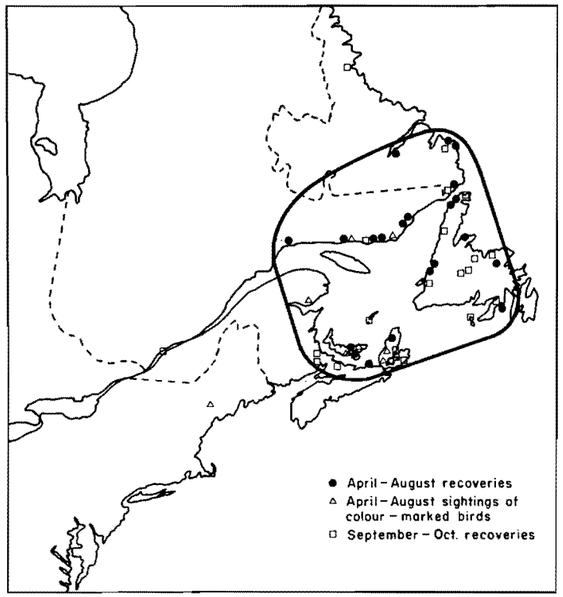


Table 10a
Mortality rates of Black Ducks banded during the winters from 1952–53 to 1956–67 at Cardigan Bay, Prince Edward Island, obtained from band recoveries

Winter banded	No. banded	No. reported dead by age (yr) 0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	>9	Total
1952–53	137	2	1	4	—	—	2	—	3	—	1[16]	13
1953–54	283	8	6	1	—	2	1	1	1	—	—	20
1954–55	373	21	6	1	3	4	1	1	—	—	1[10]	38
1955–56	369	5	5	5	3	9	1	—	—	—	2[14, 16]	30
1956–57	323	9	8	2	4	—	—	—	—	—	—	23
Totals	1485	45	26	13	10	15	5	2	4	0	4	124

Table 10b
Mortality rates of Black Ducks banded during the winters from 1957–58 to 1960–61 at Cardigan Bay, Prince Edward Island, obtained from band recoveries

Winter banded	No. banded	No. reported dead by age (yr) 0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	>9	Total
1957–58	360	13	7	10	—	1	2	1	—	—	3[11,12,14]	37
1958–59	443	6	18	5	2	2	1	—	1	—	1[12]	36
1959–60	757	59	10	2	6	5	4	—	—	—	1[11]	87
1960–61	252	4	4	1	1	—	—	—	—	—	—	10
Totals	1812	82	39	18	9	8	7	1	1	0	5	170

Migration of that population evidently begins only in late October, as very few recoveries were received from beyond the breeding area before November (Figs. 2 and 3). Subsequent recoveries of Black Ducks banded in winter on Prince Edward Island showed a regular coastal movement through Nova Scotia, extending southward to Massachusetts, Long Island, New Jersey, and Delaware (Fig. 3). This closely paralleled the pattern found for PEI-reared Black Ducks banded as flightless young (Fig. 1), and also that earlier demonstrated for birds banded on migration at Grand Codroy, Newfoundland, in 1947–51 (Addy 1953). As many January recoveries were made in southern Nova Scotia, and some December recoveries in eastern Prince Edward Island (where hunting seasons ended by 19 December in the years involved), it seemed clear that parts of the population migrated very short distances, and some were essentially sedentary.

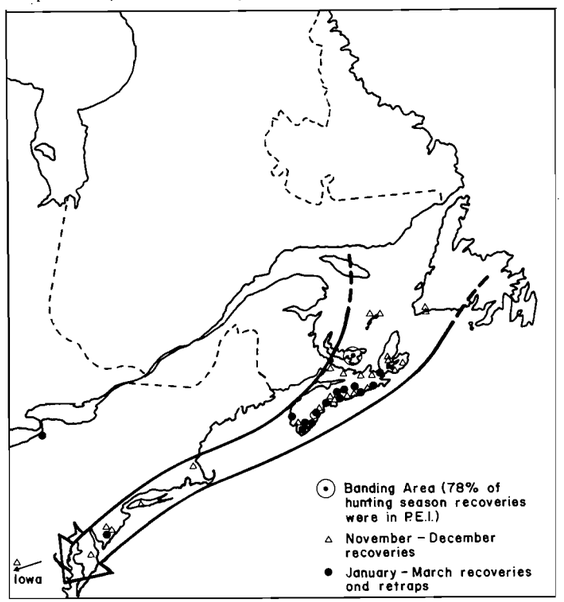
The temporal distribution of 158 recoveries on PEI of Black Ducks banded in winter at Moore's Sanctuary (Table 6) was fairly even throughout the hunting season. In view of the late arrival of northern breeders, the October recoveries (49% of the total) were higher than one would expect if the banded wintering sample was largely drawn from northern birds. Therefore the early October recoveries of winter-banded birds presumably came from the nearly sedentary portions of stocks breeding in Prince Edward Island and adjacent parts of Nova Scotia.

As with the locally reared birds, most (78%) of the 267 hunting season recoveries from the winter-banded sample were from Prince Edward Island, with the remainder largely from Nova Scotia and Newfoundland. Of the PEI recoveries, 85% were from the immediate banding area (the same or adjacent 10-minute blocks), indicating a high degree of fidelity to the wintering area.

Mortality rates for the winter-banded sample were calculated both from band recoveries (birds reported dead) and from band returns (live birds). Comparison of the period when Black Duck numbers in the Cardigan Bay area were increasing (Table 8) with the period after they had reached peak populations around 1957 showed that mortality rates (based on recoveries) were low during the population build-up but increased later (Table 10). The number of returns available was considerably larger than the number of recoveries, but there is some doubt that the data are complete for the final year; the mean mortality rate calculated from returns through April 1961 was very much higher for both sexes than that calculated earlier from returns through February 1960 (Table 11).[1]

[1]Mortality rates were recalculated using more modern methods, but the results did not differ enough to change the earlier conclusions (S. Wendt, CWS, pers. commun.).

Figure 3
Distribution of recoveries of Black Ducks banded in winter at Milltown Cross, PEI, 1953–62, during the months November through March, including recaptures away from the banding areas



The return rates for males were greater than those for females in all years except one. The sex ratio of 663 unbanded Black Ducks captured in January and February 1960, using the trap, was 345 males to 318 females, not significantly different from a 50:50 ratio. However, among 355 returns the ratio was 233 males to 122 females, significantly different from an even ratio. As the 1112 birds captured in 1960 represented nearly 75% of the maximum count of 1500 Black Ducks that winter, males evidently predominated in the wintering population unless females become more trap-shy after the initial handling.

The temporal distributions of hunter activity during the 1960 and 1961 hunting seasons were obtained from the experimental harvest questionnaires and wing collections on Prince Edward Island (Bartlett, unpublished data). Except for opening day, hunting in 1960 was fairly constant up to mid-November but declined during the last three weeks of the season. However, 63% of the reported Black Duck kill occurred in the first two weeks of the open season, associated with only 34% of hunting. In 1961, hunting was fairly constant throughout the season, and the kill was more evenly distributed. Although 37% of hunting occurred in the first two weeks of the season, only 42% of the kill took place in that period (Table 12). Because few Black Ducks migrated before mid-October, that early kill was drawn largely from local stocks.

Table 11
Mortality rates for Black Ducks wintering at Cardigan Bay, Prince Edward Island, in the period from February 1953 to February 1960, as determined from returns recorded at the banding site during the winters of 1959–60 and 1960–61

Winter of banding	No. banded	Minimum no. surviving to April 1961	% return	No. of years since banding	Possible maximum average mortality rate (%)
(a) Males					
1952–53	80	7	8.7	8	48
1953–54	149	2	1.3	7	90
1954–55	171	20	11.7	6	47
1955–56	204	13	6.4	5	72
1956–57	178	15	8.4	4	70
1957–58	238	25	10.5	3	72
1958–59	243	50	20.6	2	63
1959–60	406	110	27.1	1	73
(1960–61)	(148)				
Totals	1669	242	14.5		68*
(b) Females					
1952–53	62	1	1.6	8	88
1953–54	134	0	0.0	7	100
1954–55	209	11	5.3	6	72
1955–56	170	4	2.4	5	89
1956–57	153	9	5.9	4	78
1957–58	150	17	11.3	3	70
1958–59	205	35	17.1	2	69
1959–60	337	74	22.0	1	78
(1960–61)	(104)				
Totals	1420	151	10.6		75*
(c) Sexes combined					
	3089	393	12.8		71

* Weighted average.

6. Discussion

6.1. Breeding populations and production

In measuring production by counting broods, the question arises whether broods observed on a river system were reared there. Brood movements between marsh areas are well known elsewhere (Sowls 1955, Benson and Foley 1956). On Prince Edward Island, no movements of broods between river systems were seen, and recaptures of flightless young ducks indicated that dispersal was generally downstream, within a system. The agreement between the percentage composition by species of adults and of broods (Table 1) is further evidence that brood production figures were representative for the areas sampled. With four or five visits to each area during the brood season, surviving broods would have been detected at some time. As some broods presumably were lost without survivors, the numbers counted are minimal.

The fluctuations in numbers of Black Duck broods produced on an area require explanation, and no single factor is likely to cover all situations. One interpretation is that there is more breeding habitat available than there are ducks to use it (*cf.* Wright 1948). The loss of local breeders to hunting supports that hypothesis. If there was a large annual turnover in breeding population, the pairs in spring would have a wide choice of breeding areas.

Table 12a
Temporal distribution of hunter activity* and Black Duck kill† on Prince Edward Island in 1960

Date	Hunter-days No.	Hunter-days % of total	Black Duck kill No.	Black Duck kill % of total
Opening day	26	9.4	63	29.0
3–8 Oct.	36	13.0	52	24.0
10–15 Oct.	31	11.2	21	9.7
17–22 Oct.	29	10.5	26	12.0
24–29 Oct.	26	9.4	15	6.9
31 Oct.–5 Nov.	28	10.1	9	4.1
7–12 Nov.	39	14.1	10	4.6
14–19 Nov.	22	7.9	7	3.2
21–26 Nov.	17	6.2	8	3.7
28 Nov.–3 Dec.	14	5.1	5	2.3
5–9 Dec.	8	2.9	1	0.5
Totals	276		217	

* Questionnaire survey.
† Waterfowl wing collection.

Table 12b
Temporal distribution of hunter activity* and Black Duck kill† on Prince Edward Island in 1961

Date	Hunter-days No.	Hunter-days % of total	Black Duck kill No.	Black Duck kill % of total
Opening day	90	10.2	31	21.5
3–7 Oct.	114	12.9	16	11.1
9–14 Oct.	127	14.3	14	9.7
16–21 Oct.	116	13.1	20	13.9
23–28 Oct.	76	8.6	11	7.6
30 Oct.–4 Nov.	37	4.2	11	7.6
6–11 Nov.	68	7.7	15	10.4
13–18 Nov.	65	7.3	5	3.5
20–25 Nov.	71	8.0	6	4.2
27 Nov.–2 Dec.	60	6.8	9	6.3
5–9 Dec.	62	7.0	6	4.2
Totals	886		144	

* Questionnaire survey.
† Waterfowl wing collection.

Total waterfowl production was greatest in those rivers where brackish areas made up a relatively large part of the system. That did not apply equally to all waterfowl species, which vary in their breeding requirements. Nevertheless, it appears that the relative amounts of fresh- and brackish- water area in a river system may be an important factor affecting production.

The relative amounts and distribution of wooded areas along a river system seemed to affect use by Black Ducks and Ring-necked Ducks. Conversely, species such as Northern Pintail, Blue-winged Teal, and American Wigeon seemed to prefer systems in which cultivated fields, pastures, meadows and other open areas predominated. Soil runoff and silting, following heavy rains, were common in river systems adjoining cultivated areas; this may have an important effect on the abundance and distribution of aquatic vegetation and invertebrates.

The chronology of breeding (Table 3) in different years seemed to be correlated with monthly mean temperatures in spring (Table 13). Mean temperatures in March and April were highest in 1958, several degrees cooler in 1959 and 1960, and still lower in 1961. Temperature fluctuations and the associated variations in snow melt and break-up of ice can evidently delay laying by Black Ducks on the Island by as much as a month. The low temperatures in April 1961 led to much snow rather than rain which, coupled with above-normal rainfall during May, led to flooding of low-lying areas when runoff was hampered during high tides. The prolonged laying period in 1961 may have reflected increased renesting following the flooding of first nests, as well as delayed initiation because of low temperatures. These conditions may have resulted in reduced production of local Black Ducks in that year (Table 2) and the lower, early season kill of that species on Prince Edward Island in the fall (Table 12).

Table 13
(a) Monthly mean temperature, and (b) precipitation recorded at Charlottetown, Prince Edward Island, during March, April, and May in 1958–61

Month	1958	1959	1960	1961
(a) Temperature (°C)				
March	0	−3	−3	−5
April	+6	+4	+4	+1
May	+10	+11	+12	+9
(b) Precipitation (mm)				
March	43	71	94	92
April	69	38	33	81
May	43	43	35	104
Total precipitation	155	152	162	277

6.2. Movements and harvest patterns of locally raised Black Ducks

The geographical and temporal distribution of recoveries illustrates the importance of locally raised Black Ducks to the waterfowl kill. The scarcity of local recoveries after mid-October and the presence of later recoveries in Nova Scotia and Massachusetts indicated that some PEI-reared Black Ducks started southward migration during October. About the same time, northern breeders started to arrive on the island, and those tended to modify the effect of hunting on the local stocks.

The unusually high recovery and mortality rates, together with the temporal and geographic distribution of the recoveries, point to a relatively heavy early kill of locally raised Black Ducks. If only 23% of locally reared birds survive the first hunting season, it seems likely that hunting is the most important factor affecting Black Duck breeding numbers in the study areas.

6.3. Wintering populations

Black Ducks have wintered on Prince Edward Island as far back as present memories extend (e.g. Hurst 1947, cited by Godfrey 1954). Nevertheless, the growth of the Cardigan Bay population was clearly connected with the establishment of Moore's Sanctuary and the winter feeding program. The sanctuary reduced hunting mortality, at least during the period when the local population was increasing, and the feeding concentrated birds in a secure area as well as perhaps improving their chances of survival through the hardest part of the winter (January–February). The scale of the feeding program was reduced after Harvey Moore's death in April 1960, and the local wintering populations decreased. It is not possible to determine if changing winter climate was also involved in this drop in numbers. In the Maritimes generally, the 1950s was a period of relatively mild winters, whereas the 1960s reverted to an earlier pattern of colder and snowier winters. However, the 1970s were even milder and less snowy than the 1950s, but there is no evidence of winter Black Duck populations in eastern PEI increasing as they did in the 1950s.

6.4. Mortality and harvest patterns of the winter population

The samples banded each winter (Table 11) showed relatively even sex ratios, although males predominated except in 1954–55. The band returns, however, indicated that males were easier to pick up a second time than females, and in 1957–58 the return sample included as many as 80% males, which undoubtedly biased the samples obtained by that method. Use of the box trap apparently reduced the bias, as mentioned earlier, and analyses based on returns were restricted to the last two years of the winter trapping program when all birds were captured with the trap.

Mortality rates based on returns represent maximum possible mortality, as some birds not recaptured may have wintered in another area. The close agreement of the female mortality rate calculated from returns with that calculated from recoveries (Smith and Geis 1962) showed a high fidelity of females to the wintering area. Males apparently were less inclined to return to the same area, as it was already shown that those that did return were more likely to be recaptured than were females.

An increase in mortality rates for both sexes was indicated in the cohorts banded in the winters from 1956–57 to 1958–59. The sanctuary evidently was useful during the population build-up, but became relatively unimportant to the survival of wintering Black Ducks when the population visiting the sanctuary exceeded 1600 birds. Also, the sanctuary was not responsible for differential survival of male and female Black Ducks in the Cardigan Bay population.

A comparison of the recoveries from summer- and winter-banded birds also indicated a disproportionately heavy kill of local breeding birds. Eighty-one percent of the recoveries of local birds were from the island (Table 5); 98% of those were shot on, or within, 80 km of the natal marsh, 74% during the first two weeks of the waterfowl season (Table 6). Although recoveries from the winter-banded population were also largely from locally shot birds (78% of hunting season recoveries), only 21% of the recoveries were obtained during the first two weeks of October, and the evidence indicates that some of those were relatively sedentary.

7. Conclusions and management implications

The Black Duck kill on Prince Edward Island during the first two weeks of the waterfowl season was essentially a kill of local birds, the majority of which were living on, or within, 80 km of their natal marsh. The kill of such birds appeared to be excessive in relation to the kill of migrant and wintering Black Ducks from northern breeding grounds.

One measure to remedy the situation would be to adjust the opening of the waterfowl season to correspond with the arrival of migrant and wintering Black Ducks, that is, around the middle of October. A two- or three-week extension of the season into December would also allow a more equitable distribution of hunting pressure between breeding and wintering Black Duck populations. Over the long-term, however, one should consider species regulation. Many Blue-winged Teals, Ring-necked Ducks, American Wigeons, and Northern Pintails have migrated by the middle of October and are not available to island hunters later. However, such regulation could create enforcement problems and must be considered from all viewpoints before being implemented.[1]

The production data (App. 1) indicated that many ponds and river systems on the island were non-productive or relatively poor producers of Black Ducks. Production on the better areas also varied from one year to the next. This information, with evidence from banding and kill surveys, suggested that more breeding areas were available to Black Ducks than there were birds to occupy them. Hunting appeared to be a factor perpetuating that situation.

With increases in the demand for waterfowl hunting foreseen in the future, measures to improve existing breeding areas and to develop new areas might also be considered. Although there are no quantitative data to determine the ecological factors affecting Black Duck populations (with the exception of climatic factors), experiments could usefully be undertaken on some of the areas studied, using the hypothesis advanced in this report. However, these should be undertaken only in conjunction with measures to control and redistribute hunting pressure on waterfowl populations and particularly on Black Ducks.

[1]Editorial note: Delayed opening of the duck hunting season was implemented on Prince Edward Island in 1965–66. Subsequently, through 1970–71, the delayed opening was restricted to Black Ducks. No systematic production surveys were conducted during the period of delayed hunting seasons, so no evidence was secured of possible effects on local breeding stocks. In the absence of such evidence, early October hunting of Black Ducks was resumed in 1971, and continued, with a reduced bag limit (four per day vs. six for other ducks).

8. Acknowledgements

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Appendix 1
Number of different broods observed on 47 Prince Edward Island study areas during the summers of 1961 and 1962

Name of area	Area no.	G.-w. Teal		Black Duck		Pintail		B.-w. Teal		Am. Wigeon		R.-n. Duck	
		1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
Wizner's Pond	1	—	—	1	1	—	—	1	—	—	—	1	2
O'Keef's Lake	2	—	—	—	—	—	—	—	—	—	—	—	—
Pisquid Pond	3	—	—	—	1	—	1	—	1	—	—	—	—
Bowley's Pond	4a	—	—	—	—	—	—	—	—	—	—	1	—
Long Pond	4b	—	—	—	—	—	—	—	—	—	—	—	—
Leech Pond	5	—	—	2	3	—	—	—	—	—	—	—	—
Murray R. Pond	6	—	—	8	13	—	—	3	—	—	—	—	—
Lecco's Pond	7	—	—	1	2	—	—	2	4	1	—	—	—
Steel's Pond	8a	—	—	5	3	—	—	4	2	—	—	—	—
Graham's Pond	8b	—	—	—	—	—	—	—	—	—	—	—	—
McLure's Pond	8c	—	—	1	—	—	—	2	1	—	—	—	—
Condon's Pond	8d	—	—	4	8	—	—	1	—	—	—	2	—
Moore's Pond	9	—	—	—	3	—	—	—	—	—	—	—	—
Degro's Marsh	10	—	—	—	—	—	—	—	—	—	—	—	—
Bell's Pond	11	—	—	—	—	1	—	1	1	1	—	4	6
Dundas Pond	12	1	—	9	4	—	—	5	2	—	—	1	7
McKay's Pond	13	—	—	1	4	—	—	3	1	—	—	—	—
Adam's Pond	14	—	—	—	—	—	—	1	2	—	—	—	—
Cousin's Pond	15	—	—	2	—	—	—	—	—	—	—	—	—
Campbell's Pond	16	—	—	—	—	—	—	5	1	—	—	1	1
Big Pond	17	—	—	4	1	—	—	5	2	—	—	—	—
Dingwall Pond	18	—	—	—	—	—	—	—	—	—	—	—	—
Selkirk Pond	19	—	2	—	2	—	—	1	2	—	—	—	—
Black Pond	20	2	—	13	6	—	—	9	6	—	—	2	—
East Lake	21	—	—	1	—	—	—	11	1	—	—	3	—
Long Pond (R)	22	—	—	1	2	—	—	1	—	—	—	2	5
Campbell's Pond	23	—	—	4	7	—	—	2	1	2	—	1	—
North River	24	—	—	6	3	—	—	16	15	—	—	—	—
Rolling's Pond	25	—	—	2	—	—	—	3	4	—	—	—	—
Hunter River	26	—	—	—	—	—	—	1	—	—	—	—	—
Wheatley River	27	—	—	1	3	—	—	1	2	—	—	—	—
Nicolar Point	28	—	—	—	1	1	—	—	—	—	—	—	—
Wood Is. North	29	—	—	3	2	—	—	1	1	—	—	—	—
Smith Pond	30	—	—	—	—	—	—	—	—	—	—	—	—
Dunk River	31a	—	—	—	1	—	—	—	—	—	—	—	—
Scales' Pond	31b	—	—	1	—	—	—	2	1	—	—	—	—
Bedeque Pond	32	—	—	—	—	—	—	1	1	—	—	—	—
Tryon Pond	33	—	—	2	—	—	—	3	1	—	—	—	—
Deroche Point	34	—	4	1	4	2	3	7	10	3	10	4	4
Mt. Stewart	35	1	6	12	13	13	4	18	12	4	2	—	1
Cardigan River	36	—	—	3	1	—	—	1	2	—	—	—	—
Pinette River (a)	37a	—	—	—	2	—	—	5	1	—	—	—	—
Pinette River (b)	37b	—	—	—	—	—	—	—	—	—	—	—	—
Orwell River	38a	—	—	—	—	—	—	—	—	—	—	—	—
Vernon River	38b	—	—	5	4	—	—	5	7	—	—	—	—
St. Peters Lake	39	—	—	2	4	—	—	5	7	—	—	—	—
Pisquid River	40	—	2	1	3	—	6	1	1	—	—	—	—
Totals	47	4	14	96	101	17	14	127	92	11	12	22	26

Continuing

By 1960, CWS participation in routine year-to-year monitoring of waterfowl populations in the east was minimal, and most of the ornithological staff were involved in study of specific problems. Traditions died slowly, however, and when I joined the Service in that year I was asked to provide reports based on spring pair and brood surveys to represent, together with those done by Bartlett, Maritimes waterfowl populations. Because Bartlett was already involved in work on Prince Edward Island, and my other major assignment necessitated work on Cape Breton Island, we divided the area remaining; he covered New Brunswick, and I surveyed Nova Scotia. Difficulties became evident when we attempted to report on changes from the previous year because of the variability of survey dates and results. At the first gathering of CWS ornithologists from eastern Canada, at Morrisburg, Ontario, in October 1960, I summarized the waterfowl survey accomplishments of the 1949–60 period in the Maritimes. My conclusion was that, despite the effort devoted to those surveys, no really useful, comparable data base existed, because of the lack of standardization. I recommended that, in view of the minimal use made of such data as were available, coverage should be restricted to areas near sites of specialized or intensive investigations. This was accepted, but I was instructed to examine the methodology and make recommendations for standardizing procedures for future surveys. The following study was conducted concurrently with my studies on mergansers and Buffleheads during 1961–63.

II. Cape Breton Island waterfowl breeding populations, 1960–63[1]

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1. Abstract

The objective of intensive studies of waterfowl breeding populations on Cape Breton Island, Nova Scotia, in 1961–63 was to select the techniques that would provide the greatest amount of population data on breeding waterfowl in the least amount of time. The spring pair survey required less time per unit area than any useful brood survey. Spring and summer data had a fairly consistent relationship if allowance was made for the effect of weather on breeding success. However, in spring, the teals and Common Goldeneye were not detected in proportion to their actual numbers even by intensive surveys. Brood surveys gave the most accurate data on species composition, and the only data on breeding success. Brood coverage required at least three summer surveys spaced from late June to early August. The spring survey was best made about the time the first Black Duck broods appeared, to avoid confusion of migrants with the local breeding population. The phenological dates of the spring surveys must be comparable. Intensive ground surveys in spring were replicable; the time of day of such surveys seemed relatively unimportant. The ratio of broods to spring pairs was lower in 1962, when July was cold and wet, than in other years. Species composition varied markedly between Cape Breton Island and other waterfowl production areas in the Maritimes, so monitoring of a few localized study areas was considered unlikely to represent year-to-year fluctuations in waterfowl populations on a regional basis.

2. Introduction

Monitoring of bird population levels is essential for effective waterfowl management and for assessing the effects of hunting, land-use changes, or pollution. Before 1960, waterfowl inventory in the Maritime provinces had become a low priority because of low densities of breeding birds.

Although many parts of the Maritimes were surveyed at some time between 1949 and 1960, surveys had not been planned in a statistically acceptable manner. By 1960, it seemed clear that variations in the extent and timing of coverage in past years precluded useful comparisons in most areas. Greater standardization was essential if such surveys were to be continued. At the 1960 meeting of CWS ornithologists in Morrisburg, Ontario, a study to evaluate procedures for spring and summer waterfowl surveys was recommended, with the aim of ensuring economy of time and effort and making surveys more representative of general populations. Work on other projects dictated that the work be done in eastern Nova Scotia, and restricted manipulation of procedures to the spring surveys.

The principal variables studied were date and method of survey, intensity of coverage, time of day, and reproducibility of results. One or more variables were studied each spring. Surveys were also made each summer to estimate brood production on the study areas.

3. Study areas

Figure 1 shows areas where we made spring and summer surveys in 1961–63. Antigonish and Pomquet, on the Nova Scotia mainland about 40 km from the nearest part of Cape Breton Island, were added to the island study areas as they were generally similar. As shown on the map, McCormack and Loch Ban were combined as Kenloch, and Baddeck and Middle Rivers as Nyanza. Shoal Lake and River Inhabitants were not surveyed after 1961. Descriptions of the study areas (summarized briefly by Erskine 1971) are given in Table 1, grouped by habitat type.

4. Methods

We compared the results of ground surveys on 6–9 May, 16–21 May, and 29 May–2 June 1961 to determine the most suitable dates for spring surveys. Survey methods were compared on the two later surveys in spring of 1961. The main comparison was between numbers of waterfowl seen from one or more vantage points adjacent to each study area — the "rapid" survey, and those counted while the observer walked or canoed along the shoreline — the "intensive" survey. The latter immediately followed after the rapid count, and included all birds seen on the earlier count. We also covered the study areas from the air, using a Piper Tri-Pacer provided by the Nova Scotia Department of Lands and Forests, on 25–26 May 1961.

The following year, on 21–29 May 1962, we surveyed each study area twice by the intensive method, once either before 09:00 or after 18:00 — the "twilight" count — and once between 09:00 and 18:00 — the "daytime" count. The two surveys of an area were made on the same day or on successive days except when poor weather intervened.

On 21 May–3 June 1963, we covered each study area by the intensive method once each on three consecutive days, to assess replicability of results. All three surveys were at the same time of day, but some areas were surveyed only at twilight and others only in daytime.

Brood surveys were carried out each year, using the intensive method. Surveys were made at twilight when possible, but time constraints frequently necessitated daytime coverage. Survey dates were 22 June–11 July, 19–24 July, and 3–15 August 1961; 3–13 July, 20–31 July (incomplete), and 13–18 August 1962; and 22 June–2 July, 18–22 July, and 4–6 August 1963.

5. Weather and phenology

Pertinent weather data for 1961–63, compared to long-term means, are shown in Table 2. No one weather station was fully representative of all the study areas. Snowfall accumulations on the Cape Breton plateau are much greater than at Baddeck, and run-off from the plateau is correspondingly greater; for example, mean snowfall at North East Margaree was 2900 mm and at Cheticamp 4900 mm. Temperature inversions in the narrow valleys cutting into the plateau tended to slow run-off and to delay development of vegetation.

In 1961, a late, cold spring following a heavy accumulation of snow led to a late and prolonged run-off, but the summer was warm and very dry. The early spring of 1962 was warm, but May through July was very cool, and July was extremely wet. The spring of 1963 was similar to that of 1961, with heavy snows in April, but the summer was cool and dry. Waterfowl breeding seemed late in the cold springs of 1961 and 1963 (*cf.* Erskine 1972, Fig. 8), but summer conditions favoured brood survival in those years. Summer conditions in 1962 were evidently unfavourable, especially for late-nesting species.

Table 1
Waterfowl survey areas, Cape Breton Island, Nova Scotia, 1961–63

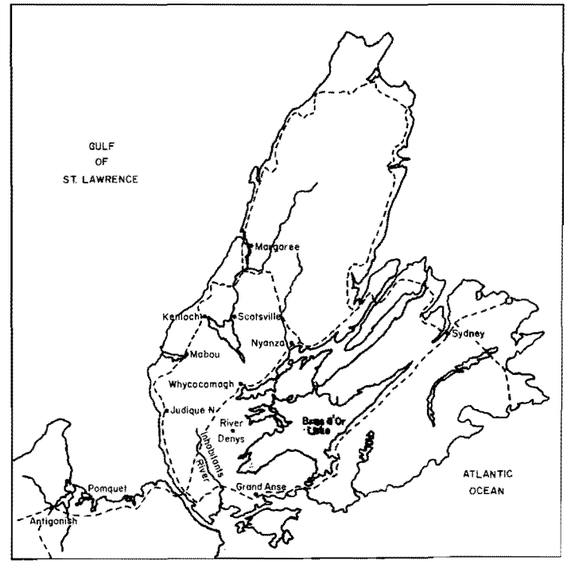
Location	Area (ha)*	Description
(a) Freshwater areas		
Scotsville	15	Marsh around lake outlet and along outlet river (stillwater stretch);
Loch Ban	72	Marsh around shallow bay off large lake;
McCormack	52	Marsh around shallow bays off large lake, and boggy creek discharging there;
Shoal Lake	37	Small, marshy lake;
River Inhabitants	500 ±	Meandering small river, with backwaters.
(b) Brackish, non-tidal areas (mostly around Bras D'Or Lakes)		
Baddeck River	154	Channels, lagoons, backwaters, in and around river delta;
Middle River	86	As above; river larger and more rapid;
Whycocomagh	28	As above; only large brook delta;
River Denys	114	As above; river smaller than Baddeck R.;
Judique Ponds	176	Four barrier-beach ponds, one with outlet to sea open, and two marshy creek mouths;
Pomquet Lake	26	Pond at head of tide; later dammed by beavers.
(c) Brackish, tidal areas		
Margaree River	500 ±	Tidal reach and estuary of river; marsh areas mostly fresh water;
Mabou	111	Tidal channels and backwater lagoons around small river mouths;
Antigonish	102	Tidal delta around small river mouths.

* Measured by planimeter from 1:50 000 NTS maps.

Table 2
Weather data for 1961–63 compared to 10-year mean, Baddeck, Nova Scotia

Year	Snowfall in preceding winter (mm)	Monthly mean temperature (°C) March	April	May	June	July	Total precipitation (mm) May	June	July
1961	2970	−4	+2	+8	+15	+17	200	131	35
1962	2320	−1	+3	+7	+13	+15	43	46	189
1963	2420	−3	+1	+9	+12	+18	76	53	43
Mean 1951–60	2500	−1	+4	+9	+14	+19	101	84	76

Figure 1
Location of waterfowl surveys, Cape Breton Island 1961–63



[1]Editorial note: The unpublished report from which this account was prepared did not include data on mergansers, as those were the subject of a concurrent and more intensive study (Erskine 1972). Mergansers frequent rivers as well as the lakes and estuarine habitats considered in this study (*cf.* Erskine 1971). However, as they are waterfowl and are also hunted, it seemed best to include data on them in this study, although surveys were less representative of merganser populations than of other ducks.

Table 3
Comparison of results of three spring surveys, with population estimate based on numbers of broods produced, Cape Breton Island, 1961

Species	Survey	No. of pairs	Total no. of adult ducks	Total no. of broods (estimated)
Wood Duck	1st	0	0	1
	2nd	0	2	
	3rd	0	0	
Green-winged Teal	1st	7	114	
	2nd	13	29	3
	3rd	2	6	
Black Duck	1st	8	88	
	2nd	18	61	13
	3rd	10	79	
Blue-winged Teal	1st	0	0	
	2nd	5	16	13
	3rd	4	16	
Ring-necked Duck	1st	15	83	
	2nd	54	139	29
	3rd	44	119	
Common Goldeneye	1st	4	14	
	2nd	1	9	11
	3rd	2	4	
Common Merganser	1st	9	93	
	2nd	9	120	10*
	3rd	14	112	
Red-breasted Merganser	1st	0	1	
	2nd	7	23	0
	3rd	1	4	

* Some merganser broods were detected during banding only, but all listed were seen on survey areas.

6. Results

6.1. Timing of the spring survey

We compared the results of the three spring surveys in 1961 (Table 3) with the numbers of broods of each species, calculated by the method of Gollop and Marshall (1954). The actual number of pairs on the study areas in spring could not be less than the number of broods, which represented successful pairs, except where broods moved onto the areas after the spring survey. Migrating ducks of most species were present on the first survey, and transient Green-winged Teal, Ring-necked Ducks, and mergansers were still present on the second survey; large flocks of Common Mergansers were still at Nyanza on the third survey. We saw the first Black Duck brood on 31 May, during the third survey.

6.2. Comparison of survey methods

Results of the rapid and intensive surveys in the spring of 1961 are compared in Table 4. No rapid survey was feasible at Baddeck River; therefore intensive counts from that area were omitted. Survey time totalled 5 h 39 min for the rapid coverage and 18 h 33 min for the intensive count on the same areas during the second survey, and 5 h 38 min vs. 18 h 45 min during the third survey.

About three-quarters of the Black Ducks, Ring-necked Ducks, and Common Goldeneyes seen on the intensive surveys were found by the rapid coverage. Less than half of the teal were found by the rapid coverage.

Results of the aerial survey and the ground surveys in the spring of 1961 were compared in Table 5. As we did not survey Shoal Lake from the air, it was omitted from the comparison. Aerial survey time totalled 55 min, compared to a mean of 20 h 26 min for the two ground counts. As no aircraft was available on Cape Breton Island that spring, ferrying to and from the study areas accounted for 70% of the total flying time. About 25–35% of the Black Ducks and

Table 4
Total numbers of ducks seen on "rapid" and "intensive" surveys on Cape Breton Island, Nova Scotia, in spring of 1961*

	No. of ducks seen			
	2nd survey		3rd survey	
Species	Rapid	Intensive	Rapid	Intensive
Wood Duck	2	2	0	0
Green-winged Teal	11	29	1	5
Black Duck	47	61	54	72
Northern Pintail (migrants)	2	2	0	0
Blue-winged Teal	5	16	4	11
Ring-necked Duck	106	123	54	74
Common Goldeneye	9	9	5	6

* Data for mergansers could not be reconstructed in this form (field notebook lost 23 June 1961).

Table 5
Numbers of ducks seen on aerial and ground surveys on Cape Breton Island, Nova Scotia, in spring of 1961

	Total no. of ducks seen	
Species	Aerial survey	Mean of "intensive" counts on 2nd and 3rd ground surveys
Black Ducks	22	65
Teal (both species)	0	26
Ring-necked Duck	23	86
Common Goldeneye	7	8
Mergansers (both species)	81	136

Ring-necked Ducks found on the intensive ground counts were detected by the aerial survey. Common Goldeneyes and mergansers were more readily seen from the air, but no teal were identified on the aerial survey.

6.3. Comparison of surveys at different times of day

Results of the daytime and twilight surveys in spring 1962 are compared, by species and by location, in Tables 6 and 7. Most Ring-necked Ducks flushed at Loch Ban flew in the direction of McCormack, and vice versa, on the daytime counts; some duplication was suspected there, and also in mergansers at Nyanza. Slightly more pairs, especially of Black Ducks, were seen on the twilight counts, and more flocked birds on the daytime surveys, but the differences were not striking.

6.4. Replication of survey results

Results of three replicate counts in spring 1963 are compared, by species and by location, in Tables 8 and 9. Some mergansers flushed at the mouth of Middle River were seen flying to the mouth of Baddeck River, and vice versa; movements of ducks between Loch Ban and McCormack were also seen. Despite this duplication, successive counts were similar for all species, totalled across areas; owing to small samples, there was more variation between counts on individual areas, though the overall patterns were similar.

Table 6
Total numbers of ducks seen on "daytime" and "twilight" surveys on Cape Breton Island, Nova Scotia, spring 1962, by species

	No. of ducks seen							
	Daytime				Twilight			
Species	Pairs	Singles*	Flocked	Total	Pairs	Singles	Flocked	Total
Green-winged Teal	1	1	1	4	2	0	0	4
Black Duck	11	11†	15	48	17	12	27	73
Blue-winged Teal	8	6	1	23	10	7	2	29
Ring-necked Duck	61	0	30	152	52	0	16	120
Common Goldeneye	2	0	10	14	2	0	7	11
Common Merganser	5	2	55	67	4	2	11	21
Red-breasted Merganser	5	0	3	13	3	0	7	13
Other species‡	0	0	1	1	1	0	0	2

* Either sex.
† +2 broods (23 May and 24–25 May).
‡ Mallard 1 male (with Black Duck female); Oldsquaw 1 male.

Table 7
Total numbers of ducks seen on "daytime" and "twilight" surveys on Cape Breton Island, Nova Scotia, spring 1962, by location

	No. of ducks seen							
	Daytime				Twilight			
Location	Pairs	Singles	Flocked	Total	Pairs	Singles	Flocked	Total
Antigonish	5	2	15	27	8	3	9	28
Pomquet	3	0	0	6	2	1	1	6
Judique	7	5	0	19	11	4	0	26
Mabou	3	1	18	25	2	1	17	22
Margaree	9	6	14	38	11	4	5	31
Baddeck River	14	2	30	60	11	1	2	25
Middle River	4	3	1	12	8	2	13	31
Whycocomagh	5	2	3	15	4	4	1	13
River Denys	8	1	15	32	9	1	11	30
Scotsville	3	2	1	9	5	2	2	14
Loch Ban	12	3	4	31	11	3	1	26
McCormack	20	4	5	49	10	3	0	23

Table 8
Total numbers of ducks seen on three spring surveys on Cape Breton Island, Nova Scotia, 1963, by species

	No. of ducks seen											
	1st survey				2nd survey				3rd survey			
Species	Pairs	Singles*	Flocked	Total	Pairs	Singles	Flocked	Total	Pairs	Singles	Flocked	Total
Green-winged Teal	1	2	2	6	3	0	3	9	0	1	0	1
Black Duck	7	7†	9	30	7	6	12	32	9	8	18	44
Blue-winged Teal	3	7	3	16	5	7	3	20	4	7	0	15
Ring-necked Duck	33	2	28	96	27	5	14	73	35	5	12	87
Common Goldeneye	1	1	0	3	1	3	0	5	1	2	0	4
Common Merganser	4	0	43	51	6	1	15	28	2	1	61	66
Red-breasted Merganser	1	1	0	3	1	0	4	6	2	0	0	4
Other species	0	1‡	0	1	0	1‡	0	1	0	0	0	0

* Either sex.
† +1 brood (Ib, 3 June).
‡ Mallard 1 male, (with Blacks).

Table 9
Total numbers of ducks seen on three spring surveys on Cape Breton Island, Nova Scotia, 1963, by location

	No. of ducks seen											
	1st survey				2nd survey				3rd survey			
Location	Pairs	Singles	Flocked	Total	Pairs	Singles	Flocked	Total	Pairs	Singles	Flocked	Total
Antigonish	2	1	19	24	5	0	17	27	3	2	10	18
Pomquet	1	0	2	4	0	0	0	0	0	0	0	0
Judique	3	0	3	9	2	1	8	13	5	3	0	13
Mabou	1	1	0	3	2	1	0	5	3	0	0	6
Margaree	4	6	0	14	2	5	0	9	1	5	1	8
Baddeck River	9	3	8	29	6	2	8	22	11	4	23	49
Middle River	2	2	38	44	3	2	5	13	3	2	39	47
Whycocomagh	5	2	0	12	5	3	4	17	3	2	0	8
River Denys	10	1	11	32	13	2	7	35	11	0	16	38
Scotsville	3	1	0	7	3	3	0	9	3	4	0	10
Loch Ban	5	2	0	12	3	0	3	9	1	2	0	4
McCormack	6	1	8	21	6	3	0	15	9	0	2	20

6.5. Relative effectiveness of individual brood surveys

Table 10 compares the numbers of duck broods seen on each summer survey in 1961–63 with the estimated total broods produced each year. No brood survey detected more than two-thirds of the total broods seen in a year. Few Blue-winged Teal or Ring-necked Duck broods were found on the first surveys, and many Black Duck broods were flying by the third surveys.

6.6. Species composition derived from spring and summer surveys

Results of spring and summer surveys in 1961–63 are compared for species composition in Table 11. Only areas covered in both spring and summer in all three years are included; Margaree and Mabou were excluded because summer surveys (except for mergansers) were incomplete. The numbers of ducks on the spring surveys thus differ from those listed in Tables 4, 6, and 8. For the spring figures, we used the results of the third survey in 1961, the twilight coverage in 1962, and the third survey in 1963. Relatively more teals and goldeneyes were detected on summer brood surveys, but more Ring-necked Ducks and Common Mergansers were found in spring. Black Ducks made up about the same proportions in spring and summer.

6.7. Breeding success

Figure 2 shows the ratios of broods seen in summer to pairs seen in spring on the same areas in 1961–63, as an indication of success of breeding. The merganser data gave inconsistent results, and were not plotted (see Discussion). Samples of completely counted broods were too small to give useful data on mean sizes of broods of different ages. The brood/pair ratios for all species were markedly lower in 1962 than in 1963, and slightly lower in 1963 than in 1961. The inter-year difference was less for Black Ducks than other species.

6.8. Population trends

Numbers of ducks (excluding mergansers) seen in spring surveys on the survey areas in Cape Breton Island in 1955–63 are shown in Figure 3. The 1956 and 1957 survey dates were probably earlier phenologically than those in the other years. Some data on numbers of broods (excluding mergansers) reported on summer surveys are summarized in Table 12. The 1956 brood survey was too early to detect broods of Ring-necked Ducks. The data suggest that numbers declined from 1955 to 1960, then stabilized.

7. Discussion

7.1. Timing of the spring survey

G. F. Boyer recommended in 1955 (unpubl.) that spring surveys on Cape Breton Island be made about 10–15 May, which would be equivalent phenologically to the second survey in 1961. In that year, many migrant ducks were still present during the first and second surveys, and Blue-winged Teal did not reach summer numbers until nearly the end of May. As waterfowl breeding densities in the Maritimes were too low to warrant repeated spring pair counts of each area, as recommended for the prairies by Dzubin (1969), I concluded that the date of the third survey in 1961, about the time of the first appearance of Black Duck broods, was the best compromise. On Prince Edward Island, the late C. O. Bartlett (pers. commun.) also preferred to make spring pair surveys about that time.

Table 10
Numbers of duck broods (all species combined) on each summer survey on Cape Breton Island, 1961–63. The 2nd survey in 1962 and the 3rd in 1963 were incomplete. The total number was estimated by the method used by Gollop and Marshall (1954)*

	No. of broods seen			
Year	1st survey	2nd survey	3rd survey	Total (est.)
1961	18	54	41	77
1962	31	24	41	75†
1963	20	44	46	75

* Some merganser broods were detected only during banding, but all were on the survey areas.
† Adjusted to allow for incomplete second survey (see Discussion).

Figure 2
Ratios of broods seen/spring pairs seen for all comparable survey areas, Cape Breton Island, 1961–63

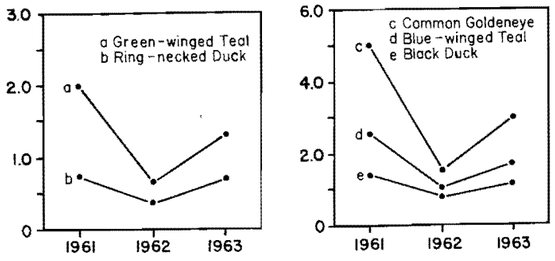


Table 11
Numbers and percentage composition of ducks seen on spring surveys and of duck broods seen on summer surveys on the same areas, Cape Breton Island, Nova Scotia, 1961–63

	Total no. of ducks seen			Mean % of ducks	No. of broods seen			Mean % of broods
Species	1961	1962	1963		1961	1962	1963	
Wood Duck	0	0	0	0	1*	0	0	1
Green-winged Teal	4	4	1	1	2	2	4	4
Black Duck	49	54	41	21	13	15	12	19
Blue-winged Teal	13	21	9	6	13	11	11	16
Ring-necked Duck	106	120	86	45	26	23	29	37
Common Goldeneye	6	7	4	2	9	2	6	8
Common Merganser	85	16	64	24	10	14	9	16
Red-breasted Merganser†	1	3	2	1	0	0	0	0
Total	264	225	207		74	67	71	

* At River Denys, where only other record was on 23 April (male).
† Nests or broods were seen upriver from Margaree survey area in 1961 and 1962 (*cf.* Erskine 1972).

Table 12
Numbers of waterfowl broods seen at Nyanza and in other areas in eastern Nova Scotia, 1952–63

	No. of broods (all species except mergansers)		
	Nyanza		Mabou, Scotsville, Margaree Whycocomagh, Antigonish
Year	Baddeck River	Middle River	
1952	22	No data	No data
1955	26	23	14
1956	8	11	5
1960	12	2	9
1961	12	3	14
1962	11	2	21
1963	11	6	19

7.2. Survey methods

The rapid method required only one-third as much survey time as the intensive survey (5.5 vs. 18.5 h) in spring, and detected about three-quarters of the Black Ducks and Ring-necked Ducks (Table 4). However, the fractions of the less common species detected were lower, and the rapid method could only be used for areas easily viewed from roads. Reproducibility of rapid surveys was not tested, but probably is less than that for intensive coverage. Although rapid surveys could probably provide population indices, rather than total population estimates on specific areas, for the major species, it seemed likely that intensive surveys would be needed to represent adequately numbers of the teals and Common Goldeneye. There would not be a substantial saving of time using the rapid survey because the travel time between areas would be the same for both methods; a reduction from 18 to 6 h of survey time would only cut down field time eastward from Antigonish from three to two days.

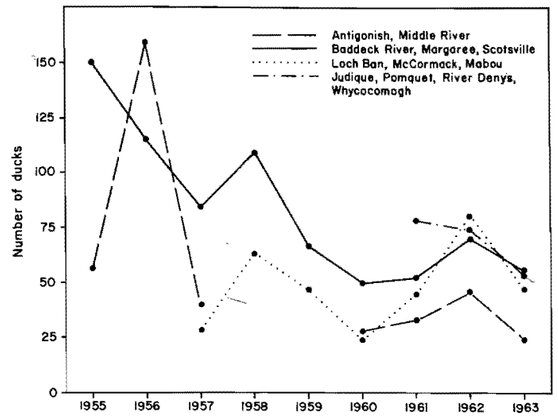
Much the same comments apply to aerial surveys, a still more rapid method. Even lower proportions of total pairs, particularly of the teals, were detected, and the variability of the data was probably greater. In view of the widely spaced survey areas and their relatively small size, travel between airports and study areas would form an important fraction of total flying time, even if aircraft were available on Cape Breton Island (which was not the case in 1961).

Conclusions as to the best survey method will depend on the purposes for which the data are to be used, and on the personnel who will conduct the surveys. In 1961, assuming that the data would contribute to personal and general understanding of waterfowl populations and requirements, by area and year, as well as providing trend data, I concluded that intensive ground surveys were preferable to more rapid methods. This was on the understanding that the surveys would be conducted by the biologists responsible for interpreting the results. This was roughly the same framework within which Dzubin (1969) made similar recommendations for waterfowl surveys in the prairies, although there the general distribution and high densities of waterfowl made the use of aircraft feasible. Mendall (1958) also recommended intensive ground coverage in Maine.

7.3. Replication of spring survey results

Contrary to expectations, there was little difference in results of spring surveys conducted by the intensive method in early morning or evening compared to those in the middle of the day. The more obvious differences involved movements of flocked birds between nearby areas. Allowing for this, the relatively close similarity of counts on successive days, using standardized times and methods, was less surprising. Poor weather conditions such as strong

Figure 3
Number of ducks (all species except mergansers) seen on spring surveys, Cape Breton island, 1955–63



winds or heavy rain often led to postponement of surveys. However, given conscientious effort, the intensive method seemed relatively insensitive to minor variations in date, time of day, or weather.

7.4. Representativeness of survey results

The spring surveys regularly under-represented the proportions of the teals and of Common Goldeneyes (Tables 3 and 11), with some over-representation of Ring-necked Ducks and Common Mergansers. The numbers of broods later detected, equivalent to numbers of successful pairs, showed minimum levels for spring pairs, unless some broods moved into the study areas after the spring survey. Movements of pairs, and presumably also of broods, occurred between closely adjacent pairs of areas (Baddeck and Middle River deltas, McCormack and Loch Ban), but these would not affect the total production. Some broods of Common Goldeneye and Common Merganser seen at Margaree, Mabou, Baddeck River, and Middle River probably hatched farther upriver (off the study areas), and descended to the estuary or delta after the spring surveys; some adult mergansers detected in spring may have reared their broods upriver. One goldeneye female was found incubating a clutch in a nestbox by the Northeast Margaree River some 15 km upstream from the Margaree study area, and no class Ia goldeneye brood was ever seen on the study areas. There was no similar explanation for the low numbers of teals on the spring counts; very few of those species were encountered away from the study areas at any season. Other workers also have remarked on the low detectability of teals, especially Green-winged Teal, particularly from the air (e.g. Haapanen and Nilsson 1979). The brood counts are the best available index to breeding populations of teals and goldeneye, and probably also of Ring-necked Ducks, of which the spring counts must include a substantial proportion of non-breeding or ultimately unsuccessful pairs over and above the surplus of drakes (noted also by Mendall 1958). Black Ducks on the other hand are undoubtedly mobile as well as versatile, and some broods detected on the study areas were probably hatched in surrounding upland areas. Surveys involving use of a dog for detecting ducks (as in 1955) indicated that both spring and summer surveys in Cape Breton were probably incomplete for Black Ducks, but the equivalent numbers of spring pairs and of broods each

year suggest that both surveys provided usable population indices for this species. We saw a few Wood Ducks each year, mostly during the summer surveys (10 adults in 1961; 2 adults 1962; 1 adult 1963); the only brood was at River Denys, in 1961, as were the only spring sightings of the species. Mergansers were more mobile than other waterfowl, with brood movements often extending 10–15 km along a river system, or between adjacent river mouths (pers. obs.); adults are similarly mobile, and flocks of subadult birds distorted the spring totals in 1961 and 1963 (Table 11). I concluded that summer brood surveys were essential for representative coverage of waterfowl populations on Cape Breton Island, but that if only one survey could be made each year the spring count was to be preferred to any single brood survey.

Survey results from Cape Breton Island were thought unlikely to represent adequately waterfowl populations in the Maritimes as a whole, owing to variations in species composition of different areas. Comparison of data from Cape Breton (Table 11) with those for Prince Edward Island (see Chapter I, Table 1) and unpublished figures from the St. John River marshes in New Brunswick (Table 13) indicate the more productive areas; most other areas would show fewer species and higher proportions of Black Ducks. Only on Prince Edward Island was there good correlation between percentage composition of spring pairs and of broods for most species. I suggested in 1964 that all major waterfowl-producing regions would need to be sampled annually to show adequately year-to-year fluctuations in waterfowl populations and production in the Maritimes. As a minimum, surveys comparable to those in Cape Breton (as described here) and Prince Edward Island (see Chapter 1) should also be made in the Nova Scotia–New Brunswick border area, the St. John River marshes, the Yarmouth County saltmarshes, and northeast coastal New Brunswick. None of those areas, individually or collectively, has any real significance in the continental waterfowl picture. However, they do produce the ducks sought after by local waterfowl hunters in the early part of each hunting season, and some picture of annual variations in their numbers should be available. The data discussed in this paper are probably typical of what could be obtained with a modest expenditure of time and effort.

7.5. Population trends

The data in Figure 3 and Table 12 suggested that waterfowl numbers on Cape Breton Island decreased appreciably between 1955 and 1963, as despite changes in observers and lack of standardization of the surveys, both spring and summer surveys showed a decrease. Most of the decline seemed to be centred at Nyanza, which was heavily frequented by hunters from the Sydney area in the early part of the hunting season.

During the relatively intensive studies reported here, numbers of most ducks were markedly higher in spring 1962 than in the other years. The incomplete second brood survey undoubtedly reduced the total numbers of broods detected in 1962; data from 1961 and 1963 suggested that only 15–20% of the total estimated broods were seen on the second brood survey. From that, the nine areas not covered on the second survey might have shown an additional 8–10 broods in 1962, making a total (exclusive of mergansers) very similar to that of the other years (as shown in Table 10). As the spring counts in 1962 were higher for all species (except mergansers) than in other years, the ratio of broods produced relative to spring ducks was certainly lower than in other years, if not to the extent shown in Figure 2. The relatively good production of broods in 1961 correlated well with the increased numbers of all species detected in the spring of 1962 (Table 11, Fig. 3). The poor production in 1962 was followed by a decrease in spring ducks in 1963, which supported the belief that the survey results reflected real trends in waterfowl numbers and productivity.

7.6. Breeding population density and total populations

Duck population densities were fairly different between the three major habitat types — freshwater, brackish non-tidal, and brackish tidal areas (Table 1) — both in spring and summer (Table 14). The indices used were total spring ducks/2 (referred to as "pairs") and total brood estimates for summer, averaged over 1961–63. Margaree, River Inhabitants, and Shoal Lake were not included, as coverage of those areas was incomplete in some years or seasons. Generally, freshwater areas had the highest densities, and tidal areas the lowest. The freshwater areas and the brackish non-tidal areas (except Judique Ponds and Pomquet Lake) are partly underlain by gypsum deposits, which increase the alkalinity and overall fertility of those wetlands irrespective of their salinity or tidal influence.

There was no possibility in 1961–65 of extrapolating the densities found to the whole of Cape Breton Island or farther, as we had no useful data on wetland areas or capabilities. The areas we surveyed, selected from maps and verified in the field, were the most productive waterfowl areas that were accessible by road (Fig. 1). With unlimited access, it might be possible to find three times as much good habitat within the areas considered, say 60 km^2 out of a total of 5200 km^2. The surveys showed about 4 pairs/km^2 on the good habitat sampled, or roughly 250 pairs on the entire good habitat. Even if the remainder of the area supported only 0.4 pairs/km^2, a figure supported by unpublished aerial survey results, the total area might support another 2000 pairs. Although the survey areas comprised an appreciable proportion of the most productive habitat, they evidently supported only a small, and not necessarily representative fraction, of the total waterfowl population. Until we obtained more precise figures for the total wetland acreage and the densities and species compositions to be expected in the different habitat types, no statement as to the importance of the study areas in the regional picture could be made.

Table 13
Species composition of adult birds observed on spring surveys, and of broods observed subsequently on the same areas, in the St. John River estuary, 1957–59

	Adult birds*		Broods			
			CWS*		NEWS†	
Species	No.	%	No.	%	No.	%
Wood Duck	60	2	18	15	18	10
Green-winged Teal	43	2	6	5	11	6
Black Duck	1450	54	38	32	40	23
Others, (Mallard, Pintail)	193	7	0	0	4	2
Blue-winged Teal	105	4	6	5	46	26
Ring-necked Duck	343	13	3	3	31	18
Common Goldeneye	477	18	48	40	26	15
Common Merganser	18	1	0	0	?	?
Totals	2689		119		176	

* Based on CWS surveys (5–12 May, 3–15 July); omitting Scaup (migrant on spring surveys.
† Based on North-eastern Wildlife Station (NEWS) surveys (16 July – 17 Aug.).

Table 14
Estimated waterfowl breeding densities, Cape Breton Island study areas, 1961–63. Spring index is total number of ducks on spring counts divided by 2 ("pairs"); summer index is total brood estimate; mean figures for 1961–63 given

	Population indices (per km^2)	
Location	Spring "pairs"	Summer broods
(a) Freshwater areas		
Scotsville	29.0	26.0
Loch Ban	14.0	9.6
McCormack	25.0	17.0
	$\bar{x}$ = 23	$\bar{x}$ = 18
(b) Brackish, non-tidal areas		
Baddeck River	10.0	7.2
Middle River	11.0	4.7
Whycocomagh	20.0	25.0
River Denys	14.0	9.6
Judique Ponds	7.4	2.2
Pomquet Lake	9.9	3.9
	$\bar{x}$ = 12	$\bar{x}$ = 9
(c) Brackish, tidal areas		
Mabou	6.4	1.0
Antigonish	9.1	3.9
	$\bar{x}$ = 8	$\bar{x}$ = 3

8. Acknowledgements

This study was conducted under the supervision, in turn, of David Munro, Louis Lemieux, and Alan Loughrey of CWS. I was assisted in the field during brood surveys in 1961 and 1963 by Robert Gibbon, and during spring and summer 1962 by Stewart MacLeod of Nova Scotia Department of Lands and Forests. Preparation of the internal reports which preceded this account was aided by comments from Nolan Perret and Denis Benson.

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First attempts towards extrapolated populations

When the results of my Cape Breton waterfowl population studies (Chapter II) were presented at the Northeastern Wildlife Conference in Hartford, Connecticut, in January 1964, one of the first questions asked was whether I could extrapolate from them to give total populations, for eastern Nova Scotia for example. My response was in the negative, as I did not know what proportion of the potential habitat had been included in my samples. The establishment of the Canada Land Inventory (CLI) in 1965 gave some hope of learning more about the extent of waterfowl habitats. The initial success of the cooperative Breeding Bird Survey (BBS), begun in 1966, and of randomized sampling for Woodcock singing ground surveys, raised the possibility of carrying out systematic sampling of inland-nesting waterfowl in the Maritimes. The next paper reports on an exploratory study of low-density waterfowl habitats which petered out as I was diverted to other work.

III. Waterfowl populations and ecology in forested areas of the Maritimes, 1967–69

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1. Abstract

Waterfowl, mainly Black Ducks, Ring-necked Ducks, and Common Goldeneyes, occurred through much of the forested parts of the Maritimes. Although breeding densities were low, so that surveys gave a low return for time and effort expended, the available habitat is so extensive that the total numbers presumably are large. Breeding chronology was similar, and breeding success as high or higher, than in previously studied areas. Predator and hunting pressures on those populations seemed likely to be relatively low. Wherever possible, such studies should be combined with other investigations to reduce costs.

2. Introduction

Before European settlement, the waterfowl of eastern North America bred in a largely forested region. The predominantly broad-leafed forests of the eastern states and southern Ontario and Quebec were greatly reduced after colonization (e.g. Edwards 1969), but major portions of the six eastern provinces are forested even now, and many of the ducks of eastern Canada still breed in forests. Intensive studies of eastern waterfowl, such as those described earlier in this publication and elsewhere, focused on localized high-density areas along major rivers (e.g. Wright 1954) or near the coasts (e.g. Reed 1975). Previous reconnaissance had indicated that densities elsewhere were too low for effective study (e.g. Addy *et al.* 1949). The need for detailed information about low-density, forested waterfowl habitats was obvious to most waterfowl biologists and managers, and the success of random sampling in providing population indices for song birds (Robbins and Van Velzen 1967) encouraged further work on waterfowl. Initial random sampling in October 1966, of one or two areas in one-degree blocks of latitude and longitude, indicated that study areas would need to be more concentrated in order to keep travel time down to practicable levels. Work in 1967 and 1968 was intended to see if I could work out a feasible study program on waterfowl in forested habitats. My transfer to other duties after 1968 ended the study except for some work peripheral to passerine censuses in 1969. This account presents my findings from 1967–69.

3. Methods

In 1967, I selected study areas from maps, using the following criteria:
(a) wetlands should have shores which were at least partly forested and with no agricultural development within 1 km;
(b) locations should be at, or above, 200 m elevation (to improve comparisons with more northern regions): this was not always possible in eastern Nova Scotia;
(c) water bodies backed up by man-made barriers were excluded;
(d) access could be by land or water, but areas more than 2 km from roads suitable for cars were omitted, for the sake of convenience.

In 1968, study was focused on two major wetlands in western New Brunswick — a sedge and shrub meadow bog along Dead Brook, in York County (45°52'N, 67°38'W), and a black spruce bog near Juniper Station, in Carleton County (46°33'N, 67°11'W). I had visited them both in 1967 and also made a census of the Juniper plot in 1969.

In 1967, I visited most areas once between 30 May and 28 June, (one on 31 July), and again between 29 August and 4 October. Work on other projects precluded visits in the intervening months. In 1968, the Dead Brook and Juniper areas were visited on eight and eleven dates, respectively, between 23 May and 19 July, and I made sporadic observations elsewhere while travelling to and between those areas. I surveyed the Juniper plot in 1969, on seven days between 16 May and 25 June, with very limited observations being made elsewhere.

On each visit, I attempted to count and identify all waterfowl present, by walking or canoeing around the area. General descriptions of habitat were obtained, with special attention being given to vegetative cover, shoreline and water characteristics. Specimens of the more common aquatic plants were preserved for identification. I made a quantitative sampling of vegetation at Dead Brook and Juniper in 1968 (Erskine 1968*a*, *b*).

4. Results

4.1. Relative densities of breeding waterfowl

In all, I went to 47 areas in 1967 (Fig. 1). I saw ducks on 23 of the 44 areas visited before the end of July. Black Ducks, Ring-necked Ducks, and Common Goldeneyes made up over 80% of the 143 ducks (plus seven broods) seen. A flock including 35 Black Ducks and 8 Blue-winged Teal at Canoose River on 1 June was thought to include moulting or non-breeding birds. With those excluded, the species composition consisted of Black Ducks 31%, Green- and Blue-winged Teal 3% each, Wood Duck 8%, Ring-necked Ducks 44%, Common Goldeneye 7%, Common Merganser 4%.

The May–July surveys in 1967 involved 33 h survey time spread over 18 days. Excluding the flock at Canoose River, the return was about three ducks per hour; owing to work on other projects on the same trips, I was not able to obtain a useable estimate of ducks seen per day.

In 1968, fairly precise population estimates were obtained from the two main study areas (Table 1). Breeding pair densities calculated for the areas actually covered were: Dead Brook (60 ha) 20 pr/km^2; Juniper (40 ha) 14 pr/km^2.

4.2. Breeding biology

One nest was found at the Juniper bog in 1969, when a Black Duck flushed from eight eggs on a tussock in a clump of low, dense black spruces. Black Ducks were also seen flying in pairs over that bog in 1968, when newly hatched young were observed there, so Black Duck nesting in that habitat is not exceptional.

All the broods I saw were aged, and I estimated hatching dates following Gollop and Marshall (1954) (Table 2). Seasonal phenology was very late in 1967, early in 1968, and intermediate in 1969.

Survival of young could only be guessed at from the available data. Black Duck broods less than a week old averaged 9.0 young (11, 10, 10, 10, 3, in 1968; 10 in 1969), but the only complete counts of older young, all in 1967, were of eight young 10 days old (Ib), and two broods of seven young 3–4 weeks old (IIa–b). Ring-necked Duck broods (all seen in 1968 at Dead Brook) under 10 days old averaged 6.8 young (9, 8, 7, 6, 4), and those 10–20 days old averaged 4.8 young (8, 5, 3, 3). Goldeneye broods under 10 days old averaged 4.6 young (6, 3, in 1967; 5, 5, 3, 3, in 1968; 7, 5, in 1969), and older broods averaged 3.4 young (4, 4, 3, 3, 1, in 1968; 5, 4, in 1969). However, individual young Goldeneyes survived independently for several weeks on bog ponds at Juniper in 1968, so the small mean size of broods of this species did not represent the overall survival of young Goldeneyes.

Circumstantial evidence of brood movements was obtained at Juniper. Neither of the newly hatched Black Duck broods seen there remained on subsequent visits, although ducklings separated from the adult were seen twice. One brood apparently moved at least 100 m from one pond to another in 40 min between observations, and it would be easy for young to become separated from the brood during such movements. Goldeneye broods behaved in a similar manner. On 25 June 1969, I found a female Goldeneye leading four class Ib ducklings along an intermittently flowing ditch between ponds on the bog; I believed this was the brood I had seen on earlier visits on a large pond some 250 m to the northwest, where only a lone duckling was seen on the same day.

Waterfowl continued to use the study areas up to the start of the hunting season, rather than moving to known concentration areas as I had expected. On the areas visited in August and early September 1967, Black Ducks, Wood Ducks, Ring-necked Ducks, and Common Goldeneyes were seen, including flying young corresponding to at least one Black Duck brood and three Goldeneye broods seen earlier in the same places. Black Ducks, Green-winged Teal, and Ring-necked Ducks were still on North Mountain Lakes, NS, on 2 October 1967. Of 21 areas I visited both in summer and fall, 12 had ducks at both seasons, 4 only in summer, and 2 only in the fall.

Figure 1
Locations of areas visited in Black Duck study in Maritimes, 1967

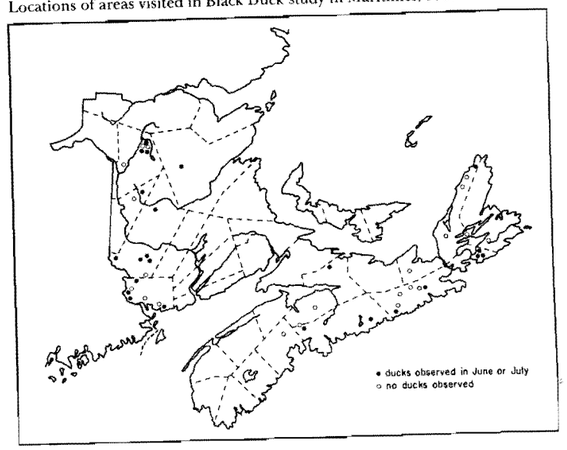


Table 1
Numbers of waterfowl seen on two study areas in New Brunswick, 1968, by species. Known or presumed breeding species in italic

Species	Maximum no. of ducks seen on one visit* at Dead Brook	Juniper
Wood Duck	1 adult (twice)	1 male (twice)
Green-winged Teal	1 adult (twice)	2 males (1 twice)
Black Duck	*3 broods*	*2 broods*
Blue-wmged Teal	*1 pair, 1 male*	—
Ring-necked Duck	*5 broods*	2 males (1 twice)
Common Goldeneye	*2 broods*	*4 broods*
Common Merganser	1 female (once)	—

* Other sightings were compatible with these estimates.

Table 2
Estimated hatching dates for waterfowl in forested areas of the Maritimes, 1967–69

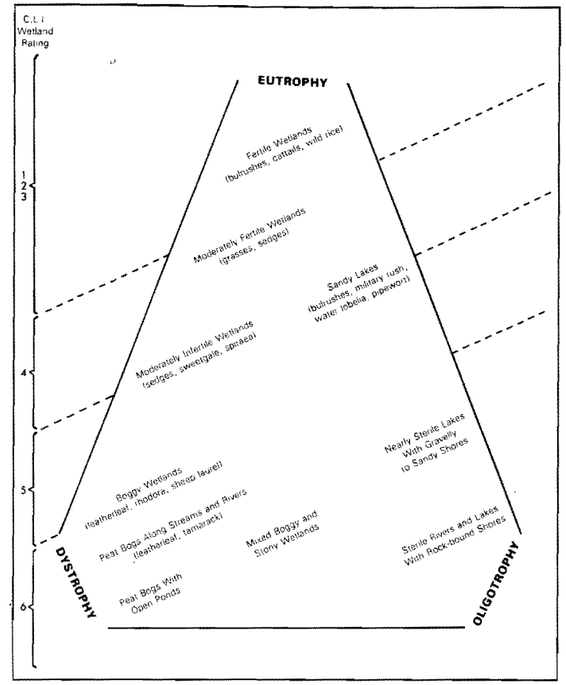
Species	Year	Range of hatching dates: Early broods (no.)	Late broods (no.)
Black Duck	1967	6–8 June (3)	5 July (1)
	1968	19 May – 5 June (7)	19 – 22 June (2)
	1969	2 – 4 June (2)	—
Ring-necked Duck	1968	16 – 26 June (5)	—
Common Goldeneye	1967	4 – 23 June (3)	—
	1968	4 – 14 June (5)	26 June (1)
	1969	4 – 13 June (2)	—

4.3. Breeding habitat and vegetation

I identified most aquatic plants I encountered, but no data on actual use of particular species were obtained. A tentative classification of the poorer freshwater wetland types (those usually encountered in forested areas) in the Maritimes, based largely on substrate and major cover plants (Fig. 2), showed a correlation with the Canada Land Inventory (CLI) waterfowl capability classification. This had been evolved independently in 1965–67, but had not yet been published. Of the two major study areas, Dead Brook exemplified the "moderately infertile wetlands" (CLI class 5) with sedges and low non-ericaceous shrubs predominating. Juniper was one of the few "peat bog with open ponds" sampled (CLI class 6), with *Sphagnum*, ericaceous shrubs, and black spruce being the most obvious vegetation.

Within each wetland type, the well-known preferences of the different duck species for different habitats were apparent, though not documented quantitatively. Black Ducks were found mainly in areas with water depths of 10–45 cm, where emergent vegetation, especially sedges (*Carex* spp.), generally grew. Ring-necked Ducks were in deeper waters, where aquatic (emergent or submerged) vegetation was usually found. Goldeneyes used mainly open water areas, where there was limited submerged vegetation (especially cow lily, *Nuphar*) or none at all. Although dabbling ducks were seen even on the open peat bog, I had the impression that they used only the more productive micro-habitats within this type, and only Black Ducks bred in that particular habitat.

Figure 2
Tentative classification of wetlands (excluding saline situations) in the Maritimes, based upon substrate and conspicuous vegetation



5. Discussion

5.1. Breeding densities

The relative densities of ducks found in the 1967 study were much lower than those found on selected areas in eastern Nova Scotia in 1961–63 (see Erskine, Chapter II). In the latter areas I found about 16 ducks/h of survey time, about 20% of which were Black Ducks, compared to 3/h, which included 30% Blacks, in this study. Densities in tidal and inland marshes on Prince Edward Island (see Bartlett, Chapter I) were also substantially higher. However, the breeding densities found in 1968 at Dead Brook were roughly comparable to those for "sedge-meadow bog" in Maine (Coulter and Miller 1968). No comparable figures for the spruce bog habitat were available, but it was ranked lower on the CLI scale so the lower density found was plausible. Even the low densities found on such habitats, extrapolated over the aggregate area, undoubtedly amount to far larger numbers of ducks than on the localized good habitats previously studied. Low densities were foreseen at the start of the study, so it is unlikely that annual monitoring studies will ever be feasible in such habitats. Studies can only be justified to answer specific questions about such areas.

5.2. Breeding biology

Other demands on my time precluded a comprehensive study of waterfowl breeding in 1967–69. Brood chronology and survival in forested habitats differed little from those in concentration areas in the Maritimes and adjacent regions, as summarized for Black Ducks by Reed (1968), for Ring-necked Ducks by Mendall (1958), and for Common Goldeneyes by Carter (1958) and Gibbs (1961). Although the Juniper area, situated in a basin (elevation 270 m) in the central highlands of New Brunswick, was somewhat of a "frost-pocket" — early morning temperatures of 1°C on 21 May 1969 and 4°C on 26 June 1968 being quite typical — the waterfowl nesting season did not seem to be obviously retarded when compared with the St. John River lowlands about 80 km to the southeast.

Perhaps the most unexpected finding was that in September, when ducks of many species were gathering in favoured concentration areas (mainly near the coasts), ducks were still present on the forested study areas in numbers little different from those that had bred and been reared there. It seemed unlikely that hunters would regularly disturb such areas because of the low densities of ducks and the difficulty of getting into and moving about in those habitats. If that situation were general in the northeast, a large proportion of the total population of ducks would be little exposed to hunting until they were forced to the coasts by freeze-up. The heavy early season kill of locally reared ducks on Prince Edward Island (see Bartlett, Chapter I), and probably elsewhere in the region, may be buffered by the larger but low-density populations in forested areas, which serve to replenish the more favoured breeding habitats. Some such restocking must be taking place in areas where banding recovery rates exceed productivity without declines being apparent over the years.

5.3. Breeding habitat and foods taken by waterfowl

We have no direct information to explain why ducks breed in some wetlands in forested regions but not in others. Presumably the basic elements of food, cover, and predation (Leopold 1933) apply. Coulter and Miller (1968) suggested that animal food was of minor importance in "northern bogs", and listed plants such as swaying-rush, pondweeds, sedges, and bur-reeds as principal waterfowl

foods. Although such plants were present in some quantity at Dead Brook, most were totally lacking at Juniper, where cow-lily was almost the only obvious aquatic plant. In such acid bogs, it seems probable that waterfowl must depend largely on animal foods. The predominance in the Juniper bog of Common Goldeneye, which is primarily an animal feeder (Cottam 1939), supports this belief. As young of most ducks eat animal food in their first week or two (Sugden 1973), it would also be possible for Black Ducks to nest in such bogs, with the broods being led away to more fertile habitats as they get older. I saw no Black Duck broods older than class Ia accompanied by an adult on the bog in 1967–69.

Nesting cover was abundant in all areas visited, but brood-rearing cover (emergent vegetation) was scarce on the less fertile areas such as the spruce bog. Young diving ducks encountered on the bog ponds dived repeatedly when approached. The general poverty of many wetland habitats in forested areas would tend to reduce the incidence of predators. I saw no sign of terrestrial predators, and fewer than one crow or raven per hour passed over the Juniper bog during my surveys. Thus nest and brood survival in any particular area is likely to be influenced mainly by available food, and with low waterfowl densities survival could be relatively high. It is possible that the large total wetland areas of both Dead Brook and Juniper contribute to their waterfowl production potential, as even young broods could move around to different areas when food became scarce in one pond or stretch of deadwater. Movement would be difficult or impossible for broods on small, isolated ponds, and selection has presumably acted against breeding attempts on water bodies of less than a certain size. In 1967, a Goldeneye brood was apparently fledged successfully (six Ia on 26 June, six flying young on 30 August) on an 8-ha pond in the New Brunswick highlands (elevation 420 m), at least 1 km overland through dense forest from the nearest alternate area. This size of pond may be near the minimum for successful brood rearing in such habitats.

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Renewed interest in surveys

After 1969, waterfowl population surveys received little attention for several years, while habitat acquisition and alteration and surveys to assess the impact of the environment on waterfowl became major parts of CWS waterfowl work in the Atlantic Provinces. The idea of estimating populations by extrapolation from systematic sampling persisted, as did concern over Black Duck numbers. Thus another preliminary effort was made to estimate Black Duck production in 1976–77.

IV. Estimating Black Duck production on beaver ponds in the Maritimes, 1976–77[1]

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E0A 3C0

1. Abstract

Beaver ponds are the preferred Black Duck habitat in forested areas and account for a major portion of the ducks produced in New England and eastern Canada. Random sampling in 1976 of habitats within Westmorland County, New Brunswick, and Cumberland County, Nova Scotia, provided estimates of beaver pond numbers, and field checking of the Westmorland County samples gave an indication of waterfowl use on such areas. An independent count from aerial photographs of beaver ponds in Cumberland County gave only fair agreement with the number estimated by random sampling, and suggested a beaver pond usage rate widely different from that found on field checks in Westmorland County. On the basis of these exploratory attempts, it was concluded that statistically valid random samples of beaver pond habitat would be unobtainable on a province-wide basis with the manpower and funding available within CWS.

In the hope of involving other agencies in developing annual indices for Black Duck production, an attempt was made in 1977 to sample 100 randomly selected beaver ponds distributed throughout New Brunswick. Of 56 survey attempts, nine failed to reach the ponds sought, and eight sites proved not to be beaver ponds, leaving 39 beaver ponds actually surveyed. Out of these, only 14 supported ducks. Delay in reaching areas resulted in most surveys being made in the middle of the day, when ducks tend to be less active and visible. The samples obtained were judged to be totally inadequate for index purposes, but further exploration of this approach using increased effort was recommended.

2. Introduction

The Black Duck is the most important waterfowl species for hunters in the Maritime Provinces and the northeastern United States. Concern over the apparently declining numbers of that species has focused attention on techniques for measuring annual production. At present, the method of assessment is indirect, using wing surveys, banding data, and local air or ground brood counts. A broader and more accurate measurement is needed.

The manner in which Black Duck use secluded forested areas tends to disperse the breeding population, resulting in low densities on most production sites. Beaver ponds are preferred habitat (Renouf 1970), accounting for a major portion of the Black Ducks produced in eastern Canada and New England. In the St. John River basin of New Brunswick, Choate (1973) estimated that 16 800 beaver flowages annually produce 9000–11 000 duck broods, over half of which are Black Ducks. Although the density of beaver ponds there may be high relative to other parts of the northeast, such ponds are distributed throughout most of the Black Duck's breeding range and represent a major portion of the available habitat. A measurement of Black Duck populations on beaver ponds should contribute to their management.

A survey of a representative sample of beaver ponds should provide a basis for estimating production over a larger area. In New Hampshire, Lacaillade (1960) surveyed waterfowl production on a randomly selected five per cent sample of four-square-mile blocks throughout the state. Erskine (see Chapter III) investigated the feasibility of studying Black Ducks in forested areas of the Maritimes, but concluded that waterfowl studies there were inefficient use of time. This study was concerned primarily with beaver pond habitat, but it may be applicable to other habitats.

The objectives were to (*a*) test the feasibility of estimating beaver pond habitat in New Brunswick and Nova Scotia by random sampling; (*b*) estimate Black Duck production in Westmorland County, New Brunswick by field checking; and (*c*) determine the feasibility of applying random sampling techniques on a province-wide scale.

3. Methods

Westmorland County, New Brunswick, was selected as a test area because of its close proximity to the Canadian Wildlife Service office. The county was divided into 201 three-minute blocks, of which 21 blocks (about 10%) were selected using a table of random numbers. A one-minute block at the centre of each randomly selected three-minute block constituted the sample to be surveyed. This procedure distributed sampling over the county as well as permitting use of a less detailed grid system for sample selection.

We surveyed every water body in each block on the ground during the week of 10 May 1976, and recorded all waterfowl observed. During the week of 22 June, we made a survey of blocks found to contain suitable habitat. Those survey dates coincided with peak numbers of breeding pairs and broods, respectively, based on local experience.

We sampled Cumberland County, Nova Scotia, in a similar manner. In 228 three-minute blocks, one-minute blocks were randomly selected from 45 (20%). All beaver ponds shown on aerial photographs (taken in 1975) of the sample blocks were recorded. Concurrently, the Nova Scotia Department of Lands and Forests enumerated all beaver ponds in Cumberland County, using aerial photographic interpretation: the inventory was conducted independently of the random block survey, so it provided a check on the random approach.

After the 1976 field season, we selected 100 beaver ponds throughout New Brunswick. The manpower available limited the size of the sample. Within the province, 100 ten-minute blocks were selected at random using latitude and longitude coordinates. We eliminated blocks immediately adjacent to the north, south, east, and west, but diagonally situated blocks remained in the sampling universe. A one-minute block was randomly selected in each ten-minute block, using a numbered grid, and 1976 air photo coverage was obtained for each block. One selected pond in each block was scheduled to be surveyed once between 15 and 31 May 1977.

4. Results

4.1. Westmorland County

Out of the 21 blocks surveyed in Westmorland County in 1976, 6 (29%) contained a total of 10 beaver ponds. Seven ponds supported active beaver colonies. If the 1809 one-minute blocks in Westmorland County contained beaver ponds at the same frequency as in the random sample, the extrapolated number of ponds in the county would be 875, of which about 615 would be active and 260 inactive.

During the June surveys of the ten beaver ponds within the sample blocks, we observed four broods of Black Ducks. No broods were detected on inactive ponds during June, but we saw one breeding pair on an inactive pond during the May survey. Considering only the active beaver ponds, four broods were observed on seven ponds in the sample. By extrapolation to the estimated number of active ponds in the county (615), 350 broods of Black Ducks might have been produced on those in 1976.

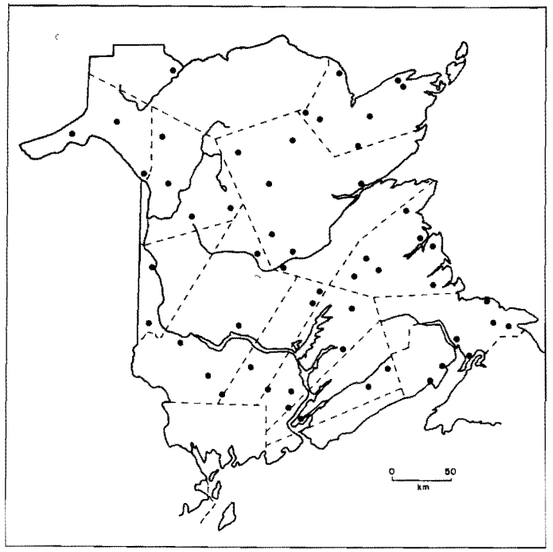
4.2. Cumberland County

Among 45 randomly selected one-minute blocks, 12 contained active and/or inactive beaver ponds, giving an average of 1.6 ponds per block. Extrapolation gave an estimated 885 beaver ponds in the county. The Nova Scotia Department of Lands and Forests counted a total of 1135 beaver ponds on aerial photographs of the county, 250 (28%) more than estimated by the random sampling method. They judged that 789 (70%) were inactive and 346 (30%) were active, a ratio of active to inactive ponds nearly opposite to that determined by us in the field in adjacent Westmorland County.

4.3. New Brunswick

Attempts were made to visit only 56 of the 100 randomly selected beaver ponds between 15 and 31 May 1977. Sixteen excursions were made by provincial staff, 18 by Ducks Unlimited (Canada), and 22 by CWS personnel. Twenty-eight beaver ponds (50%) were inactive and only eleven (20%) contained active beaver colonies. Eight sites (14%) (bog ponds, gravel pits, etc.) proved to have been misidentified from the aerial photographs. Nine ponds (16%) were not reached on the surveys. Figure 1 shows the distribution of the ponds surveyed in 1977.

Figure 1
Distribution of 56 sample sites to which visits were attempted in 1977



Black Ducks were observed on 10 ponds, including two with pairs, six with singles or grouped birds, and two with broods. Eight of these 10 ponds showed no beaver activity. Four active ponds contained waterfowl other than Black Ducks, but only one inactive pond contained other species. Considering all species, five active ponds and nine inactive ponds contained waterfowl. Most (29 of 39) surveys were conducted between 10:00 and 16:00, with the peak occurring between 12:00 and 14:00. More Black Ducks were observed between 06:00 and 08:00 than during any other two-hour interval, but other species were most commonly seen between 12:00 and 14:00.

5. Discussion

5.1. Sampling of beaver ponds

Bradt (1938) and others found that the number and size of beaver ponds depend on local topography rather than on the numbers of beavers in an area. Availability of trees used as food by beavers also influences duration of activity. Such factors could help to explain the differences in proportions of active and inactive ponds found in the various areas sampled.

Differences in interpretation of air photos may also be critical. In 1977, 17% of the sites checked proved to have been misidentified as beaver ponds. Also, what one person counted as a single pond might be counted by another as two or more ponds, if more than one dam or lodge was present.

In view of the small samples of ponds visited, no significance can be attached to differences between the various results. In any future studies of a similar kind, allowance for misidentification and faulty interpretation will be needed when sample sizes are determined.

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5.2. Surveying beaver ponds

The small samples obtained on the two surveys (Westmorland County, 1976) or one survey (New Brunswick, 1977) were insufficient to make accurate estimates of Black Duck production. Renouf (1970), in an intensive study of beaver ponds near Fredericton, New Brunswick, continued to detect additional waterfowl pairs up to his sixth survey, and Dzubin (1969) recommended making four or five spring pair counts in the prairies. Bartlett (see Chapter I) and Erskine (see Chapter II) made four or five counts and three counts, respectively, of broods on each study area, aside from spring counts.

The time of day of waterfowl observations suggested that efforts in future should be more concentrated in the early morning and evening hours, contrary to Erskine (see Chapter II). However, the problem of ground travel to beaver ponds limits the possibilities for standardizing survey time.

The 1977 survey was not given high priority by the co-operating agencies, and the observers conducted observations only when their other duties allowed it. This perhaps accounts for the high proportion of ponds not visited (60%). Increased effort and manpower could be made available, but much larger samples would be needed before confidence could be placed in the results.

5.3. Recommendations

Investigations of survey techniques for Black Ducks should be continued, because of the importance of the species to sport hunting. As data on their production are necessary for management, a production index seems preferable to absolute production figures. I suggest using a random sampling approach similar to that attempted in 1977, as has been used in forested areas of Ontario (Dennis 1974, Dennis and North 1984). To reduce travel relative to survey time, all water areas within each one-minute block should be investigated. Continued participation of provincial and Ducks Unlimited personnel should be requested, but CWS should consider this as a high priority and take the lead in such efforts. The ultimate objective is to develop standardized annual indices from which to detect and measure trends and major fluctuations in Black Duck numbers.

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Towards a waterfowl management plan for Canada

The USFWS had been developing a waterfowl management plan for the United States. In 1977, Canadian and American administrators conferred and requested that a Canadian waterfowl management plan be available for integration with the US plan in autumn 1978. In view of the information then available for much of Canada, the request seemed unrealistic and unrealizable. The CWS regional Migratory Birds chiefs met in January 1978 to explore possible approaches. One suggestion was to look into potential losses of waterfowl production habitat to other competing land uses in the future, using the Canada Land Inventory (CLI) capability ratings. In the Atlantic Region further losses of waterfowl habitat — beyond those from past drainage of salt marshes — seemed unlikely to be of any significance. However, the CLI waterfowl capability ratings offered the possibility of extrapolation to total populations within the Maritimes, if plausible estimates of waterfowl breeding density could be found. No CLI data existed for Newfoundland or Labrador, and survey data for those areas were also scanty. In 1978–79, a preliminary attempt at a population estimate for the Region made use of fragmentary data, guesswork and intuition to fill in the gaps for Newfoundland and Labrador.

At the same time, in early 1978, CWS appointed a waterfowl surveys biologist, Ian Goudie, with responsibilities for Newfoundland. His first assignment was to obtain a preliminary estimate of the breeding waterfowl population of the island of Newfoundland. In 1980, ten years after the first CWS waterfowl surveys made there, we undertook a multipurpose survey in Labrador from which population estimates might be derived. The next two papers present the results of those two studies, which were partly conceived to fill gaps in the preliminary population model.

V. Preliminary estimates of waterfowl breeding populations in Newfoundland, 1978–79

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1. Abstract

The numbers, distribution, habitat and production of waterfowl breeding in Newfoundland were studied in 1978–79, with some additional surveys being made in 1981. Sampling on the island of Newfoundland (referred to hereafter as Newfoundland) was stratified by ecoregion, and coverage within the seven ecoregions ranged from 1% to 4%, making a total for all ecoregions of 1% in 1978 and 1.6% in 1979. Emphasis was placed on inland water systems because coastal breeding is minimal.

Densities of breeding ducks varied from 105 to 666 per 100 km^2 of open water in the different ecoregions, and the highest production was in ecoregions where small ponds and lakes were numerous. There was very low production in alpine ecoregions relative to maritime barrens and boreal (forested) ecoregions, which supported low waterfowl densities compared with central Canada. Few high densities of breeding ducks were found, although some significant staging areas were noted.

The total breeding population of ducks (average of 1978 and 1979) for Newfoundland was estimated to be 31 200 pairs made up of: American Wigeon — 250 ± 130 (SE); Green-winged Teal — 6300 ± 1800; Black Duck — 11 100 ± 3030; Northern Pintail — 540 ± 280; Blue-winged Teal — 140 ± 70; Ring-necked Duck — 4800 ± 2100; Common Goldeneye — 4000 ± 2400; Red-breasted Merganser — 2400 ± 1200; Common Merganser — 1700 ± 900. In addition, the Mallard, Greater Scaup, Harlequin Duck, Black Scoter, and Common Eider breed in very low densities. The last species historically bred in large colonies around coastal Newfoundland but the present population is less than 1000 pairs. Canada Geese were surveyed incidentally and the population estimate of 4200 ± 2200 breeding pairs is low. Rough estimates based on extent of prime breeding habitat (patterned or ribbed fens) suggested that goose populations could be two or three times that figure.

2. Introduction

Waterfowl, particularly Black Ducks, are the most important game birds in eastern North America (Wright 1954). Most Canadian studies of waterfowl production have concentrated on areas of high density in the south, but ducks also breed throughout the northern forested regions of Canada. Previous surveys of ducks in boreal areas often foundered because densities were too low for economical study (Chamberlain and Kaczynski 1965; see Erskine, Chapter III; Whitman, Chapter IV). No extensive ground surveys of waterfowl had previously been undertaken on Newfoundland.

Fragmentary aerial surveys flown in 1950 by L.M. Tuck (unpubl.) in the Gander area, and in 1954 by W.F. Crissey and F.A. Glover (in Tuck 1954) across central and southern Newfoundland, suggested duck densities totalling 22–84 pairs/100 km^2 total area and Canada Goose densities of 13–15 pairs/100 km^2 total area. Aerial transects sampling the whole island in 1968 (D.I. Gillespie and B. Roberts, unpubl.) gave similar results for ducks, i.e. 43 pairs/100 km^2 total area but fewer geese, i.e. 3 pairs/100 km^2 total area. Those aerial surveys were not ground-checked, and studies elsewhere suggested that surveys using fixed-wing aircraft detect fewer than half the ducks and perhaps two-thirds of the geese actually present in an area (Diem and Lu 1960, Haapanen and Nilsson 1979). Additionally, such all-encompassing surveys did not relate breeding distribution to biophysical factors, and waterfowl numbers are averaged across noncontributing habitats (e.g. forests) as well as wetlands, which vary tremendously in proportion in the different ecological regions (e.g. 10–50% in Newfoundland).

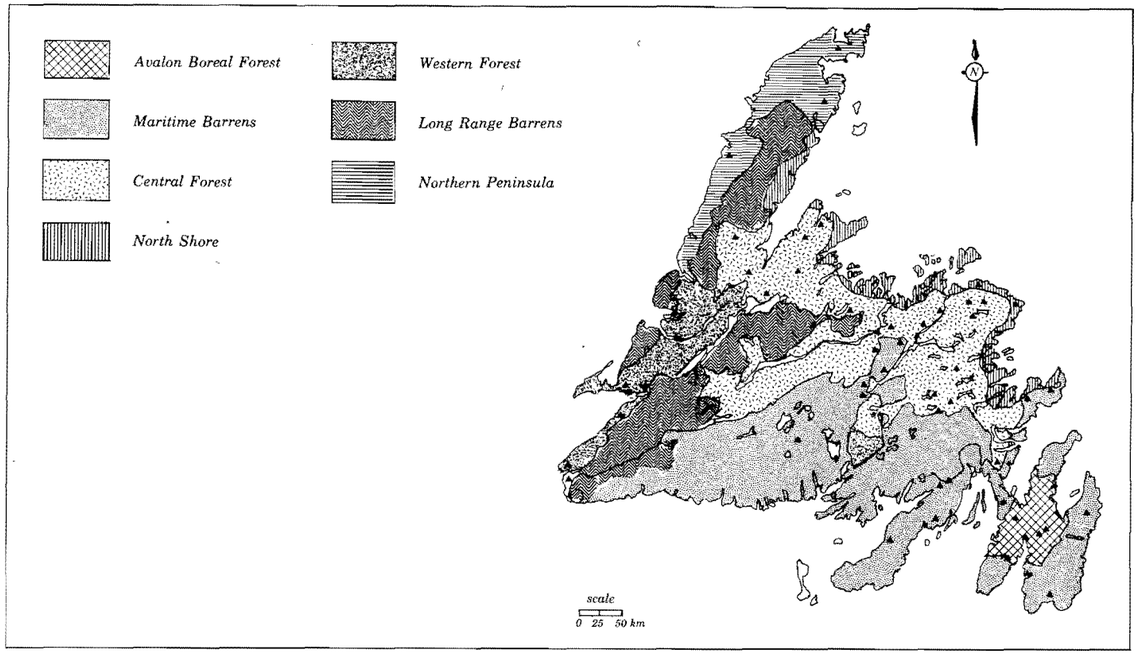
During 1978–81 we studied waterfowl throughout Newfoundland, and gathered data on the density and diversity of waterfowl within ecological strata, habitat characteristics, and chronology of use.

Table 1
Water surface area of ecoregions with calculated sample size and non-contributing water

Ecoregion	Total water surface area (km^2)*	Noncontributing water (area in large water bodies > 0.5 km from shore) (km^2)	Area sampled (km^2) 1978	1979	1981
Avalon Boreal Forest	220	0	7.6	8.3	
Central Forest	2 810	651	29.5	40.8	
Maritime Barrens	4 350	360	19.6	61.8†	
North Shore	430	6	4.5	0	
Northern Peninsula	1 030	70	7.9	0	(+9.4 in 1981) Total = 17.3
Western Forest	450	135	0	14.8	
Long Range Barrens	1 850	150	0	0	18.5 (1981)‡
Total	11 140	1372	69.1	125.7	27.9

* From estimates by Newfoundland Department of Forest Resources and Lands.
† Includes aerial survey in conjunction with L.G.L. Ltd. (i.e. 5508 ha of contributing water). Densities were subsequently ground-checked by that company.
‡ 1981 samples in the Northern Peninsula and Long Range Barrens ecoregions were included to strengthen sample size.

Figure 1
Ecoregions of Newfoundland



3. Methods

Newfoundland has a total surface area of 112 300 km^2, of which about 10% is water. Sampling was initially carried out on ecological land districts (ecodistricts) (J. Bouzane, then of Newfoundland Forest Research Centre, St. John's, pers. commun.) but later changed to ecoregions (Fig. 1) (Damman 1983). Extrapolations were based on water area surveyed as a fraction of total water area within an ecoregion, and it was assumed that waterfowl frequency and habitat types were uniform throughout each ecoregion. Subsequently, those parts of large water bodies lying more than 0.5 km from shorelines were eliminated as they did not contribute to waterfowl production (Table 1). Water surface areas sampled were estimated from 1:50 000 NTS maps using dot grids. Total water area (not including peatland and marine areas) in each ecoregion was drawn from estimates by the Newfoundland Department of Forest Resources and Lands.

We made field observations from a canoe or from shore (Fig. 1) in areas previously chosen because they were easily accessible. Observations such as species, numbers, age, and sex of waterfowl were recorded, with additional notes on vegetation, water quality, and weather. We carried out surveys intermittently throughout daylight hours. Areas of prime marsh habitat were closely examined, sometimes on foot. More often, we canoed the perimeters of promising areas and endeavoured to flush concealed waterfowl. On 5 May 1979, I accompanied L.G.L. Ltd. personnel on an aerial survey encompassing 5500 ha of water in the Maritime Barrens ecoregion, and data from that survey, which was adjusted following ground checks, were included in the results. Some additional coverage in the Northern Peninsula and Long Range Barrens ecoregions in May–June 1981, carried out for Newfoundland and Labrador Hydro with W.A. Montevecchi, Memorial University of Newfoundland, was also included, as those ecoregions were poorly sampled in 1978–79.

We recorded waterfowl sightings in the following categories, of which all except the last were assumed to represent breeding pairs:
a) mated pair
b) lone drake or female apparently on territory
c) female on eggs (nest)
d) female with young (brood)
e) broody female
f) flightless young of the year (brood), unaccompanied
g) group of two or more grown birds (three or more birds for Black Ducks and Canada Geese, whose sexes were often indistinguishable).

Table 2
Probability of missing birds of various species of waterfowl at different times in the breeding season, and expansion factors to allow for birds missed

Species	1978	1979	Probability of missing birds present	Probable miss expansion index: i.e. average probability of observation
				1
Green-winged Teal	25 May – 30 June*	17 May – 22 June	0.50	2.0
	prior 25 May and post 30 June	prior 17 May and post 22 June	0.25	1.3
Black Duck	4 May – 14 June	26 April – 6 June	0.50	2.0
	prior 4 May and post 14 June	prior 26 April and post 6 June	0.30	1.4
Northern Pintail	25 May – 30 June	17 May – 22 June	0.50	2.0
	prior 25 May and post 30 June	prior 17 May and post 22 June	0.25	1.3
Blue-winged Teal	25 May – 30 June	17 May – 22 June	0.50	2.0
	prior 25 May and post 30 June	prior 17 May and post 22 June	0.25	1.3
American Wigeon	25 May – 30 June	17 May – 22 June	0.50	2.0
	prior 25 May and post 30 June	prior 17 May and post 22 June	0.25	1.3
Ring-necked Duck	7 June – 17 July	29 May – 8 July	0.30	1.4
	prior 7 June and post 17 July	prior 29 May and post 8 July	0.20	1.25
Common Goldeneye	27 May – 10 July	14 May – 27 June	0.50	2.0
	prior 27 May and post 10 July	prior 14 May and post 27 June	0.20	1.25
Common Merganser	Entire breeding season	Entire breeding season	0.30	1.4
Red-breasted Merganser	Entire breeding season	Entire breeding season	0.30	1.4
Canada Goose	Entire breeding season	Entire breeding season	0.20	1.25

* Birds considered to be more easily missed during incubation. (Incubation periods not the same for all spp. and not all broods equally apparent.).

Because an observer rarely sees all waterfowl present on a wetland, especially when it is surveyed only once, I calculated correction factors for each species in order to account for those birds missed (Table 2). Values were based on detectability of given species during different stages of the breeding season (e.g. detectability lowest during incubation and highest before initiation of clutch). Using a standardized scoring system, I classified some areas following Golet (1973), to evaluate the physical, chemical, and biological aspects of the wetlands. This indicated the potential of the wetland for waterfowl.

4. Results

4.1. Coverage

In 1978, 1979, and 1981, I surveyed totals of 69.0 km^2, 125.7 km^2, and 27.9 km^2 of wetlands respectively (Table 1). The areas covered in the different ecoregions were often small, (ranging from 1.0 to 3.8% for each ecoregion) and averaged 1.0% in 1978 and 1.6% in 1979 of the entire island. Only the Avalon Boreal Forest, Central Forest, and Maritime Barrens ecoregions were sampled in both 1978 and 1979.

4.2. Waterfowl populations

Calculated breeding pairs of ducks detected in the field totalled 184 in 1978 and 362 in 1979 (both adjusted to include 32 calculated pairs from 1981 surveys), and 28 and 57 pairs of Canada Geese respectively, (including one pair from 1981 surveys) (Appendices 1 and 2). Calculated pairs of all species were extrapolated to total populations for each ecoregion (Table 3), and the totals were then adjusted (following Table 2) to allow for birds missed during the surveys (Table 4). Estimates for most species were higher in 1979 than 1978. Black Ducks had the highest estimated population, 11 100 pairs (mean of 1978 and 1979), followed by Green-winged Teal, 6300 pairs, Ring-necked Duck, 4800 pairs, and Common Goldeneye, 4000 pairs, with at least

Table 3
Example: Waterfowl breeding pair population (unadjusted) calculation

Ecoregion*	Calculated breeding prs. during incubation/ prior and post incubation 1978	Calculated breeding prs. during incubation/ prior and post incubation 1979	Estimated breeding population ± SE (unadjusted) 1978	Estimated breeding population ± SE (unadjusted) 1979
	Species			
Avalon Boreal Forest (220 km^2 of open water)	2/9	Green-winged Teal 6/4	320 ± 91	264 ± 75
	5/6	Black Duck 1/19	320 ± 87	527 ± 143
	1/0	Northern Pintail 0/1	29 ± 15	26 ± 13
	0/4	Ring-necked Duck 4/3	116 ± 52	185 ± 83
	1/1	Common Goldeneye 0/0	58 ± 34	0
	0	Common Merganser† 0	0	0
	0	Red-breasted Merganser† 3	0	79 ± 40
	0	Canada Goose† 3	0	79 ± 41
Total ducks	29	44	843	1160

* Intensity of sample 0.034 (1978) and 0.038 (1979).
† Incubation period sightings not differentiated.

3800 pairs of Canada Geese. Breeding densities, based on wetland areas contributing to production, were calculated from the adjusted population estimates for each species (Table 5). Duck densities were highest (360–660 pr/100 km^2 water area) in the forested ecoregions and lowest (60 pr/100 km^2 water area) in the coastal and alpine barrens. The Maritime Barrens ecoregion had goose densities (55 pr/100 km^2 water area) as high as those in the forested ecoregions.

4.3. Chronology of waterfowl activity, by species

Black Ducks were the earliest breeders, some broods being observed during the last week of May in the Central Forest and Avalon Boreal Forest ecoregions. Clutch initiation varied (e.g. hatching mean was one week earlier in 1979 than 1978) and was later in the Maritime Barrens and Long Range Barrens ecoregions. Most Black Duck broods were flying by the first week of August. Breeding started later, going from east to west and from south to north.

Newfoundland-reared Black Ducks assemble in coastal staging areas after the breeding season; the only inland concentration observed was in the Upper Humber River valley (Birchy Basin, 49°33'N, 57°05'W). There is probably intermittent and variable movement westward and southward from these areas, depending on the severity of the winter. Freeze-up occurs in late October on the west coast and the Northern Peninsula, in early November in the Central Forest zone, and in December or January on the south coast and Avalon coastal area. The winters of 1977–78 and 1978–79 were mild, and most coastal areas used by Black Ducks were open well into January. Black Ducks wintered at Newman Sound, Terra Nova National Park, in 1977–78 (*ca.* 100 birds), and an aerial survey of the southwest coast of Newfoundland in February 1980 detected some 380 Black Ducks (A.R. Lock, CWS, pers. commun.). Other dabbler species seldom remain into the freeze-up period.

Table 4
Adjusted waterfowl breeding population estimates ± SE* for Newfoundland

Species	Estimated breeding pair population from surveys during incubation/ prior and post 1978	Estimated breeding pair population from surveys during incubation/ prior and post 1979	Expansion factors (Table 1)	Adjusted waterfowl breeding pair estimate 1978	Total	Adjusted waterfowl breeding pair estimate 1979	Total
Green-winged Teal	1 400/2930	1 760/1860	2/1.3	2800/3800	6 600 ± 1890	3520/2420	5 940 ± 1700
Black Duck	1 460/4390	2 350/6050	2/1.4	2920/6150	9 070 ± 2470	4700/8470	13 170 ± 3580
Northern Pintail	200/100	0/320	2/1.3	400/260	660 ± 340	0/420	420 ± 220
Blue-winged Teal	100/0	0/60	2/1.3	200/0	200 ± 100	0/80	80 ± 40
American Wigeon	0/190†	0/190	2/1.3	0/250	250 ± 130	0/250	250 ± 130
Ring-necked Duck	340/2780	2 000/2200	1.4/1.25	480/3480	3 960 ± 1770	2800/2750	5 550 ± 2480
Common Goldeneye	620/2000	1 000/1860	2/1.25	1240/2500	3 740 ± 2200	2000/2330	4 330 ± 2550
Common Merganser‡	1 210	1 210	1.4		1 690 ± 920		1 690 ± 920
Red-breasted Merganser‡	1 140	2 230	1.4		1 600 ± 810		3 120 ± 1580
Total ducks	18 960	23 090			27 770		34 550
Canada Goose‡	3 040	3 690	1.25		3 800 ± 1960		4 610 ± 2380

* Standard error based on variance of density.
† Assumed the same value as 1979.
‡ Incubation period observations not segregated.

Table 5
Adjusted density in pairs/100 km^2 open water ± SE of more common waterfowl species by ecoregion*

Species	Avalon Boreal Forest 1978	Avalon Boreal Forest 1979	Central Forest 1978	Central Forest 1979	Maritime Barrens 1978	Maritime Barrens 1979	Western Forest† 1979	North Shore† 1978	Northern Peninsula† 1978	Long Range Barrens 1981*
Green-winged Teal	208 ± 59	206 ± 59	125 ± 36	124 ± 36	27 ± 8	29 ± 8	44 ± 13	29 ± 8	15 ± 4	6 ± 2
Black Duck	243 ± 66	343 ± 93	130 ± 35	287 ± 78	62 ± 17	70 ± 19	57 ± 16	31 ± 8	122 ± 33	22 ± 6
Northern Pintail	26 ± 13	16 ± 8	0	0	10 ± 5	0	35 ± 18	0	15 ± 8	0
Ring-necked Duck	66 ± 30	112 ± 50	112 ± 50	156 ± 70	6 ± 3	16 ± 7	28 ± 13	0	14 ± 6	0
Common Goldeneye	43 ± 25	0	64 ± 38	110 ± 65	16 ± 9	16 ± 9	40 ± 24‡	0	116 ± 68	5 ± 3
Common Merganser	0	0	17 ± 9	17 ± 9	9 ± 5	9 ± 5	20 ± 11‡	0	81 ± 44	0
Red-b. Merganser	0	50 ± 25	19 ± 10	48 ± 24	7 ± 4	9 ± 5	85 ± 43	0	0	27 ± 14
Canada Goose	0	45 ± 23	85 ± 44	71 ± 37	45 ± 23	61 ± 32	0	0	7 ± 4	5 ± 3
Approximate total (excluding geese) (Includes rare and unidentified species)	586	727	467	742	137	149	309	60	363	60
	$\bar{x}$ = 657		$\bar{x}$ = 606		$\bar{x}$ = 143					
Grand total	586	772	552	813	182	210	309	60	370	65
	$\bar{x}$ = 679		$\bar{x}$ = 684		$\bar{x}$ = 201					

* Long Range Barrens ecoregion was not sampled in 1978 and 1979 and densities were derived from 1981 data.
† No surveys were conducted in North Shore and Northern Peninsula ecoregions in 1979, nor in Western Forest in 1978.
‡ Common Mergansers and Common Goldeneyes certainly bred in this ecoregion; however, samples were biased to more coastal–estuarine sites; I have therefore assigned an arbitrary density for this species based on an assumed density similar to the Central Forest ecoregion.
Differences between years $\bar{x}^2 = 7.264$, df = 1 $0.025 < P < 0.05$
Proportions (no./100 km^2) of ducks and geese different between all ecoregions ($P < 0.001$), except Avalon Boreal Forest and Central Forest.

Green-winged Teal breeding phenology was about two weeks later than that of Black Ducks, but most were also fledged by early August. Most birds staged with Black Ducks in the coastal areas and had migrated by late October.

The Ring-necked Duck was later in its breeding schedule, and broods were not seen until early July. That species migrated early and few remained beyond mid-October. No important staging areas were noted, and this species appeared to avoid saline and brackish waters.

Common Goldeneyes bred relatively early, similar to Green-winged Teal; however, their long flightless period resulted in few young fledging before mid-August. Dispersal was poorly documented, but substantial numbers of Goldeneyes winter on open coastal waters and inland in Newfoundland. Presumably those birds were reared on the island.

Red-breasted Mergansers were relatively late breeders, and most broods appeared from mid-July onward. They wintered in small concentrations in coastal, marine and estuarine areas of Newfoundland (see Goudie, 1981). The Common Merganser is uncommon in mid- to late winter and most probably migrated southward.

Common Eider, Harlequin Duck, and Greater Scaup have not been studied on their restricted Newfoundland breeding grounds, but all three are late nesters, especially the Harlequin Duck (Palmer 1976). Wintering marine concentrations of all three species are known (see Goudie 1981); however, the wintering Common Eiders are thought to be predominantly of *Somateria m. borealis*, with the local breeding birds (*S. m. dresseri*) wintering farther south. The origins of the small wintering concentrations of Harlequin Ducks and Greater Scaup (less than 300 individuals each) are unknown, but they probably came from Labrador and Newfoundland.

Canada Geese and their preferred habitats were little sampled. Clutch initiation began by late April to early May, and in eastern Newfoundland most hatchings occurred in early June. Family groups concentrated on enriched deltas and floodplains where adults moulted and juveniles fledged. The majority of geese migrated by late December but often appeared early in spring (e.g. early March in the Avalon area). Coastal concentrations in spring and fall were substantial, and may reflect their selection for bar lagoons vegetated with eelgrass (*Zostera marina*) before moving to breeding grounds or southern wintering areas, respectively.

4.4. Waterfowl habitat

4.4.1 Habitat at the ecoregion level — The Northern Peninsula and Western Forest are the only ecoregions where appreciable amounts of limestone are present. This is reflected in their floral composition and waterfowl diversity. These two ecoregions consist of lowlands lying along the base of the Long Range Mountains. The large streams and rivers draining these mountains cause frequent flooding and formation of floodplain meadows and fluvial marshes. Thirteen per cent of the total water surface area of Newfoundland is found here.

The Central Forest and Avalon Boreal Forest ecoregions, with 27% of the water surface area, have hummocky, undulating terrain with a variety of small ponds and lake systems. The pH is often low (5.0–6.0) and aquatic vegetation, when it occurs, consists predominantly of sedges and ericaceous shrubs. Productivity of a system is often related to succession of the surrounding forest land and beaver activity. Forest fires have been followed by regeneration of a black spruce (*Picea mariana*) forest from which the acidic leachings are less beneficial to surrounding water systems than those from balsam fir, hardwood, or mixed forests. Successional hardwood forests in particular attract beaver, which indirectly benefit waterfowl habitat.

Maritime Barrens and North Shore, and Long Range Barrens ecoregions include coastal subarctic barrens and elevated alpine plateaux, respectively. The latter appeared to be the most unproductive for waterfowl (Table 5). All are characterized by shallow, acid soils with exposed bedrock and extensive peatlands. Patterned fens with open areas of grasses and sedges are extensive locally, and important to breeding Canada Geese. Trees are often stunted, but productive growth may occur in valleys. Other peatland types such as raised bogs, blanket bogs, and slope bogs constitute 30–50% of the land area in these ecoregions (see Wells 1976) but appeared relatively unimportant for breeding waterfowl. Together, these ecoregions include about 60% of the water area of Newfoundland.

4.4.2 Wetland characteristics — The island has an abundance of fresh water (10% of total area); however, most waters are acidic and generally unproductive. Suitable waterfowl habitat was largely restricted to alluvial floodplain and delta areas. Other favourable habitat resulted from beaver activity in productive forest areas during successional hardwood growths. Except in areas of limestone or enriched ground water, wetlands in areas of heath, whether alpine, coastal, or anthropogenic, were relatively low in productivity owing to the accumulation of acidic undecomposed peat and nutrient leachings (Damman 1967). The predominance of ericaceous shrubs appeared strongly correlated to poor dabbling duck habitat (see also Ringelman and Longcore 1982).

Most major emergent plant species characteristic of wetlands in the Maritimes were lacking or scarce in Newfoundland. Round-stem bulrush (*Scirpus acutus*) and cattail (*Typha latifolia*) were important only in the Codroy Valley (47°50'N, 59°10'W), Stephenville area (48°30'N, 58°25'W) and a few isolated areas in the Western Forest and Northern Peninsula ecoregions; all evidently had neutral waters. Those species are believed to be recently established in Newfoundland and their ranges may be expanding; cattails were frequently seen in roadside ditches.

In Newfoundland, waterfowl habitat was dominated by sedges. *Carex rostrata* was by far the most important cover species in the wetlands, probably because of its tolerance to low pH and low nutrient concentrations. *C. lasiocarpa* displayed similar characteristics but its narrow leaves restricted its value as cover. *C. aquatilis* and *C. oligosperma* were effective cover plants, but their distribution was limited and they usually occurred in lesser proportions accompanying *C. rostrata*. Shrub and dead tree swamps usually resulted from beaver activity, and were encountered frequently. Submerged and floating-leafed aquatic plants (e.g. *Potamogeton* spp., *Sparganium* spp., *Glyceria fluitans*, and *Nuphar varigetum*) varied in abundance but were often present in areas that lacked effective emergents.

Salt marsh habitat is uncommon, but occurs locally along the west and northeast coasts. In general, brackish lagoons and estuaries lacked emergent vegetation, and were scarcely used by breeding waterfowl. Many, however, contained eelgrass and associated invertebrates, and were extensively used by waterfowl in spring and autumn, e.g. Stephenville Crossing, St. Georges River (48°30'N, 58°25'W); and Haricot Pond, St. Mary's Bay (47°10'N, 53°32'W).

4.5. Waterfowl concentration areas

No major concentrations of breeding waterfowl were located by these surveys. Previous areas of waterfowl banding, in the Codroy Valley (banding 1947–51) and in Birchy Basin (1965–66), were confirmed as having the largest numbers of breeding ducks. Both also supported good numbers of staging ducks (and geese in Codroy) in spring and autumn. Coastal concentrations, chiefly of Black Ducks (although Green-winged Teal, goldeneye, Greater Scaup, and mergansers were apparent in some areas), were found at Haricot Pond, John's Pond (47°06'N, 53°40'W), Big Barachois (47°02'N, 53°45'W), Newman Sound (48°35'N, 53°58'W), Deadman's Bay (49°20'N, 53°40'W), Middle Arm (49°22'N, 54°13'W), Carmanville Pond (49°25'N, 54°20'W), Grey Islands (50°40'N, 55°35'W), Hare Bay (51°20'N, 56°05'W), Pistolet Bay (51°36'N, 55°50'W), Parson's Pond (49°58'N, 57°35'W), and Stephenville Crossing.

By far the most significant waterfowl concentrations on the island consist of wintering flocks of eiders. Total numbers are unknown but may sometimes approach half a million birds (Gillespie and Learning 1974) and single concentrations might be close to 10 000 in several areas, including Cape St. Mary's (46°50'N, 54°12'W) (Goudie 1981).

5. Discussion

5.1. Habitat

The existing ecoregions reflect human history as well as environmental influences. The Avalon Peninsula and parts of the outer coasts have been settled for 300 years, and woodcutting and forest fires have eliminated most of the forests from those areas. Development of *Kalmia angustifolia* heath barrens on formerly forested areas is a common form of land degeneration (Damman 1967, Meades 1973). This may result in acid leachings into slightly productive waters (pH 6.2–6.5), rendering them unproductive; acid rain, a growing threat, can only accelerate that process. The island is characterized by large areas of low productivity, inferior-quality waterfowl habitat with only limited potential for improvement by intervention.

5.2. Waterfowl populations

Extensive data for comparison were available only for Canada Geese. Working from aerial transects carried out in May 1968, D.I. Gillespie and B. Roberts (unpubl.), estimated a goose population of some 3800 ± 400 (SE) pairs plus 4400 non-breeding birds. They referred to earlier estimates, based on more restricted aerial surveys by W. Crissey and F. Glover (USFWS) in 1954 and by L.M. Tuck (CWS) in 1955 of 14 000 and 40 000 geese respectively. The unadjusted estimate here of 3300 ± 1700 (SE) pairs (mean of 1978 and 1979, Table 4) is similar to that of Gillespie and Roberts but is certainly minimal because the preferred peatland habitats were not covered in this survey. On a brief coverage of patterned fens (1.5 km^2) in the area of Swift Current (47°55'N, 54°20'W) in June 1979, a density of 2.6 pr/km^2 was calculated (based on pairs with broods only) compared with 1.7 pr/km^2 determined by Gillespie in 1968 from aerial surveys in the same general area. Pollett and Wells (1980) mapped five main areas covered by patterned fens, totalling approximately 11 000 km^2. Within the 3750 km^2 peatland area near Swift Current, 5000–10 000 pairs of geese may breed (assuming a minimum of 1.5 pr/km^2 of ribbed fen). If such densities were attained on other patterned fen sites, Newfoundland may support 15 000 or more pairs of Canada Geese. The presence of flightless Canada Geese and juveniles on various deltas and floodplains surveyed in July and August suggested post-breeding migrations from patterned fen sites on the barrens to more enriched sites where fledging and moulting were completed.

Gillespie and Roberts also recorded ducks on their surveys, but did not attempt extrapolation to total populations except for Black Ducks; they observated mainly goldeneyes and mergansers. Their samples of Green-winged Teal and Ring-necked Duck were too small to permit useful comparisons, even if adjustments for detectability were made. Tuck (1949) indicated that the Ring-necked Duck had only recently established a breeding population. Subsequent dispersal has increased the importance of this desirable game species. Gillespie and Roberts' unadjusted aerial estimate of 2000 ± 700 (SE) pairs of Black Ducks is much lower than the unadjusted value of 7000 ± 1900 (SE) pairs derived here; however, other studies suggested only one-third of the Black Ducks seen on the ground are detected from the air (*cf.* Erskine, see Chapter II; Haapanen and Nilsson 1979).

5.3. Waterfowl densities

Mean waterfowl densities varied among ecoregions from 60 to 684 per 100 km^2 of open water (Table 5). Lowest densities were in alpine and coastal sites where the habitat is subarctic in nature and relatively unproductive. Boreal sites exhibited higher breeding duck densities and species diversity (when bias due to noncontributing water was eliminated; see Methods). The highest production appeared in ecoregions supporting a large number of small ponds or lakes (less than 100 ha) which provided maximum water–land interface.

Haapanen and Nilsson (1979) studied a 333 500 km^2 area in Northern Fennoscandia with similar ecoregions to those studied here. They also found that densities were low in alpine areas (20 pr/100 km^2 total area). Densities of up to 2370 pr/100 km^2 were calculated on some special study sites in Northern Fennoscandia, but other boreal areas there demonstrated waterfowl densities similar to, or lower than, those calculated here for boreal ecoregions in Newfoundland. Such variation in density in Northern Fennoscandia was difficult to interpret, although high-density zones frequently coincided with the abundance of mires. When mires were excluded from comparison, the density of 618 pr/100 km^2 of open water on the boreal study areas of Northern Fennoscandia was remarkably similar to that found in Newfoundland, i.e. 682 pr/100 km^2.

Research in Sweden indicated a trend toward higher densities of waterfowl closer to the coasts, for example, as high as 5420 pr/100 km^2 on open water (Danell and Sjoberg 1979). Such a trend was not evident in this study, which indicated higher production on inland sites. The prevailing maritime air flows from the south, coupled with high fog frequency from the mixing of Labrador and Gulf Stream currents, are the major factors influencing the Maritime Barrens ecoregion (Fig. 1).

The prairie provinces of North America support vastly higher waterfowl densities (Johnsgard 1975, Bellrose 1976) than those in Newfoundland. Dennis (1974*a*,*b*) studied waterfowl in the Precambrian Shield and clay belt areas of north-central Ontario and in southern Ontario, and derived breeding pair densities of 800 per 100 km^2 total area and 1020 per 100 km^2 total area, respectively. Those areas are obviously much more productive for waterfowl than Newfoundland, where highest total densities did not exceed

100 pr/100 km^2 total area. Such low densities are, in part, compensated by the large expanse of hinterland which, overall, contributes significant numbers of waterfowl to Flyway stocks.

Generally, densities of breeding waterfowl ranged from 40–70 pr/100 km^2 total area in the forested ecoregions to less than 30 pr/100 km^2 total area in the barrens ecoregions (based on adjusted values in Table 5). Those were averaged over extensive areas, so they are understandably much lower than the densities for individual study areas on the island or in the Maritimes (see Bartlett, Chapter I; Erskine, Chapter II). The best areas in Newfoundland, i.e. Grand Codroy and Birchy Basin, have densities comparable to Maritimes sites, but few other areas of that level of productivity exist.

5.4. Harvest estimates

Comparison of waterfowl population estimates for Newfoundland with the kill estimates derived from the National Harvest Survey and Species Composition Survey presented anomalies. Band recoveries suggested that Newfoundland depends almost entirely on locally reared ducks for its harvest, except for arctic-nesting eiders and Oldsquaws shot in winter on the coasts. If fall populations of inland-breeding ducks in Newfoundland are derived using the expansion factors presented by Erskine (Chapter VII), the estimated kill of these species seems improbably high for most species. Even with a "brag factor" of 30% (S. Wendt, CWS, pers. commun.) applied to reduce the kill figures, they seemed excessive (Table 6). This supported Erskine's (Chapter VIII) suggestion that some improvements to the existing kill estimates are needed.

Banding data for Black Ducks (summarized by Erskine, unpubl.) indicated that not more than 50% of Newfoundland-reared ducks shot outside the island are recovered south of Nova Scotia. This is most likely true also of goldeneyes from Newfoundland, but all other species are found through the Atlantic Flyway states and provide higher contributions to the duck and goose harvest there. Green-winged Teal, Ring-necked Duck, and Canada Geese probably make up most of the Newfoundland-reared waterfowl that leave the region. Overall, the island's contribution to regional and Flyway waterfowl stocks may amount to 200 000 ducks and 45 000 geese.

5.5. Special notes on scarce species

Several waterfowl species appear to be extending their ranges into the northeast. The Mallard (see Johnsgard 1967) is important because of its habitat tolerance and its hybridization with the Black Duck. The Northern Pintail may now breed throughout Newfoundland in low densities. The American Wigeon has only recently become established in southwestern Newfoundland (Goudie 1985). The scaups, particularly the Lesser Scaup, appear to be expanding in range since the last glaciation (see Palmer 1976). The Lesser Scaup appeared as abundant as Greater Scaup on Labrador breeding grounds (Goudie and Whitman, see Chapter VI; see also Gillespie and Wetmore 1974) and closer scrutiny of breeding scaups in Newfoundland will probably reveal both species there.

The eastern Harlequin Duck is the rarest waterfowl species breeding in eastern Canada. The historical data (e.g. Merriam 1883, Peters and Burleigh 1951) and statements by Palmer (1976) and Bellrose (1976) indicate that the Harlequin Duck was formerly more abundant. Recent breeding records in Newfoundland are few, and only two substantial west Atlantic wintering sites (i.e. 100–150 individuals) are apparent (i.e. Cape St. Mary's, Newfoundland (Goudie 1981) and the Ile aux Haut, Maine). The species breeds along rivers in coastal Labrador but the eastern North American stock of these birds probably does not exceed 2000 individuals.

The Black Scoter was considered an infrequent breeder by Peters and Burleigh (1951), and was observed only once during this study (six pairs on the Long Range Barrens in June 1981).

5.6. Concluding remarks

Systematic study of waterfowl populations of low density requires extensive coverage to derive sufficient samples. Small sample size can distort estimates because confidence limits are broad. The accuracy of estimates of mean breeding pair density can be improved through repeated surveys of established study areas (e.g. Dzubin 1969); however, resulting data may be biased by site abandonment by failed nesters, which nevertheless are part of the waterfowl population. Estimates presented in this paper are unlikely to be too high, although the limited overall coverage raises the possibility that other above-average production sites exist, and peatland was excluded from extrapolations but probably contributes to waterfowl production to a minor degree.

Northern boreal hinterlands pose unique waterfowl management problems. Although breeding densities may be low, the large expanse of available habitat results in significant overall populations. Little effort has been focused on management of such zones, even where decimation of local waterfowl populations or the potential to improve habitat may exist. Presumably tradition plays a strong role in the homing of breeding waterfowl from wintering grounds, and even dispersal over available habitat may not be random. In the absence of any earlier systematic work on inland waterfowl, this study was entirely justified, but it provided only a sketchy outline of the waterfowl populations of Newfoundland.

Table 6
Comparison of estimated 1979 fall duck flights in Newfoundland to estimated local hunter harvest by Wendt and Hyslop (1980)

Species	Estimated population (pairs)	Calculated fall population	Estimated kill	Less 30% brag factor	Kill as % of fall population	
					Unadjusted	Adjusted for brag
Green-winged Teal	5 940 x 5.66* =	33 600 ± 9 600	13 362	9 350	40	28
Black Duck	13 170 x 5.66 =	74 500 ± 20 264	33 398	23 380	45	31
Ring-necked Duck	5 550 x 5.66 =	31 400 ± 14 050	12 555	8 790	40	28
Common Goldeneye	4 330 x 6.33 =	27 400 ± 16 120	11 227	7 860	41	29
Red-breasted Merganser	3 120x 6.33 =	19 700 ± 9 950	1 344	941	5	5
Canada Goose	4 610 x 7.28 =	33 600 ± 17 350	8 717	6 100	26	18

* Based on calculation presented by Erskine (Chapter VII).

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Appendix 1
Summarized field data 1978

Species	Observation per ecoregion*									
	Avalon Boreal Forest		Central Forest		Maritime Barrens		North Shore		Northern Peninsula (including 1981 data)	
	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.
Green-winged Teal 25 May – 30 June	0/0, 2(+0), 0	2	2/2, 2(+0), 3	6	1/0, 1(+0), 3	2	0/0, 1(+0), 0	1	0	
Prior 25 May and post 30 June	2/1, 3(+3), 0	9	0/5, 11(+3), 9	19	0/1, 0(+0), 0	1	Not sampled		0/2, 2(+0), 0	4
Black Duck 4 May – 14 June	3/0, 2(+0), 3	5	0/1, 0(+0), 0	1	3/0, 1(+0), 0	4	Not sampled		4/0, 3(+0), 3	7
Prior 4 May and post 14 June	0/2, 1(+3), 11	6	2/6, 15(+3), 51	26	0/2, 1(+0), 0	3	1/0, 0(+0), 0	1	1/2, 1(+1), 0	5
Northern Pintail 25 May – 30 June	0/0, 1(+0), 0	1	0		0/0, 1(+0), 2	1	0		0	
Prior 25 May and post 30 June	0		0		0		Not sampled		0/0, 2(+0), 0	2
Blue-winged Teal 25 May – 30 June	0		0		0/0, 1(+0), 0	1	0		0	0
Prior 25 May and post 30 June	0		0		0		Not sampled		0	0
Ring-necked Duck 7 June – 17 July	0		1/2, 0(+1), 7	4	0		0		0/0, 0(+0), 10	0
Prior 7 June and post 17 July	4/0, 0(+0), 4	4	4/15, 3(+0), 12	22	0/0, 1(+0), 8	1	Not sampled		Not sampled	
Common Goldeneye 27 May – 10 July	0/0, 1(+0), 0	1	2/0, 0(+0), 0	2	0		0		4/0, 6(+0), 9	10
Prior 27 May and post 10 July	0/0, 1(+0), 0	1	0/6, 2(+4), 6	12	0		Not sampled		Not sampled	—
Common Merganser	0		0/2, 0(+0), 5	2	0		0		2/1, 5(+0), 4	10
Red-breasted Merganser	0		0/4, 0(+0), 13	4	1/0, 0(+0), 0	1	0		—	—
Canada Goose	0		20/0, (+0), 48	20	7/0, (+0), 15	7	0		1/0, 0(+0), 0	1

* Breeding pairs/♀ with brood or incubating, lone hens or drakes on territory (+ unaccompanied broods), individuals in groups of two or more.

Appendix 2
Summarized field data 1979

Species	Observation per ecoregion*									
	Avalon Boreal Forest		Central Forest		Maritime Barrens		Western Forest		Long Range Barrens (1981 data)	
	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.	Birds obs.	Calc. prs.
Green-winged Teal 17 May – 22 June	1/3, 2(+0), 0	6	6/3, 3(+1), 7	13	1/0, 8(+0), 0	9	Not sampled		0	
Prior 17 May and post 22 June	1/3, 0(+0), 8	4	1/6, 8(+4), 0	19	0		1/1, 2(+1), 68	5	1/0, 0(+0), 0	1
Black Duck 26 April – 6 June	0/0, 1(+0), 4	1	12/0, 9(+1), 0	22	4/1, 9(+0), 0	14	Not sampled		Not sampled	
Prior 26 April and post 6 June	12/5, 2(+0), 3	19	6/12, 22(+12), 29	52	2/6, 3(+0), 0	11	12/0, 2(1), 9	6	3/0, 0(+1), 0	4
Northern Pintail 17 May – 22 June	0		0		0		Not sampled		0	
Prior 17 May and post 22 June	0/1, 0(+0), 0	1	0/0, 1(+0), 0	1	0		0/1, 3(+0), 4	4	0	
Blue-winged Teal 17 May – 22 June	0		0		0		Not sampled		0	
Prior 17 May and post 22 June	0		0/1, 0(+0), 0	1	0		0		0	
American Wigeon 17 May – 22 June	0		0		0		Not sampled		0	
Prior 17 May and post 22 June	0		0		0		0/0, 2(+1), 7	3	0	
Ring-necked Duck 29 May – 8 July	1/2, 1(+0), 0	4	10/3, 2(+0), 29	15	6/0, 1(+0), 21	7	1/1, 1(+0), 0	3	0	
Prior 29 May and post 8 July	3/0, 0(+0), 0	3	25/5, 3(+1), 22	34	0		Not sampled		0	
Common Goldeneye 14 May – 27 June	0/0, 0(+0), 4	0	3/3, 4(+0), 3	10	3/0, 2(+0), 0	5	Not sampled		Not sampled	
Prior 14 May and post 27 June	0		1/8, 5(+6), 20	20	0		0		1/0, 0(+0), 0	
Common Merganser	0		1/2, 2(+0), 5	5	1/0, 3(+0), 0	4	Not sampled		0	
Red-breasted Merganser	3/0, 0(+0), 0	3	8/4, 2(+0), 26	14	0/2, 2(+0), 2	4	5/3, 1(+0), 3	9	2/3, 0(+0), 0	5
Canada Goose	3/0, (+0), 24	3	13/5, 5(+0), 50	23	10/10, 10(+0), 51	30	0		0/0, 1(+0), 0	1

* Breeding pairs/♀ with brood or incubating, lone drakes or hens on territory (+ unaccompanied broods); individuals in groups of two or more.

VI. Waterfowl populations in Labrador, 1980–82

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1. Abstract

In 1980–82 Canadian Wildlife Service (CWS), Atlantic Region, conducted extensive aerial and ground surveys of southern Labrador to estimate species composition, populations, and flyway contributions of waterfowl breeding there. Surveys focused on the Lake Plateau area where we duplicated previous work carried out in 1970 before the flooding of the Smallwood Reservoir. Our results confirmed that the Smallwood Reservoir ecoregion is the most productive waterfowl breeding area in southern Labrador, despite an estimated 10% loss of potential habitat. Waterfowl productivity was significantly correlated to phosphorus concentrations, a nutrient found to be limiting during the course of other hydrological studies. Because of the major hydroelectrical development, potential productivity and resulting fall waterfowl populations originating in Labrador were reduced by about 5–10%.

Comparisons of the 1970 vs. 1980 data supported general population trends suggested by other authors for eastern North America, such as increasing Canada Goose populations and declining Black Duck stocks. Other species such as Lesser Scaup seem to be expanding their breeding range into the Labrador area.

Labrador is a vast hinterland that contributes about 40% of northern Atlantic Flyway stocks. The bulk of the Canada Goose population originates there, in adjacent parts of Quebec, and on the island of Newfoundland. Overall waterfowl breeding densities are low, as in most boreal-subarctic zones, but the vast area partly compensates for the low densities.

2. Introduction

As concern about eastern waterfowl populations increased in the early 1950s, the USFWS made exploratory flights into Labrador and Quebec. Coverage was varied and generally failed to provide a reliable basis for following trends in waterfowl numbers. The cost relative to numbers of birds seen was high (R.C. Hanson, USFWS unpubl. rep.; Chamberlain and Kaczynski 1965).

Concern by governments over the possible impact of resource development on wildlife led to resumption of surveys in 1969. In 1970, CWS and the Newfoundland Wildlife Division co-operated in surveys covering the Michikamau Lake Plateau of southwestern Labrador, as well as areas to the north and northeast (Gillespie and Wetmore 1974). They studied numbers of waterfowl and their distribution in relation to biophysical characteristics of the region. As well, they established baseline data for assessing the effects of the major hydroelectric development at Churchill Falls.

Several environmental consultants subsequently studied waterfowl in the Smallwood Reservoir and Churchill River area to predict or evaluate the effects of hydroelectric development (see App. 1). All recognized the potential harm of flooding on local waterfowl populations, and they recommended clear-cutting of flooded forest and stabilization of water levels during the waterfowl breeding season. Those studies were not extensive enough to assess the full effect of flooding, and the water-level management plan was not completed until the late 1970s.

In 1980, CWS undertook surveys to determine numbers of waterfowl breeding in Labrador and their contribution to regional and flyway stocks, and to make a final assessment of the effect of the Smallwood Reservoir impoundment on waterfowl. The Michikamau Lake Plateau (now Smallwood Reservoir) aerial survey plan of Gillespie and Wetmore (1974) was repeated, and aerial surveys also covered southeastern Labrador, north to about 54°30'N. We made ground surveys of sample plots distributed through the regions surveyed from the air, as a check on the aerial results and to obtain more detail on species composition, chronology, and habitat use. Six of the same ground plots were studied more intensively in the summer of 1981, and we conducted further ground studies in the lowlands of inner Groswater Bay in 1982.

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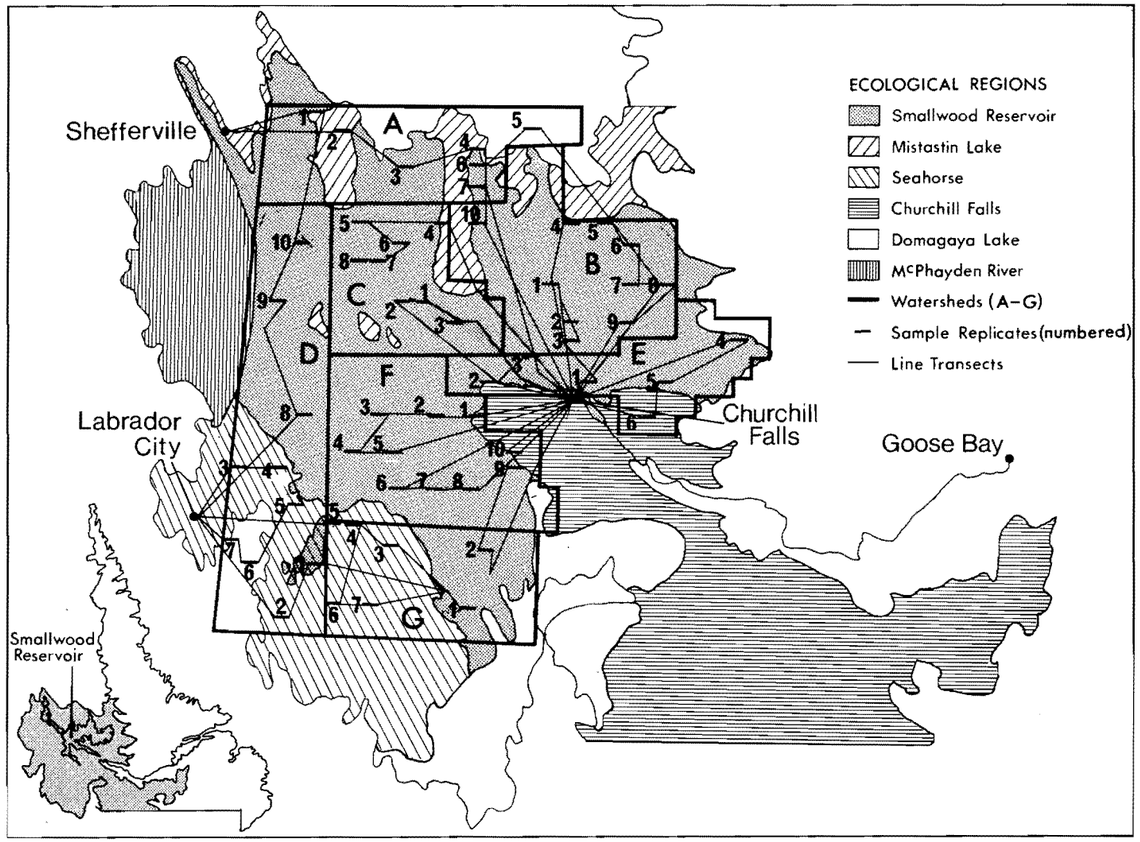
Figure 1
Sample replicates and line transects surveyed in the Lake Plateau in 1970



3. The study area

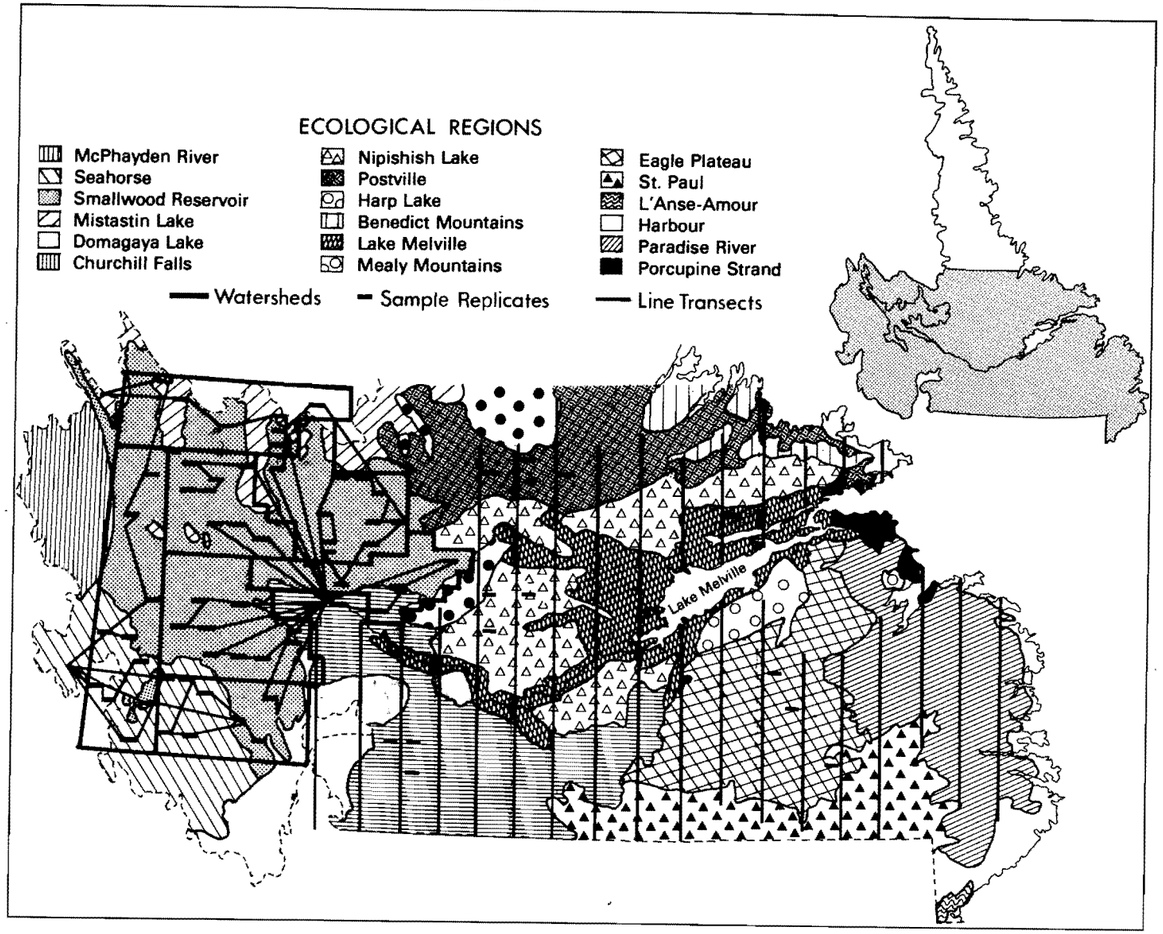
The Lake Plateau, as defined by Gillespie and Wetmore (1974), encompasses 57 000 km^2 of Labrador south of 55°N and west of 63°W, and includes the Churchill Falls (Smallwood Reservoir) and Twin Falls power projects (Fig. 1). Over 4100 km^2 of island-studded lakes and associated peatland have been flooded since 1970, and water levels were reduced on another 780 km^2. The reservoir area, including a few islands, totals about 8800 km^2 with a border of flooded forest. Much of the surrounding woodland is open spruce-lichen forest, and the higher hilltops support arctic/alpine plant communities. The lowlands are a maze of ribbed fens, string bogs, marsh-peatland complexes and island-studded water bodies.

The remaining area of southern Labrador from Churchill Falls east to the coast includes over 188 000 km^2. Lopoukhine *et al.* (1977) recognized 14 biophysical regions (ecoregions) in that area, of which 6 are small in area or largely unsuitable for waterfowl so have been ignored in this report. The other 8 include a variety of types, which are briefly summarized, with emphasis on their value to waterfowl:

(1) Postville — alluvial valley sites and enriched swamp/marsh deltas, particularly at Snegamook and West Micmac Lakes, form oases amid sand and gravel plains and uplands;
(2) Lake Melville — and
(3) Porcupine Strand — localized fluvial marshes and palsa bogs; extensive salt marsh units, and grass meadows on the coastal plain bordering the large saltwater inlet and bay;
(4) Churchill Falls — upland plains and wide valleys with numerous small string bogs and rocky ponds;
(5) Nipishish Lake — a plateau region characterized by extensive string bogs;
(6) Eagle Plateau — upland with very extensive string bogs and esker complexes, large complex water systems, and considerable sedge marsh-shrub swamp areas; this area has the highest snowfall in Labrador;
(7) St. Paul — rolling upland with forested valleys and small lake systems;
(8) Paradise River — relatively productive forest region inland from the barren coastal strip; blanket and string bogs dominate the organic terrain.

In all regions, peatlands make up a large proportion of the wetland area, although richer wetland types occur locally.

Figure 2
Sample replicates and line transects surveyed in southern Labrador in 1980



4. Methods

4.1. Aerial surveys

The 1980 aerial survey of the Lake Plateau duplicated, as closely as possible, the 1970 coverage by Gillespie and Wetmore (1974). All surveys were flown on 3–11 June 1980, in a Bell 206B Jet Ranger helicopter on floats, with a pilot and two observers. Of 58 sample plots surveyed in 1970, eight had been completely flooded and were not resurveyed in 1980. The area sampled by the 1980 aerial surveys was 1200 km^2 (2.1% sample) over plots and a distance of 2740 km (1100 km^2) (1.9% sample) en route between plots.

The remainder of the area, termed "southeastern Labrador", was surveyed by north–south transects spaced at 30 km, extending from the Quebec border (52°N) to about 54°30'N (Fig. 2). We used a Cessna 185 fixed-wing aircraft on floats, with a pilot and two observers, at an average altitude of 60 m above ground level and a speed of 160 km/h, covering a distance of 4750 km (1900 km^2 or 1.0% sample), on 12–21 June 1980.

4.2. Ground surveys

We chose three randomly selected plots, in each of the seven strata ("watersheds") used by Gillespie and Wetmore (1974) for ground coverage in the Lake Plateau area; two of those plots had been flooded and were not replaced. Ground coverage on 6–27 June 1980 varied, depending on accessibility of waterfowl habitat, time available and weather (Σ = 102.7 km^2, x = 5.4, range = 1.25–13.3). Observers were landed on the plot and canoed or walked through suitable habitat to prearranged pick-up points. Two plots were reached from roads. Most open water or river systems were surveyed by canoe, whereas string bog, ribbed fen and wetland complexes required coverage on foot, usually with observers spaced 100 m apart.

In southeastern Labrador, three plots were randomly selected adjacent to aerial transects in each of five major ecoregions (omitting St. Paul and Paradise River). Lack of suitable landing sites for fixed-wing aircraft sometimes necessitated choosing alternative areas near those originally selected. Coverage on 2–20 July 1980 followed the same procedure as that carried out in the Lake Plateau.

In 1981, previously surveyed plots on the Lake Plateau (three) and in southeastern Labrador (three) were selected for more intensive coverage (Fig. 3). Criteria for selection included high previous waterfowl counts, accessibility from aircraft bases, and representation of different ecoregions. We surveyed each area for 3–4 days during late June. On 5–10 July 1981 we undertook aerial surveys of broods on the six study areas in a DeHavilland Beaver aircraft, with a pilot and two observers, at a height of about 30 m and a speed of 100 km/h. From 20 June to 1 August 1982, 68.7 km^2 of potential waterfowl habitat, including salt marsh, fluvial marsh, string bog, palsa bog, and ribbed fen were ground-surveyed in the Groswater Bay coastal lowlands (terminology follows Rubec and Pollett 1980).

4.3. Data recording and processing

On aerial surveys, the species, numbers and groupings of waterfowl sighted and, where possible, additional information (sex, age class of broods) were recorded. On ground surveys, we mapped the location of all waterfowl observed and made additional notes on habitat, vegetation, water characteristics, and weather. Waterfowl were classified as pairs, lone birds (male, female or unspecified), female on nest, female with brood, unaccompanied brood, or groups of two or more fully grown birds (groups of three or more, for species in which sexes are often indistinguishable (Dzubin 1969)). All except the last of these were counted as equivalent to pairs in subsequent calculations; total waterfowl populations involved doubling the number of pairs or pair-equivalents and adding the number of grouped birds.

Water samples for chemical analyses were collected in collaboration with work on Long Range Transport of Air Pollutants. The samples were analysed by Inland Waters Directorate Water Quality Laboratory, Moncton, NB (Clair *et al.* 1982).

Survey coverage was outlined on 1:50 000 NTS maps or air photos, and areas of potential waterfowl habitat such as peatland, marsh, rivers-brooks, and open water were estimated by use of dot grids. We estimated total areas of these habitat types in each ecoregion from NTS maps or (for open water) following Lopoukhine *et al.* (1977).

As ground surveys were confined to potential waterfowl habitat as far as possible, the aerial survey coverage was adjusted to a similar base for air/ground comparison. We tested differences between ground and aerial results using a paired *t*-test and Wilcoxon paired sample non-parametric

Figure 3
Special study areas surveyed in southern Labrador in 1981

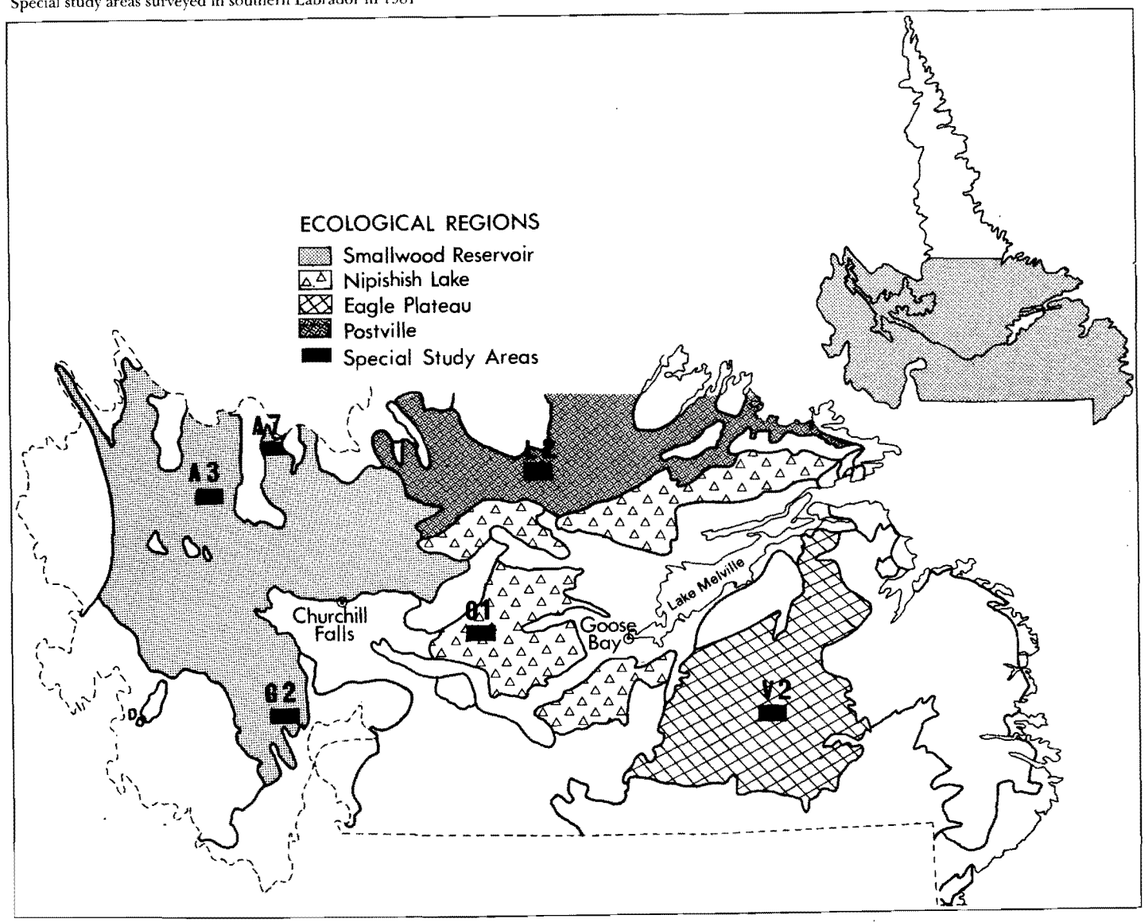


Table 1
Comparison of total waterfowl and equivalent breeding pairs per 100 km^2 observed during aerial surveys of the Lake Plateau in 1970 and 1980

Species	Total waterfowl						
	1970[a] Plots	1970 Transects	1970 Aver.	1980[b] Plots	1980 Transects	1980 Aver.	Aver. % change
Canada Goose	23.3	24.2	23.7	25.5	15.8	20.7	−13
Black Duck	17.2	18.0	17.6	8.4	12.3	10.4	−41
Total dabbling ducks[c]	20.7	21.6	21.1	15.4	15.4	15.4	−27
Scaups	0	0	0	4.0	2.0	3.0	+100
Scoters	22.4	35.2	28.8	4.8	5.3	5.1	−82
Common Goldeneye	7.5	15.4	11.5	3.1	7.0	5.1	−56
Mergansers	11.9	22.9	17.4	4.8	6.2	5.5	−68
Total diving ducks[d]	41.8	73.5	57.7	18.0	26.4	22.2	−62
Total ducks[e]	68.2	95.0	81.6	32.6	43.0	37.8	−54
	Equivalent pairs						
Species	1970 Plots	1970 Transects	1970 Aver.	1980 Plots	1980 Transects	1980 Aver.	Aver. % change
Canada Goose	8.8	6.2	7.5	10.1	5.7	7.9	+5
Black Duck	5.3	4.4	4.9	3.1	3.1	3.1	−37
Total dabbling ducks[c]	7.5	6.2	6.9	5.3	5.0	5.2	−25
Scaups	0	0	0	1.8	2.0	1.9	+100
Scoters	2.2	1.8	2.0	2.6	2.2	2.4	+20
Common Goldeneye	3.5	1.8	2.7	1.3	2.6	2.0	−26
Mergansers	3.5	5.7	4.6	2.6	2.6	2.6	−43
Total diving ducks[d]	9.2	9.3	9.3	8.8	10.6	9.7	+4
Total ducks[e]	18.5	17.2	17.9	15.0	16.3	15.7	−12

[a] 58 plots surveyed in 1970; total area 1390 km^2. Transects between plots and from base to plots covered 1120 km^2.
[b] 50 plots surveyed in 1980; total area 1200 km^2. Transects between plots and from base to plots covered 1100 km^2.
[c] Includes Northern Pintail, Mallard and Green-winged Teal.
[d] Includes Bufflehead and Ring-necked Duck.
[e] Includes unidentified ducks.

Table 2
Comparison of total waterfowl and equivalent breeding pairs per 100 km^2 total area in aerial surveys of line transects in the Lake Plateau and southeastern Labrador, 1980

Species	Lake Plateau		Southeastern Labrador		Mann-Whitney U test
	Total waterfowl	Pairs	Total waterfowl	Pairs	
Canada Goose	16	6	14	3	$P<0.01$
Green-winged Teal	2	1	3	1	n.s.[§]
Black Duck	12	3	9	2	n.s.
Total dabbling ducks*	15	5	13	3	n.s.
Scaups	2	2	3	1	$P<0.05$
Scoters	5	2	10	1	$P<0.05$
Common Goldeneye	7	3	3	1	$P<0.001$
Mergansers	6	3	4	2	n.s.
Total diving ducks†	26	11	21	6	$P<0.001$
Total ducks‡	43	16	36	9	$P<0.001$

* Includes Mallard and Northern Pintail.
† Includes Ring-necked Duck and Bufflehead.
‡ Includes unidentified ducks.
§ Not significant.

test (α = 0.05). Aerial values were adjusted if demonstrated to be under-represented. Inter-year comparisons were also tested in that manner. Adjusted aerial figures provided the basis for estimating the potential size of the fall flight.

Segregation of aerial data by ecoregions was straightforward for the sample plots on the Lake Plateau. Observations during the southeastern Labrador transects were timed, and assignment to ecoregions was by interpolation within the flying time for each transect. Observations during the Lake Plateau transects were not timed, so interpolation was in proportion to the distance flown in each ecoregion on a transect. That tended to overestimate the numbers detected in the less productive ecoregions while underestimating those in the better ones, but that method was used in preference to ignoring those data in ecoregion comparisons. Many of the transects radiating out from Churchill Falls passed over the birdless waters of Smallwood Reservoir, and it could be argued that an under-representation of this, the most productive ecoregion, was to be expected from the transects. Therefore, potential waterfowl populations for the Lake Plateau were extrapolated based on plot data only.

Correlation and regression analyses for the three major waterfowl groups (geese, dabbling ducks, and diving ducks) with major habitat types (i.e. peatland, open water, rivers and brooks) and water chemistry were made. We estimated the loss of waterfowl breeding potential due to flooding by application of the regression equations to inundated habitat estimates of Bajzak (unpubl.).

5. Results

5.1. Aerial surveys

Canada Geese and 14 species of ducks were observed during the 1980–82 aerial and ground surveys of southern Labrador. Ducks were primarily represented by Black Duck, Green-winged Teal, scaups, Common Goldeneye, Surf and Black Scoters, and Red-breasted Mergansers. Densities of total waterfowl (105.3 vs. 58.5 per 100 km^2) and of breeding pairs (or equivalent) (25.4 vs. 23.6 per 100 km^2) were higher in 1970 than in 1980 for all major species (Table 1). The late spring in 1970 presumably resulted in later concentrations of migrants than in 1980, so we believe that numbers of breeding pairs are more comparable than total birds sighted, particularly for the later-nesting diving ducks.

Breeding pairs (or equivalent) were more frequently observed, relative to total waterfowl, on the earlier (3–11 June 1980) Lake Plateau surveys than the later (12–21 June 1980) southeastern Labrador transects. That is attributable particularly to early nesting by Canada Geese and most dabbling ducks. Densities of total waterfowl (50 per 100 km^2) and of breeding pairs or equivalent (12 per km^2) calculated for southeastern Labrador were generally lower than those on the Lake Plateau (59 + 22 per 100 km^2, respectively) (Table 2). This contrast could be explained by differences in densities of diving ducks and Canada Geese ($P < 0.01$, Mann-Whitney U test). The data suggested that the Labrador peninsula is more important to diving ducks than dabbling ducks; that could be due to the expanse of open water there.

Aerial survey data were segregated by ecoregion (Tables 3 and 4); the Smallwood Reservoir was by far the most productive for all paired waterfowl. Other ecoregions were important to specific groups: Postville ecoregion showed high densities of Canada Geese; Mistastin Lake, Postville, Churchill Falls, and Eagle Plateau had mostly diving ducks.

5.2. Ground surveys

The observations during the 1980 ground surveys are summarized, by ecoregion, in Tables 5 and 6 for the Lake Plateau (22[1] plots) and southeastern Labrador (12[1] plots) respectively. The lower counts, especially of pairs or equivalents, in southeastern Labrador reflected, to some degree, the later survey dates there. The ground surveys of southeastern Labrador were even later than the aerial counts relative to those of the Lake Plateau.

Results of the more intensive surveys in 1981 (Table 7) were compared with the 1980 coverage of the same areas (Table 8). Most differences reflected inadequacy of sampling because the 1980 coverage was relatively superficial, resulting in unduly low productivity estimates for some sites that year. Aerial-ground comparisons using 1980 ground data consequently presented anomalies (Table 9).

[1]All plots in Churchill Falls ecoregion were included here under the Lake Plateau.

Table 3
Total waterfowl and breeding pairs (or equivalent) per 100 km² on Lake Plateau aerial survey of 1980 by ecoregion

	Ecoregion (area sampled – km²)							
	Smallwood Reservoir		Churchill Falls		Seahorse		Mistastin Lake	
Species	Sample plots (888 km²)	Transects (710)	Plots (48)	Transects (140)	Plots (192)	Transects (186)	Plots (72)	Transects (118)
Canada Goose	31.4(12.4)*	13.5(3.9)	2.1(2.1)	6.5(2.4)	8.3(3.6)	6.9(3.5)	13.9(5.6)	14.1(4.7)
Green-winged Teal	3.8(2.4)	1.3(0.3)	0(0)	2.6(0.2)	1.6(1.0)	0(0)	2.8(1.4)	0.6(0)
Black Duck	10.5(3.5)	7.4(1.2)	0(0)	7.4(0.8)	1.0(1.0)	3.8(0.5)	8.3(1.4)	6.9(1.1)
Total dabbling ducks†	15.1(6.2)	9.4(1.8)	0(0)	10.0(1.0)	2.6(2.1)	3.8(0.5)	13.9(2.8)	8.6(1.7)
Scaup	4.4(2.3)	1.4(0.6)	0(0)	3.9(1.4)	1.6(1.0)	3.2(1.6)	5.6(2.5)	2.8(0)
Scoters	5.9(3.2)	5.5(1.7)	4.2(2.1)	6.7(2.6)	0(0)	2.5(0.4)	2.8(1.4)	5.7(1.1)
Common Goldeneye	3.6(1.9)	4.5(0.9)	4.2(2.1)	10.5(3.1)	2.1(0)	13.3(1.8)	0(0)	4.0(0.6)
Mergansers	5.2(2.5)	3.3(1.4)	0(0)	4.8(2.1)	4.7(3.1)	4.7(1.0)	8.3(4.2)	8.3(3.8)
Total diving ducks‡	20.7(10.2)	15.3(4.9)	8.4(4.2)	26.0(9.7)	8.4(4.2)	23.7(4.8)	16.7(8.1)	21.8(5.5)
Total ducks§	38.7(17.9)	25.7(7.2)	8.4(4.2)	37.7(11.1)	11.0(6.3)	28.6(5.8)	30.6(11.1)	30.4(7.2)

* Total waterfowl per 100 km² (pairs or equivalent per 100 km²).
† Including Mallard and Northern Pintail.
‡ Including Ring-necked Duck and Bufflehead.
§ Including unidentified ducks.

Table 4
Total waterfowl and breeding pairs (or equivalent) per 100 km² total area on 1980 aerial surveys of southeastern Labrador, by ecoregion (omitting six minor ecoregions)

	Ecoregions (area sampled in km²)							
Species	Postville (145 km²)	Nipishish Lake (197)	Churchill Falls (342)	Domagaya Lake (57)	Lake Melville (246)	Eagle Plateau (241)	St. Paul (223)	Paradise River (251)
Canada Goose	46(7)*	20(2)	8(2)	3(0)	2(2)	6(3)	13(2)	20(4)
Green-winged Teal	2(1)	1(1)	2(1)	2(1)	1(1)	11(0)	3(2)	6(0)
Black Duck	9(1)	1(1)	3(1)	8(4)	3(2)	5(3)	1(1)	2(0)
Total dabbling ducks†	12(3)	2(2)	6(2)	10(5)	4(3)	16(3)	4(3)	8(0)
Scaup	5(1)	2(0)	6(3)	2(2)	2(1)	5(1)	3(2)	0(0)
Scoters	25(1)	5(0)	6(3)	9(0)	2(0)	9(2)	1(0)	0(0)
Common Goldeneye	3(2)	3(2)	3(2)	0(0)	2(2)	1(0)	4(2)	2(0)
Mergansers	5(4)	3(2)	8(3)	6(3)	1(1)	6(4)	3(1)	1(0)
Total diving ducks	40(9)	15(5)	23(11)	17(5)	7(4)	24(9)	11(5)	3(0)
Total ducks‡	56(16)	18(8)	33(13)	35(10)	11(7)	42(13)	16(9)	11(0)

* Total waterfowl per 100 km² (pairs or equivalent per 100 km²).
† Includes Mallard and Northern Pintail.
‡ Includes unidentified ducks.

The chronology in 1970 was probably two to three weeks later than in 1980. Canada Geese were the earliest nesters, followed closely by the Black Duck (i.e. mid-May–mid-June). Common Goldeneye were relatively early (June) nesters. Green-winged Teal and Red-breasted Mergansers were late breeders (mid-June–mid-July) and most of the latter species were not flying until mid-September. The data suggest that north of 56°N latitude breeding chronology of the Canada Goose and Black Duck near the coast is retarded by up to a month compared to southern Labrador. However, the earliest breeding was noted in the Woods Lake area, northwest of Smallwood Reservoir, rather than in the more southern sectors as one might expect (Table 10). In no year were surveys continued late enough for a representative sample of broods of the later-nesting diving ducks to be made.

Table 5
Total waterfowl/equivalent pairs and equivalent pairs per square kilometre of potential habitat per study plot, ground surveys 1980, by ecoregion for the Lake Plateau study area*

Ecoregion plot	Potential habitat coverage (km²)	Canada Goose Total/ pr.	Canada Goose Pair dens.	Green-w. Teal Total/ pr.	Green-w. Teal Pair dens.	Black Duck Total/ pr.	Black Duck Pair dens.	Total dabblers Total/ pr.	Total dabblers Pair dens.	Scaup Total/ pr.	Scaup Pair dens.	Common Goldeneye Total/ pr.	Common Goldeneye Pair dens.	Scoters Total/ pr.	Scoters Pair dens.	Mergansers Total/ pr.	Mergansers Pair dens.	Total divers Total/ pr.	Total divers Pair dens.	Total ducks Total/ pr.	Total ducks Pair dens.
Smallwood Reservoir																					
A3	(5.0)	6/3	0.6	1/1	0.2	—	0	1/1	0.2	—	0	—	0	—	0	1/1	0.2	1/1	0.2	2/2	0.4
A7	(4.0)	7/4	1.0	2/1	0.3	2/1	0.3	4/2	0.5	13/1	0.3	—	0	11/8	2.0	5/2	0.5	29/11	2.8	38/13	3.3
B10	(3.0)	4/2	0.7	3/2	0.7	2/2	0.7	5/4	1.3	—	0	—	0	5/3	1.0	—	0	5/3	1.0	10/7	2.3
C6	(2.9)	7/1	0.3	1/1	0.3	—	0	1/1	0.3	—	0	—	0	8/0	0	9/6	2.1	17/6	2.0	18/7	2.4
C8	(2.3)	—	0	2/1	0.4	4/3	1.3	6/4	1.7	5/1	0.4	6/2	0.9	2/1	0.4	—	0	13/4	1.7	19/8	3.5
E1	(3.0)	2/1	0.3	3/2	0.7	1/1	0.3	4/3	1.0	—	0	—	0	1/1	0.3	3/2	0.7	4/3	1.0	8/6	2.0
E2	(5.0)	—	0	—	0	1/1	0.2	1/1	0.2	—	0	—	0	—	0	2/1	0.2	2/1	0.2	3/2	0.4
E5	(3.0)	4/2	0.7	—	0	—	0	—	0	—	0	—	0	—	0	1/1	0.3	1/1	0.3	1/1	0.3
F2	(3.0)	4/2	0.7	—	0	1/1	0.3	1/1	0.3	—	0	—	0	3/2	0.7	1/1	0.3	4/3	1.0	5/4	1.3
F9	(9.0)	17/9	1.0	1/1	0.1	2/1	0.1	3/2	0.2	—	0	—	0	1/1	0.1	2/2	0.2	3/3	0.3	6/5	0.6
G1	(7.0)	—	0	—	0	—	0	1/1	0.1	—	0	—	0	—	0	1/1	0.1	1/1	0.1	2/2	0.3
G2	(7.5)	33/10	1.3	3/0	0	6/3	0.4	16/6	0.8	7/1	0.1	—	0	—	0	—	0	7/1	0.1	23/7	0.9
Total	(54.7)																				
Weighted mean			0.6		0.2		0.2		0.5		0.06		0.04		0.3		0.3		0.7		1.2
Mistastin Lake																					
A6	(5.4)	5/1	0.2	2/2	0.4	1/1	0.2	3/3	0.6	—'	0	—	0	4/2	0.4	2/1	0.2	6/3	0.6	9/6	1.1
C4	(6.6)	—	0	1/1	0.2	3/2	0.3	4/3	0.5	—	0	—	0	—	0	2/1	0.2	2/1	0.2	6/4	0.6
Total	(12.0)																				
Weighted mean			0.1		0.3		0.3		0.5		0		0		0.2		0.2		0.3		0.8
Seahorse																					
D4	(4.5)	7/4	0.9	—	0	—	0	—	0	—	0	—	0	—	0	1/1	0.2	1/1	0.2	1/1	0.2
D6	(6.0)	7/2	0.3	—	0	—	0	—	0	—	0	1/1	0.2	—	0	—	0	1/1	0.2	1/1	0.2
D7	(1.5)	3/2	1.3	1/1	0.7	—	0	1/1	0.7	—	0	—	0	—	0	—	0	—	0	1/1	0.7
G7	(2.5)	2/1	0.4	—	0	—	0	—	0	—	0	—	0	—	0	2/1	0.4	2/1	0.4	2/1	0.4
Total	(14.5)																				
Weighted mean			0.6		0.1		0		0.1		0		0.1		0		0.1		0.2		0.3
Churchill Falls																					
F1	(3.3)	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
S1	(7.0)	12/1	0.1	—	0	—	0	—	0	—	0	—	0	—	0	1/1	0.1	1/1	0.1	1/1	0.1
S2	(4.7)	—	0	—	0	—	0	—	0	—	0	3/0	0	1/1	0.2	3/0	0	7/1	0.2	7/1	0.2
S3	(7.0)	—	0	1/1	0.1	—	0	1/1	0.1	—	0	—	0	—	0	2/2	0.3	2/2	0.3	3/3	0.4
Total	(22.0)																				
Weighted mean			0.05		0.05		0		0.05		0		0		0.04		0.1		0.2		0.2

* Includes three plots in Churchill Falls ecoregion surveyed under southeastern Labrador section.

Table 6
Total waterfowl/equivalent pairs and equivalent pairs per square kilometre of potential habitat per ground study plot, by ecoregion for the southeastern Labrador study area 1980

Ecoregion plot	Potential habitat coverage (km^2)	Canada Goose		Green-w. Teal		Black Duck		Total dabblers		Scaup		Common Goldeneye		Scoters		Mergansers		Total divers		Total ducks	
		Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.
Lake Melville																					
T1	(2.5)	12/0	0	1/1	0.4	2/2	0.8	6/3	1.2	—	0	—	0	9/0	0	—	0	9/0	0	15/3	1.2
T2	(42.0)	—	0	—	0	9/0	0	9/0	0	3/0	0	—	0	—	0	6/4	0.1	9/4	0.1	18/4	0.1
T3	(1.7)	—	0	—	0	—	0	—	0			—	0	—	0	—	0	—	0	—	0
Total	(46.2)																				
Weighted mean			0		0.02		0.04		0.1		0		0		0		0.1		0.1		0.2
Nipishish Lake																					
01	(1.3)	6/0	0	1/1	0.8	1/1	0.8	4/3	2.3	—	0	—	0	—	0	3/0	0	3/0	0	7/3	2.3
02	(2.2)	7/2	0.9	—	0	—	0	—	0	—	0	—	0	—	0	1/1	0.5	1/1	0.5	1/1	0.5
03	(4.5)	32/0	0	—	0	—	0	—	0	—	0	—	0	2/0	0	2/1	0.2	4/1	0.2	4/1	0.2
Total	(8.0)																				
Weighted mean			0.3		0.1		0.1		0.4		0		0		0		0.3		0.3		0.6
Postville																					
L1	(5.5)	98/1	0.2	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
L2	(2.8)	—	0	—	0	10/0	0	10/0	0	—	0	3/2	0.7	—	0	4/1	0.4	7/3	1.1	17/3	1.1
L3	(4.0)	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
Total	(12.3)																				
Weighted mean			0.1		0		0		0		0		0.2		0		0.1		0.3		0.2
Eagle Plateau																					
V1	(1.8)	—	0	—	0	—	0	—	0	—	0	—	0	4/1	0.6	3/3	1.7	7/4	2.2	7/4	2.2
V2	(10.0)	—	0	2/0	0	1/1	0.1	3/1	0.1	4/1	0.1	8/3	0.3	—	0	3/1	0.1	15/5	0.5	18/6	0.6
V3	(6.5)	—	0	—	0	2/2	0.3	2/2	0.3	—	0	6/2	0.3	—	0	2/2	0.3	8/4	0.6	10/6	0.9
Total	(18.3)																				
Weighted mean			0		0		0.2		0.2		0.1		0.3		0.1		0.3		0.7		0.9

Table 7
Total waterfowl/equivalent pairs and equivalent pairs per km^2 of potential habitat per ground study plot, ground surveys 1981

Ecoregion plot	Potential habitat coverage (km^2)	Canada Goose		Green-w. Teal		Black Duck		Total dabblers		Scaup		Common Goldeneye		Scoters		Mergansers		Total divers		Total ducks	
		Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.	Total/ pr.	Pair dens.
Smallwood Reservoir																					
A3	(13)	28/14	1.1	5/4	0.3	27/10	0.8	42/16	1.2	9/3	0.2	27/2	0.2	6/5	0.4	30/12	0.9	76/25	1.9	118/41	3.2
A7	(9)	32/16	1.8	10/5	0.6	33/10	1.1	45/16	1.8	8/1	0.1	—	0	1/1	0.1	4/1	0.1	15/4	0.4	60/20	2.2
G2	(22)	16/6	0.3	2/1	0.05	8/2	0.1	10/3	0.1	2/1	0.05	4/3	0.1	8/0	0	—	0	16/5	0.2	26/8	0.4
Total	(44)																				
Weighted mean			0.8		0.2		0.5		0.8		0.1		0.1		0.1		0.3		0.8		1.6
Nipishish Lake																					
01	(14)	4/3	0.2	1/1	0.1	1/1	0.1	2/2	0.1	—	0	2/1	0.1	—	0	16/6	0.4	18/7	0.5	20/9	0.6
Postville																					
L2	(27)	49/4	0.1	2/1	0.04	78/17	0.6	84/19	0.7	15/5	0.2	61/15	0.6	—	0	51/20	0.7	127/40	1.5	211/59	2.2
Eagle Plateau																					
V2(a)	(25)	1/1	0.04	—	0	5/4	0.2	6/5	0.2	—	0	19/11	0.4	32/4	0.2	7/5	0.2	59/21	0.8	65/26	1.0
V2(b)	(20)	4/0	0	2/2	0.1	11/7	0.4	14/10	0.5	—	0	11/3	0.2	4/4	0.2	23/10	0.5	39/18	0.9	53/28	1.4
Total	(45)																				
Weighted mean			0.02		0.04		0.2		0.3		0		0.3		0.2		0.3		0.9		1.2

5.3. Air/ground comparisons

Comparisons of 1980 aerial and ground survey results were restricted to plots in the Lake Plateau area. The plots surveyed on the ground in southeastern Labrador were adjacent to the transects, but did not receive aerial coverage. Those ground surveys were made up to a month later than the air coverage in the same general area, and would not have provided a useful comparison. Air and ground surveys of the Lake Plateau plots were asynchronous by as much as two weeks; movement of waterfowl in and out of the plots between surveys is possible. Thus the 1980 air/ground comparison provided only an approximation of the relative effectiveness of the aerial surveys. It seemed likely that the 1980 ground surveys also gave an incomplete picture of dabbling duck densities; similar densities of Black Ducks were seen from the air as on the ground, whereas other studies (e.g. Haapanen and Nilsson 1979) have shown much lower detectability of Mallards and Green-winged Teal from the air. The comparison of air and ground data between 1980 and 1981 (Table 9) confirmed our belief that the 1980 ground surveys were of little use for adjusting the aerial survey estimates. Consequently 1981 ground data were used to calculate correction factors (Table 11) with which to adjust observed breeding densities (Tables 12 and 13). The small samples obtained by low sampling intensity left some conspicuous gaps in the breeding population estimates at the ecoregion level, and some arbitrary adjustments were made to fill those gaps (see footnotes to Tables 12 and 13).

Table 8
Inter-year comparison of calculated total waterfowl and equivalent pairs of waterfowl for selected study areas* in southern Labrador in 1980 and 1981

Species	Lake Plateau (3 plots) 1980 Coverage 16.5 km^2 Mean density (per km^2)	No. obs.	Lake Plateau (3 plots) 1981 Coverage 44 km^2 Mean density (per km^2)	No. obs.	Snegamook Lake (1 plot) 1980 Coverage 2.8 km^2 Mean density (per km^2)	No. obs.	Snegamook Lake (1 plot) 1981 Coverage 27 km^2 Mean density (per km^2)	No. obs.	Eagle Plateau (1 plot) 1980 Coverage 10.3 km^2 Mean density (per km^2)	No. obs.	Eagle Plateau (1 plot) 1981 Coverage 25 km^2 Mean density (per km^2)	No. obs.
Canada Goose	3.4/1.0	(56/17)	2.5/0.8	(111/36)	0		1.8/0.2	(49/4)	0		0.2/0.04	(6/1)
Green-winged Teal	0.4/0.1	(6/2)	0.4/0.2	(17/10)	0		0.1/0.04	(2/1)	0.2/0	(2/0)	0.1/0.1	(2/2)
Black Duck	0.5/0.3	(8/4)	1.6/0.5	(68/22)	3.6/0	(10/0)	2.9/0.6	(78/17)	0.1/0.1	(1/1)	0.4/0.3	(11/7)
Total dabbling ducks	1.3/0.6	(21/9)	2.2/0.8	(97/35)	3.6/0	(10/0)	3.1/0.7	(84/19)	0.3/0.1	(3/1)	0.6/0.4	(14/10)
Scaup	1.2/0.1	(20/2)	0.4/0.1	(19/5)	0		0.6/0.2	(15/5)	0		0	
Scoters	0.7/0.5	(11/8)	0.3/0.1	(14/6)	0		0		0		1.3/0.2	(32/4)
Common Goldeneye	0		0.7/0.1	(31/5)	1.1/0.7	(3/2)	2.3/0.6	(61/15)	0.8/0.3	(8/3)	0.8/0.4	(19/11)
Mergansers	0.4/0.2	(6/3)	0.8/0.3	(34/13)	1.4/0.4	(4/1)	1.9/0.7	(51/20)	0.3/0.1	(3/1)	0.9/0.4	(23/10)
Total diving ducks	2.6/0.8	(42/13)	2.4/0.7	(106/34)	2.5/1.1	(7/3)	4.7/1.5	(127/40)	1.1/0.4	(11/4)	3.0/1.0	(75/26)
Total ducks	3.9/1.4	(63/22)	4.6/1.5	(203/69)	6.1/1.1	(17/3)	7.8/2.2	(221/59)	1.4/0.5	(14/5)	3.6/1.4	(89/36)

* Most waterfowl had been driven out of plot 01 (Cache River) by hunting by Indians before the 1981 survey, so no comparisons are presented for that area.

Table 9
Effectiveness of 1980 aerial survey of Lake Plateau study area for detecting waterfowl, in comparison with 1980 and 1981 ground coverage of same areas. Effectiveness is expressed as percentage detected from the air of the number seen from the ground, given as total waterfowl per equivalent pairs

Species	Effectiveness of aerial survey: Compared to 1980 ground survey (79.8 km^2), with intensity 0.8 h/km^2	Compared to 1981 ground survey (44 km^2), with intensity 1.7 h/km^2
Canada Goose	60%/57%	53%/50%
Green-winged Teal	33%/25%	20%/17%
Black Duck	100%/105%	25%/42%
Total dabbling ducks	75%/61%	25%/34%
Scaups*	20%/40%	20%/40%
Scoters†	33%/30%	50%/45%
Common Goldeneye	200%/90%	29%/90%[§]
Mergansers‡	33%/23%	25%/30%[§]
Total diving ducks	42%/34%	31%/43%
Total ducks	52%/43%	28%/38%

* Includes both *Aythya marila* and *A. affinis*.
† Primarily *Melanitta perspicillata* (75%) and *M. nigra* (25%).
‡ Includes predominantly *Mergus serrator* and a few *M. merganser*.
§ Probably attributable to confusion of *M. serrator* and *B. clangula* from the air.

Table 10
Approximate laying and fledging chronology of waterfowl breeding in Labrador (details in App. 2)

Species	Area (sample size)	Mean start of incubation	Mean date of fledging (range)
Canada Goose	SW (Labrador City) — Natashquan River (5)	16 May	8 Aug. (22 July, 11–16 Aug.)
	West (Woods Lake) (3)	22 April	15 July (12–20 July)
	Central (Snegamook Lake — Goose River) (17)	25 May	17 Aug. (10–26 Aug.)
	East-Central (Micmac Lake — Groswater Bay) (13)	19 May	11 Aug. (3–19 Aug.)
	North (Nain) (2)	2 June	25 Aug. (23–27 Aug.)
Green-winged Teal	all areas (7)	14 June	10 Aug. (3–14 Aug.)
Black Duck	West (Woods Lake) (5)	2 May	21 July (14–28 July)
	Southeast (Eagle Plateau) (5)	21 May	9 Aug. (5–14 Aug.)
	East-Central (Groswater Bay) (1)	12 May	31 July
	Central (Snegamook Lake) (8)	24 May	12 Aug. (21–25 July, 15–22 Aug.)
	North (Nain) (2)	8 June	27 Aug. (19 Aug.–3 Sept.)
Mallard	Central (Snegamook Lake) (1)	12 May	31 July
Northern Pintail	all areas (7) (SE, EC, and C)	23 May	30 July (23 July–12 Aug.)
American Wigeon	Central (Snegamook Lake) (1)	18 June	29 Aug.
Black Scoter	all areas (1)	12 May*	8 Aug.*
Common Goldeneye	all areas (10) (C and SE)	1 June	26 Aug. (14 Aug.–1 Sept.)
Red-breasted Merganser	all areas (8) (EC and N)	11 June	11 Sept. (28 Aug.–22 Sept.)

* Seems improbably early for that species (*cf.* Palmer 1976); might perhaps have been a brood of another duck seen with a female scoter.

Table 11
Air/ground adjustment factors based on 1980 aerial and 1981 ground surveys of Lake Plateau study areas (coverage 44 km^2). Waterfowl densities are expressed as total waterfowl or as equivalent pairs per square kilometre of waterfowl habitat; waterfowl habitat estimated to be 44% (10.6 km^2) of 24 km^2 plots surveyed from the air, but ground survey confined to wetlands

Species	Density from 1980* aerial survey: Total waterfowl	Density from 1980* aerial survey: Equivalent pairs	Density from 1981† ground survey: Total waterfowl	Density from 1981† ground survey: Equivalent pairs	Adjustment factors for aerial data, based on equivalent pairs
Canada Goose (aerial pairs = 43% of total)	0.9	0.4	1.7	0.8	2.0
Green-winged Teal	0.1	0.05	0.5	0.3	6.0
Black Duck	0.4	0.2	1.6	0.5	2.4
Total dabbling ducks (aerial pairs = 52% of total)	0.6	0.3	2.4	0.9	2.9
Scaups	0.1	0.04	0.5	0.1	2.5
Scoters	0.2	0.1	0.4	0.2	2.2
Common Goldeneye	0.2	0.1	0.7	0.1	1.1‡
Mergansers	0.2	0.1	0.8	0.3	3.3‡
Total diving ducks (aerial pairs = 43% of total)	0.8	0.3	2.6	0.8	2.4
Total ducks	1.4	0.7	5.0	1.7	2.6

* Densities based on 13 sample plots (each 24 km^2) on Lake Plateau. Number of pairs assumed equal to 40% of total waterfowl. Pair density was significantly different only for Canada Geese ($P<0.05$; paired t-test and Wilcoxon nonparametric test).
† Densities based on three study plots within Smallwood Reservoir ecoregion.
‡ Probably attributable to confusion of goldeneyes and mergansers from the air; one would expect both to be equally detectable.

Table 12
Adjusted equivalent breeding pairs per 100 km^2 total area on Lake Plateau sample plot surveys

Species (adjustment factor)	Smallwood Reservoir: Sample plots (888 km^2)	Churchill Falls: Sample plots (48 km^2)	Seahorse: Sample plots (192 km^2)	Mistastin Lake: Sample plots (72 km^2)
Canada Goose (x2.0)	24.8 ± 5.3 (SE)	4.2 ± 0.9	7.2 ± 1.5	11.2 ± 2.4
Green-winged Teal (x6.0)	14.4 ± 4.1	6.0[d] ± 1.7	6.0 ± 1.7	8.4 ± 2.4
Black Duck (x2.4)	8.4 ± 3.0	1.2[e] ± 0.4	2.4 ± 0.9	3.4 ± 1.2
Total dabbling ducks[a]	23.5 ± 8.3	7.2 ± 2.6	8.5 ± 3.0	11.8 ± 4.2
Scaups (x2.5)	5.8 ± 3.5	1.2[e] ± 0.7	2.5 ± 1.5	6.3 ± 3.9
Scoters (x2.2)	7.0 ± 3.0	4.6 ± 2.0	1.1[e] ± 0.5	3.1 ± 1.3
Common Goldeneye (x1.1)	2.1 ± 1.7	2.3 ± 1.9	1.1[d] ± 0.9	0.6[e] ± 0.5
Mergansers (x3.3)	8.3 ± 2.9	3.3[d] ± 1.2	10.2 ± 3.6	13.8 ± 4.8
Total diving ducks[b]	23.9 ± 6.5	11.4 ± 3.1	14.9 ± 4.1	23.8 ± 6.5
Total ducks[c]	51.9 ± 11.5	18.6 ± 4.2	23.4 ± 5.3	36.1 ± 8.1

[a] Including Mallard and Northern Pintail (x2.4).
[b] Including Ring-necked Duck and Bufflehead (x0.25).
[c] Including unidentified ducks (x2.4).
[d] Not detected as equivalent pairs on aerial survey, but seen in ecoregion either on ground surveys or as flocked birds from air; an arbitrary density of 1.0 pr/100 km^2 total area is inserted before adjustment.
[e] Not detected in ecoregion, but undoubtedly occurs; an arbitrary density of 0.5 pr/100 km^2 is inserted before adjustment.

Table 13
Adjusted equivalent breeding pairs of waterfowl per 100 km^2 total area on southeastern Labrador surveys

Species (adjustment factor)	Postville (145 km^2)	Nipishish Lake (197)	Churchill Falls (342)	Domagaya Lake (57)	Lake Melville (246)	Eagle Plateau (241)	St. Paul (225)	Paradise River (251)	Porcupine Strand[d] (69)
Canada Goose (x2.0)	14.0 ± 11.4	4.0 ± 3.3	4.0 ± 3.3	2.0[e] ± 1.6	4.0 ± 3.3	6.0 ± 4.9	4.0 ± 3.3	8.0 ± 6.5	14.0 ± 11.4
Green-winged Teal (x6.0)	6.0 ± 4.3	6.0 ± 4.3	6.0 ± 4.3	6.0 ± 4.3	6.0 ± 4.3	6.0[e] ± 4.3	12.0 ± 8.6	6.0[e] ± 4.3	4.4 ± 3.2
Black Duck (x2.4)	2.4 ± 1.3	2.4 ± 1.3	2.4 ± 1.3	9.6 ± 5.1	4.8 ± 2.6	7.2 ± 3.8	2.4 ± 1.3	2.4[e] ± 1.3	14.0 ± 7.5
Total dabbling ducks[a]	10.4 ± 6.7	8.4 ± 5.4	8.4 ± 5.4	15.6 ± 10.1	10.8 ± 7.0	13.2 ± 8.5	14.4 ± 9.3	8.4 ± 5.4	21.8 ± 14.1
Scaups (x2.5)	2.5 ± 2.5	2.5[e] ± 2.5	7.5 ± 2.5	4.4 ± 4.4	2.5 ± 2.5	2.5 ± 2.5	5.0 ± 5.0	0.0[h]	0.8 ± 0.8
Scoters (x2.2)	2.2 ± 2.5	2.2[e] ± 2.2	6.6 ± 6.6	2.2[e] ± 2.2	0.0[g]	4.4 ± 4.4	2.2[e] ± 2.2	0.0[h]	—
Common Goldeneye (x1.1)	2.2 ± 1.3	2.2 ± 1.3	2.2 ± 1.3	0.6[f] ± 0.4	2.2 ± 1.3	1.1[e] ± 0.6	2.2 ± 1.3	1.1[e] ± 0.6	2.2 ± 1.3
Mergansers (x3.3)	13.2 ± 6.7	6.6 ± 3.4	9.9 ± 5.0	9.9 ± 5.0	3.3 ± 1.7	13.2 ± 6.7	3.3 ± 1.7	3.3[e] ± 1.7	4.8 ± 2.4
Total diving ducks[b]	22.5 ± 9.9	15.9 ± 7.0	26.2 ± 11.5	17.1 ± 7.5	8.0 ± 3.5	26.0 ± 11.4	12.7 ± 5.6	4.4 ± 1.9	7.8 ± 3.4
Total ducks[c]	32.9 ± 10.4	24.3 ± 7.7	34.6 ± 11.0	32.7 ± 10.4	18.8 ± 6.0	39.2 ± 12.4	27.1 ± 8.6	12.8 ± 4.1	29.6 ± 9.4

[a] Includes Northern Pintail and Mallard (x2.4).
[b] Includes Ring-necked Ducks and Buffleheads (x2.5).
[c] Includes unidentified ducks (x2.4).
[d] Derived from 1982 ground data — potential waterfowl breeding habitat <20% of this ecoregion.
[e] Not detected as equivalent pairs on aerial survey, but seen in ecoregion either on ground surveys or as flocked birds from air: an arbitrary density of 1.0 pr/100 km^2 total area is inserted before adjustment.
[f] Not detected in ecoregion, but undoubtedly occurs; an arbitrary density of 0.5 pr/100 km^2 is inserted before adjustment.
[g] Many non-breeding scoters summer in this ecoregion.
[h] Considered unlikely that scaup and scoters breed in this ecoregion (lowland, forested).

5.4. Estimated populations of waterfowl in Labrador

We extrapolated total populations by using the estimated densities (adjusted for air/ground visibility differences) of breeding waterfowl in each ecoregion (Tables 12 and 13) across the total area of each ecoregion. Densities for the small or poorly sampled ecoregions were assigned by comparison with others of similar nature, following descriptions given by Lopoukhine *et al.* (1977); e.g. Churchill Falls and Domagaya Lake were grouped with Nipishish Lake, Porcupine Strand with Lake Melville (based on 1982 data), while Hopedale, Benedict Mountains, and Mealy Mountains were ignored as having negligible densities. Two other ecoregions on the southeast coast and one in extreme western Labrador, not covered by the aerial surveys, were also ignored. The eight ecoregions lying north of latitude 55°N corresponded to the "Northeast Unit" of Gillespie and Wetmore (1974). Thus we obtained a preliminary estimate of waterfowl species populations (excluding eiders, *cf.* Lock 1986) (Tables 14 and 15), which could be used for comparison with other parts of the Atlantic Region and Flyway. Despite the generally low breeding densities, Labrador's large area produces about 420 000 ducks and 153 000 geese.

5.5. Habitat

From data collected during the 1980 ground surveys, we were able to make a rough characterization of the study plots (Appendix 3). The habitat classification used by Gillespie and Wetmore (1974), a modification of that of Hare (1959), was further altered in view of more recent studies (Newfoundland Forest Research Centre, by E.D. Wells, pers. commun.; Raveling and Lumsden 1977; Haapanen and Nilsson 1979). Most habitat types were distinguishable from the air or from air photographs, but further differentiation among peatland types was possible on the ground.

5.5.1. Peatlands — Peatlands in Labrador vary greatly, from raised bogs of no value to waterfowl, to string bogs, ribbed fens, and unpatterned fen-marsh complexes that may be relatively productive habitats for geese and dabbling ducks. String bogs are nutrient-poor, and derive more input from rain and less from surface runoff or drainage than the more productive areas. Typical bog vegetation is dominant, and includes *Sphagnum fuscum, Scirpus cespitosus, Carex rostrata, Kalmia polifolia,* and often clumps of black spruce (*Picea mariana*) and larch (*Larix laricina*). Bog pools often have no vegetation, but occasionally *Menyanthes trifoliata, Carex limosa* and *C. oligosperma* are fairly common. String bogs cover large expanses, especially in the Lac Joseph (plot G2) and Eagle Plateau (plot V2) areas. In contrast, ribbed fens (indistinguishable from string bogs on small-scale air photos) may have relatively lush vegetation, owing to rapid drainage and the presence of ground water. Characteristic vegetation may include *Sphagnum compactum, S. pulchrum, Cladopodiella fluitans, Scirpus cespitosus, Carex exilis, C. oligosperma,* with minerotrophic indicators such as *Betula michauxii, B. pumila, Myrica gale, Lonicera villosa, Rubus acaulis, Sanguisorba canadensis, Aster novibelgii, Selaginella selaginoides.* Pool vegetation is similar to that of string bogs except that marsh vegetation is often extensive and *Sphagnum* mosses are less frequent; *Nuphar variegatum* and *Utricularia vulgaris* are also found occasionally. That habitat is most extensive north of Smallwood Reservoir, where it represents some of the most important waterfowl breeding habitat in Labrador.

There are also unpatterned fen-marsh complexes which appear to represent early succession toward ribbed fen or string bog. The pronounced patterning of water bodies is lacking, and the general impression is that of a random array of shallow ponds amid sedge marshes. This habitat may be as important to waterfowl as ribbed fen, and often more important to diving ducks as the water bodies are larger and deeper.

5.5.2. Fringed lakes ("encroachment" of Gillespie and Wetmore 1974) — Apart from the extensive expanses of peatland there are areas where encroachment of peatland vegetation around the margins of lakes and ponds or suitable substrate conditions, result in formation of a fringe of bog or marsh between forest and open water. Those areas are individually unimportant, but fringed lakes provide potential waterfowl habitat in areas where extensive peatlands are lacking.

5.5.3. Rocky-shored lakes — Those areas are important only to diving ducks — mainly mergansers, goldeneyes, and scoters; lakes with islands, in particular, may provide nesting sites.

5.5.4. Esker impoundments — Eskers often disrupt drainage patterns, with subsequent development of sedge marsh or bog around the ponds thus formed, depending on local site conditions. This is not a very extensive type, but it is easily recognized and surveyed.

5.5.5. Alluvial sites — Most alluvial sites comprise river deltas (extending into lakes) and flood plains where flooding and sedimentation alternate with oxidation and decomposition of organic matter. On some sites, succession leads to alder/willow/dwarf birch (*Alnus/Salix/Betula*) swamps with only a small amount of sedge marsh. Where water levels remain high into the summer, those areas support relatively few breeding dabbling ducks, but where the flats are drier in summer the sedge-shrub (*Carex/Myrica*) marshes may be important to breeding and moulting waterfowl. Those habitats are restricted in Labrador, but are especially important along the large rivers of the Postville and Eagle Plateau ecoregions (e.g. Snegamook Lake delta, plot L2, and Lake 1155 delta, plot V2, respectively). Low-relief brooks, especially in the Lake Melville and Porcupine Strand ecoregions, frequently support stable and often extensive

Table 14a
Estimated breeding pair population by species and ecological region for Lake Plateau area (based on adjusted 1980 aerial data), rounded to nearest 10

	Populations (pairs) by ecoregions (total area [km²])				
Species	Smallwood Reservoir (36 300 km²)	Seahorse (13 800)	Mistastin Lake (14 400)	Churchill Falls§ (23 490)	Total Lake Plateau
Canada Goose	9 000 ± 1920	990 ± 210	1610 ± 340	950 ± 200	12 550 ± 2680
Green-winged Teal	5 230 ± 1490	830 ± 240	1210 ± 350	1410 ± 400	8 680 ± 2470
Black Duck	3 050 ± 1080	330 ± 120	490 ± 170	500 ± 180	4 370 ± 1550
Total dabbling ducks*	8 530 ± 2210	1170 ± 300	1700 ± 440	1900 ± 490	13 300 ± 3450
Scaups	2 110 ± 1290	350 ± 210	910 ± 560	1460 ± 890	4 830 ± 2950
Scoters	2 540 ± 1100	150 ± 70	450 ± 190	1460 ± 630	4 600 ± 1980
Common Goldeneye	760 ± 620	150 ± 120	90 ± 70	550 ± 450	1 520 ± 1250
Red-breasted Merganser	3 010 ± 1050	1410 ± 490	1990 ± 690	2020 ± 700	8 430 ± 2930
Total diving ducks†	8 680 ± 2370	2060 ± 560	3430 ± 940	5460 ± 1490	19 630 ± 5360
Total ducks‡	18 510 ± 4160	3230 ± 730	5200 ± 1170	7460 ± 1680	34 400 ± 7720

* Includes Northern Pintail and Mallard.
† Includes Common Merganser, Bufflehead, and Ring-necked Duck.
‡ Includes unidentified ducks.
§ Densities in Tables 12 and 13 weighted as 1:4, as SE Labrador sample relatively much larger than that from Lake Plateau.

Table 14b
Estimated breeding pair population by species and ecological region for southeastern Labrador (based on adjusted 1980 aerial data), rounded to nearest 10

	Populations (pairs by ecoregion (total area [km²])								
Species	Postville (18 140)	Nipishish Lake (18 900)	Domagaya Lake (9990)	Lake Melville (16 850)	Porcupine Strand (1390)	Eagle Plateau (19 090)	St. Paul (12 250)	Paradise River (19 900)	Total SE Labrador
Canada Goose	2540 ± 2070	760 ± 620	200 ± 160	670 ± 550	190 ± 160	1150 ± 940	490 ± 400	1590 ± 1300	7 590 ± 6 190
Green-winged Teal	1090 ± 790	1130 ± 810	600 ± 430	1010 ± 730	60 ± 40	1150 ± 830	1470 ± 1060	1190 ± 860	7 700 ± 5 540
Black Duck	440 ± 240	450 ± 240	950 ± 510	810 ± 430	190 ± 100	1370 ± 730	290 ± 160	480 ± 260	4 970 ± 2 650
Total dabbling ducks*	1890 ± 1220	1590 ± 1030	1560 ± 1010	1820 ± 1180	300 ± 190	2520 ± 1630	1760 ± 1140	1670 ± 1080	13 110 ± 8 470
Scaups	450 ± 450	470 ± 470	440 ± 440	420 ± 420	10 ± 10	480 ± 480	610 ± 610	—	2 880 ± 2 880
Scoters	400 ± 400	420 ± 420	220 ± 220	—	—	840 ± 840	270 ± 270	—	2 150 ± 2 150
Common Goldeneye	400 ± 230	420 ± 250	60 ± 40	370 ± 220	30 ± 18	210 ± 120	270 ± 160	220 ± 130	1 980 ± 1 160
Red-breasted Merganser	2390 ± 1220	1250 ± 640	990 ± 500	560 ± 290	70 ± 40	2520 ± 1280	400 ± 200	660 ± 340	8 840 ± 4 500
Total diving ducks†	4080 ± 1790	3010 ± 1320	1710 ± 750	1350 ± 590	110 ± 50	4960 ± 2180	1560 ± 690	880 ± 390	17 660 ± 7 750
Total ducks‡	5970 ± 1890	4590 ± 1450	3270 ± 1040	3170 ± 1000	410 ± 130	7480 ± 2370	3320 ± 1050	2550 ± 810	30 760 ± 9 740

* Includes Northern Pintail and Mallard.
† Includes Common Mergansers, Ring-necked Ducks, and Buffleheads.
‡ Includes unidentified ducks.

Table 14c
Estimated waterfowl breeding pair population of Northeast Unit (80 290 km²) after Gillespie and Wetmore (1974) (adjustment factors applied)

Species	Density	Adjusted	Estimated pair population
Canada Goose	1.5	(x2.0) 3.0	2410
Black Duck	1.2	(x2.4) 2.9	2310
Total dabbling ducks	1.2	(x2.9) 3.5	2790
Scoters	0.2	(x2.2) 0.4	350
Goldeneyes*	0.4	(x2.2) 0.9	710
Mergansers*	0.4	(x2.2) 0.9	710
Total diving ducks	1.0	(x2.4) 2.4	1930
Total ducks	2.2	(x2.6) 5.7	4720

* Merganser and Goldeneye adjustment factors were averaged as aerial misidentifications need not be assumed.

Table 15
Estimated total waterfowl breeding pair population of Labrador and fall flight forecast, rounded to nearest 100

Species	Breeding pairs	Expansion factor*	Fall population
Canada Goose	22 550 ± 8 900	6.80	153 300 ± 60 300
Green-winged Teal	16 400 ± 8 100	5.66	92 700 ± 45 800
Black Duck	11 650 ± 4 300	5.66	65 900 ± 24 300
Total dabbling ducks	29 200 ± 12 000	5.66	165 300
Scaups	7 710 ± 5 900	6.33	48 800 ± 37 300
Scoters	7 100 ± 4 200	5.33	37 800 ± 22 400
Goldeneyes	4 210 ± 2 500	6.33	26 600 ± 15 800
Mergansers	17 980 ± 7 500	6.33	113 800 ± 47 500
Total diving ducks	39 220 ± 13 200	6.50	254 900
Total ducks	68 420 ± 17 500		420 200

* From Erskine, Chapter VII.

Table 16
Correlation matrix and regression analysis for 1980 Lake Plateau study plots

n = 42	Area of open water (km²)	Area of peatland (km²)	Area of rivers and brooks (km²)	Total potential habitat (km²)
Total numbers of geese	− 0.08	0.69‡	0.21	0.47*
Equivalent pairs of geese	− 0.12	0.64†	0.42*	0.42*
Total numbers of dabbling ducks	− 0.06	0.36*	− 0.11	0.22
Equivalent pairs of dabbling ducks	− 0.01	0.20	− 0.12	0.13
Total numbers of diving ducks	0.02	− 0.26	0.0	− 0.19
Equivalent pairs of diving ducks	0.07	− 0.28	0.04	− 0.16

* $P < 0.05$.
† $P < 0.002$.
‡ $P < 0.001$.

Note:
Total number of geese = − 0.633 + 3.296 (area of peatland) ($P < 0.001$).
Equivalent pairs of geese = − 0.510 + 1.086 (area of peatland) ($P < 0.005$).
Total number of dabbling ducks = 0.868 + 0.810 (area of peatland) ($P < 0.10$).
Diving ducks — regressions not significant ($P > 0.50$).

Table 17
Correlation matrix for study plot A3 (10.44 km²) Smallwood Reservoir ecoregion, 1981

	Area of open water (km²)	Area of peatland (km²)	Area of rivers and brooks (km²)	Total potential habitat (km²)
Total numbers of geese	− 0.315	0.641‡	0.040	0.528†
Total numbers of dabbling ducks	0.041	0.416*	− 0.061	0.497*
Total numbers of diving ducks	0.443*	− 0.033	− 0.021	0.271
Equivalent pairs of diving ducks	0.07	− 0.28	0.04	− 0.16

* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.002$.

Note:
Total number of diving ducks = 0.931 + 12.428 (area of open water) ($P < 0.05$).
Total number of dabbling ducks = 0.395 + 3.843 (area of peatland) ($P < 0.05$).
Total number of geese = 0.0776 + 2.393 (area of peatland) ($P < 0.001$).

Table 18
Correlation matrix for waterfowl density and water chemistry parameters for study plots, 1980

	Chemical parameter*			
n = 42	pH	Alkalinity	Specific conductance	PO_4
Canada Goose density†	0.099	− 0.056	− 0.081	− 0.095
Dabbling duck density	− 0.145	− 0.188	− 0.169	− 0.041
Diving duck density	− 0.061	− 0.177	− 0.235	0.473‡
pH		0.722§	0.741§	− 0.108
Alkalinity			0.972§	− 0.030
Specific conductance				− 0.083
Phosphorus				

* Water chemistry data only relevant to one site of open water on each plot, and did not include peatlands.
† Waterfowl guilds were not correlated to one another ($P > 0.50$).
‡ $P<0.01$.
§ $P<0.001$.

Table 19
Estimated loss of waterfowl breeding pair potential due to flooding, Smallwood Reservoir Ecoregion

Species	Potential pair loss due to flooding* (95% confidence interval)	Breeding pair population estimate	Estimated pre-flooding pair population (% change in pop. since 1970)	% decrease in potential breeding pair population
Geese	990 ± 330	9 000	8 570 (+5%)	12
Dabbling ducks	1400 ± 540	8 530	11 370 (−25%)	12
Diving ducks	3740 ± 680	8 680	8 350 (+4%)	45
Total ducks	5140 ± 1220	18 510	21 030 (−12%)	24

* Calculated by regression analyses of waterfowl productivity of potential major waterfowl habitat types based on estimates of habitat loss by Bajzak (Memorial University, unpublished). Only significant regression models were applied.

Total no. of Canada Geese (y) (n = 22)	= 0.633 + 3.296 x 700 km² (peatland) = 2310/990 pr† r^2 = 48.2% $P < 0.001$
No. of dabbling ducks (y) (n = 26)	= 0.395 + 3.843 x 700 km² (peatland) = 2690/1400 pr† r^2 = 17.3% $P < 0.05$
No. of diving ducks (y) (n = 26)	= 0.931 + 12.428 x 700 km² (open water) = 8700/3740 pr† r^2 = 19.6% $P < 0.025$
Total ducks lost	= 11 390/5140 pr†

† Proportion of total in pairs as in Table 11.

sedge (*C. oligosperma*) marsh (e.g. Flatwater Brook at Groswater Bay, or Otter Creek in Lake Melville). Such marsh sites are often enhanced by beaver activity.

5.5.6. Waterfowl/habitat correlations — Within the Lake Plateau, habitats fell into three major categories: open water, rivers/brooks, and peatlands. There were virtually no fluvial marshes. To assess segregation between the three waterfowl groups — grazing geese, dabbling ducks, and diving ducks — we made correlation-regression analyses for the 13 ground-sampled plots on the Lake Plateau with at least 50% coverage in 1980, and for special study plot A3 in 1981 (Tables 16 and 17). The latter analysis was probably more accurate as effort per unit area was low in 1980 and most probably under-represented waterfowl usage; however, such a difference could not be demonstrated statistically ($P > 0.10$). The major trends were evident in both analyses; i.e. geese ($P < 0.002$) and dabbling ducks ($P < 0.05$) were positively and significantly correlated to peatland area, whereas diving ducks ($P < 0.05$) were significantly and positively correlated to open water area only in the 1981 A3 analysis. The analyses suggested that habitat types other than the obviously exploited ones were not used, and in some instances avoided, by waterfowl groups during breeding (e.g. negative correlation of geese ($P < 0.20$) to open water in 1981). Diving duck density was positively correlated to phosphorus concentration ($P < 0.01$). All other chemistry parameters appeared unrelated to waterfowl densities but were highly inter-correlated (Table 18).

5.5.7. Population losses to flooding by the Churchill Falls hydroelectric development — Under commission to the Churchill Falls Labrador Corporation, D. Bajzak (Memorial Univ. Nfld., unpubl.) estimated areas of different cover types to be flooded by Smallwood Reservoir at about 66 000 ha of bog, fen, marsh, and swamp, and an equivalent area of small ponds and lakes, a total area of some 1400 km². The regression equations permitted interpretation of those habitat losses in terms of the waterfowl they could have supported before flooding. Using the significant relationships only (1980 data for Canada Geese, Table 16; 1981 data for dabbling and diving ducks, Table 17), the estimated effects of the habitat losses translate into about 990 pairs of geese, 1400 pairs of dabbling ducks, and 3740 pairs of diving ducks (Table 19).

6. Discussion

6.1. Aerial vs. ground surveys

Aerial surveys do not detect all waterfowl in the areas surveyed, nor do they detect equal proportions of all species (Diem and Lu 1960, Martinson and Kaczynski 1967, Haapanen and Nilsson 1979). Use of ground surveys to provide adjustment factors for incomplete detection of waterfowl from the air depends on the ground surveys (a) detecting all (or at least a consistently high proportion) of the waterfowl present, and (b) being representative of the region sampled from the air. Although surveys of coastal wintering waterfowl have shown little consistency in air/ground comparisons (Stott and Olsen 1972, Savard 1982), work in breeding areas has often provided useful adjustment factors (Haapanen and Nilsson 1979, Martinson and Kaczynski 1967).

Our results, based on a comparison of the 1981 ground surveys to the 1980 aerial results on the Lake Plateau, produced efficiency values similar to those from other studies (Table 11). Dabbling ducks (primarily Black Duck and Green-winged Teal) seemed to be detected more effectively in the aerial Labrador surveys (53%) than in similar studies elsewhere (34% in Haapanen and Nilsson 1979, 44% for Alberta in Martinson and Kaczynski 1967). Some of those studies were in more forested areas, which may have reduced visibility. Also, the Labrador surveys were made early in the season, before growth of emergent vegetation could obscure view of ducks on the water. Diving duck efficiency values (65% in this study) were more comparable to other studies (68 and 60%, respectively). There was some confusion between Common Goldeneyes and Red-breasted Mergansers from the air, but data for those species were rationalized by the air/ground visibility adjustment.

The ground surveys in southeastern Labrador were made during July, when geese and dabbling ducks were much less visible than in June. There seems little doubt that southeastern Labrador waterfowl populations were underestimated relative to those of the Lake Plateau. Conversely, our inability to extend survey coverage beyond 20 July in 1980 and 10 July in 1981, because of other work commitments, meant that diving duck production was poorly sampled. Nonbreeding is more prevalent among diving ducks than dabbling ducks, so broods are better evidence of actual production levels than are spring pairs for diving ducks, many broods of which hatch during the latter part of July (*cf.* Erskine, Chapter II).

6.2. Population estimates

We estimated that some 152 900 ± 60 300 pairs of Canada Geese, 165 300 ± 67 900 pairs of dabbling ducks, 254 900 ± 85 800 pairs of diving ducks breed in the interior of Labrador. Our estimates of waterfowl populations have wide confidence limits because they were based on extrapolations from small samples. Work in those remote areas will always be expensive, and it is unlikely that another survey on a comparable scale can be made before 1990.

Extrapolation to unsampled ecoregions may be questioned. Our experience, both on the island of Newfoundland and in Labrador, is that for migratory birds, including waterfowl, the outlined ecoregions are too finely divided. Considerable merging can be done without introducing serious inaccuracies. The difficulty lies principally with differences in species composition, i.e. loss of boreal species and addition of subarctic or arctic species as one moves northward or towards the coast. Our data for Oldsquaw, Harlequin Duck, Barrow's Goldeneye, and Greater Scaup were not adequate for reliable extrapolation to areas where those make up larger proportions of the total waterfowl. However, data from the "Northeast Unit" of Gillespie and Wetmore (1974), where those species are most common, indicated that total densities were low there, so the overall estimates are not likely to be much affected by inaccuracies in those species. Mergansers and scoters were not segregated to species from the air; most mergansers seen on ground surveys were Red-breasted, and more Surf Scoters were seen than Black Scoters. One pair of White-winged Scoters seen in the Eagle Plateau area, and a lone drake observed in the same area two weeks later, suggested that that species also may breed there. Gilchrist and Chamberlain (unpubl. report on summer banding in Labrador, 1955) reported broods of White-winged Scoters in the Nain area, but their record has not been verified.

The overall similarities between densities of dabbling and diving ducks in this study, compared to those on the island of Newfoundland (Goudie, Chapter V) and in northern Fennoscandia (Haapanen and Nilsson 1979), support our belief that these results provide an approximation of existing populations. Relatively high densities of different waterfowl groups frequently occurred together, suggesting that basic site productivity has an important influence in habitat selection by waterfowl in these hinterland areas.

6.3. Habitat

6.3.1. Habitat use by waterfowl — We found Canada Geese mainly on peatlands, particularly ribbed fens and fen-marsh complexes (see Tables 16 and 17 for correlations). Those habitats correspond closely with those identified as preferred nesting habitats for Canada Geese of the Hudson Bay Lowlands (Raveling and Lumsden 1977); their "open fens with sedge marsh" correspond to our fen-marsh complexes, and their "fen-ponds" and "bog-ponds with islands" to our ribbed fens and string bogs. As they found 82% of goose nesting in fen habitat, which morphologically is almost indistinguishable from string bog, overall productivity seems likely to be the factor that governs habitat use by geese in those subarctic areas. Fens, in particular, provide a greater diversity and density of grasses and, presumably, insect larvae.

Dabbling ducks also used mainly peatlands, although we noted some use of other types by Black Ducks. Dabbling ducks generally frequented shallow water with emergent or fringe cover, with highest densities where the interspersion of water and land gives high shoreline length per unit area (see also Haapanen and Nilsson 1979). In Labrador, such combinations were scarce except in peatlands.

Lesser Scaup and Ring-necked Ducks also use habitat with emergent cover (Palmer 1976), which may partly explain their limited numbers in Labrador. We had difficulty in assigning scaup to species, but most of those seen in the Lake Melville and Postville ecoregions (relatively boreal areas) were Lesser Scaup; those on the Lake Plateau (more subarctic) were Greater Scaups.

The other diving ducks observed in Labrador were virtually lacking from peatland areas. Most scoters, mergansers, and goldeneyes frequented rocky-shored ponds and lakes with little or no emergent cover, and thus were ecologically segregated from the dabbling ducks.

Ostrofsky and Duthie (1975) demonstrated that productivity for phytoplankton within the Michikamau Lake (Smallwood Reservoir) watershed was limited by the availability of phosphorus. Our findings that diving duck productivity may be limited by this essential nutrient applied only to open water systems, the habitat frequented by this waterfowl group. Water samples were not collected from peatlands but phosphorus is probably limiting on those sites as well.

Common Goldeneyes were probably restricted also by scarcity of tree cavities for nesting; this may also restrict Common Mergansers, although that species may nest on the ground under brush or in cliff crevices in northern areas (Palmer 1976).

6.3.2. Ecoregions as a reflection of waterfowl habitat — Ecological Land Classification integrates physical and biological elements to describe an area for land-use planning, including wildlife management. In the Labrador waterfowl surveys of 1980–82, we made use of the Lands Directorate classification (Lopoukhine *et al.* 1977). Our data supported Gillespie and Wetmore's (1974) assertion that the area around Smallwood Reservoir is the most important waterfowl breeding area in Labrador (and eastern Quebec). The high waterfowl productivity in that area and adjacent Mistastin Lake ecoregions is probably attributable to the extensive peatland and water networks there. The more boreal ecoregions (Postville, Lake Melville, Eagle Plateau, St. Paul) also tended to have more breeding waterfowl than the subarctic ecoregions other than Smallwood Reservoir and Mistastin Lake. Porcupine Strand, and to some degree Lake Melville, featured salt marshes and adjacent fluvial sedge marshes on low-relief areas near shores. Those areas appear critical to spring and fall staging populations of Canada Geese and dabbling ducks and, to a lesser degree, moulting and breeding ducks.

6.3.3. Habitat losses associated with flooding — D. Bajzak (unpubl.) estimated that about 1400 km^2 of habitat were lost in the flooding of Smallwood Reservoir. Besides the areas actually flooded, the reservoir development affected areas elsewhere in the watershed. Flooded shorelines with fluctuating water levels offer low-quality nesting habitat. During spring runoff, control structures are opened; this may flood shorelines and islands in the lower storage areas of the reservoir and along the Churchill River downstream as far as Lake Winokapau. Other secondary effects include reduced runoff to areas "downstream" from dykes and dams other than that on the main Churchill River. Overall, the waterfowl habitat losses resulting from the hydrodevelopment may amount to 10% of that orginally present in the Lake Plateau region.

6.3.4. Population losses resulting from the Smallwood Reservoir — The direct comparison between 1970 and 1980 data (Table 1) showed substantial decreases in waterfowl numbers. Part of the difference is believed to reflect differing phenology, as the late breakup of ice in 1970 would have held migrants in the area, thus inflating the total count. The decrease in pairs (or equivalent) was only 23% compared to 50% in total waterfowl. Phenological differences affect areas not influenced by the reservoir as well as those in the flooded area. Different species showed markedly different variations in numbers (Canada Geese +5%, Black Ducks −37%, scoters +20%, mergansers −43%), and no pattern was obvious. Overall trends in Atlantic Flyway populations (Bellrose 1976) showed Canada Geese increasing and Black Ducks decreasing, which agreed with our findings, but data for the other species were not suitable for comparison.

Waterfowl displaced from the reservoir area might have settled in nearby areas, but the densities we found for those areas gave no evidence of such an emigration. The losses may have amounted to 8% of goose production and 15% of the duck production. Fall waterfowl populations were potentially reduced by 10% (i.e. 32 000 ducks and 7000 geese). In spite of the losses, the Lake Plateau area remains the most important waterfowl production area in Labrador.

Proposed hydroelectric developments on the lower Churchill River (Gull Island, Muskrat Falls) seem unlikely to have major effects, as that region is much less productive than the Lake Plateau.

6.4. Labrador's contribution to waterfowl populations of the Atlantic Region and Flyway

Breeding densities of waterfowl in Labrador are low, but its large area supports a substantial total population. The fall flight may total some 150 000 geese, 165 000 dabbling ducks, and 255 000 diving ducks (Table 15). As shown elsewhere (see Erskine, Chapter VII), those amount to 63, 25, and 55%, respectively, of the totals for those groups within the Atlantic Region. Geese and diving ducks make up larger proportions of the total in Labrador than in the Maritimes, with the island of Newfoundland in an intermediate position. Similar north-south trends (except for geese) were found in Fennoscandia (Haapanen and Nilsson 1979).

Labrador's contributions of Canada Geese to the Atlantic Flyway are substantial, considerably exceeding Bellrose's (1976) estimate of the entire northeastern population. Numbers of ducks produced in Labrador are less important to the flyway totals, except in New England and northward, because from New York south, Atlantic Flyway populations include both dabbling and diving ducks from central and western Canada. Nevertheless, together with eastern Quebec, Labrador probably provides a larger proportion of many species to the Atlantic Flyway than any other political unit, owing to its large area. However, it is not an inexhaustible hinterland, on which other areas can rely after their own waterfowl resources have been squandered, but its remoteness buffers it from many of the environmental insults as well as the threats of local overexploitation to which more southern areas are vulnerable.

7. Acknowledgements

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Appendix 2
Waterfowl brood chronology data, Labrador

Species	Sources (unpubl. reps.)	Location (lat.–long.)	Age class/date	Est. start of incubation	Est. date of fledging
Canada Goose*	Gilchrist and Chamberlain 1955	Nain Bay area 5635-06200	9 Ic, 22 Jul. 55 3 III, 19 Aug. 55	4 June 55 31 May 55	27 Aug. 55 23 Aug. 55
	Goudie 1980	Atikonak R. 5255-06435	4 Ia, 20 June 80	19 May 80	11 Aug. 80
	Hicklin and Wade 1980	Lac Ministouc 5250-06635	1 Ia+, 25 June 80	21 May 80	13 Aug. 80
	Smith and Hicks 1980	Wightman Lake 5310-06615	5 Ia, 25 June 80	24 May 80	16 Aug. 80
	Barkhouse and Morton 1980	Goose River 5335-06215	4 Ic, 6 July 80 1 Ib, 6 July 80	19 May 80 27 May 80	11 Aug. 80 19 Aug. 80
		S. of Riv. Natashquan 5225-06325	3 IIa, 14 July 80	19 May 80	11 Aug. 80
	Whitman and Barrow 1981	Snegamook Lake 5435-06145	4 Ia, 5 July 81 4 Ib, 5 July 81 5 Ib, 5 July 81 3 Ib, 5 July 81 3 IIa, 14 July 81	4 June 81 26 May 81 26 May 81 26 May 81 19 May 81	26 Aug. 81 18 Aug. 81 18 Aug. 81 18 Aug. 81 11 Aug. 81
		W. Micmac L. 5445-06010	5 Ib, 5 July 81	26 May 81	18 Aug. 81
		E. of Woods L. 5435-06445	7 III, 8 July 81 5 III, 8 July 81 2 IIc, 8 July 81	19 April 81 19 April 81 27 April 81	12 July 81 12 July 81 20 July 81
		Atikonak R.	4 IIc, 10 July 81	29 April 81	22 July 81
	Barrow 1982	Snegamook L.	4 Ib, 6 July 82 4 Ic, 8 July 82 3 Ic, 8 July 82	27 May 82 21 May 82 21 May 82	19 Aug. 82 13 Aug. 82 13 Aug. 82
		W. Micmac L.	4 IIa, 10 July 82 4 IIa, 10 July 82 4 IIa, 10 July 82 5 IIa, 11 July 82	15 May 82 15 May 82 15 May 82 16 May 82	7 Aug. 82 7 Aug. 82 7 Aug. 82 8 Aug. 82
	Goudie *et al.* 1982	S. of Snooks Cove 5410-05745	4 Ia, 28 June 82 6 Ia, 28 June 82 3 Ib, 28 June 82 3 Ib, 28 June 82 5 Ib, 28 June 82 2 Ic, 28 June 82 4 Ic, 28 June 82	27 May 82 27 May 82 19 May 82 19 May 82 19 May 82 11 May 82 11 May 82	19 Aug. 82 19 Aug. 82 11 Aug. 82 11 Aug. 82 11 Aug. 82 3 Aug. 82 3 Aug. 82
	Goudie 1983	Double Brook 5420-05805	4 Ic, 12 July 83	25 May 83	17 Aug. 83
	Barrow 1983	Snegamook L.	6 Ic, 5 July 83 6 I, 5 July 83 5 I, 5 July 83 2 I, 5 July 83 2 Ib, 6 July 83 8 Ib, 6 July 83 8 Ib, 6 July 83	18 May 83 26 May 83 26 May 83 26 May 83 27 May 83 27 May 83 27 May 83	10 Aug. 83 18 Aug. 83 18 Aug. 83 18 Aug. 83 19 Aug. 83 19 Aug. 83 19 Aug. 83
Green-winged Teal*	Hicklin and Johnson 1980	Cache River 5320-06210	7 Ib, 6 July 80	7 June 80	3 Aug. 80
	Barkhouse and Morton 1980	S. of Natashquan R. 5220-06310	4 Ic, 16 July 80	12 June 80	8 Aug. 80
	Whitman and Barrow 1981	NW of Woods L. 5440-06525	4 Ia, 8 July 81	14 June 81	10 Aug. 81
		Eagle Plateau 5245-05855	8 Ia, 9 July 81 5 Ia, 9 July 81	15 June 81 15 June 81	11 Aug. 81 11 Aug. 81
	Whitman and Barrow 1982	W. Micmac L.	4 Ia, 11 July 82	17 June 82	13 Aug. 82
	Barrow 1983	Snegamook L.	11Ia, 12 July 83	18 June 83	14 Aug. 83

Appendix 2
Waterfowl brood chronology data, Labrador (cont'd)

Species	Sources (unpubl. rep.)	Location (lat.–long.)	Age class/date	Est. start of incubation	Est. date of fledging
Black Duck*	Gilchrist and Chamberlain 1955	Nain Bay area	III, 28 Aug. 55 III, 13 Aug. 55	15 June 55 31 May 55	3 Sept. 55 19 Aug. 55
	Goudie and Johnson 1980	St. Paul R. 5230-05820	6 IIa, 11 July 80 7 Ic, 11 July 80	19 May 80 26 May 80	7 Aug. 80 14 Aug. 80
	Whitman and Barrow 1981	Snegamook L.	5 IIb, 5 July 81 6 Ib, 5 July 81 4 Ia, 5 July 81	6 May 81 27 May 81 3 June 81	25 July 81 15 Aug. 81 22 Aug. 81
		E. of Woods L.	3 IIb, 8 July 81 4 III, 8 July 81	9 May 81 25 April 81	28 July 81 14 July 81
		NW of Woods L.	4 IIc, 8 July 81 5 IIb, 8 July 81 3 III, 8 July 81	2 May 81 9 May 81 25 April 81	21 July 81 28 July 81 14 July 81
		Eagle Plateau	6 IIa, 9 July 81 6 IIa, 10 July 81 7 Ic, 10 July 81	17 May 81 18 May 81 25 May 81	5 Aug. 81 6 Aug. 81 13 Aug. 81
	McKee and Stotts 1981	Tinker Harbour 5405-05745	III, 25 July 81	12 May 81	31 July 81
	Barrow 1982	Snegamook L.	4 Ib, 6 July 82	28 May 82	16 Aug. 82
	Barrow 1983	Snegamook L.	8 Ia, 5 July 83 1 + Ib, 8 July 83 1 + IIc, 8 July 83 1 + Ib, 9 July 83	3 June 83 31 May 83 2 May 83 1 June 83	22 Aug. 83 18 Aug. 83 21 July 83 19 Aug. 83
Mallard	Barrow 1983	Snegamook L.	2 + IIb, 11 July 83	12 May 83	31 July 83
Northern Pintail*	Goudie 1981	Eagle Plateau	6 Ib, 29 June 81	28 May 81	4 Aug. 81
	Erskine 1981	Tinker Harbour	8 III, 25 July 81	24 May 81	31 July 81
	Barrow 1983	Snegamook L.	6 IIb, 5 July 83 6 IIb, 5 July 83 8 IIb, 7 July 83 6 Ib, 7 July 83 1 + IIb, 11 July 83	16 May 83 16 May 83 18 May 83 5 June 83 22 May 83	23 July 83 23 July 83 25 July 83 12 Aug. 83 29 July 83
American Wigeon	Barrow 1983	Snegamook L.	12 eggs, 12 July 83 (pipping)	18 June 83	29 Aug. 83
Black Scoter	Whitman and Barrow 1981	E. of Woods L.	6 IIa, 8 July 81	12 May 81	8 Aug. 81
Common Goldeneye*	Barkhouse and Morton 1980	Eagle Plateau	5 Ib, 9 July 80	28 May 80	22 Aug. 80
	Whitman and Barrow 1981	Snegamook L.	12 Ia, 5 July 81 9 Ia, 5 July 81	1 June 81 1 June 81	26 Aug. 81 26 Aug. 81
		Eagle Plateau	7 Ic, 9 July 81	20 May 81	14 Aug. 81
	Barrow 1982	Snegamook L.	11 Ib, 9 July 82	28 May 82	22 Aug. 82
	Barrow 1983	Snegamook L.	5 + Ia, 5 July 83 9 Ia, 9 July 83 7 Ia, 10 July 83 11 Ia, 11 July 83 5 Ib, 11 July 83	1 June 83 5 June 83 6 June 83 7 June 83 31 May 83	26 Aug. 83 30 Aug. 83 21 Aug. 83 1 Sept. 83 25 Aug. 83
Red-breasted Merganser*					
	Gilchrist and Chamberlain 1955	Nain Bay area	9 broods Ia, 28 July 55	22 June 55	22 Sept. 55
	Goudie 1980	Sebasquashu Cove 5345-06005	10 Ic, 20 July 80 10 Ic, 20 July 80 10 Ib, 20 July 80 5 Ia, 20 July 80	28 May 80 28 May 80 6 June 80 14 June 80	28 Aug. 80 28 Aug. 80 6 Sept. 80 14 Sept. 80
	McKee and Stotts 1981	Snooks Cove	8 Ia, 25 July 81 9 Ia, 28 July 81	19 June 81 22 June 81	19 Sept. 81 22 Sept. 81
	Erskine 1981	Snooks Cove	9 Ib+, 26 July 81	9 June 81	9 Sept. 81

* Ages used in calculating chronology (days)

Species	Ia	Ib	Ic	IIa	IIb	IIc	III	Fledging	Incubation period
Canada Goose	4	12	20	28	36	44	52	56	28
Green-winged Teal	3	8	13	18	23	28	33	36	21
Black Duck and Mallard	4	11	18	25	32	39	46	52	28
Northern Pintail	3	9	15	21	27	33	39	45	23
Common Goldeneye	4	12	20	28	36	44	52	56	30
Red-breasted Merganser	4	12	21	29	37	45	54	60	32

From Gollop and Marshall (1954), except Canada Goose and Red-breasted Merganser added by interpolation from ages at fledging.

Appendix 3a
Habitat type and importance per plot surveyed in the Lake Plateau, 1980. Water chemistry data from Clair *et al.* 1982

Plot	Peatland	Alluvial	Fringed lake (encroachment)	Rocky shored lakes	Alder/willow thickets	Esker impoundments	pH*	Alk.*	Specific cond.*	Total P (mg/L)*
A3	I†	A†	P†	P	P	A	6.24	2.3	10.6	0.020
A6	I	A	P	I	P	A	—	—	—	—
A7	I	A	P	I	P	I	6.2	1.6	7.0	0.013
B10	P	A	I	I	A	A	6.38	4.1	9.8	0.013
C4	P	A	P	I	P	A	6.11	2.8	9.4	0.009
C6	A	A	I	P	A	A	6.17	2.2	8.5	0.014
C8	A	A	P	A	A	I	6.8	6.4	17.0	—
D4	I	A	A	P	A	A	7.0	10.1	22.0	0.009
D6	I	A	P	A	A	P	—	—	—	—
D7	I	A	P	A	A	A	7.1	11.6	29.0	0.006
E1	A	A	P	P	A	I	5.7	1.9	6.7	0.010
E2	A	A	A	I	P	A	—	—	—	—
E5	I	A	P	P	A	A	6.2	2.4	9.1	0.011
F1	A	A	P	P	P	A	—	—	—	—
F2	A	A	P (beaver)	I	A	A	6.95	12.6	26.0	0.006
F9	I	A	A	P	P	A	6.1	4.4	11.0	0.010
G1	P	A	A	P	A	A	6.6	5.0	15.0	0.006
G2	I	A	P	A	P	A	6.2	2.6	8.4	0.077
G7	I	A	A	A	A	A	—	—	—	—

* Water chemistry data represent only one specific site within sampled area.
† I — Important.
P — Present.
A — Absent.

Appendix 3b
Habitat type and importance per plot surveyed in southeastern Labrador, 1980. Water chemistry data after Clair *et al.* 1982

Plot	Peatland	Alluvial	Fringed lake (encroachment)	Rocky shored lakes	Alder/willow thickets	Esker impoundments	pH*	Alk.*	Specific cond.*	Total P (mg/L)*
T1	P†	A	I	A	A	A	5.1	1.6	11.7	—
T2	A	I (brackish)	A	A	A	A	—	—	—	—
T3	P	A	A	P	A	A	6.2	2.8	9.9	—
01	P	A	I	A	A	P	6.5	2.6	10.3	0.011
02	I (beaver)	A	P	P	A	A	6.22	3.6	7.9	0.004
03	P	A	I	P	P	A	6.01	1.5	7.1	0.007
L1	A	I (flood-plain)	P	P	P	P	6.81	9.0	23.0	0.013
L2	P	P(I)	I	P	P	A	—	—	—	—
L3	A	A	A	P	P	A	7.1	11.8	28.0	<0.001
V1	P	A	A	I	A	A	6.4	5.9	14.0	0.055
V2	P	I	I (beaver)	I	I	A	5.9	4.4	12.2	0.013
V3	A	P	P (beaver)	I	P	A	5.8	3.6	9.1	0.013
S1	I	A	P	P	P	A	6.27	3.5	10.2	0.003
S2	P	A	A	P	A	A	6.4	3.1	11.7	0.01
S3							6.2	2.6	11.4	0.007

* Water chemistry data represent only one specific site within sampled area.
† I — Important.
P — Present.
A — Absent.

Using survey results in management

One of the first prerequisites for regional waterfowl planning was a model that would integrate population and harvest estimates into a balanced whole. Precision could hardly be hoped for, but even an approximate balance would provide a better picture. A preliminary population budget was prepared for the Region in 1978, during the early stages of developing the waterfowl management plan for Canada. With new estimates available for Newfoundland and Labrador waterfowl, it was now possible to present figures which were based more on real counts than rough estimates. The data base for eiders was also improved, using funding provided by the Offshore Labrador Biological Surveys (OLABS) program for surveys in 1978 and 1980, and spurred on by requests in 1980 for Atlantic Region input to a CWS compendium on eiders (Reed 1986*).

The next chapter illustrates the development of the waterfowl population model. The final chapter of the volume takes this model as a point of departure in formulating a regional waterfowl management plan at the strategic level where priorities are determined.

* Reed, A., ed. 1986. Eider Ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47. 177 pp.

VII. A preliminary waterfowl population budget for the Atlantic Provinces, 1978–85

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1. Abstract

The Canada Land Inventory (CLI) provided data on areas of wetlands classified according to their level of capability for waterfowl production in the Maritime Provinces. Those for New Brunswick, however, required adjustment for inconsistent treatment of riverine habitats. The application of waterfowl breeding density data to the area in each CLI capability class allowed estimates of waterfowl breeding populations for each province. Estimates for Newfoundland and Labrador were drawn from other papers in this volume. Data for species breeding mainly in areas not adequately covered by the CLI were added as required. Losses of waterfowl from hunting were drawn from the National Harvest Survey and Species Composition Survey, and further adjustments were made for native harvest and crippling loss. Using data from all those sources, I was able to construct a preliminary population budget for the Atlantic Provinces. Early fall populations of over one million ducks, 30% of which are Black Ducks, and at least 185 000 geese, come from regional breeding stocks. Although some of the waterfowl killed are reared elsewhere in Canada, the surplus available for sport harvest in the United States and losses from natural winter mortality make up a relatively small proportion of the totals for many species. The region is of minor importance for winter waterfowl other than sea ducks. Long-range estimates suggested that regional waterfowl populations are likely to decrease over the next 20 years, but may stabilize thereafter at levels 20 to 30% below present numbers.

2. Introduction

Waterfowl management is made necessary because of human activity in the environment. There are probably no waterfowl populations in North America today that are not affected by human intervention. Management thus includes measures aimed at reducing direct stresses on birds and maintaining appropriate habitats for them, so that people may continue to enjoy or use them in various ways. Such measures are often summarized under the headings: habitat, populations, and use/demand. The first two of these interact everywhere continuously; the last, intermittently and indirectly. There has been a tendency in North America to view habitat as the key factor, on the assumption that if there were more (suitable) habitat there would be more ducks. This may be plausible in areas used mainly for wintering, but it is debatable or untrue for much of Canada. When there aren't enough ducks to fill the available habitat — as has been the recurrent complaint in the Atlantic Region for the last 40 years — the main issue has to be: what is the status of our duck populations? Is it decreasing, stable, or increasing? The effectiveness of management is measured primarily through changes in waterfowl populations, as shown by systematic surveys. The first six papers in this volume described the manner in which parts of the data base on waterfowl populations has been built up through surveys over the past 30–40 years. Studying populations in small areas is unlikely to be very helpful, as a Black Duck that breeds in Nova Scotia may moult in Labrador and be shot at in New Brunswick and Massachusetts before wintering in New Jersey, and a Ring-necked Duck raised in Newfoundland may spend half the year in Florida. The population data must be summarized so as to recognize the birds' movements through space and time. The preliminary population model developed for the Atlantic Provinces in 1978 was a first attempt to do this.

The studies reported in Chapters I–III provided breeding density data for a variety of habitats in the Maritimes. The CLI waterfowl capability mapping conducted in 1965–68 and published over the next five years provided a basis for extrapolating those densities across the Maritimes. Many waterfowl biologists have little confidence in the CLI mapping because it did not consider the small areas on which most local problems arise. No other classification yet covers all Maritime wetlands in a uniform manner in comparable detail, and I had hoped that it might prove suitable for use on a broader scale. As the project evolved, additional sources of data (e.g. Chapters V and VI) became available and were incorporated. A revised version is presented here in some detail as a summary of information essential for planning waterfowl management for the future. It is inevitably incomplete and imprecise; that it can be attempted now is evidence of how far we have progressed since 1964. (Compare "First attempts towards extrapolated populations.")

3. Methods

3.1. Waterfowl habitat

The wildlife capability sector of the CLI mapped seven classes of waterfowl habitats in the Maritime Provinces. The higher capability classes (1–3) assumed that there was appropriate management in such areas to enhance waterfowl use (e.g. impoundments to increase water area). Thus the indicated capability did not always agree with the present carrying capacity, even if enough birds were present to stock fully the available habitat. Computer printouts, obtained in 1978 from Lands Directorate, Environment Canada, of land area in the various

capability classes of the CLI gave a starting point (Table 1a). Apparent anomalies in these data called for adjustment of the data base. The areas originally were identified and outlined on air photos and transferred to 1:50 000 NTS maps, whence they were combined on the published 1:250 000 scale maps, from which the listed areas were derived. The process of combining classified areas gave rise to many inconsistencies, and we believe that the method used differed in New Brunswick (NB), particularly with respect to linear habitats along river valleys. Most rivers in Nova Scotia (NS) were combined in the class 7 category (no capability for waterfowl) with surrounding lands, whereas in NB long strips of class 2, 5, or 6 habitat were shown along valleys. The width of such strips would inevitably have to be exaggerated for them to show on maps of progressively smaller scale, thus inflating the estimated areas of these three classes relative to those in NS. The total area of NB is about one-third greater than NS. Although NB includes proportionately more sedimentary areas than NS, it also includes much more highland area (above 300 m elevation), so it seems unlikely that wetland area in NB is much greater relative to total area than in NS. Without an alternative data base for NB, any adjustments must be somewhat arbitrary. Reduction of class 5 and 6 areas in NB to 1.5 times the areas shown for NS is probably adequate recognition of the greater fertility of lowland rivers in NB. The floodplains of the St. John River system were mostly classed as CLI 2, which may be appropriate; as no comparable areas exist in NS, a plausible adjustment is to reduce the NB CLI 2 area by one-half. The areas deducted from the higher classes were added to class 7 lands.

The virtual absence of CLI 4, 5, and 6 lands in Prince Edward Island (PEI), and the very large area of CLI 1 lands relative to those in NB and NS (Table 1a), are anomalous. Combining may have inflated the areas of CLI 1 and 2 lands unduly, as described above, and it may be best to reduce those to one-half. As PEI is about one-tenth the area of NS, I have assigned areas to CLI 4, 5, and 6 there in proportion to those found in NS.

The CLI 3 areas included, besides the breeding areas, those classified as 3M, a special category used to indicate areas important for migration and wintering rather than for breeding. Although some duck production doubtless occurs on CLI 3M areas, it seemed reasonable to count only 20% of those areas in each province as contributing to production. Some of the CLI 3M areas mapped were bays and estuaries (salt water), which would not be included in the total land area of a province, whereas other, lacustrine areas would be included. As the areas of CLI 7 lands were derived from the total area by subtracting the areas in higher categories, it seemed best to subtract only the productive part of 3M areas, while assuming the rest to have been coastal waters.

In the absence of CLI mapping of waterfowl habitats in Newfoundland and Labrador, I initially interpreted topographic and biophysical maps of those areas as shown in Table 1a. When recent, direct estimates of waterfowl populations there became available (Chapters V and VI), the original extrapolated figures were not used further. When compared with the direct estimates, they were usually of the correct order, which was encouraging, as it indicated that the classification system had been interpreted correctly.

The revised areas used in the final extrapolations for the Maritimes are shown in Table 1b.

Table 1a
Areas, in square kilometres, by waterfowl capability class of the Canada Land Inventory and by province, from computer summaries for the Maritimes; areas for Newfoundland and Labrador estimated from topographic and biophysical maps

Province	Area (km²) in CLI class							Total area (km²)
	1	2	3	4	5	6	7	
Nova Scotia	4	1	1000	318	496	890	50 326	53 035
Prince Edward Island	45	25	340	1	—	10	5 214	5 635
New Brunswick	1	211	904	523	2563	2012	65 209	71 423
Newfoundland (island)	—	—	52	518	1295	2590	102 665	107 120*
Labrador	—	—	—	1383	2911	7148	249 697	261 139†

* Excluding 5180 km² in large lakes and reservoirs.
† Excluding 31 080 km² in large lakes and reservoirs.

Table 1b
Adjusted areas, in square kilometres, by waterfowl capability class of the Canada Land Inventory and by province for the Maritimes. See text for adjustments.

Province	1	2	3	4	5	6	7	Total*
Nova Scotia	4	1	317	318	496	890	53 465	55 491
Prince Edward Island	22	12	67	32	50	89	5 385	5 657
New Brunswick	1	106	393	477	744	1335	70 381	73 437

* From Canadian Almanac and Directory 1986.

3.2. Waterfowl breeding densities

Densities of breeding ducks in habitats of known capability class were drawn from my fieldwork on Cape Breton Island in 1960–63, and in New Brunswick in 1967–69 (see Erskine, Chapters II and III), with some additional data from Fred Payne, Nova Scotia Wildlife Branch (unpubl.). Those sources covered capability classes 3 to 7, and I extrapolated upwards to classes 1 and 2 (which are scarce in the Region) (Table 2a). As all surveys, even under ideal conditions, miss some birds, it seemed reasonable to increase all the figures by 50% to allow for this (Table 2b). Comparable densities were found in intensively studied areas in Quebec (A. Reed, unpubl.). Class 7 lands, by definition, have negligible capability for waterfowl, but many waterfowl-producing areas too small to show on the map scales used are included in areas mapped as class 7. Collectively, such lands become increasingly important as one moves northward (in the Maritimes 93% of all lands are CLI class 7 for waterfowl, and in Labrador at least 96%).

I divided the estimated duck populations for each province into the various species, excluding mergansers and eiders, using species composition data from various surveys (summarized in Table 3), including both ground and aerial counts. Aerial surveys generally detected only a small fraction of the Green-winged Teal present; I adjusted the figures for this species upward in areas where aerial surveys provided the only extensive coverage. The CLI classification did not assess capability for mergansers and eiders, whose preferred breeding habitats differ from those of other ducks.

For mergansers on rivers and lakes, data from Cape Breton Island (Erskine 1972) suggested inland densities of one pair per 75 km². In mainland NS, with higher levels of disturbance, merganser densities were set at one-half of those found in Cape Breton. In NB, shooting programs on the Miramichi and Pollett Rivers, and the long-term application of DDT during spruce budworm control operations, had virtually eliminated breeding mergansers from most inland waters by the late 1960s. There are no recent data for

NB, except on the Restigouche system, where merganser numbers were normal in 1981–82 (Atl. Salmon Fdn., unpubl.). Meagre data from Cape Breton Island (in the absence of DDT spraying) suggested that recovery from shooting was slow. Coastal populations have never been estimated. I assigned one pair per 8 km of coast, measured headland to headland (on the outer coast of NS), but local concentrations on the Gulf of St. Lawrence and Northumberland Strait average higher densities. Many long stretches of coasts with unbroken cliffs or cobble beaches, as well as the upper Bay of Fundy with its silt-laden waters, lack breeding mergansers altogether.

No systematic data on eider populations were available in 1978, and guesses were used in the original population model. Counts of breeding birds were made on surveys in Labrador in 1978 and 1980, supported by the Offshore Labrador Biological Studies (OLABS) program, and in 1981 by CWS. Some eider surveys were done in the Maritimes in 1979 and 1981. Compilation of unpublished data on eiders in the Region followed requests for contributions to a CWS compendium on the species. Two MSS were produced (Lock 1986; Erskine and Smith 1986), from which population estimates have been incorporated in the present paper.

Goose numbers in the Maritimes are low, estimated at 100 pairs, and consist largely of feral birds living near existing or former captive flocks. Information for Newfoundland and Labrador was derived from the new surveys (see Chapters V and VI).

3.3. Expansion of pairs to total populations in spring and fall

The duck densities used were based partly on breeding pair counts and partly on brood counts (i.e. successful pairs), and must be adjusted to allow for non-breeding and subadult birds included in the spring population. I assumed that allowing one additional bird per pair for non-breeders and failed breeders; i.e. multiplying the spring pair figures by three, was probably a little too much for most dabbling ducks, but certainly too little for species that do not breed until two years old (goldeneyes, mergansers, scoters) or three years old (eiders, geese). Thus, the extrapolation factors I used for spring numbers were 2.8 for dabbling ducks, 3.5 for those breeding at two years, and 4.0 for those breeding when (mostly) three or more years old. Reed (1986) used 3.5 for eiders, but my calculations suggest at least 3.9 for those birds.

Fall populations also include young of the year. Most ducks rear about five young to flying per successful brood; with allowance for totally-failed nests and broods (*cf.* Reed 1970), this corresponds to three young per pair attempting breeding, for geese and most ducks. Fledging rates for eiders, scoters, and Oldsquaw are lower than for other ducks, so one and two flying young (y) per spring pair were used for those species. Mortality during the summer among the breeding and non-breeding segments of the spring population was estimated at 5% of spring totals. Thus the adjustments to spring pair figures (x) to arrive at fall populations (z) were:

	$(x - 0.05x)$	$+ y = z$
for dabbling ducks and Ring-necked Ducks	$2.8 - 0.14 = 2.66,$	$+ 3 = 5.66;$
for most diving ducks and mergansers	$3.5 - 0.17 = 3.33,$	$+ 3 = 6.33;$
for scoters and Oldsquaw	$3.5 - 0.17 = 3.33,$	$+ 2 = 5.33;$
for eiders	$4.0 - 0.20 = 3.80,$	$+ 1 = 4.80;$
for geese	$4.0 - 0.20 = 3.80,$	$+ 3 = 6.80.$

3.4. Waterfowl harvest

Waterfowl harvest data in Canada are obtained through two national surveys, one using questionnaires to estimate the numbers of hunters and the total duck and goose kills (National Harvest Survey — NHS), the other involving collections of duck wings and goose tails by which the total duck and goose kills may be divided among the various species. Harvest data for 1973–83 (Cooch and Newell 1977, Wendt *et al.* 1978, Wendt and Hyslop 1981, Métras 1984, 1985) for the Atlantic Region were averaged for the various species. The final date for responses was 15

Table 2a
Estimated breeding densities of ducks, for Canada Land Inventory capability classes, based on various studies in the Maritimes (Erskine, Chapters II and III; F. Payne, unpubl.)

	Density (pr/km²) in CLI class						
	1	2	3	4	5	6	7
All ducks except eiders and mergansers	77	39	19	7.7	3.9	1.9	0.04

Table 2b
Estimated breeding densities of ducks, for Canada Land Inventory capability classes, based on various studies in the Maritimes, expanded to allow for birds missed on surveys (see text)

	Density (pr/km²) in CLI class						
	1	2	3	4	5	6	7
All ducks except eiders and mergansers	115	60	30	12	6	3	0.06

Table 3
Species composition (%) of breeding ducks, excluding eiders and mergansers, by province, estimated from various surveys

Species	Percentage composition in province				
	NS[a]	PEI[b]	NB[c]	Nfld.[d]	Labr.[e]
Wood Duck	<1	<1	4	—	—
Green-winged Teal	12	3	10	20	33
Black Duck	50	41	48	44	24
Mallard	<1	<1	1	<1	<1
Northern Pintail	1	7	1	1	2
Blue-winged Teal	16	35	12	1	—
Northern Shoveler	<1	<1	<1	—	—
Gadwall	<1	—	—	—	—
American Wigeon	1	5	1	1	—
Redhead	<1	—	—	—	—
Ring-necked Duck	18	8	15	19	1
Greater Scaup	—	—	—	<1	10
Harlequin Duck	—	—	—	<1	1
Oldsquaw	—	—	—	—	1
Black Scoter	—	—	—	—	4
Surf Scoter	—	—	—	—	10
Common Goldeneye	1	<1	8	14	8
Barrow's Goldeneye	—	—	—	—	<1
Hooded Merganser	<1	—	<1	—	—
Ruddy Duck	<1	—	—	—	—

[a] Composite figures, from Chapter II and unpublished surveys.
[b] From Chapter I.
[c] Composite figures, from Chapters II and III and unpublished surveys.
[d] From Chapter V.
[e] From Chapter VI.

January, so some adjustment was necessary for the latter part of the hunting seasons, which extend for some or all species to 19 January in NS, to 25 February in southwestern NB, and to 10 March in Newfoundland and southern Labrador. Only a small number of hunters are involved in the late seasons except in Newfoundland, where a special survey (focused particularly on murres, but including sea ducks in 1977–79) was made over several years; the hunters active then were enthusiastic and effective. I assumed an additional 5% in NS for Black Duck, eiders, Oldsquaw, goldeneyes, and mergansers, and an additional 33% for sea ducks and mergansers in NB. The late season kill of geese in NS may account for an additional 10%, as that is the main hunting period for geese in the wintering areas of the South Shore.

More adjustment seemed necessary for Newfoundland and Labrador, where the meagre samples in the Species Composition Survey (SCS) did not represent the kill in the latter part of the season, resulting in an inflation of the early kill of "sport ducks" and an underestimate of the later sea-duck kill. The total kill of the latter was taken from the special murre and sea-duck survey (Wendt, CWS, unpubl.). That kill was separated into different species in Newfoundland following the SCS breakdown (from the published accounts listed above), and in Labrador using the SCS figures and preliminary data from a survey of subsistence use of migratory birds in Labrador (Northland Associates Ltd., unpubl.). The total sea-duck kill during September through December was subtracted from the total duck kill estimated by the NHS/SCS, to give the total kill of "sport ducks". This in turn was divided into different species following the SCS data.

Not all the ducks and geese shot in the Atlantic Region are raised there. Inter-regional and international movements are known from band recoveries for some species, but we can only make guesses as to the fraction of total kill of each species that originated outside the Region. All the kill of Buffleheads and White-winged Scoters, which are not known to breed in the region, is from outside stocks, as is at least 95% of the kill of Oldsquaw, 90% for eiders and Black Scoter, and at least 80% for Surf Scoter. Band recoveries suggest that half the Wood Ducks and Blue-winged Teal harvested are of outside origin, and we think that 50% of Mallard, Northern Pintail, Northern Shoveler, American Wigeon, scaups, Harlequin Duck and Hooded Merganser also are reared elsewhere. Only about 10% of Green-winged Teal, Black Duck, Ring-necked Duck, goldeneyes, and large mergansers and Canada Geese are not locally reared. Most of the Oldsquaws and eiders and some pintails and Red-breasted Mergansers come from the eastern Arctic; probably most other "outsiders" originate in Quebec, except for some Blue-winged Teal from Ontario and the prairies, and some Wood Ducks from the northeastern states. Recent band returns suggest some moult migration of Black Ducks from New England to Labrador (unpubl. data), and such birds could also contribute to the harvest in our region later.

Table 4
Estimated duck populations (breeding pairs) by capability class of the Canada Land Inventory and province (Maritimes), excluding eiders and mergansers.

Province	No. ducks (pr) in CLI class							Total duck population (pr)
	1	2	3	4	5	6	7	
Nova Scotia	460	60	9 510	3816	2976	2670	3208	22 700
Prince Edward Island	2530	720	2 010	384	300	267	323	6 534
New Brunswick	115	6366	11 790	5724	4464	4005	4223	36 687

Table 5
Estimated breeding duck populations (pairs) by province and species, Maritimes (rounded to nearest 100, or to nearest 10 if less than 100). Eiders and large mergansers omitted. Newfoundland and Labrador data from Chapters V and VI

Species	NS	PEI	NB	Nfld. (island)	Labrador
Wood Duck	100	30	1 500	0	0
Green-winged Teal	2 700	200	3 700	5 900	16 400
Black Duck	11 400	2 700	17 600	13 200	11 700
Mallard	100	30	400	50	200
Northern Pintail	200	500	400	400	900
Blue-winged Teal	3 600	2 300	4 400	100	0
Northern Shoveler	40	10	50	0	0
Gadwall	10	0	0	0	0
American Wigeon	200	300	400	300	0
Redhead	10	0	0	0	0
Ring-necked Duck	4 100	500	5 500	5 600	1 400
Greater Scaup	0	0	0	30	5 000
Lesser Scaup	0	0	0	0	2 700
Harlequin Duck	0	0	0	20	500
Oldsquaw	0	0	0	0	300
Black Scoter	0	0	0	0	2 100
Surf Scoter	0	0	0	0	5 000
Common Goldeneye	200	30	2 900	4 300	4 000
Barrow's Goldeneye	0	0	0	0	200
Hooded Merganser	40	0	100	0	0
Ruddy Duck	10	0	0	0	0
Totals (from Table 4)	22 710	6 600	36 950	29 900	50 400

Table 6
Extrapolated spring populations of waterfowl (individuals), including non-breeders and subadults, Atlantic Provinces (rounded to nearest 100, or to nearest 10 if less than 100)

Species	NS	PEI	NB	Nfld. (island)	Labrador	Total
Wood Duck	300	100	4 200	0	0	4 600
Green-winged Teal	7 600	600	10 400	16 500	45 900	81 000
Black Duck	31 900	7 600	49 300	37 000	32 800	158 600
Mallard	300	100	1 100	100	600	2 200
Northern Pintail	600	1 400	1 100	1 100	2 500	6 700
Blue-winged Teal	10 100	6 400	12 300	300	0	29 100
Northern Shoveler	100	30	100	0	0	230
Gadwall	30	0	0	0	0	30
American Wigeon	600	800	1 100	800	0	3 300
Redhead	30	0	0	0	0	30
Ring-necked Duck	11 500	1 400	15 400	15 700	1 400	45 400
Greater Scaup	0	0	0	100	17 500	17 600
Lesser Scaup	0	0	0	0	9 400	9 400
Common Eider	32 000	0	28 000	1 200	55 000	116 200
King Eider	0	0	0	0	1 000	1 000
Harlequin Duck	0	0	0	70	1 800	1 900
Oldsquaw	0	0	0	0	1 100	1 100
Black Scoter	0	0	0	0	7 400	7 400
Surf Scoter	0	0	0	0	17 500	17 500
Common Goldeneye	700	100	10 200	15 100	14 000	40 100
Barrow's Goldeneye	0	0	0	0	700	700
Hooded Merganser	100	0	400	0	0	500
Common Merganser	600	0	600	6 000	7 000	14 200
Red-br. Merganser	600	400	800	10 900	56 000	68 700
Ruddy Duck	30	0	0	0	0	30
Total ducks	97 090	18 930	135 000	104 900	271 600	628 500
Canada Goose	300	300	100	18 400	90 400	109 500

Table 7
Extrapolated fall populations of waterfowl (individuals), prior to hunting season, after adjustment for summer mortality of adults (rounded to nearest 100, or to nearest 10 if less than 100)

Species	NS	PEI	NB	Nfld. (island)	Labrador	Total
Wood Duck	600	200	8 500	0	0	9 300
Green-winged Teal	15 300	1 100	20 900	33 400	92 800	163 500
Black Duck	64 500	15 300	99 600	74 700	66 200	320 300
Mallard	600	200	2 300	300	1 100	4 500
Northern Pintail	1 100	2 800	2 300	2 300	5 100	13 600
Blue-winged Teal	20 400	13 000	24 900	600	0	58 900
Northern Shoveler	200	60	300	0	0	600
Gadwall	60	0	0	0	0	60
American Wigeon	1 100	1 700	2 300	1 700	0	6 800
Redhead	60	0	0	0	0	60
Ring-necked Duck	23 200	2 800	31 100	31 700	2 800	91 600
Greater Scaup	0	0	0	200	31 600	31 800
Lesser Scaup	0	0	0	0	17 100	17 100
Common Eider	38 400	0	33 600	1 400	66 200	139 600
King Eider	0	0	0	0	1 200	1 200
Harlequin Duck	0	0	0	100	3 200	3 300
Oldsquaw	0	0	0	0	1 600	1 600
Black Scoter	0	0	0	0	11 200	11 200
Surf Scoter	0	0	0	0	26 600	26 600
Common Goldeneye	1 300	200	18 400	27 200	25 300	72 400
Barrow's Goldeneye	0	0	0	0	1 300	1 300
Hooded Merganser	300	0	600	0	0	900
Common Merganser	1 100	0	1 100	10 800	12 700	25 700
Red-br. Merganser	1 100	700	1 400	19 600	101 300	124 100
Ruddy Duck	60	0	0	0	0	60
Total ducks	169 380	38 060	247 300	204 000	467 300	1 126 000
Canada Goose	500	500	200	31 300	153 700	186 200

Table 8
Estimated waterfowl harvest, by province (mean of 1973–83 figures, after Cooch and Newell 1977 *et seq.*), with adjustments for late seasons (mainly sea ducks) as in text; rounded to nearest 100, or to nearest 10 if less than 100

Species	NS	PEI	NB	Nfld. (island)	Labrador	Total
Wood Duck	500	20	2 100	100	30	2 800
Green-winged Teal	12 500	6 700	9 700	8 600	1 600	39 100
Black Duck	59 100	17 900	25 000	15 000	4 000	121 000
Mallard	1 800	600	1 500	300	100	4 300
Northern Pintail	900	800	1 100	400	400	3 600
Blue-winged Teal	1 600	1 100	5 000	500	50	8 200
Northern Shoveler	30	10	70	0	0	100
American Wigeon	400	300	1 600	100	40	2 400
Ring-necked Duck	2 900	500	3 800	3 900	300	11 400
Greater Scaup	1 600	100	700	800	300	3 500
Lesser Scaup	700	60	700	300	1 300	3 100
Eiders*	9 400	50	600	63 800	10 700	84 600
Oldsquaw	3 100	500	400	10 200	1 500	15 700
Black Scoter	3 200	10	100	9 800	2 600	15 700
Surf Scoter	4 000	200	600	9 000	3 400	17 200
White-wing. Scoter	2 100	50	200	3 200	600	6 200
Goldeneyes†	5 300	300	4 900	6 100	3 400	20 000
Bufflehead	2 500	80	600	10	200	3 400
Hooded Merganser	300	20	400	40	100	900
Common Merganser	2 200	90	1 000	2 600	700	6 600
Red-br. Merganser	2 500	700	800	1 900	1 300	7 200
Ruddy Duck	100	20	20	0	0	100
Total ducks	116 700	30 100	60 900	136 600	32 600	377 100
Canada Goose	8 400	13 300	3 800	7 200	3 500	36 200

* Common and King Eiders (females not separable from wings), probably all Commons except 10–20% in Labrador.
† Common and Barrow's Goldeneyes (females not separable from wings), probably at least 95% Commons in all areas.

4. Results

4.1. Waterfowl breeding populations

Combining the adjusted areas in each waterfowl capability class (Table 1b) with the total breeding duck densities in those classes (Table 2b) gave estimates of the total duck populations (excluding eiders and mergansers) in the Maritime Provinces (Table 4). Those totals were divided into species, as in Table 3, to arrive at species totals, in breeding pairs (Table 5). Extrapolating to allow for non-breeding birds, and adding estimates for eiders, mergansers, and geese, gave values for total spring populations (Table 6).

Of the total land area, the Maritimes account for only 27%, the island of Newfoundland 21%, with 52% in Labrador (Table 1). Owing to more fertile wetlands there (larger area in the better CLI classes 1–4; Table 1), the Maritimes contain 39% of the spring ducks, compared to 17% in Newfoundland and 44% in Labrador (Table 6), whereas nearly all of the breeding geese are in the last two areas. The species composition differs; more species and higher proportions of dabbling ducks are found in the Maritimes, and more species of diving ducks in Labrador, while Newfoundland is in an intermediate position (Table 3). Nevertheless, the major duck species are the same in all parts of the region, except that Blue-winged Teal are nearly absent from Newfoundland and Labrador. Black Ducks make up 30–40% of the breeding ducks in all areas except Labrador.

4.2. Fall populations and sport harvest

Extrapolation from the spring pair figures to cover production of young and summer mortality of adults gave estimates of the early fall population ("fall flight") (Table 7). Estimates of the sport-hunting kill of waterfowl, averaged for 1973–83 (after Cooch and Newell 1977, Wendt *et al.* 1978, Wendt and Hyslop 1981, Métras 1984, 1985), were adjusted to allow for late seasons in the Maritimes and for difficulties with the harvest data for Newfoundland and Labrador, giving the figures in Table 8.

The proportions of the fall flight derived from the various areas differ little from the proportions present in spring, as both were obtained by arithmetical expansion from the same spring pair values. The differences observed reflect differences in species composition and in the expansion factors used for different species-groups. The Black Duck made up the largest proportion of the fall flight (320 000 birds), followed by Canada Goose (186 000), Green-winged Teal (164 000), Common Eider (140 000), and Red-breasted Merganser (124 000); Ring-necked Duck, Common Goldeneye, and Blue-winged Teal also contributed over 50 000 birds each to the fall flight.

Black Ducks made up one-third of the duck kill reported (121 000 birds shot), followed by Common Eider (85 000), with Green-winged Teal a distant third (39 000). Common Goldeneye, Surf and Black Scoters, Oldsquaw, and Ring-necked Duck each had 10 000–20 000 birds killed. About 36 000 Canada Geese were also taken. The proportions of the kill differed between areas most strikingly in PEI, where only 4% of the ducks but 37% of the geese were shot. Collectively, the Maritimes accounted for 53% of the ducks and 70% of the geese killed, with 38% and 20% respectively on the island of Newfoundland, and about 10% each of ducks and geese in Labrador.

4.3. Population budget

The various estimates and guesses assembled in preceding sections were combined into a tentative population balance (Table 9), which also included estimates of native harvest (McFarland and Cooch 1976) and of crippling loss (arbitrarily set at 25%). Subsistence harvest outside the hunting season by non-natives in Labrador was not allowed for, but seemed likely to involve mainly eiders.

This summary of existing information and educated guesswork shows that except for a few minor species there was an "exportable surplus". The adjustments necessary for harvest derived from outside the Region are the largest area of uncertainty for most species; it is noteworthy that the major species, for which that adjustment was relatively small, all showed positive population balances. Species with relatively large "surplus" balances included Red-breasted Merganser (45 000 birds), Green-winged Teal (37 000), Ring-necked Duck (33 000), Canada Goose (33 000), Blue-winged Teal (25 000), and Black Duck (21 000). That the two species with largest hunting kills in the Region, Black Duck and Common Eider, had substantially smaller surpluses than several other less numerous species suggests that these preferred species are being exploited at, or beyond, the levels they can sustain. Overall, the "fall flight" of somewhat over one million ducks and 186 000 geese yields "surpluses", to cover winter mortality and hunting losses outside the Region, of about 217 000 ducks and 33 000 geese.

Wintering birds did not appear in the population balance, inasmuch as those birds had survived hunting within the Region and had not migrated farther. Except for those that died during the winter, they would be included in the total of "spring survivors". Rough estimates of wintering birds, based largely on aerial surveys during January and February in various years, are presented in Table 10. The Region is of major importance for wintering eiders (and possibly for other sea ducks — for which our data are meagre). All other ducks combined add up to only a few tens of thousands, hardly more than one-quarter of the nearly quarter-million eiders.

5. Discussion

5.1. The use of a waterfowl population budget

Some waterfowl biologists have viewed our development of a waterfowl population budget as an attempt to cover up deficiencies in CWS information and operational programs. We again emphasize that this kind of modelling exercise is an aid to planning rather than a final product. By constructing a balanced equation that takes into account reproduction, losses to hunting and natural causes, immigration and emigration for each waterfowl species, we can see where real data exist and where we can only offer educated guesses, where gaps in the information base can be simply remedied, and where we don't know enough even to plan

Table 9
Tentative population balance for Atlantic Region waterfowl, based on preceding tables and text (rounded to nearest 100). See footnotes for derivation of data in each column

	A	B	C	D	E	F	G	H
Species	Early fall populations	Sport harvest in region	Native harvest	Adjusted total harvest	Harvest plus crippling loss	Fall pop'n – hunting loss in Region	Spring survivors needed to maintain balance	"Surplus" for other Canadian and US harvest plus winter mortality
Wood Duck	9 300	2 800	0	1 400	1 800	7 500	4 600	2 900
Green-winged Teal	163 500	39 100	1 100	36 200	45 200	118 300	81 000	37 300
Black Duck	320 300	121 000	4 600	113 000	141 200	179 100	158 600	20 500
Mallard	4 500	4 300	0	1 700	2 100	2 200	2 200	0
Northern Pintail	13 600	3 600	0	1 800	2 300	11 300	6 700	4 600
Blue-winged Teal	58 900	8 200	0	4 100	5 100	53 800	29 100	24 700
Northern Shoveler	600	100	0	50	60	500	200	300
American Wigeon	6 800	2 400	0	1 200	1 500	5 300	3 300	2 000
Ring-necked Duck	91 600	11 400	0	10 300	12 900	78 700	45 400	33 300
Greater Scaup	31 800	3 500	600	2 100	2 600	29 200	17 600	11 600
Lesser Scaup	17 100	3 100	600	1 900	2 400	14 700	9 400	5 300
Common Eider	139 600	84 100	6 700	9 100	11 400	128 200	116 200	12 000
King Eider	1 200	500	200	100	100	1 100	1 000	100
Harlequin Duck	3 300	200	0	100	100	3 200	1 900	1 300
Oldsquaw	1 600	15 700	0	400	500	1 100	1 100	0
Black Scoter	11 200	15 700	1 800	1 800	2 300	8 900	7 400	1 500
Surf Scoter	26 600	17 200	2 800	4 000	5 000	21 600	17 500	4 100
Common Goldeneye	72 400	19 500	2 200	19 500	24 400	48 000	40 100	7 900
Barrow's Goldeneye	1 300	500	100	500	600	700	700	0
Hooded Merganser	900	900	0	300	400	500	500	0
Common Merganser	25 700	6 600	0	5 900	7 400	18 300	14 200	4 100
Red-br. Merganser	124 100	7 200	2 300	8 600	10 800	113 300	68 700	44 600
Total ducks	1 125 900*	367 600†	23 000	224 100	280 200	845 500	627 400	218 100
Canada Goose	186 200	36 200	3 000	35 300	44 100	142 100	109 500	32 600

* Omitting Gadwall (60), Redhead (60), and Ruddy Duck (60).
† Omitting White-winged Scoter (6 200) and Bufflehead (3 400).

A. from Table 7.
B. from Table 8.
C. from McFarland and Cooch (1976), divided thus: eiders 30%; Black Duck and scoters 20%; goldeneyes and large mergansers 10%; Green-winged Teal 5%.
D. from B + C minus harvested birds reared outside region (see text).
E. from D × 1.25.
F. from A minus E.
G. from Table 6.
H. from F minus G.

further studies. A number of operations based on gaps identified in this exercise have been started already.

We used data from systematic surveys where possible, but many of those were 15–20 years old, and there were many gaps. The lack of usable data from Newfoundland, and difficulties with the one extensive survey in Labrador (Gillespie and Wetmore 1974), pointed the way to field studies recently undertaken in those areas in 1978–81 and reported in this compendium (Chapters V and VI). Relative to their numbers in the Region, eiders were poorly represented in existing surveys. Additional surveys since 1978 and compilation of data from a wide variety of unpublished sources led to papers in another CWS compendium (Erskine and Smith 1986, Lock 1986). In some instances, new data have substantiated the guesses made in 1978; in others, errors in the earlier work have been corrected. Revised population figures are included in this paper where appropriate.

The waterfowl harvest data were obtained in a systematic manner (Boyd and Finney 1978), but the continuing disillusionment with the figures obtained from Newfoundland and Labrador pointed to the rather sweeping adjustments described in this paper. CWS Populations and Surveys Division is exploring ways of improving the harvest surveys.

No attempt was made to account for illegal kill. We know of a number of areas within the Maritimes where traditional out-of-season hunting takes place, and there is some hunting in spring and summer, at least partly for subsistence purposes, in Newfoundland and Labrador, but quantitative data are lacking. Except for eiders, most illegal hunting may affect the non-breeding or subadult segments of species populations more than the breeding birds. Similarly we have no firm data on crippling losses; the 25% figure used here was strictly a guess.

The biggest question yet to be answered concerns the proportion of the kill derived from birds reared outside the Region. That value affects the figures for every species, and some values could be in error by 20% or more. Many of the immigrant birds are drawn from stocks not represented by banding samples, and increased banding in northern (boreal and arctic) areas would help to clarify this matter.

5.2. Implications of the population "balance"

Table 9 shows a net "surplus" for most species, except for a few minor species which are balanced. Nevertheless, no species shows a really large surplus relative to the demands likely to be made on it south of the Canada – US border, the Canada Goose most likely being in a better situation than any of the more common duck species. Comparison of columns E (losses to hunting within the Region) and H (the pool from which US hunting kill must be drawn) shows that the Regional kill exceeds the exportable surplus for Green-winged Teal, Black Duck, Common Eider, scoters, goldeneyes, and Common Merganser. If there is overharvesting of these species, which has never been demonstrated conclusively, it probably occurs within the Atlantic Provinces, rather than south of the border.

Nearly all the species that migrate south of the Region in winter mix there with much larger numbers of the same species reared farther west in Canada. Most of the diving ducks migrate rather limited distances, and are little hunted in the United States, Ring-necked Duck and Red-breasted Merganser being the only exceptions among the more common species. The species which seem most likely

Table 10
Tentative estimates of winter populations (individuals) of waterfowl, Atlantic Region, expanded from mid-winter aerial surveys, Christmas bird counts, and other unpublished data, rounded to nearest 100; species represented by only stray individuals omitted

Species	NS	PEI	NB	Nfld. (island)	Labrador	Total
Black Duck	12 000	3 000	4 000	1 000	0	20 000
Greater Scaup	5 000	0	0	0	0	5 000
Common Eider	5 000	1 000	3 000	200 000	20 000	229 000
King Eider	0	0	0	100	2 000	2 100
Harlequin Duck	100	0	100	1 000	300	1 500
Oldsquaw	1 000	500	1 000	3 000	2 000	7 500
Black Scoter	300	0	100	400	0	800
Surf Scoter	100	0	400	0	0	500
White-winged Scoter	600	0	500	100	0	1 200
Common Goldeneye	6 000	2 000	2 000	1 000	0	11 000
Barrow's Goldeneye	20	200	50	50	0	320
Bufflehead	300	0	700	20	0	1 020
Common Merganser	1 000	500	500	100	0	2 100
Red-br. Merganser	2 000	500	500	500	0	3 500
Canada Goose	9 000	0	0	0	0	9 000

to be in trouble are thus the three major "sport ducks" — Black Duck, Green-winged Teal, and Common Goldeneye, which collectively make up about 50% of the reported hunting kill; Common Eider, the mainstay of the kill in Newfoundland and Labrador; and Common Merganser. This last species has been persecuted in the name of salmon management, and, like other fish-eating birds, has been subject to the hazards of toxic chemicals in the food chain.

We also have a number of scarce species, most of which have much larger populations outside of the Region to the west and northwest. Barrow's Goldeneye and Harlequin Duck have eastern populations that are completely separate from those of western North America and Europe. Like other marine birds, those stocks are likely to be exposed to increasing hazard from oil pollution of nearshore waters.

5.3. The future for Atlantic Region waterfowl

Forecasting the future allows a lot of scope for the imagination — but very little for accuracy. Extrapolation of existing trends is of only doubtful value even in the short-term (say 20 years), and totally useless in the long-term future (say 200 years). What follows is a little more than an opinion.

5.3.1. Habitat losses or gains — Losses of the better production land will continue, as money to buy such land is not available, and other means of protection are uncertain. However, even protection of all land in CLI classes 1 and 2 (for waterfowl) would only include about 15% of all duck production, and protection of lower-quality lands would give an even poorer return on money spent.

Migration areas are subject to disturbance, encroachment, and hunting. Acquisition or zoning of such areas might make a difference, if overharvesting is serious. Losses to developments such as tidal power will have local significance, but probably will not affect the regional picture greatly.

Habitat gains are unlikely to be really significant. Removing subsidies for maintenance of marginal agricultural land would probably be the most productive approach, as these areas probably have higher waterfowl potential relative to other possibilities for their development. The few hundred or thousand ducks reared on artificial impoundments are never likely to make any major contribution to

total waterfowl numbers, although certain species of "prairie ducks" (Pintail, Gadwall, Shoveler, Wigeon, Redhead, Ruddy), which are scarce elsewhere in the region, favour such environments.

Over the next 20 years, we may lose 10% of present productivity through net loss of habitat. Over the next 200 years, I doubt if the total losses from this will exceed 20%, as increasing energy costs will limit further drainage and other uses of wetlands.

5.3.2. Pollution — Oil spills from tankers and offshore drilling sites seem likely to increase and may affect sea ducks considerably. Other species are unlikely to be in serious danger, as coastal concentration areas are largely away from existing and probable future tanker routes and drilling areas.

Direct, acute damage from industrial pollution will probably be localized. Because industry usually requires the proximity of deepwater ports it is unlikely that shoalwater habitats preferred by most coastal waterfowl will be affected.

Chronic damage through industrial fallout (LRTAP, or "acid rain") could be more serious, as the more productive parts of the region are those closer to, and directly downwind from, the main US sources of such pollution. The damage caused by acid rain is the only type worth trying to forecast at a regional level, and only wild guesses are possible. We could lose 10 or even 20% of productivity to this hazard before it is taken seriously, i.e. before agriculture or forestry are hit hard enough to prove a cause–effect relationship and demand action. This would mostly occur over the next 20 years; over 200 years, we might even see some reversal of that loss.

5.3.3. Hunting — The evidence from delayed hunting season openings for Black Ducks in NS and PEI in the late 1960s suggests that we can reduce the Canadian harvest considerably, if we can persuade regional hunters of the need to do so. A reduction in US harvest is unlikely to have much impact on "sport ducks" in Newfoundland, NS, or PEI, but it could influence numbers in NB and north of the Gulf of St. Lawrence to some extent. We may expect that eventually, increased petroleum costs will slowly reduce or at least localize Atlantic Region hunting.

Over the next 20 years, the kill will probably increase more gradually, then stabilize at a level possibly 10% above present harvests. Accompanying this there will be a levelling-off in the number of hunters. But over 200 years, a decrease of 10% or even 20% from present numbers seems likely to be forced on all hunters in the northeast, and the decrease could be substantially more than that if we really do lose 30% of productivity to habitat loss and acid rain.

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VIII. Atlantic Region waterfowl populations and surveys in perspective

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1. Abstract

Development of a population model allowed Atlantic Region waterfowl numbers and kill to be compared with national totals. Atlantic Region's production of waterfowl is of minor importance continentally, except for Black Ducks and Canada Geese, but its kill of Black Ducks and eiders is significant. The overall effect of regulations to restrict hunting, which were introduced in 1916, has been beneficial, and some species have increased compared to formerly low numbers (Wood Duck, Common Eider, Bufflehead). Recent changes in regulations have had little effect, and existing regulations need better enforcement, particularly in Newfoundland and Labrador. Habitat losses, especially affecting salt marshes which have been drained and diked in some places, were widespread up to 1960, but since then a number of areas have been developed as impoundments for waterfowl production. These have added little to regional waterfowl numbers because hunting on such areas is very effective in exploiting local production. Surveys have hardly influenced regional management operations in the past, but they did provide the basis for the population model, and thus the general overview needed for future planning. Breeding population surveys are still generally lacking.

In some areas, we need more enforcement of hunting regulations, coupled with public education on the need for restrictions. As an experiment, it may be necessary to curtail Black Duck hunting to determine if such a measure will raise numbers of this species to desired levels. Closure of some managed areas to hunting may also help to increase regional populations. Habitat improvements should be conducted as planned experiments so as to demonstrate their effectiveness in meeting planned objectives. Adequate breeding population surveys are essential for effective management, even though their cost may be high. Such experimental surveys will be made in concert with modifications in hunting regulations or habitat management.

2. Introduction

The papers that make more up this compendium were assembled to make more readily available the information they contained, and to offer some interpretation of the data for use in waterfowl management in the Atlantic Region. Management includes regulations concerning hunting, the release of toxic chemicals and oil into the aquatic environment, and the disturbance of birds in breeding areas; also the maintenance, restoration, or enhancement of waterfowl habitats. The effectiveness of such management can be measured by changes in waterfowl numbers and harvest as shown by systematic surveys. This compendium includes studies that provide baseline surveys against which comparisons may be made, studies of methodology for improving surveys, and a preliminary population model based on survey data. With the population model (Chapter VII) and the other papers as a basis, this chapter discusses the Region's waterfowl in general, to try to determine what has been accomplished, what problems still persist, and what should be done to solve those problems.

3. Discussion

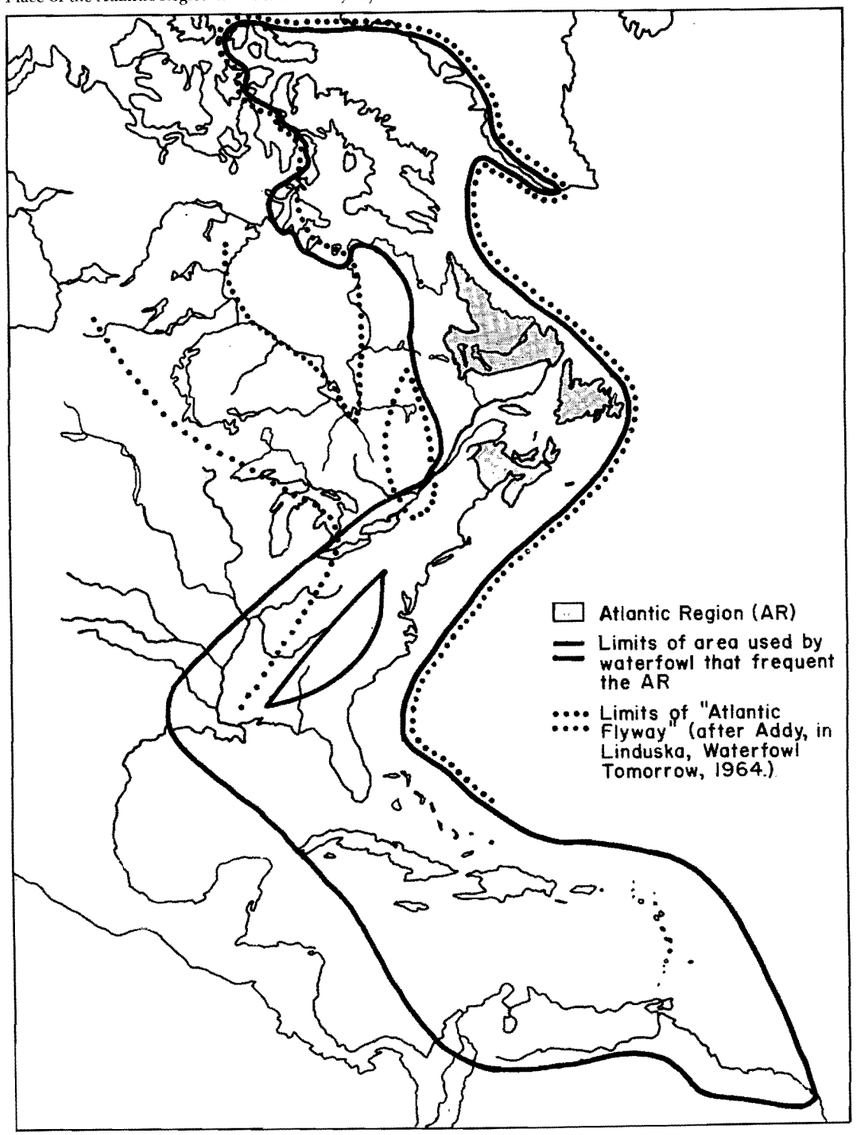
3.1. Atlantic Region waterfowl populations in perspective

The Atlantic Region is relatively small, and lies on the outer periphery of the Atlantic Flyway (Fig. 1). Much of the region is made up of habitats having low capability for producing waterfowl. Furthermore, it is not traversed by major stocks of waterfowl that breed elsewhere, except for the coastal movements of diving ducks flying from the eastern arctic and Ungava to the eastern shores of the United States and Canada.

The regional population model (Chapter VII) invited comparisons with similar data for the whole of Canada, as summarized in the "Waterfowl Management Plan for Canada: an overview" (CWS 1981) and by Boyd and Finney (1978). The Atlantic Region produces about 3% of the national goose population, but only about 1.5% of the ducks, in about 5.5% of the total area of Canada. Roughly 5% of the national goose kill, and about 11% of the national kill of all duck species combined, occurs in the region. The region's human population is about 10% of the national total, and about 13% of the migratory game bird hunting permits are sold here. Apparently the local duck populations are being hit relatively harder than others in Canada, and the duck kill includes many birds reared outside the region.

The model revealed some discrepancies compared with published estimates (*cf.* Bellrose 1976). Bellrose's estimate of 35 000 Canada Geese in the North Atlantic population cannot be equivalent to the fall flight (before hunting in the region) of about 185 000 birds (Chapter VII, Table 9). Presumably the regional figure includes many geese from Labrador that Bellrose assigned to the mid-Atlantic population. Numbers for Black Ducks also suggest a larger "export" than indicated by Bellrose. The fall flight minus hunting losses here is about 180 000 birds, of which only about 20 000 winter in the region, the remainder presumably moving to the eastern States. Regional contributions of Ring-necked Ducks to the flyway are considerably larger, and those of mergansers smaller, than Bellrose suggested. Overall, such discrepancies are not serious, as the regional populations comprise less than 10% of the Canadian totals for individual species except for Black Duck (15%).

Figure 1
Place of the Atlantic Region in the Atlantic Flyway



The goal of waterfowl management is to maintain or increase populations so as to increase the resultant benefits to people, while ensuring that no species or recognizable population becomes extinct. Waterfowl management activities can be grouped under three headings:
a) regulations of various kinds to limit losses arising from man's actions;
b) protection and improvement of habitat to produce more waterfowl;
c) surveys to monitor the status of waterfowl populations and the kill of waterfowl and to assess the effectiveness of regulations and habitat management. Banding is a specialized tool used in several kinds of surveys. The questions posed in the Introduction to this chapter will be considered under these three headings.

3.2. Accomplishments to date in waterfowl management in the Region

3.2.1. Through regulations — The history of waterfowl exploitation in the Atlantic Region is typical of elsewhere in Canada. At first there was unregulated use. Then regulations were introduced and gradually made more restrictive, but there was no serious assessment of their effectiveness. Education regarding the need for conservation and restrictions on hunting accompanied the enforcement of regulations during the first 10–15 years after the signing of the Migratory Birds Convention in 1916. The union of Newfoundland with Canada in 1949 raised the issue of subsistence use of waterfowl (and other migratory birds) — a different problem from the sport hunting that had dominated waterfowl regulations in the rest of southern Canada. Neither enforcement nor conservation education has received high priority in Newfoundland since 1949, and hunting there has continued with little regulation up to the present.

The only substantial changes in waterfowl hunting regulations during the last 35 years were a reduction in daily bag limits, from eight to six ducks, starting in 1959, and delayed openings in the hunting seasons for Black Ducks (or all ducks) in Nova Scotia and Prince Edward Island in 1966–68. The former was provoked by concern expressed at the flyway management level, and its effect was probably minimal, as few local hunters, then or now, reached the daily bag limit. The delayed openings arose from Bartlett's concern (see Chapter I) that the kill of locally reared Black Ducks was excessive; they reduced the level of local kill for one or two years, but no surveys were carried out to measure the effects on local breeding populations, and there was insufficient enforcement to ensure continued compliance.

Overall, however, the effect of restrictive regulations since 1916 was substantial, and it can be detected even without "before and after" surveys. Compared with the situation in 1916, insofar as that can be reconstructed, many birds have recovered well from the low population levels to which they had been reduced by unrestricted hunting in the 1800s. This has been the case with the Wood Duck throughout its range, the Common Eider south of the St. Lawrence, the Bufflehead and the Ring-necked Duck in the northeast, as well as various egrets, shorebirds, and terns. Sport hunting of waterfowl is practised more widely than ever, although with reduced bag limits and seasons, and bird watching has grown to an extent that would have been inconceivable in 1916. All this activity is a direct or indirect result of the greater numbers and availability of birds made possible by the implementation of protective regulations under the Migratory Birds Convention.

3.2.2. Through habitat protection and manipulation — In the Atlantic Region, productive wetlands were probably never numerous, most of the more notable examples being either salt marshes and adjacent brackish areas under tidal influence, or alluvial floodplains. By 1960, most of the larger salt marshes and associated areas had been diked and drained for agriculture. In the 1960s, national emphasis in waterfowl management turned toward habitat protection and enhancement. The Atlantic Region took part in this movement, and during 1965–80 both federal and provincial agencies acquired and reserved various wetlands for the use of waterfowl and other wildlife. The areas protected had been identified as important for waterfowl production, and most were under some threat of drainage. Nevertheless, no conclusive evidence was advanced to show that a shortage of breeding habitat was limiting the numbers of waterfowl in the region, although the assumption was plausible. However, if habitat was limiting, one might expect that areas of suitable habitat would be stocked to capacity, with a surplus spilling over into less suitable areas, but that is not obviously the case at present.

Many protected areas were developed subsequently, usually by creating shallow impoundments with controlled water levels. Such areas usually proved attractive to inland duck species and thus provided added capability for waterfowl production. Duck densities on impoundments are usually higher than those on natural marshes in the area, and such concentrations are also attractive to waterfowl hunters in the fall. On the local scale at least, this type of protected area provides immediate and obvious benefits to people because of conspicuous concentrations of waterfowl and improved hunting. Their long-term effects at the regional level are harder to assess, as will be shown.

3.2.3. Through surveys — To date, the role of surveys in assessing the effectiveness of regulations and habitat protection in raising waterfowl numbers has been minimal. The Migratory Birds Convention was negotiated because of the (indisputably correct) impression that the numbers of many bird species had declined, and not because surveys had shown that decreases had actually occurred. The general reduction in waterfowl bag limits in 1959 was made because midwinter counts of Black Ducks in the eastern states had declined — biologists are still arguing about the reality and scale of that decline. Data from the Atlantic Region at that time did not indicate decreases. The surveys of the 1950–63 period (Bartlett, Chapter I; Erskine, Chapter II) had ended before the delayed openings of 1966–68 were introduced, and the absence of any monitoring tool was one factor in the ultimate termination of that restriction.

Surveys also have proved little about the value of habitat protection and manipulation. As predicted, following the development of impounded areas, numbers of broods rapidly increased to levels well above those seen on the same areas earlier (Whitman 1976). However, the ducks that initially settled on impoundments evidently came from surrounding areas, and probably from an area much larger than the development; no series of "before and after" surveys covering extensive areas are available for any habitat development in the region. The assumption behind such developments is that the improved habitat will produce a surplus of ducks, to replenish the area from which birds

moved to stock the new impoundment, while producing more birds than the same area did before development. CWS bag-check surveys on National Wildlife Area impoundments suggest that the opening-day kill may approach the total number of ducks raised there. If confirmed, that situation is similar to the "put-and-take" approach commonly applied to trout ponds and pheasant preserves, and indicates that impounded areas may do little to increase waterfowl populations on any level larger than the local area.

The role of surveys in providing baseline data on waterfowl numbers and kill, and of monitoring changes in them, is less ambiguous. The many approximations needed in the development of the population model (Chapter VII) were necessary because of deficiencies in past surveys, but the model could not have been developed at all without those surveys. From the information and experience gained from them, combined with other information in the population model, I was able to produce an overall picture that probably was the most important result of the surveys.

Perspective develops only gradually. The idea that most ducks in the region are produced in low-quality wetlands at very low densities is difficult to prove and perhaps harder to accept. The corollary is that specially impounded areas, acquired and developed at substantial cost, produce less than 5% of the region's ducks. Modelling exercises can hardly be precise in the absence of complete data, but lack of precision need not preclude an understanding of the general situation. After 35 years of trying to count invisible ducks in the region, precision in population estimates is still a dream. But without adequate surveys, only gross changes can be detected, and management is reduced to intuitive responses to local pressures. Improved perspective, even if based on incomplete surveys, allows one to recognize which management activities are unproductive and which must be pursued in spite of cost and logistical difficulties.

3.3. Problems that still persist

3.3.1. Regulations — Most regulations relating to waterfowl are directed toward the hunting of these birds and the need to prevent their overexploitation. Despite the successes of waterfowl protection under the Migratory Birds Convention since 1916, hunting and egg-taking are implicated in the failure of some former stocks to recover their numbers since then. The most obvious examples deal with eiders, which have increased greatly in parts of the Maritimes and in the St. Lawrence estuary (Reed 1986). However, they remain very scarce and localized as breeding birds on the island of Newfoundland and in Labrador south of 53°N, and their breeding numbers are far below expectable levels on the rest of the Labrador coast and on the north shore of the Gulf of St. Lawrence. Spring hunting and the taking of eggs in summer still persist in those areas, and presumably are still depressing eider numbers there. Coastal residents formerly depended on marine birds for much of their food, and the tradition persists. The depletion of local stocks seems to be easily overlooked by people who still see large numbers of eiders coming south each autumn. In recent years, the exploitation has increased in parts of the Arctic, where eiders are available only during the breeding season (F. G. Cooch, CWS, pers. commun.). Eiders that are protected on their breeding grounds can support considerable hunting pressure, but when the breeding stock is exposed to hunting in spring and brood production is cut off by egg-taking they may not be able to support any hunting. Better management of sea ducks, starting with the enforcement of existing laws, must be a high priority in waterfowl management in the northern part of the region.

Debate has raged for decades over whether deficiencies in regulations or in their enforcement leading to excessive exploitation, that is, overhunting, is a problem in the region or the flyway. In 1945, concern over apparent declines in Black Duck numbers prompted the start of studies in the Maritimes by Bruce Wright. After one season's fieldwork, Wright concluded that excessive hunting was the major factor limiting waterfowl (or at least Black Duck) numbers in the northeast. Presumably his conclusion was based on observation of large kills early in the hunting season, on the abundance of apparently suitable but unoccupied wetland habitat, and on the absence of other obvious limiting factors. It was, in fact, based on impressions and experience rather than quantitative data. Subsequent workers in the Maritimes (Boyer, Bartlett, Erskine) in the next 20 years made similar observations and drew similar conclusions, more or less independently, but still without the use of systematic, wide-ranging surveys of waterfowl populations. Biologists in the region and elsewhere in the flyway were, and are, reluctant to press for regulations seriously restricting waterfowl kill on the basis of impressions alone. Grandy (1983) summarized the impressions of Black Duck decline expressed in various compendia, but he seems to have treated them as established facts rather than only impressions. The continuing problem is the result of deficiencies not in the regulations themselves but in the information on which they are based and against which their efficacy can be assessed.

3.3.2. Habitat — The continuing dilemma in habitat work in the region is that, as most habitats support low densities of ducks, hunters are dependent for success on the few areas of good habitat where ducks are concentrated, but those same areas are the ones where habitat enhancement to improve production is most cost-effective. Most of these areas are relatively small and accessible, and thus are especially vulnerable to local overharvesting. Use of a managed site as a public hunting area may nullify its value as a "duck factory".

There is also confusion, or at least a difference of opinion, about the role of bird sanctuaries or "no-hunting" areas. Few people disagree openly with the concept of sanctuaries to protect breeding areas, although neither federal nor provincial sanctuaries created to protect eider colonies in Newfoundland (Hare Bay islands) and Labrador (St. Peter's Bay) were respected. During waterfowl hunting seasons, sanctuaries are desired by some persons more as a means of concentrating birds to provide better hunting around the edges than as refuges to protect the birds from hunting. It may be difficult to justify establishing more sanctuaries without having proved the existence of overharvesting, in view of the small numbers of birds using such reserves. But there may be little prospect of raising population levels without more protection of existing stocks, which may be done more effectively on managed areas.

3.3.3. Surveys — By far the most persistent problem in waterfowl management in the Atlantic Region is the lack of reproducible, representative surveys of breeding duck populations. The low densities of ducks encountered on most surveys provide limited return on the effort and money needed to count them, and this is exacerbated by the relative invisibility in breeding habitat of the major game species, Black Duck and Green-winged Teal.

Concern over Black Duck numbers throughout its range has been based chiefly on the decreasing numbers of these ducks detected on the annual midwinter inventories. Those surveys are incomplete, as they detect only a fraction of the total population (probably one-quarter to one-third), and chiefly those in coastal and other areas suitable for survey by fixed-wing aircraft. The coastal bias is unimportant in the Atlantic Region, where inland areas are frozen by January when the counts are made. However, the influence of adverse weather and varying ice cover in these northern wintering areas renders January surveys imprecise, as well as causing wide and unpredictable variations in the numbers of birds wintering there. Given the relatively small numbers of ducks detected in most areas and the great variability of such counts, extensive winter surveys in the region may not be justifiable on an annual basis; any that are done should be standardized to permit comparisons when necessary.

The waterfowl harvest surveys conducted across Canada annually (*cf.* Boyd and Finney 1978) have acceptable statistical rigour, but there are recurring questions about some of the results. In the Atlantic Region, the Newfoundland kill data are viewed with particular suspicion, and in the population model (Chapter VII) it was thought desirable to adjust those figures by increasing the sea-duck kill while reducing that of inland ducks. Although data from other surveys were used in those adjustments, the process was partly subjective, and improvement is still needed.

Despite concern over declining Black Duck numbers in the Atlantic Flyway, the harvest survey data for the Atlantic Region indicate that Black Duck kill has increased steadily in every province except New Brunswick, where it remained constant. Numbers of hunters showed parallel trends. Atlantic Region kills of other major waterfowl species, apart from Green-winged Teal, also increased except in New Brunswick. Increasing kills cannot be supported indefinitely by finite stocks, but harvest surveys to date do not suggest drastic over-hunting in the region, even with the loss of much formerly productive habitat.

Local surveys also support a previously identified weakness in the regulatory process. Duck species that migrate early are not exposed to heavy hunting on the breeding grounds and thus may survive better. Blue-winged Teal and Ring-necked Ducks make up increasing proportions of the ducks reared on most impounded areas (unpubl. data), and most of them leave before the hunting season. It has not been practicable to allow early seasons on these species because, under field conditions, hunters cannot reliably distinguish between the teals, even if they refrain from shooting at recognizable species for which the season is not yet open. Our inability to manage species individually, except where they frequent distinct habitats (e.g. sea ducks), is a serious constraint on waterfowl management that cannot be overcome by improving surveys or regulations.

3.4 Possible approaches in addressing the problems

The three main components of waterfowl management have been emphasized throughout this paper, but their relative importance varies in different situations. The enforcement of existing regulations needs to be initiated, maintained, or improved. Where previously enforcement was lax, special efforts will be needed in public education on the reasons why regulation is necessary. Existing regulations may not be inappropriate in present circumstances. However, it may be necessary to restrict the hunting of waterfowl much more, as that would be the simplest way to build up populations to the levels called for in the North American Waterfowl Management Plan, whether or not hunting is actually regulating present numbers of ducks. This approach has never been attempted in the Atlantic Region even on an experimental basis, although it was suggested more than 15 years ago. There may never be a better time to try it than now, when reduction of Black Duck kill is a recurring theme.

If less hunting, effected through restrictive regulations, fails to result in measurably larger duck populations, one would be forced to look for alternative limiting factors, among which availability of suitable habitat would be a popular choice. On the other hand, if reduction in kill resulted in much larger duck numbers, concern would then arise as to where they could breed, leading to demands for habitat improvement. Too little is known about the carrying capacity of different habitats to state firmly that there is room for more (two or perhaps three times as many?) ducks than we now have in existing wetlands in the region. Even if room exists, duck hunters in settled parts of the region would undoubtedly prefer that any increased numbers of ducks should breed in accessible impoundments rather than in the distant hinterlands of Labrador. If pressure to increase the amount of waterfowl habitat can be expected, it will be essential to ensure that the measures taken are appropriate and effective. Probably little can be done to explore the carrying capacity of habitats experimentally, so it will be necessary to experiment in "real-life" situations, with forethought as to experimental design and predictive capacity, something that has not been done in past operations. Greater use of "no-hunting" areas will be essential if the effects of habitat change are to be distinguished from those of varying kill levels.

If substantial increases in duck numbers did result from reduction in kill, these might be apparent to hunters and biologists even without systematic surveys. Failing that highly optimistic situation, good surveys of breeding waterfowl populations will be essential to monitor the success of whatever remedial measures are implemented. Surveys on the required scale will call for resources far greater than those devoted to surveys in the past. Even though the return on expenditure for reliable surveys will be low and the cost high, there is no useful alternative. Past efforts have shown repeatedly that inadequate surveys give inconclusive results. If management agencies cannot accurately assess the effects of measures they use to manage duck numbers, the assertion that the resource is being mismanaged will be reinforced.

Historical baseline data from earlier periods exist only in a few areas for which survey procedures and study areas were described in sufficient detail to allow replication. For further comparisons, new baselines will have to be established, using well-standardized procedures, which need not be the same in all areas but must give results that can be compared or combined with those from other areas and regions. The scale of variation in breeding success between years is not great in most parts of this region (*cf.* Bartlett, Chapter I; Erskine, Chapter II). As there is little justification for adjusting hunting seasons or bag limits every year and strong arguments against doing so, there may be little need for annual breeding population surveys, if it can be shown that trends may be measured reliably by surveys at longer intervals.

Banding is usually grouped with survey activities, as it provides information on movements and harvest of particular stocks. Bartlett (Chapter I) reported on the only banding study — as distinct from operational banding — yet completed in the Region. Preliminary examination of

more extensive banding data, largely carried out in the Maritimes in 1965–78 (W. R. Whitman, CWS, unpubl.) yielded no surprises. The recovery patterns for Black Ducks and Green-winged Teal differed very little from those given by Addy (1953) and Moisan *et al.* (1967), respectively. The few recoveries for Northern Pintail, Blue-winged Teal, American Wigeon, and Ring-necked Duck provided only bare outlines of the expectable migration southward down the Atlantic Flyway, and data for other species were too few to be worth summarizing. Recovery data for Common Eiders, largely from females banded on nests, indicated shorter and more complex movements within the region (Erskine and Smith 1986). Common Goldeneyes and Canada Geese, as well as most of the scarcer species, still have not been banded in useful numbers. More banding of most species will be essential for serious management of those birds.

Questionnaire surveys of hunter activity and success have been conducted as parts of national operations (Boyd and Finney 1978). Experience has shown that it is nearly impossible to obtain reliable data for sampling units with fewer than 5000 hunters, as the same people are asked too often to co-operate in the surveys. Thus, data from Prince Edward Island and Labrador for the scarcer species are seldom helpful. Yet for intensive management it may be desirable to obtain data on hunter performance from much smaller units than those now used. If mail questionnaires are not effective, there will have to be direct bag-checking and observation of hunters.

Compared to the knowledge of waterfowl in the Atlantic Region in 1960, we have come a long way. Now, as then, the measures that can be taken to influence the numbers of waterfowl are limited more by the resources needed to monitor the effectiveness of management practices than by those available for regulating human activity or for managing waterfowl habitat. In view of the high cost of effective surveys of breeding waterfowl, it is likely that these will remain experimental for years to come and thus may be viewed as research projects. As past surveys conducted as parts of research projects (*cf.* Bartlett, Chapter I; Erskine, Chapter II) have provided more helpful data than most earlier operational surveys, this may be the most productive approach in the short term.

4. Acknowledgements

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List of common and scientific names

This list contains the common and scientific names of all waterfowl species mentioned in this publication.

American Wigeon	*Anas americana*
Barrow's Goldeneye	*Bucephala islandica*
Black Duck	*Anas rubripes*
Black Scoter	*Melanitta nigra*
Blue-winged Teal	*Anas discors*
Bufflehead	*Bucephala albeola*
Canada Goose	*Branta canadensis*
Common Eider	*Somateria mollissima*
Common Goldeneye	*Bucephala clangula*
Common Merganser	*Mergus merganser*
Gadwall	*Anas strepera*
Greater Scaup	*Aythya marila*
Green-winged Teal	*Anas crecca*
Harlequin Duck	*Histrionicus histrionicus*
Hooded Merganser	*Lophodytes cucullatus*
King Eider	*Somateria spectabilis*
Lesser Scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Northern Shoveler	*Anas clypeata*
Oldsquaw	*Clangula hyemalis*
Red-breasted Merganser	*Mergus serrator*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Ruddy Duck	*Oxyura jamaicensis*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Wood Duck	*Aix sponsa*

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