BLACK DUCK JOINT VENTURE

1994 Annual Progress Report

Prepared by the Black Duck Joint Venture Technical Committee

May 1, 1996

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TABLE OF CONTENTS

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1.0 Introduction

The goal of the Black Duck Joint Venture (BDJV) is to implement a cooperative international program of population monitoring and research. The program will provide information required to improve the management of black ducks. The primary objectives, as stated in the BDJV Strategic Plan (1993), are to:

i) provide statistically reliable indices of population trends and relative densities of black ducks and other waterfowl species throughout the primary breeding range of black ducks,

ii) determine the distribution and derivation of the harvest of black ducks and mallards from throughout the breeding range, along with their harvest and survival rates,

iii) determine, through research, the important factors influencing population status and dynamics of black ducks.

The purpose of this report is to describe the progress made in 1994 toward meeting those objectives.

2.0 Surveys

<u>Operational Surveys in 1994:</u>

Helicopter surveys were conducted as described in the draft BDJV Operational Plan (1992). The survey was designed to detect a 10% change in numbers of black ducks in the survey area with 90% confidence over a 5-year period. The sample was enhanced to allow detection of significant changes within each province/state over a 10-year period.

In 1992, re-evaluation of the survey design showed that the sample could be reduced from 229 to 175 plots while maintaining the desired power of the trend test. The plots after 1992 were distributed as follows: Ontario - 25, Quebec - 43, Nova Scotia - 25, New Brunswick - 25, Newfoundland - 19, Labrador - 6, and Maine - 25. Table 1 shows the population indices for all years (1990-1994), using only the plots that were part of the reduced sample. The coefficients of variation (cv=s.e./mean) for the entire survey area were 5% and 6% respectively for black duck indicated pairs and total individuals. For individual provinces/state, the cv's fell between 8 and 17% for indicated pairs, and between 9 and 34% for total individuals. The cv's were highest in Maine, where variability among plots is increased due to large counts on some coastal plots.

Table 2 shows the results of trend analysis for 1990-1994. For black ducks, the number of indicated pairs declined signficantly in Quebec, Newfoundland and Maine, whereas the total number of individuals declined in Ontario, Quebec and Newfoundland. Black ducks showed no siginficant trends in the other provinces. For interest, Table 2 also shows estimated trends for mallards and ring-necked ducks. A description of the first five years of the helicopter surveys is given in Appendix A.

Table 1: Estimates of the total population of black ducks (indicated pairs and total individuals) with standard errors. From *Collins*, September, 1994.

Year	Stratum	Number of Plots	Indicated Pairs			Total Individuals		
90	ME	25	6814	±	1193	15174	±	3407
	NB	25	8187	±	2060	20926	±	7026
	NF	25	16947	±	2314	27581	±	4275
	NS	25	7102	±	829	14013	±	1678
	ON	25	38649	±	4115	70094	±	7603
	PQ	43	84137	±	7502	153605	±	13924
	TOTAL	178	161835	±	9215	301393	±	18268
91	ME	25	6226	±	1188	20116	±	5595
	NB	25	5096	±	899	9132	±	1551
	NF	25	21063	±	4492	36089	±	8370
	NS	25	8095	±	969	16381	±	2141
	ON	25	40034	±	4287	91427	±	9668
	PQ	43	74312	±	6680	132294	±	12059
	TOTAL	178	154826	±	9292	305438	±	18634
92	ME	25	5247	±	877	15522	±	4112
	NB	25	7157	±	1088	12481	±	1982
	NF	25	13173	±	1890	22435	±	3700
	NS	25	8497	±	1209	22510	±	3876
	ON	25	43636	±	4599	88934	±	9079
	PQ	43	67531	±	5812	129250	±	10387
	TOTAL	178	145240	±	7869	291132	±	15487
93	ME	23	5064	±	798	15358	±	4632
	NB	25	8473	±	984	14972	±	1906
	NF	25	9125	±	1343	20583	±	4011
	NS	25	7060	±	817	15091	±	1870
	ON	25	42804	±	3821	78544	±	8008
	PQ	43	44559	±	3782	97975	±	10152
	TOTAL	176	117086	±	5743	242523	±	14555
94	ME	25	4768	±	810	13106	±	4391
	NB	25	7328	±	1196	13389	±	2123
	NF	25	10772	±	1887	23121	±	6201
	NS	25	6996	±	832	14950	±	1676
	ON	25	38649	±	3235	74250	±	6973
	PQ	43	48019	±	4045	94654	±	8389
	TOTAL	178	116532	±	5759	233469	±	13566

Table 2: Route regression analysis of breeding pairs and total individuals, 1990-1994 (using only the plots that have been surveyed in all years). From *Collins*, September, 1994.

Species[a]	Variable[b]	Stratum	Number of Plots	Estimated Trend	Annual Change Factor	Estimated p-value
ABDU	IP	NF	25	-0.1799	0.8353	0.0001 *
		PQ	43	-0.1733	0.8409	0.0001 *
		ME	25	-0.0987	0.9060	0.0127 *
		NB	25	-0.0406	0.9603	0.5496
		NS	25	-0.0281	0.9722	0.3984
		ON	25	-0.0197	0.9805	0.4965
		TOTAL	168	-0.1291	0.8789	0.0001 *
	TI	PQ	43	-0.1382	0.8710	0.0001 *
		NB	25	-0.1376	0.8714	0.1451
		NF	25	-0.0932	0.9110	0.0311 *
		ON	25	-0.0840	0.9195	0.0071 *
		ME	25	-0.0578	0.9439	0.5281
		NS	25	-0.0173	0.9829	0.6633
		TOTAL	168	-0.1094	0.8964	0.0001 *
RNDU	IP	NF	25	-0.3209	0.7255	0.0001 *
		NB	22	-0.2125	0.8086	0.3910
		PQ	43	-0.0987	0.9060	0.0082 *
		ON	25	-0.0155	0.9846	0.7158
		NS	24	-0.0062	0.9938	0.8903
		ME	23	-0.0061	0.9940	0.8972
		TOTAL	163	-0.1229	0.8843	0.0001 *
	TI	NB	23	-0.2837	0.7530	0.1738
		ME	24	-0.1642	0.8486	0.0007 *
		NF	25	-0.1282	0.8797	0.0014 *
		PQ	43	-0.0688	0.9335	0.0228 *
		ON	25	-0.0496	0.9516	0.1587
		NS	25	0.0215	1.0217	0.5872
		TOTAL	165	-0.0780	0.9250	0.0001 *
MALL	IP	NB	11	-0.1118	0.8943	0.5235
		ME	20	-0.0565	0.9451	0.4195
		NS	13	-0.0455	0.9555	0.7542
		ON	25	0.0131	1.0131	0.5692
		PQ	42	0.0510	1.0523	0.3091
		NF	5	0.1645	1.1788	0.4712
		TOTAL	116	0.0222	1.0225	0.3163
	TI	NB	11	-0.1233	0.8840	0.4909
		ME	20	-0.0515	0.9498	0.4949
		NS	13	-0.0475	0.9536	0.7965
		ON	25	-0.0011	0.9989	0.9638
		PQ	42	0.0601	1.0619	0.2530
		NF	6	0.1325	1.1416	0.4991
		TOTAL	117	0.0143	1.0144	0.5353

[a]ABDU- American Black Duck
MALL- Mallard
RNDU - Ring-necked Duck

[b]IP- indicated pairs
TI - total individuals

The fixed-wing aircraft surveys in the southern part of the survey area were also conducted in 1994. The results of the fourth year of surveys in the Lake States of Michigan, Minnesota and Wisconsin are shown in Appendix B. The fifth year of fixed-wing surveys in southern Ontario, Quebec and New York is described in Appendix C. Helicopters were used to establish visibility rates for species sufficiently common to allow calculation of the ratio.

Other surveys of relevance to the BDJV include ground counts that are conducted annually in Prince Edward Island.[1] 1994 was the twelfth consecutive year of the ground-based survey of breeding waterfowl in Prince Edward Island. One hundred randomly selected wetlands covering a wide range of habitat types are surveyed four times each summer. The number of early and late breeding pairs, and their productivity are estimated annually. The results for black ducks are shown in Appendix D. There has been an overall decline in the number of breeding pairs since the beginning of the survey. However, the trend since 1989 (when further restrictions on hunting in PEI were imposed) shows a stable breeding pair index.

Appendix E shows the results of the midwinter inventories from 1955-1994. The winter population index for black ducks appears to have stabilized since 1980 at about 300,000 birds. This figure is about 85,000 below the population goal as stated in the North American Waterfowl Management Plan.

Experimental Surveys

In 1994, the Technical Committee continued its review of the survey methodologies with the goal of identifying the most reliable and cost-effective survey technique. The draft report included as Appendix F, describes the results from the five year experimental survey program (1990-1994). Although final recommendations have not been made, the report compares the results of the two survey methods and demonstrates the costs associated with surveys using different designs.

3.0 Banding

Recoveries of banded birds can be used to determine the distribution and derivation of the harvest of individuals from throughout the breeding range, and their harvest and survival rates. Black ducks were captured at about 40 banding stations distributed across eastern Canada.

A total of 5,125 black ducks were banded in 1994 (5,832 were banded in 1993). The banding sites in Canada are illustrated on the map in Appendix G. The total number of black ducks banded throughout Michigan, Wisconsin and the northeastern Atlantic Flyway States in 1994 was 1,834. The number of ducks banded at each station is also shown in Appendix G where they are, for the most part, broken down by age and sex categories. Much of the banding occurs as part of the Atlantic Flyway Eastern Cooperative Banding Agreement. A final report on the preseason banding activities in eastern Canada and the northeastern U.S. is provided annually at the summer meeting of the Atlantic Flyway Technical Section.

[1] Bateman, M.C. and R.L. Dibblee. 1994. Progress Report: Waterfowl Surveys on Prince Edward Island 1994. Unpubl. Rep. of Can. Wildl. Serv. (Atlantic Region). 29 pp.

4.0 Research

Trends in population size, productivity, survival and harvest rates can not be explained, or managed, without adequate understanding of the relationships among population parameters and ecological factors. The research component of the BDJV addresses important information gaps in our knowledge that are required to improve the management of black ducks, and to provide necessary information to the habitat oriented joint ventures. It remains unclear to what extent production, mortality, habitat change, and hybridization with mallards has affected the status of black duck populations. Research funded by the BDJV is intended to assess the relative importance of these factors.

Several research projects were funded in 1994. The objectives and current status of each project are presented in Appendix H. Briefly, they addressed such issues as: nest success and summer survival of ducklings and adult female black ducks and mallards; the use of LANDSAT satellite images to characterize breeding habitat of black ducks; the use of beaver pond habitats by ducks; impacts of wetland restoration on Atlantic dykeland soils; and the productivity of sympatrically breeding black ducks and mallard on wetlands of forested and agricultural landscapes in Maine.

5.0 Budget

Allocation of 1994 BDJV funds (the upper value is in Canadian dollars, and the lower in US dollars using 1.25 for conversion).

Organization		Surveys	Rese arch	Banding	Communi-cations	Coordin-ation
Canadian Wildlife Service:						
	367,600	264 ,900	95 ,700			7 ,000
	294, 200	212 ,000	76 ,600			5 ,600
USFWS- BDJV:						
	493 ,750	375 ,000		118 ,750		
	395 ,000	300 ,000		95 ,000		
Patuxent Wildlife Research Center:						
	366,250		366 ,250			
	293 ,000		293 ,000			
Atlantic Waterfowl Council:						
	257 ,250			257,250		
	205 ,800			205 ,800		
Mississippi Flyway Council:						
	16 ,250			16 ,250		
	13 ,000			13 ,000		
Total:						
	1,501,100	639 ,900	461 ,950	392 ,250		7 ,000
	1,201,000	512 ,000	369 ,600	313 ,800		5 ,600

Appendix A

Breeding Waterfowl Survey in Eastern Canada and the State of Maine

Progress Report

18 July 1994

A component of the Black Duck Joint Venture

Helicopter Surveys conducted by:
Atlantic, Quebec and Ontario Regions of the
Canadian Wildlife Service, and the
Maine Department of Inland Fisheries and Wildlife

Introduction

In the past, surveys of black ducks on their wintering areas have been used to examine trends in population size. This information is useful for studying overall population trends, but not for evaluating the status of various components of the breeding population. Among other goals, the Black Duck Joint Venture (BDJV) of the North American Waterfowl Management Plan (NAWMP) was designed to provide improved information on black duck populations in their breeding areas.

A historical database of waterfowl population status does exist for breeding areas, but it is not continuous. In Ontario, for instance, the relative abundance of ducks breeding in southern Ontario was measured in 1951 (Boyd 1974) and surveys from 1971 to 1987 documented the decline of black duck populations in the south (Dennis et. al. 1989). Some early information on black ducks in boreal Ontario, Quebec and Labrador was recorded by Kaczynski and Chamberlain (1968) in the late 1950s and 1960s. Ross (1987, 1990) has been studying waterfowl population densities in northern Ontario since about 1980.

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

To improve the continuity and coverage of surveys of eastern waterfowl populations, systematic helicopter surveys have been conducted in the Atlantic provinces, Quebec and Ontario since about 1985. These surveys provided the basis for the BDJV surveys initiated in 1990. As a result of the BDJV, there now exists a substantial survey effort in eastern Canada and Maine. This report summarizes the results obtained in 1994 in comparison to the years 1990 through 1993.

The 1994 Helicopter Survey

The helicopter survey procedures are described in the draft Operational Plan for the BDJV. In total, 229 100-km^2 plots were originally planned for the survey, and were included from 1990 through 1992. Re-evaluation of sample size requirements showed that the sample could be reduced and continue to provide sufficient precision of the population estimates. The new sample consists of a subset of the original plots, with a total of 175 plots distributed as follows: Ontario - 25, Quebec - 50, Nova Scotia - 25, New Brunswick - 25, Newfoundland - 19, Labrador - 6, and Maine - 25 (Figure 1).

All waterfowl were counted and the social structure of groups was recorded. Birds were recorded by sex, when possible, and identified as singles, or as belonging to pairs, groups or flocks. The total numbers of birds of each species were calculated by summing all observations for each plot. Population densities within the survey area are presented in Table 1 as birds per 100-km^2. The densities were calculated using all of the plots surveyed each year, with the exceptions of plots 7 and 8 in Maine which were dropped as outliers and are no longer being surveyed. Please note that these data are preliminary and subject to further verification and analyses.

Spring 1994 Habitat Conditions

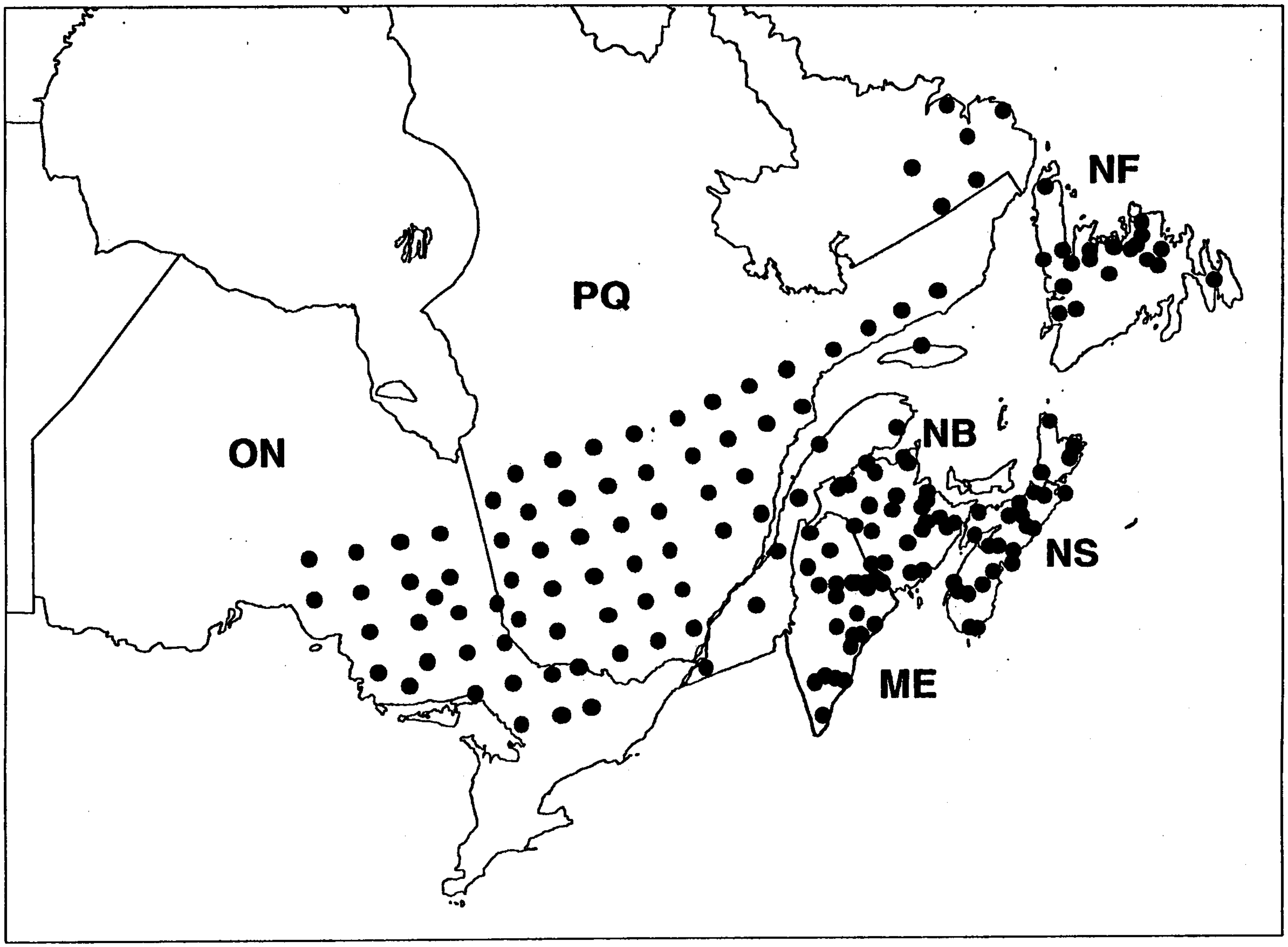
Spring arrived in the Maritime Provinces at an average time. April was mild at most locations and precipitation was light. Higher than average amounts of precipitation fell in May and water levels were generally high during the BDJV surveys. Flooding of early nests may have occurred in some areas. Ice and snow cover were similar to, or less than, during the 1993 survey. Mean temperature and precipitation were similar to the long term average in June. Waterfowl production is expected to be average or above average.

In southern Quebec, the 1994 weather conditions were very cold during the winter period. Snow fall was more abundant than usual. Ice cover on lakes of the boreal forest was thicker than in previous years and the spring thaw was delayed by about two weeks. During the survey period in May, weather conditions were cooler than normal. However, the small water bodies were ice-free although a number of large lakes were still ice-covered. The survey of 6 blocks in eastern Quebec was postponed by one week to allow the lakes to melt. Normal temperatures occurred in June. It is expected that brood production may be delayed, particularly in eastern Quebec.

April in Ontario was very cool, which caused a substantial delay in vegetational phenology (by as much as two weeks). Water levels were comparable to 1993 even though the snow pack was less in 1994. The exceptionally cold winter may have provided for a particularly effective seal keeping water in the wetlands. Waterfowl productivity is expected to be comparable to 1993 which was below normal. Some delays in breeding phenology were evident, particularly in southern plots. As well, cool conditions prevailed through May and was likely detrimental to brood rearing.

Evaluation

The survey design and techniques are currently being evaluated to determine the most cost effective method that will continue to meet the objectives of the BDJV. During the 1993 and 1994 field seasons, the effects of intra- and inter-crew variation were examined. Those data are now being analysed.



Figurel: Distribution of helicopter survey plots, in 1994.

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Table 1: Density (per 100km²) of total waterfowl observed on BDJV plots, 1990 - 1994. 16:32 Thursday, July 14, 1994

	Indicated birds per 100km2														
	ME					NB					NF				
	90	91	92	93	94	90	91	92	93	94	90	91	92	93	94
1290 COME Common Merganser	24.12	18.64	14.28	15.48	16.08	8.96	8.88	4.40	7.84	4.20	4.68	5.08	5.56	3.32	2.28
1300 RBME Red-breasted Merganser	.	.	.	.	.	1.20	.	.	.	0.12	1.52	2.08	1.32	2.00	3.08
1310 HOME Hooded Merganser	5.00	5.36	5.96	5.52	5.80	2.04	0.32	0.76	0.80	0.56	0.16	0.20	.	0.08	0.32
131a UNME unid. merganser	.	.	.	.	.	.	.	.	0.88	4.60	.	.	.	0.60	.
1320 MALL Mallard	4.84	5.48	5.40	3.83	4.52	0.60	0.20	0.32	0.28	0.28	0.08	0.08	0.04	0.16	0.12
1330 ABDU American Black Duck	27.88	36.96	28.52	28.22	24.08	29.24	12.76	17.44	20.92	17.96	16.08	21.04	13.08	12.00	13.48
133a MBDH Mallard-like Hybrid	.	0.04	.	.	0.08	.	.	.	.	.	.	.	.	0.04	.
133b BDMH Black Duck-like Hybrid	.	.	.	.	.	.	.	.	.	.	.	0.08	.	.	.
133c BLML M Black, F Mallard	.	.	.	.	.	.	.	.	0.16	.	.	.	.	.	.
133d MLBL M Mallard, F Black	.	.	0.16	0.09	0.24	0.24	0.24	0.56	0.28	0.24	.	.	.	0.08	.
133e BHML M blck-like hyb, F Mallard	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
133f BHBL M blck-like hyb, F Black	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
133h MHBL M mall-like hyb, F Black	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1350 GADW Gadwall	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1370 AMWI American Wigeon	.	0.08	.	0.09	0.20	2.56	0.56	0.16	2.44	1.72	0.08	.	.	.	.
1390 AGWT American Green-winged Teal	7.12	7.36	2.76	2.13	4.16	13.64	2.40	3.80	4.40	3.24	9.24	13.48	7.08	5.56	5.88
1400 BWTE Blue-winged Teal	0.12	0.72	0.08	0.70	0.08	2.32	1.20	0.84	1.44	1.40	.	.	.	.	.
1401 UNTE Unidentified Teal	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1420 NSHO Northern Shoveler	.	.	.	0.09	.	.	.	.	.	.	.	.	.	.	.
1430 NOPI Northern Pintail	.	.	.	0.09	.	0.16	.	.	0.08	0.08	0.24	1.00	.	0.04	0.04
1440 WODU Wood Duck	4.28	3.56	3.60	3.09	2.76	0.76	0.32	1.04	2.64	4.04	.	.	.	.	.

(CONTINUED)

Table 1 (continued): Density (per 100km^2) of total waterfowl observed on BDJV plots, 1990 - 1994. 16:32 Thursday, July 14, 1994

	Indicated birds per 100km2														
	NS					ON					PQ				
	90	91	92	93	94	90	91	92	93	94	90	91	92	93	94
1290 COME Common Merganser	4.32	5.88	7.04	7.40	7.24	16.84	17.57	23.89	17.32	19.68	17.86	20.20	16.52	9.36	13.95
1300 RBME Red-breasted Merganser	0.04	.	.	.	.	0.25	0.20	0.43	1.88	0.80	0.45	0.43	0.27	0.88	1.02
1310 HOME Hooded Merganser	0.80	0.08	0.16	0.64	0.56	22.09	24.86	28.91	23.64	29.68	5.17	4.94	3.53	4.16	6.65
131a UNME unid. merganser	2.44	1.96	.	.	.	.	.	.	.	0.12	0.05	.	0.35	.	0.02
1320 MALL Mallard	0.60	0.32	0.68	0.36	0.52	19.57	23.27	27.98	20.48	21.36	2.87	1.59	4.66	8.56	3.19
1330 ABDU American Black Duck	26.52	31.00	42.60	28.56	27.16	18.34	24.80	25.16	22.68	21.44	27.49	22.67	21.65	16.78	15.91
133a MBDH Mallard-like Hybrid	.	.	.	.	.	0.05	0.16	0.48	0.28	0.16	0.07	.	.	.	.
133b BDMH Black Duck-like Hybrid	.	.	.	.	.	0.02	0.18	0.32	0.32	0.08	0.24	0.06	0.01	0.02	0.05
133c BLML M Black, F Mallard	.	.	.	0.16	.	0.05	0.07	0.05	0.08	.	0.02	0.04	0.05	.	0.05
133d MLBL M Mallard, F Black	.	1.12	0.52	0.12	0.72	0.09	0.14	0.09	.	0.48	0.07	0.29	0.07	0.12	0.28
133e BHML M blck-like hyb, F Mallard	.	.	.	.	.	.	.	.	.	.	.	0.02	.	.	.
133f BHBL M blck-like hyb, F Black	.	.	.	.	.	.	.	.	.	.	.	.	0.05	.	.
133h MHBL M mall-like hyb, F Black	.	.	.	.	.	.	.	.	.	.	.	0.10	0.02	.	.
1350 GADW Gadwall	.	.	.	.	.	.	0.02	.	.	.	.	.	.	.	.
1370 AMWI American Wigeon	0.48	1.48	1.72	1.40	0.80	0.50	1.07	0.80	0.64	0.40	0.24	0.17	0.06	0.16	0.47
1390 AGWT American Green-winged Teal	7.28	8.16	13.80	8.04	8.96	5.43	5.77	7.82	3.92	5.88	13.61	9.94	7.37	2.86	7.60
1400 BWTE Blue-winged Teal	1.68	2.32	2.80	1.52	1.04	6.11	5.00	6.34	1.72	1.84	0.93	0.19	0.39	0.22	0.44
1401 UNTE Unidentified Teal	.	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.
1420 NSHO Northern Shoveler	.	.	.	.	.	.	0.09	0.02	0.08	.	0.02	.	0.02	.	.
1430 NOPI Northern Pintail	.	.	.	.	.	0.07	0.09	0.07	.	.	0.48	0.05	0.11	0.04	0.05
1440 WODU Wood Duck	1.20	0.84	1.92	1.84	3.64	13.09	11.84	13.82	15.00	20.28	1.06	0.46	0.40	0.32	1.09

(CONTINUED)

	Indicated birds per 100km2														
	NS					ON					PQ				
	90	91	92	93	94	90	91	92	93	94	90	91	92	93	94
144a UNDA unid. dabbling duck	.	.	.	.	.	0.41	.	.	.	.	0.01	.	0.01	0.02	0.33
1460 REDH Redhead	.	.	.	.	.	.	.	.	.	.	.	.	.	0.04	.
1480 GRSC Greater Scaup	.	.	.	.	.	0.36	0.05	3.11	0.24	0.04	0.14	0.54	1.47	0.80	0.63
1490 LESC Lesser Scaup	.	.	.	.	.	3.18	1.05	0.39	0.12	0.76	2.48	3.80	2.20	0.54	2.79
149a USCA unid. Scaup	.	.	0.36	0.64	.	2.20	0.80	2.30	.	0.20	0.20	0.04	0.11	.	0.79
1500 RNDU Ring-necked Duck	12.60	14.08	23.88	15.12	12.92	36.23	30.34	42.34	28.28	31.24	25.82	20.33	19.57	16.02	22.88
150a UNAY unid. Aythya	.	.	.	.	.	.	.	.	.	.	.	0.04	0.17	.	0.02
1510 COGO Common Goldeneye	.	1.48	2.44	1.20	.	18.32	18.66	20.02	12.64	14.40	16.82	16.77	14.67	13.26	16.70
1520 BAGO Barrow's Goldeneye	.	.	.	.	.	.	.	.	.	.	0.31	0.88	0.76	1.16	0.05
152a UNGO unid. goldeneye	3.40	.	.	.	.	.	.	.	.	.	0.01	0.13	0.48	0.06	0.09
1530 BUFF Bufflehead	.	0.32	1.08	0.28	0.24	7.07	2.98	14.05	3.92	5.48	2.54	2.31	1.58	0.12	2.00
1540 OLDS Oldsquaw	.	.	.	.	.	.	.	.	.	0.92	0.16	0.02	0.02	1.62	1.35
1550 HARD Harlequin Duck	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.05
1590 COEI Common Eider	7.08	9.08	7.84	2.96	2.92	.	.	.	.	.	.	.	.	0.72	.
1630 BLSC Black Scoter	.	.	1.56	.	.	.	0.05	.	.	.	0.14	1.23	2.39	1.60	.
1650 WWSC White-winged Scoter	.	.	.	.	.	.	0.07	.	.	0.40	0.01	0.04	1.08	0.32	4.91
1660 SUSC Surf Scoter	.	.	0.76	.	1.16	.	0.05	0.11	.	.	1.23	1.05	2.04	1.98	4.47
166a USCO unid. scoter	1.88	0.48	.	.	0.16	.	.	.	.	.	.	0.02	0.35	0.02	0.07
168a UNDI unid. diving duck	.	.	.	.	.	0.25	0.41	1.30	1.44	3.28	1.04	1.08	2.73	0.50	1.16
168b UNDU unid. duck	0.12	1.00	0.12	0.08	.	0.45	0.14	0.27	0.12	0.12	.	0.07	0.66	0.08	1.14
1720 CAGO Canada Goose	0.32	0.44	1.96	0.32	0.44	3.50	2.77	3.95	2.64	4.52	18.75	13.20	15.88	15.30	10.60

(CONTINUED)

Table 1 (continued): Density (per 100km^2) of total waterfowl observed on BDJV plots, 1990 - 1994. 16:32 Thursday, July 14, 1994

	Indicated birds per 100km2														
	ME					NB					NF				
	90	91	92	93	94	90	91	92	93	94	90	91	92	93	94
144a UNDA unid. dabbling duck	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1460 REDH Redhead	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1480 GRSC Greater Scaup	.	.	.	.	.	.	.	.	.	.	2.04	1.88	.	.	.
1490 LESC Lesser Scaup	.	.	.	.	.	.	.	.	.	.	1.00	0.44	.	.	.
149a USCA unid. Scaup	.	.	.	.	.	0.52	0.92	0.52	.	.	.	.	1.44	0.80	1.64
1500 RNDU Ring-necked Duck	21.56	31.16	13.44	13.26	14.64	20.00	12.00	11.52	14.88	13.92	29.12	44.72	26.56	25.80	20.40
150a UNAY unid. Aythya	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1510 COGO Common Goldeneye	10.36	2.64	6.88	7.04	2.72	3.60	5.44	1.88	1.68	2.32	21.28	18.44	11.76	12.52	10.84
1520 BAGO Barrow's Goldeneye	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
152a UNGO unid. goldeneye	.	.	.	.	.	0.24	.	.	.	.	.	.	.	.	.
1530 BUFF Bufflehead	14.44	10.76	0.72	0.91	5.04	.	.	0.04	.	.	.	0.08	.	.	.
1540 OLDS Oldsquaw	.	0.08	.	.	0.28	.	.	.	.	.	.	.	.	0.08	.
1550 HARD Harlequin Duck	.	.	.	.	.	.	.	.	.	.	.	.	.	0.16	.
1590 COEI Common Eider	0.32	12.68	1.44	5.13	0.88	0.08	.	.	1.60	.	.	.	.	.	.
1630 BLSC Black Scoter	.	.	.	.	.	.	.	.	.	.	.	0.12	0.16	.	.
1650 WWSC White-winged Scoter	.	.	.	0.04	.	.	.	.	.	.	.	.	.	.	.
1660 SUSC Surf Scoter	.	.	.	0.87	.	0.16	.	.	.	.	3.04	3.20	2.20	2.44	2.08
166a USCO unid. scoter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.04
168a UNDI unid. diving duck	.	.	.	.	.	.	.	.	.	.	.	.	.	0.08	0.20
168b UNDU unid. duck	1.52	1.96	0.28	0.43	0.72	.	0.08	.	0.16	0.16	0.04	0.08	0.20	.	.
1720 CAGO Canada Goose	5.72	2.92	2.28	4.39	2.16	0.16	.	.	.	.	13.44	16.84	13.76	16.96	15.20

(CONTINUED)

Table 1 (continued): Density (per 100km^2) of total waterfowl observed on BDJV plots, 1990 - 1994. 16:32 Thursday, July 14, 1994 16:32

	Indicated birds per 100km2				
	SUM				
	90	91	92	93	94
1290 COME Common Merganser	15.05	16.21	15.89	10.79	13.21
1300 RBME Red-breasted Merganser	0.57	0.62	0.48	1.36	1.20
1310 HOME Hooded Merganser	8.68	9.22	11.16	8.57	11.36
131a UNME unid. merganser	0.24	1.96	0.35	0.68	0.38
1320 MALL Mallard	6.84	7.24	9.93	9.65	7.44
1330 ABDU American Black Duck	23.60	23.42	22.37	18.92	17.99
133a MBDH Mallard-like Hybrid	0.06	0.14	0.48	0.20	0.15
133b BDMH Black Duck-like Hybrid	0.16	0.10	0.12	0.13	0.06
133c BLML M Black, F Mallard	0.03	0.05	0.05	0.10	0.05
133d MLBL M Mallard, F Black	0.09	0.28	0.13	0.12	0.36
133e BHML M blck-like hyb, F Mallard	.	0.02	.	.	.
133f BHBL M blck-like hyb, F Black	.	.	0.05	.	.
133h MHBL M mall-like hyb, F Black	.	0.10	0.02	.	.
1350 GADW Gadwall	.	0.02	.	.	.
1370 AMWI American Wigeon	0.44	0.53	0.39	0.51	0.53
1390 AGWT American Green-winged Teal	10.31	8.69	7.32	3.77	6.58
1400 BWTE Blue-winged Teal	2.62	1.87	2.35	0.85	0.95
1401 UNTE Unidentified Teal	.	0.04	.	.	.
1420 NSHO Northern Shoveler	0.02	0.09	0.02	0.08	.
1430 NOPI Northern Pintail	0.31	0.21	0.09	0.05	0.05
1440 WODU Wood Duck	4.92	4.14	4.82	5.21	7.41

(CONTINUED)

	Indicated birds per 100km2				
	SUM				
	90	91	92	93	94
144a UNDA unid. dabbling duck	0.16	.	0.01	0.02	0.33
1460 REDH Redhead	.	.	.	0.04	.
1480 GRSC Greater Scaup	0.50	0.59	2.07	0.59	0.41
1490 LESC Lesser Scaup	2.47	2.42	1.54	0.39	2.04
149a USCA unid. Scaup	0.91	0.36	0.94	0.76	0.74
1500 RNDU Ring-necked Duck	28.01	25.99	26.07	20.39	23.54
150a UNAY unid. Aythya	.	0.04	0.17	.	0.02
1510 COGO Common Goldeneye	16.81	15.65	14.18	11.60	13.80
1520 BAGO Barrow's Goldeneye	0.31	0.88	0.76	1.16	0.05
152a UNGO unid. goldeneye	0.28	0.13	0.48	0.06	0.09
1530 BUFF Bufflehead	4.77	2.48	5.27	1.42	3.22
1540 OLDS Oldsquaw	0.16	0.03	0.02	1.28	1.14
1550 HARD Harlequin Duck	.	.	.	0.16	0.05
1590 COEI Common Eider	2.22	10.91	4.59	1.26	1.88
1630 BLSC Black Scoter	0.14	0.69	1.87	1.60	.
1650 WWSC White-winged Scoter	0.01	0.05	1.08	0.30	3.25
1660 SUSC Surf Scoter	1.51	1.07	1.43	2.00	3.75
166a USCO unid. scoter	1.88	0.06	0.35	0.02	0.07
168a UNDI unid. diving duck	0.75	0.84	2.21	0.73	1.67
168b UNDU unid. duck	0.41	0.21	0.45	0.11	0.72
1720 CAGO Canada Goose	11.62	9.74	10.99	10.80	8.71

Appendix B

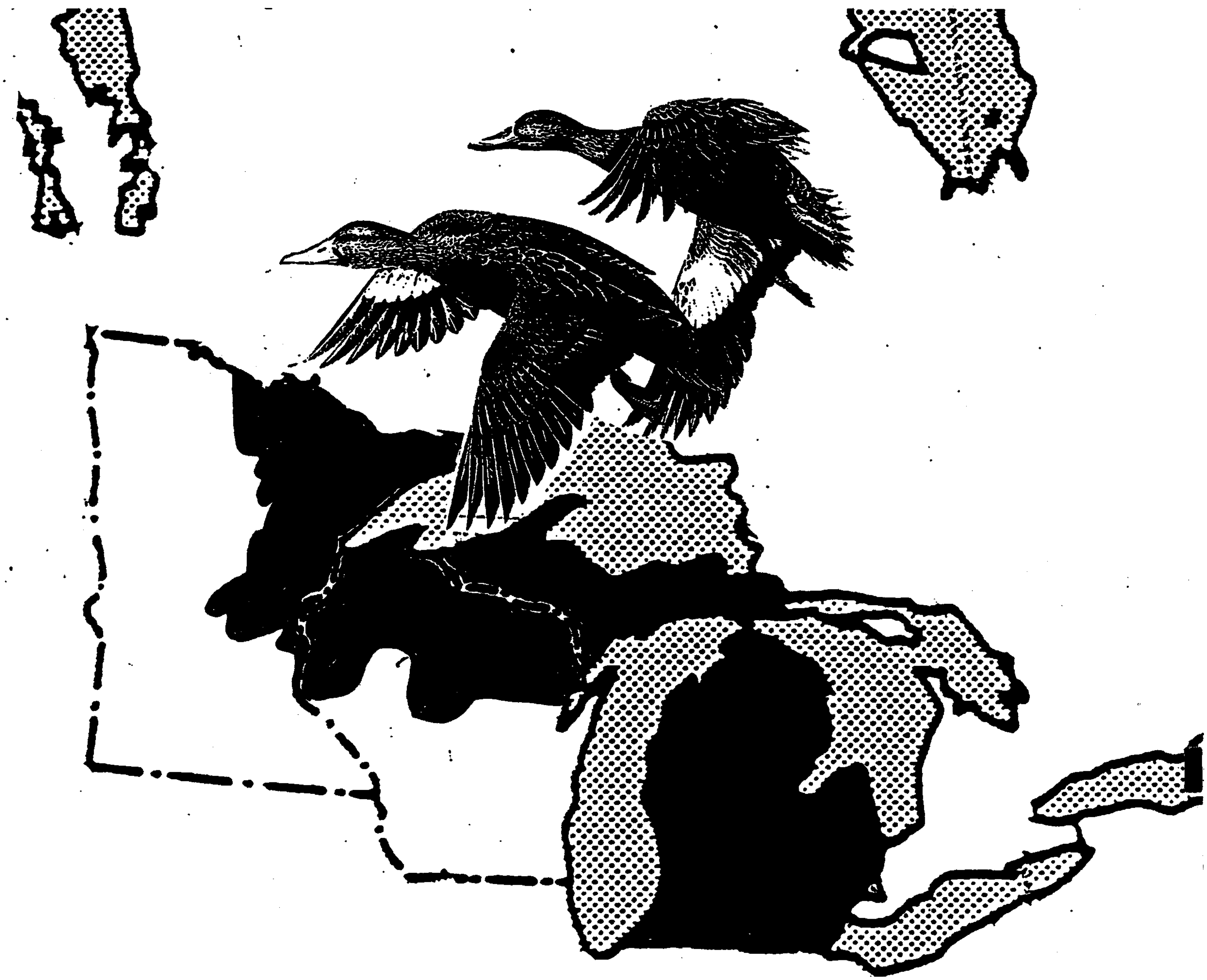
1994 WATERFOWL BREEDING POPULATION SURVEY RESULTS

FOR THE LAKES STATES

OF MICHIGAN, MINNESOTA AND WISCONSIN

A Cooperative Project of the Black Duck Joint Venture

JULY 1994



TITLE 1994 Waterfowl Breeding Population Survey for the Lakes States of Michigan, Minnesota and Wisconsin - a cooperative project of the Black Duck Joint Venture

STRATA SURVEYED Michigan (statewide) and Wisconsin (northern)
Minnesota did not conduct a 1994 survey.

DATA SUPPLIED BY Michigan Department of Natural Resources
Wisconsin Department of Natural Resources
United States Fish and Wildlife Service

Fixed-wing Aerial Crews
Michigan Pilots - J. Kincaide and C. Black (Pontiac Flight Service), W. Greene and S. Adkins (DNR)
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Wisconsin DNR - M. Anderson, T. Bahti, C. Botwinski, C. Cold, G. Dahl, D. Evenson, M. Gappa, R. Greene, W. Hall, J. Huff, G. Kessler, K. Morgan, J. Olson, J. Robaidek, M. Rowe, and F. Vanacek,
Great Lakes Indian Fish and Wildlife Commission - J. Denomie and J. Heim
U. S. Fish and Wildlife Service - B. Goche and D. Johnson

ABSTRACT
This report presents results of the 1994 Lakes States breeding waterfowl survey, partially funded by the Black Duck Joint Venture. The Lakes States breeding waterfowl survey, as designed, consists of three separate strata including Michigan (statewide), Minnesota (northeast) and Wisconsin (northern) at the western extreme of historic black duck breeding range. In 1994, however, Minnesota did not participate in the survey effort. The 1994 study was the fourth year of experimental fixed-wing surveys (adjusted by helicopter visibility segments). Almost 3,330 lineal miles of fixed-wing transects were flown within the 81,358 square miles of Lakes States strata in Michigan and northern Wisconsin. Helicopter versus fixed-wing visibility corrections were obtained in Michigan (12 segments; 216 linear miles) and Wisconsin conducted 20 ground crew routes (about 250 linear miles).

The 1994 Lakes States breeding waterfowl population estimate for the Michigan and northern Wisconsin portions adjusted for visibility, was 973,214 ducks, including 518,003 mallards, 196,418 wood ducks, and 9,162 black ducks. The breeding Canada goose estimate (giant

Canadas) was 216,580. The overall 1994 duck population estimate compares with 889,502 during 1993, a nine percent increase. The 1994 fall flight from the Lake States strata of Michigan and northern Wisconsin is expected to be increased from 1993.

BACKGROUND AND METHODS

The survey strata encompassed in this report are on the western extreme of the historic range of the black duck and encompasses northeastern Minnesota, northern Wisconsin and all of Michigan. Surveyed areas are shown in Figures 1-3 and the survey coverage is shown in Table 1. This was the fourth year for the experimental fixed-wing survey in the Lake States for Michigan although Wisconsin has been conducting fixed-wing surveys on a statewide basis for 22 years.

Partial funding for this effort was made available from the Black Duck Joint Venture.

Fixed-wing survey flights were conducted using a Cessna 172RG in southern Michigan, a Cessna 182 and a Cessna 206 in northern Michigan, and a Cessna 185 in Wisconsin. The procedures followed in conducting the survey are contained in the *Standard Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys* (USFWS/CWS revised 1987).

Air/ground Comparisons: A total of 20 air/ground comparisons were run in Wisconsin. All comparisons were on operational transect lines and each was 10 to 15.5 miles in length traversed by 2 observers. Wisconsin has been conducting air/ground checks for 12 years.

Fixed-wing/helicopter Comparisons: Fixed-wing/helicopter comparisons were conducted in Michigan for the third year in 1994 to help establish species visibility corrections. A Bell 206 Jet Ranger and a Hughes 500 helicopter were used. Seven helicopter/fixed-wing segments were flown in the Farm/Urban Stratum and five in the northern Lower Peninsula's Forest Stratum within one day of the fixed-wing coverage. Each segment was 18 miles long by 0.25 miles wide and their selection was based on high numbers of waterfowl observed in 1991 through 1993 or characteristic habitats.

Weather and Habitat Conditions

In Michigan, 1994 spring water conditions were somewhat drier than normal across most of the state. Little precipitation was received during the survey period, however, on 4-21-94 southern lower Michigan did receive an evening of heavy rain which resulted in considerable sheet water observed on the following days' flight. High winds also posed a hazard, and did prevent flights on a few occasions. Average temperatures ranged from near normal in the north to slightly above normal in the south, as opposed to the below average temperatures experienced in the spring of 1993 and 1992. The onset of nesting for Canada geese and mallards came at the normal time this year in contrast to both 1992 and 1993 when the onset was 10-14 days later than normal.

Overall, the survey timing was appropriate to this year's phenology, although, observers in the north half of Michigan's Farm/Urban strata were slightly hampered by advancing leafout.

In 1993 and 1994, Michigan compared a growing degree day index obtained from the Dept. of Agriculture's Cilimatology unit at Michigan State University to develop survey timing. The growing degree days index appears to be a valuable predictor for determining the approximate time to begin survey efforts.

Wisconsin reported that October-April precipitation was 28 percent less than normal for that period. Overall, precipitation statewide during the spring period of April 1 - May 31 was near normal. Southeast Wisconsin experienced less than normal amounts, while west central Wisconsin experienced slightly higher than normal levels. Wetland numbers were down overall from 1993, however, type III wetlands showed a dramatic increase in numbers. Type III wetlands were at record levels and may be attributed to the new observer used in 1994.

BREEDING POPULATION ESTIMATES

The 1994 Lakes States waterfowl breeding population estimate for Michigan and northern Wisconsin (adjusted for visibility) is 973,214 ducks, including 518,003 mallards and 9,162 black ducks (Table 2). There were 53,645 blue-winged teal and 196,418 wood ducks. There were also 34,749 ringnecks tallied, 26,476 scaup and 61,849 mergansers. Michigan reported an estimate of 210,598 breeding Canada geese (statewide) while Wisconsin recorded 5,982 in its northern forests. The coot estimate was only 862.

It should be noted at this point that Wisconsin data in this report was submitted for inclusion in the *1994 USFWS STATUS REPORT*. Wisconsin has now been contributing to that report for 22 years.

Based on these data, the overall Lake States duck breeding population estimate for 1994 in Michigan and northern Wisconsin was 9 percent more than 1993. This included a 7 percent increase for mallards but an 11 percent decrease for blue-winged teal. The wood duck estimate declined 7 percent from 1993 although precision of the estimate is not good. (Wisconsin's statewide mallard estimate this year was the highest on record in their 22 year survey and 128% higher than the previous 21 year mean.)

The 81,358 square miles of habitat sampled in the Lakes States survey region in 1994 is supporting about one-half million mallards but less than 10,000 black ducks in this historic black duck breeding range. At this point, biometric analysis of annual variability of survey results is incomplete, but overall precision of estimates for total ducks and that of several important species have fluctuated from 20 to over 50 percent in the four years of survey effort. Helicopter visibility corrections obtained for wood ducks in Michigan habitats is much larger than for other species, and additional evaluation is warranted. It is recommended that these surveys be continued in future years, including a Minnesota effort, to better estimate long-term average densities and population trends for the various duck species in the historic black duck range of the Lakes States.

VISIBILITY CORRECTION FACTORS

Visibility correction factors utilized to obtain the 1994 breeding waterfowl estimates are shown in Table 3 and are discussed below.

Michigan - The helicopter/fixed-wing visibility correction used to calculate the 1994 estimates of mallards, wood ducks, blue-winged teal, and Canada geese were derived from Michigan data. Those for the Farm/Urban stratum (F/U) were derived by pooling data from the last three years (1992-94) and those from the Forest stratum (FOR) by pooling the 1993-94 data. The Visibility correction for blue-winged teal was a statewide value, not broken out by stratum, since there were insufficient sightings of bluewings from the fixed-wing routes in forested areas. The remainder of the species values used in the Michigan estimates were obtained from USFWS stratum 50, (pers. comm., Clint Moore, Biometrician, Population Assessment Section, OMBM, Laurel, MD).

Wisconsin - pooled strata data yielded an air/ground visibility ratio of 1.893 for mallards, 2.554 for Blue-winged teal, and 1.96 for Canada Geese. Data were too variable for Wood ducks and all other species, so the 1994 air/ground data were pooled with the prior years (2-6) to yield the correction ratios shown in Table 3.

CONCLUSIONS

In general, habitat conditions throughout the Michigan and northern Wisconsin portions of the Lake States survey region included fewer water areas this spring than in 1993. Temperatures were normal to slightly above normal in Michigan, and normal in Wisconsin during the spring survey period. Breeding duck populations were 9 percent greater than the levels estimated in 1993. Mallards made up about 53 percent of the 973,214 ducks estimated, but the 9,162 black ducks were only 1 percent. If good summer water conditions continue, the fall flight for 1994 will be slightly larger than 1993.

TABLE 1. LAKE STATES SURVEY DESIGN FOR MICHIGAN, MINNESOTA AND WISCONSIN April/May 1994*

STRATUM	MICHIGAN (statewide)	MINNESOTA (northeast)	WISCONSIN (northern)	TOTAL
<u>Survey Design</u>				
Square miles in stratum	55,948	19,590	25,410	100,948
Square miles in sample	684	270	195	1,149
Lineal miles in sample	2,736	1,080	780	4,596
No. of transects in sample	22	14	26	62
No. of segments in sample	152	60	10	222
Expansion factor	81.795	72.556	130.308	87.857
<u>Current Year Coverage</u>				
Survey Dates	4/22 - 5/19	NO SURVEY	5/2-5/16	---
Square miles in stratum	55,948	"	25,410	81,358
Square miles in sample	679.5	"	195	874.5
Lineal miles in sample	2,718	"	780	3,498
No. of transects in sample	22	"	26	48
No. of segments in sample	151	"	20	171
Expansion factor	82.337	"	130.308	93.034

* Historic Black Duck Range - In Michigan the statewide survey encompasses two sub - strata (northern Forest A & B and southern Farm - Urban). In Wisconsin the survery encompasses two forested sub - strata (northern high density and northern low density).

TABLE 2. A COMPARISON OF LAKE STATES WATERFOWL BREEDING POPULATION ESTIMATES BY SPECIES AND STRATUM BETWEEN 1994 AND 1993 WITH ADJUSTMENTS FOR VISIBILITY BIAS

	LAKE STATE STRATUM (1994)			1994	1993	% CHANGE
SPECIES	MICHIGAN	MINNESOTA	WISCONSIN	TOTAL	TOTAL	VS. 1993
DUCKS						
Dabblers						
Mallard	428,996	NO SURVEY	89,007	518,003	482,888	+ 7%
Black Duck	8,147	"	1,015	9,162	5,523	+ 66%
Gadwall	0	"	0	0	1,835	---
Widgeon	6,965	"	0	6,965	7,288	- 4%
G-W Teal	1,926	"	3,045	4,971	1,603	+ 310%
B-W Teal	26,224	"	27,421	53,645	59,072	- 9%
Shoveler	1,486	"	0	1,486	0	---
Pintail	323	"	0	323	612	---
Wood Duck	176,883	"	19,535	196,418	210,454	- 7%
SUBTOTAL	650,950		140,023	790,973	769,275	+ 3%
Divers						
Redhead	0	"	0	0	831	---
Canvasback	0	"	0	0	0	---
Scaup	26,476	"	0	26,476	27,995	- 5%
Ringneck	15,806	"	18,943	34,749	41,116	- 15%
Goldeneye	6,104	"	7,893	13,997	9,039	+ 55%
Bufflehead	32,203	"	12,967	45,170	14,765	+ 306%
Ruddy Duck	0	"	0	0	3,324	---
SUBTOTAL	80,589		39,803	120,392	97,070	+ 24%
Miscellaneous						
Oldsquaw	0	"	0	0	0	---
Eider	0	"	0	0	0	---
Scoter	0	"	0	0	0	---
Merganser	38,254	"	23,595	61,849	23,157	+ 267%
SUBTOTAL	38,254	"	23,595	61,849	23,157	+ 267%
TOTAL DUCKS	769,793	*	203,421	973,214	889,502	+ 9%
Canada Geese	210,598	"	5,982	216,580	186,651	+ 16%
American Coot	862	*	*	862	1,135	---

*Not surveyed

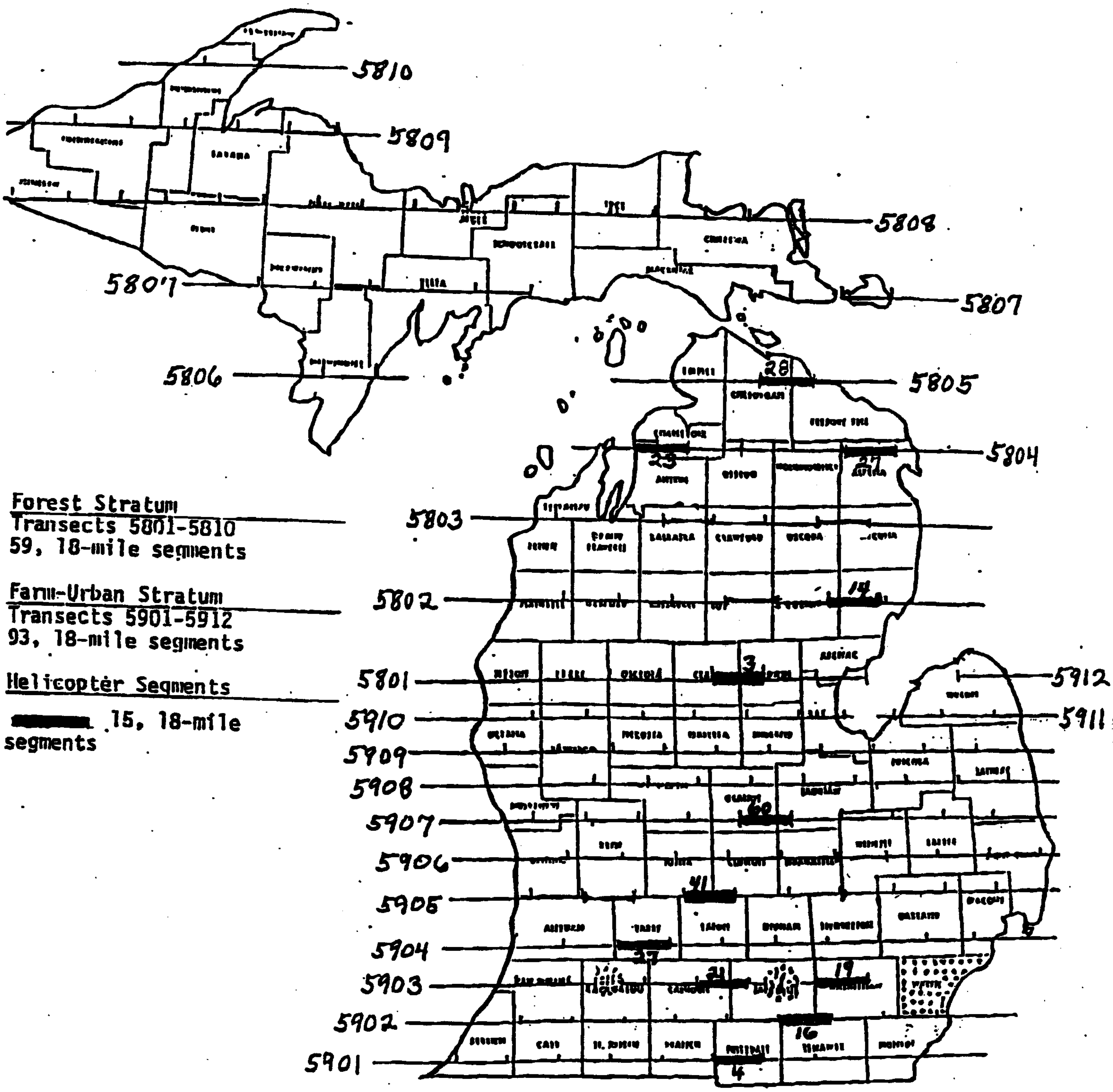
TABLE 3. 1994 VISIBILITY RATES, LAKE STATES, BREEDING WATERFOWL POPULATION SURVEY

SPECIES	VISIBILITY RATES MICHIGAN*	MINNESOTA	WISCONSIN**
Mallard	3.87 (F/U)	NO SURVEY	1.893
	5.50 (FO)	"	
Black Duck	2.86	"	5.246
Wood Duck	19.32 (F/U)	"	5.246
	94.5 (FO)	"	
Gadwall	---	"	---
Wigeon	5.71	"	---
G-W Teal	2.43	"	5.246
B-W Teal	8.27	"	2.554
Shoveler	3.48	"	---
Pintail	2.65	"	---
Redhead	3.11	"	---
Canvasback	---	"	---
Scaup	1.98	"	---
Ringneck	3.00	"	5.246
Goldeneye	1.59	"	5.246
Bufflehead	2.21	"	5.246
Oldsquaw	---	"	---
Scoters	---	"	---
Ruddy Duck	---	"	---
Mergansers	2.10	"	5.246
Coot	4.71	"	---
Canada Goose	4.25 (F/U)	"	1.96
	6.2 (FO)	"	

* Visibility rates for the mallard, wood duck, and Canada goose are unique to Michigan and were obtained by fixed-wing versus helicopter comparisons. All other rates were supplied by the USFWS. F/U = Farm-Urban and FO = Forest Stratum.

** The visibility rates for Wisconsin were optained by fixed-wing versus ground crew comparisions; 1994 data was used for mallards and pooled 1993-94 data for blue-winged teal; pooled 1992-94 data were used for all other ducks; and 1989-94 data were used for Canada geese.

Fig. 1. 1994 MICHIGAN BREEDING WATERFOWL SURVEY TRANSECT LOCATIONS



= Areas ommited from the survey

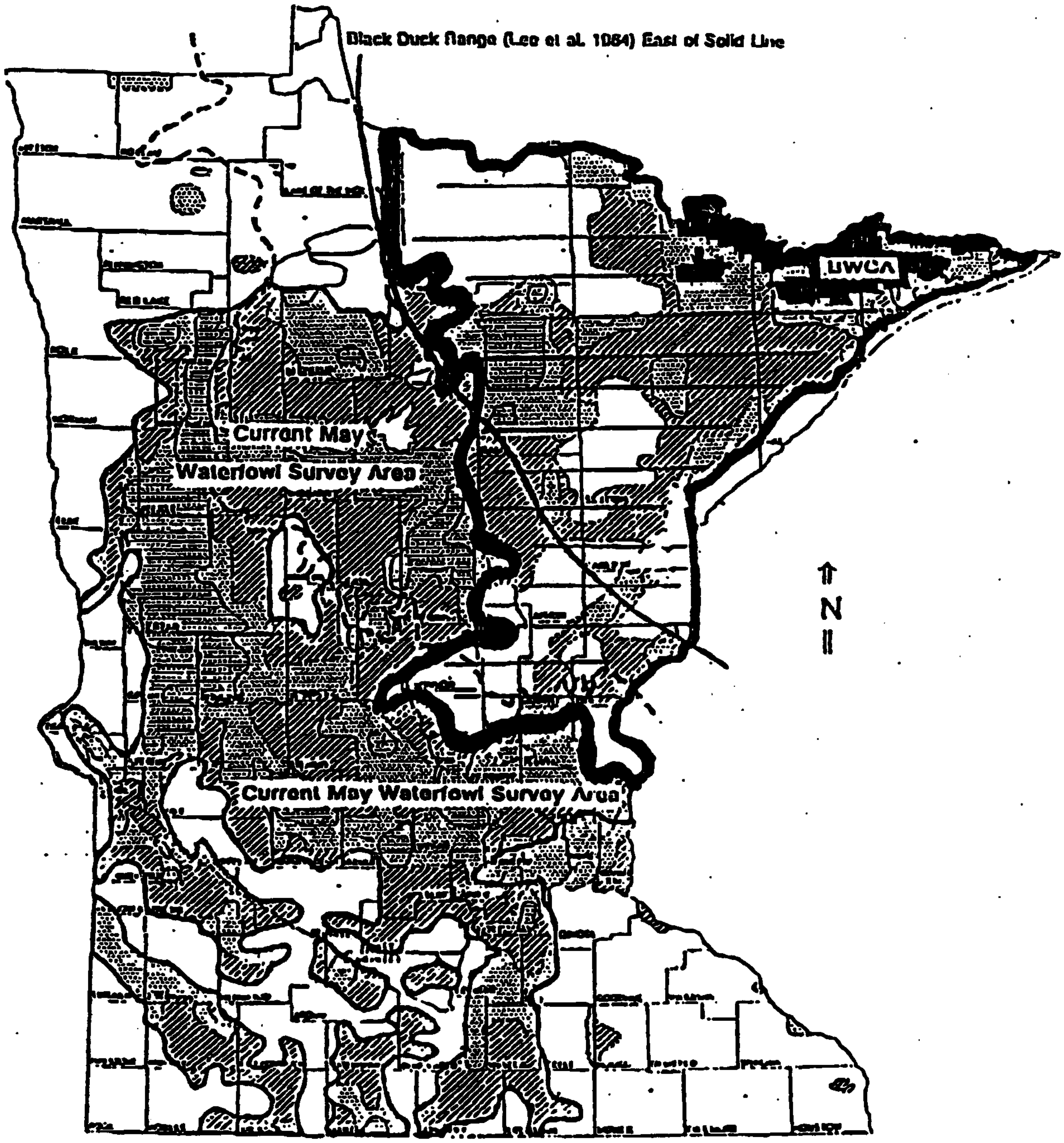


Fig 2 Minnesota's historic Black Duck breeding range is located within the heavy solid black line (excluding Boundry Waters Canoe Area). The approximate location of the transects from previous years are displayed within this line, however, Minnesota did not participate in the survey this year.

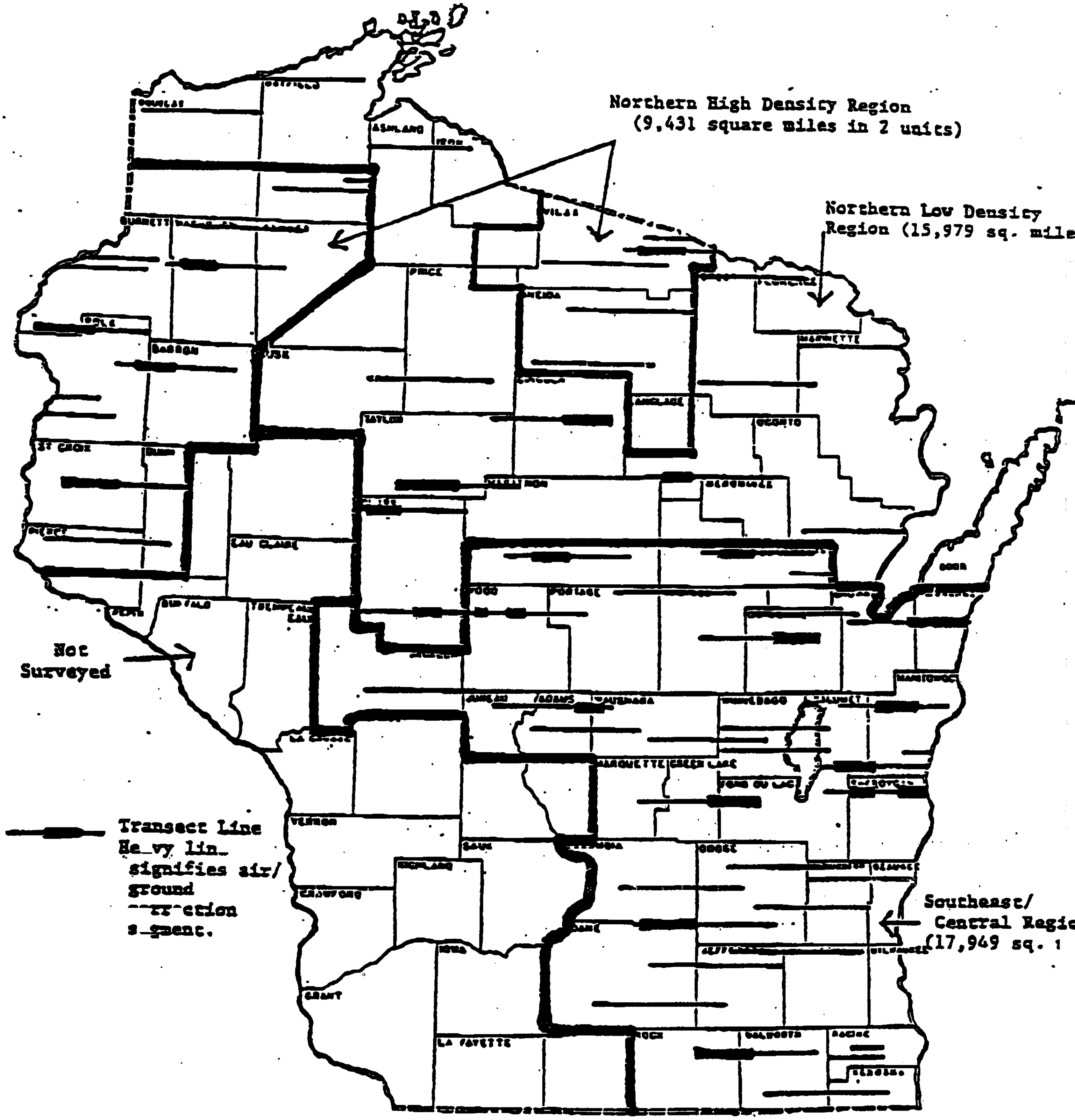


Fig. 3. Transect Lines and Regions Surveyed during the 1994 Wisconsin Breeding Waterfowl Study.

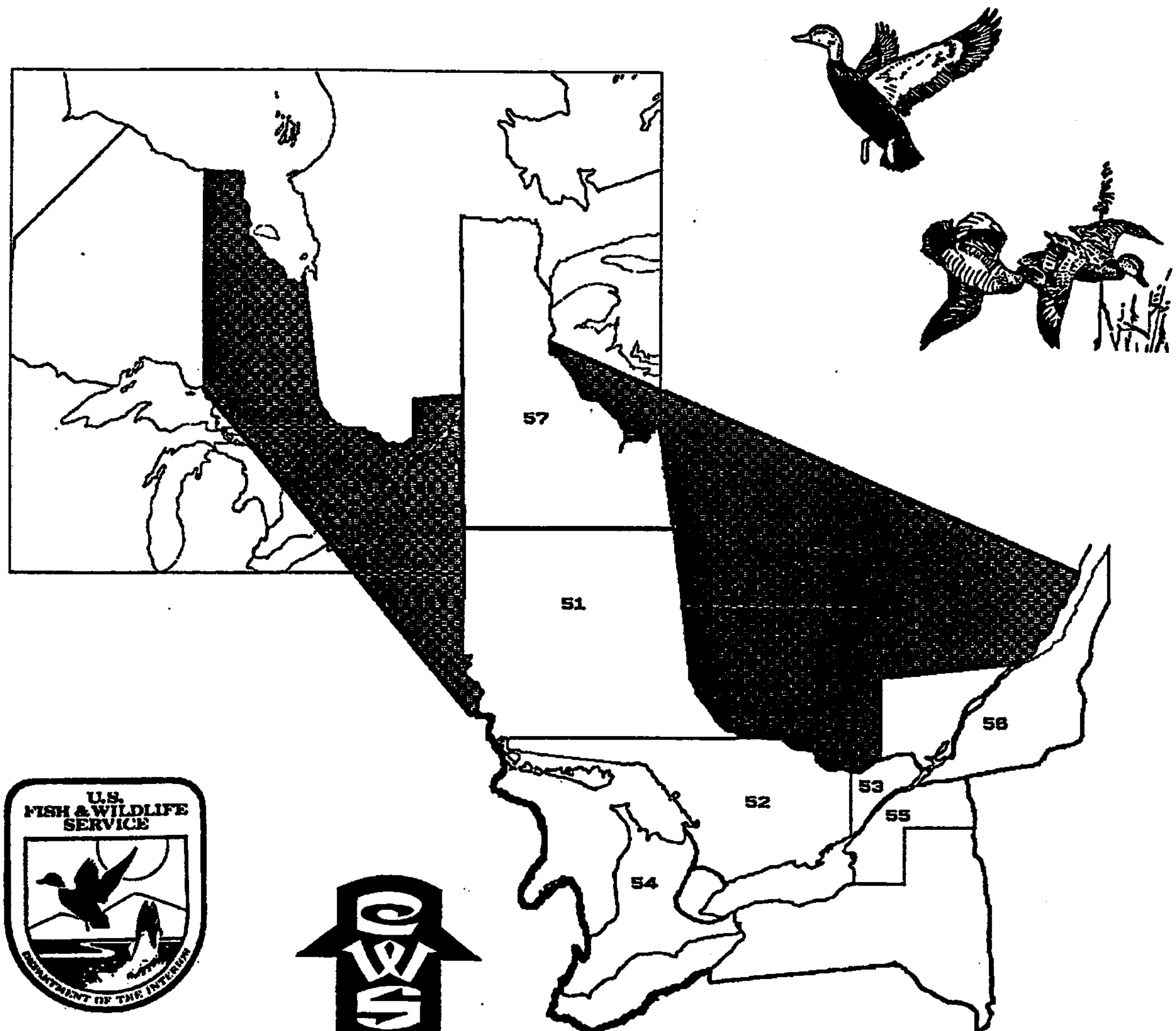
Appendix C

PILOT STUDY

WATERFOWL BREEDING POPULATION SURVEY

ONTARIO, QUEBEC, AND NEW YORK

MAY 1994



The data presented in this report are preliminary. Final estimates are available from the U. S. Fish and Wildlife Service, Office of Migratory Bird Management, Patuxent Wildlife Research Center, Laurel, Maryland 20708-9619

TITLE	Waterfowl Breeding Population Survey for Ontario, Quebec, and New York
STRATA SURVEYED	51, 52, 53, 54, 55, 56
DATES	April 28 - May 24, 1994
DATA SUPPLIED BY	United States Fish and Wildlife Service Canadian Wildlife Service

Aerial Crew

Pilot/Observer	J. R. Goldsberry, USFWS
Observer	P. Poulos, USFWS
Pilot/Observer	F. H. Roetker, USFWS
Observer	E. Rauber, USFWS

Helicopter Crews

Crew Members	N. North, CWS D. Turcotte, Hussion Helicopters

ABSTRACT

The Spring of 1994 was the fifth year of a five year experimental survey to determine the waterfowl breeding populations of New York, Ontario, and Quebec. Generally, the spring was wet and cool in the survey area. Waterfowl breeding populations in the surveyed areas indicated 1,289,600 for all species. This number was down -9.9 percent from 1993 but up 2.3 percent from the four-year average. Due to an illness on the principal crew, not all lines were completed and stratum 51 was flown by a different crew.

REVISIONS TO THE MAY BREEDING WATERFOWL SURVEY

Several revisions to the analytical procedures for the May Breeding Waterfowl Survey were implemented this year. These revisions resulted in more accurate and precise population estimates. As a result of these revisions, population estimates of some species changed. Also, for the first time, measures of precision are available for all estimates.

In 1984 the Office of Migratory Bird Management (MBMO) contracted Dr. David C. Bowden, a statistician at the Statistical Laboratory, Colorado State University, to review the May Survey. Dr. Bowden's review dealt primarily with the problem of visibility bias and he recommended a number of changes in the survey. During 1989-90 another review of the survey was conducted by the Population Assessment Section, Branch of Operations, Office of Migratory Bird Management. In this review, questions about the survey posed by Dr. Bowden were answered and decisions were made for changes in the survey.

Each year the ground and air counts on the air/ground transects of the survey are used to estimate visibility correction factors (VCFs). Usually there is adequate data to reliably estimate a VCF for the major species (i.e., mallard, pintail, blue-winged teal). However, in some areas, and with some species, too few ducks are seen to reliably estimate a VCF. When this occurs, the Standard Operating Procedure (SOP) requires the use of data from previous years to aid in the estimation. In the past, average VCFs from prairie portions of the survey during 1961-1973 were used. This approach was not used this year. Instead 1992 data, along with data from the most recent past, was used to calculate a VCF. This is a better approach because the most recent, and therefore, the most relevant data have been used to calculate the VCF.

Additional aspects of the survey were also addressed this year. Recent experimental helicopter work has supplied information on VCFs for boreal forest regions of Canada and Alaska and for tundra areas in Alaska. In previous years average VCF values from the prairie and parkland areas of the survey were used in these areas. The new VCFs, for the most part, are lower values than those used historically. This has resulted in population estimates being lower than historical values. The northern pintail is an example of a species with lower population estimates resulting from declines in VCFs in Alaska boreal forest and tundra areas.

MBMO's review of the survey is nearing completion. Results of the review will be distributed as a USFWS Biological Report. The May Breeding Waterfowl Survey must remain dynamic to take advantage of improvements in both survey design and analytical techniques. CWS and USFWS, in cooperation with other federal, provincial, and state entities, are in the process of implementing a number of other improvements. CWS and its Canadian partners are expanding the number of air/ground transects with the hope of improving monitoring capabilities for the Prairie Habitat Joint Venture under the North American Waterfowl Management Plan. MBMO biologists have and will be expanding the number of air/ground transects in the Dakotas and Montana to calculate more precise VCFs. MBMO is cooperating with Flyway Technical Committees to upgrade or initiate surveys in areas currently not part of the Survey. Experimental surveys in eastern Canada, as part of the Black Duck Joint Venture, have been initiated. Surveys by states in the Pacific Flyway have been upgraded and new surveys have begun or will be initiated soon. It is the hope of CWS and USFWS that a better understanding of continental duck populations will result from these efforts.

Due to the above revisions, the reader should be aware that data and tables contained herein should not be compared to tables from previous issues of the Waterfowl Breeding Population Survey reports.

METHODS

The procedures followed in conducting the survey are contained in the Standard Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys, Section III, revised April 1987.

The spring of 1994 was the fifth year of a five year experimental survey to determine waterfowl breeding populations in portions of New york, Ontario, and Quebec. Due to an illness only strata 53, 54, and 55 were flown completely, while strata 52 and 56 were partially surveyed by the principal crew. Stratum 51 was flown by a substitute crew that had flown the area experimentally in 1993. Visibility rates for the substitute crew were determined using a helicopter. Stratum 57 was not flown.

Fixed-wing/helicopter comparisons: In 1994 fixed-wing/helicopter comparisons were flown on six transects in stratum 51 for crew 2. This was the second year of comparisons in stratum 51. A total of 20 segments were compared. The work will be presented in another report. Visibility rates were established by helicopter comparisons or by the same methods as used in western Canada, the United States prairie, and Alaska using the long-term average for bush, prairie, and parkland (see Table 1).

Survey dates: The survey was initiated on April 28 and completed on May 24, 1994. Crew 1 pilot and observer were the same as in 1990, 1991, 1992 and 1993. Crew 2 pilot and observer were also the same as in 1993.

WEATHER AND HABITAT CONDITIONS

The fall of 1993 was mild with normal precipitation well into December. Late December brought winter in with a bang and one of the longest and coldest periods was recorded across the region. Precipitation was variable but tended to be above normal. The end of January brought the normal late month thaw but then cold temperatures returned. The early part of February was cold followed by mid-month temperatures in the double digits, and a severe storm late in the month. March was generally colder than normal throughout the month with normal precipitation. April had snow early in the month, with mild temperatures and a dry period in the middle. A cool, damp period followed at the end. May was cool and damp all month with a very unusual snowfall across the region late in the month. The ducks, particularly mallards, were well into breeding, since several large flocks of drakes were observed. Since habitat conditions are more permanent and wetlands more stable, habitat should be adequate throughout the area.

BREEDING POPULATION ESTIMATES

1994 data show a total breeding population of 1,289,600, for all species in northern New York, northern and southern Ontario, and southern Quebec (strata 51-56). This breeding population was -9.9% below 1993, and 2.3% above the previous four-year mean (see Table 1). Dabbling ducks were -31.4% below 1993, and -15.1% below the four-year mean. Diving ducks were up 18.6% from 1993, and up 9.5% from the four-year mean. Miscellaneous species were up 50% from 1993 and up 71.7% from the four-year mean. Mallards declined -0.5% from 1993 and were 27.3% above the four-year mean. Black ducks were down -14.0% from 1993 and also down -16.2% from the four-year mean. In the diving species Ring-necked ducks were down -18.1% from 1993, but were 16.0% above the four-year mean. Mergansers showed a 42.2% increase over 1993, and a 67.1% increase over the four-year mean.

Although comparisons have been made, this is a new survey area and increases or decreases in the populations maybe significant or just normal fluctuations.

The Canada goose population indicated an increase of 24.5% over 1993 and a decrease of -32.7% from the four-year mean. It must be noted that many of the geese counted in strata 53 and 56 are staging geese and fluctuate from year to year, depending on the chronology of the season. However, Canada geese counted in the other strata are geese actually nesting in those strata.

Habitat conditions appeared to be as good or better than in 1993 and production in the surveyed area should be about the same as last year and the previous four years.

CONCLUSIONS

1994 should be a normal breeding season for the area. Although there was a snow storm across some of the area in late May, production should not be affected.

Table 1. Status of waterfowl breeding population estimates by species and stratum with comparisons against the previous year (estimates in thousands).[a]

	Stratum (1994)									% Change	
Species/Ponds	51	52	53	54	55	56	1994 Total	1993 Total	4-Year Mean	1993	4-Year Mean
Ducks											
Dabblers											
Mallard	68.8	76.2	25.9	68.1	29.7	63.7	332.5	334.2	261.1	-0.5%	27.3%
Am. black duck	57.0	23.6	7.4	6.0	3.0	10.0	107.0	124.4	127.7	-14.0%	-16.2%
Gadwall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	5.9	-100.0%	-100.0%
Am. widgeon	4.6	4.0	0.0	8.0	0.0	3.9	20.6	10.3	27.6	100.4%	-25.5%
Am. green-winged teal	28.7	13.8	1.4	9.7	0.8	0.9	55.3	47.4	127.9	16.6%	-56.7%
Blue-winged teal	4.2	43.2	0.0	47.3	4.8	14.2	113.6	400.5	184.5	-71.6%	-38.4%
N. shoveler	0.0	0.0	0.0	1.1	0.0	0.0	1.1	1.0	1.3	8.5%	-19.4%
N. pintail	0.0	0.0	1.1	0.0	0.0	0.0	1.1	0.4	7.9	194.2%	-85.8%
Subtotal	163.3	160.8	35.8	140.3	38.2	92.8	631.2	920.1	743.8	-31.4%	-15.1%
Divers											
Redhead	0.0	0.0	0.0	5.8	0.0	0.0	5.8	4.5	2.9	30.3%	97.9%
Canvasback	0.0	0.0	0.0	4.6	0.0	0.0	4.6	3.0	3.1	56.1%	50.9%
Scaups	4.4	38.7	0.0	5.4	0.0	0.0	48.5	19.8	25.2	145.3%	92.6%
Ring-necked duck	64.7	91.1	1.8	32.7	2.9	10.2	203.3	248.2	175.2	-18.1%	16.0%
Goldeneyes	44.3	10.5	0.0	3.5	0.0	36.3	94.7	42.2	63.2	124.3%	49.8%
Bufflehead	9.9	27.0	0.0	11.0	0.3	0.0	48.2	18.9	96.0	155.5%	-49.8%
Ruddy duck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	4.3	-100.0%	-100.0%
Subtotal	123.3	167.3	1.8	63.0	3.3	46.5	405.1	341.6	369.8	18.6%	9.5%
Miscellaneous											
Oldsquaw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.8	-100.0%	-100.0%
Eiders	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	--
Scoters	18.3	0.0	0.0	0.0	0.0	0.0	18.3	0.0	3.1	--	488.2%
Mergansers	86.2	122.8	0.2	15.8	2.7	7.1	235.0	165.2	140.6	42.2%	67.1%
Subtotal	104.6	122.8	0.2	15.8	2.7	7.1	253.3	168.9	147.5	50.0%	71.7%
Total Ducks	391.1	450.9	37.8	219.1	44.2	146.4	1289.6	1430.6	1261.2	-9.9%	2.3%
Canada Goose[b]	3.7	3.5	181.5	14.9	6.2	40.3	250.1	200.9	371.7	24.5%	-32.7%
Am. coot	0.0	1.6	0.0	0.7	0.0	0.0	2.4	5.1	8.2	-53.6%	-71.1%

[a]Adjusted for visibility bias.

[b]Canada Goose data includes some staging migrants in strata 53 and 56.

Table 2. Survey design for Ontario, Quebec, and New York, May, 1994.

STRATUM	51	52	53	54	55	56	57
Survey Design							
Square miles in stratum	78,680	28,266	4,259	12,245	4,149	21,721	27,136
Square miles in sample	378	180	54	189	54	234	270
Lineal miles in sample	1,512	720	216	756	216	936	1,080
Number of transects in sample	6	4	4	10	5	9	6
Number of segments in sample	84	40	12	42	12	52	60
Expansion factor	208.1481	157.0333	78.8704	64.7894	76.8333	92.8248	100.5037
Current Year Coverage[a]							
Square miles in stratum	78,680	28,266	4,259	12,245	4,149	21,721	27,136
Square miles in sample	387	81	40.5	157.5	54	63.0	0
Lineal miles in sample	1,548	324	162	630	216	252	0
Number of transects in sample	6	2	4	9	5	2	0
Number of segments in sample	86	18	9	35	12	14	0
Expansion factor	203.3074	348.9629	105.1604	77.7460	76.8333	344.7777	

This is a preliminary survey design subject to review. Data is based on information obtained from a small scale map.

[a]Due to illness of a crew member, Strata 52 and 56 were only partially surveyed.

Table 3. Visibility Rates, 1994

Strata 51 - 56

Species	Visibility Rate[a] Strata 52-56	Visibility Rate[b] Stratum 51
Mallard	2.80	1.81
Am. black duck	2.42	2.86
Gadwall	3.04	3.04
Am. Widgeon	5.71	5.71
Am. green-winged teal	1.32	2.43
Blue-winged teal	10.31	10.31
N. shoveler	3.48	3.48
N. pintail	2.65	2.65
Redhead	3.11	3.11
Canvasback	2.58	2.58
Scaups	1.98	1.98
Ring-necked duck	4.21	3.00
Goldeneyes	7.53	1.59
Bufflehead	2.21	2.21
Oldsquaw	1.93	1.93
Eiders	3.58	3.58
Scoters	1.27	1.27
Ruddy duck	5.94	5.94
Mergansers	1.00	2.10
Am. coot	4.71	4.71
Ponds	1.0	--

[a]Rate calculated using 1993 data and recent years

[b]Rate calculated from 1994 and 1993

Appendix D

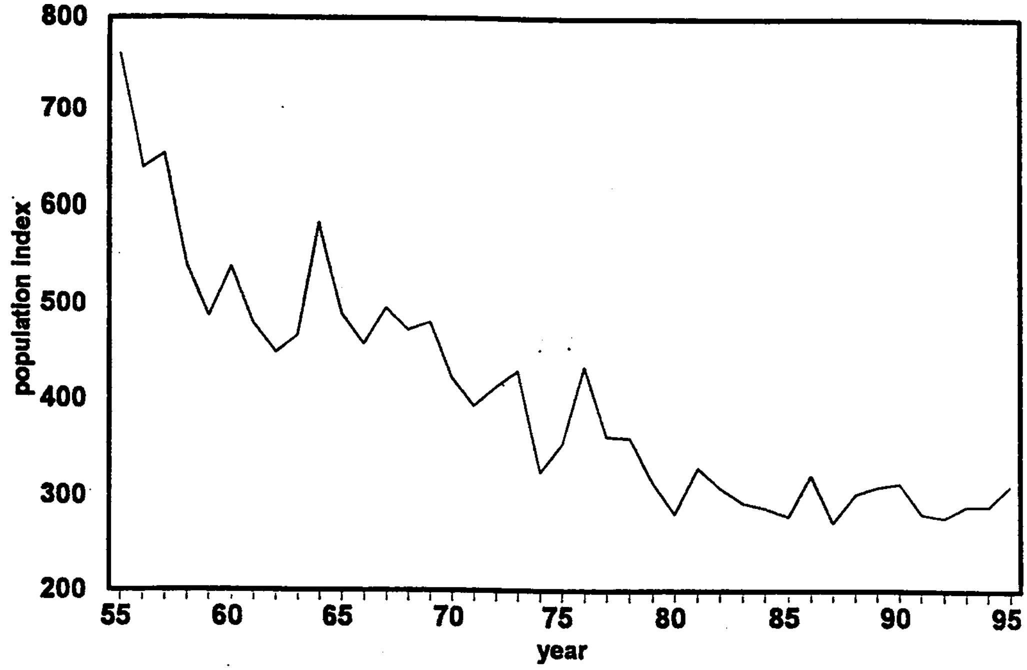
Table 1. Black Duck results from the PEI surveys, 1985-1994

Year	1985		1986		1987		1988		1989		1990		1991		1992		1993		1994	
Count	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
No. of wetlands surveyed within specified time period (see text)	53	74	76	79	74	66	62	67	78	79	76	73	71	73	70	63	75	74	73	72
No. of indicated pairs	113	116	165	90	131	83	105	95	136	80	167	115	154''	118	168'	86'	155'	97	167	116
Total birds observed	207	195	363	163	240	203	293	255	279	174	656	234	469	283	459	287	336	270	350	311
Mean no. birds per wetland	3.9	2.6	4.8	2.1	3.2	3.1	4.7	3.8	3.6	2.2	8.6	3.2	6.6	3.9	6.6	4.6	4.5	3.6	4.8	4.3
Ave. no. indicated pr. per wetland	2.1	1.6	2.2	1.1	1.8	1.3	1.7	1.4	1.7	1.0	2.2	1.6	2.2	1.6	2.4	1.4	2.0	1.3	2.3	1.6
No. of wetlands surveyed for broods (both surveys 3, 4)	33		33		28		30		22		25		29		25		30		28	
Min no. Bl. Duck broods	38		34		48		39		27		29		48		26		34		37	
Ave. no. broods* per wetland	1.2		1.2		1.6		1.3		1.2		1.1		1.6		1.0		1.1		1.3	

* corrected for missing data
' 1 Blk-Mal. pair included
'' Blk+Hyb. pair and 1 Blk + Mal. pair included

From M.C. Bateman and R.L. Dibblee. 1994. Progress Report: Waterfowl Surveys on Prince Edward Island 1994. Unpubl. Rep. of Can. Wildl. Serv. (Atlantic Region). 29 pp.

Appendix E



Black duck population estimates from mid-winter surveys.

Appendix F

DRAFT

Review of the Black Duck Joint Venture Experimental Survey Program, 1990-1994

BDJV Technical Committee

November 1994

Executive Summary:

very short description of contents and final recommendation to the Mgmnt Board

Introduction:

The primary objective of the BDJV is to establish a long term database to evaluate changes over time in the size of the black duck population. Historical information for populations on the breeding grounds in eastern Canada does exist, but it is not continuous. The failure to maintain consistent effort was related to the low perceived contribution of the east to the continental duck population, the difficulty in working in boreal forest (which comprises the major part of duck habitat in the east), and high expense relative to the number of ducks present. Moreover, because duck habitat in eastern Canada has been considered to be relatively constant in quantity (in comparison to the prairies where cyclic droughts have considerable impact on population sizes), it was thought that annual surveys were not needed (Caswell and Dickson 1995).

In contrast, the grasslands and parklands of Prairie Canada have traditionally supported the largest component of the breeding population of ducks in Canada. Because of the significance of its contribution to the continental duck population, this region has been the subject of long term monitoring. Experimental surveys from fixed-wing aircraft began in 1947, and the technique was modified and improved over the next few years. Concurrent ground surveys to provide correction factors for aerial visibility bias were initiated in the southern prairies in 1961. The ground crews also collect information describing the condition of wetlands and surrounding uplands. The status of these duck populations has now been evaluated annually since 1955 by aerial surveys covering Manitoba, Saskatchewan, Alberta, the Mackenzie Valley of the Northwest Territories, Old Crow Flats in northern Yukon, and various parts of Alaska (USFWS 1987).

There has recently been renewed interest in eastern waterfowl populations because of the decline in the number of black ducks counted on the wintering grounds, and because the role of eastern birds in the continental duck population was reconsidered and may be more important and variable than was thought. The Black Duck Joint Venture (BDJV) of the North American Waterfowl Management Plan (NAWMP) provided resources required to increase monitoring in eastern Canada and the northeastern United States. The new resources have allowed for continuous coverage, since 1990, of the major part of the black duck breeding range.

The area covered by the survey includes strata 28 and 29 of the Breeding Bird Survey, which are considered to represent the main part of the breeding range of the black duck. The goal of the BDJV survey program is to detect changes of 10% in numbers of black ducks with 90% confidence interval over a 5-year period. In addition to detecting the overall population changes, a further objective of the

BDJV is to detect regional changes in population trends with a 90% confidence interval over a 10-year period, or 80% confidence in a 6 to 7 year period. While the survey goals specifically address objectives for black ducks, it is also important to develop good population indices for other species. It was initially decided that helicopters on plots would be used in the boreal portions of the range, and that fixed-wing aircraft on transects would be used in the southern more open habitats.

In designing the survey program, much discussion has centred on the relative merits of the two types of surveys; helicopters on large square plots and fixed-wing aircraft on long thin plots. Examples of some of the concerns include questions about missed habitat on square plots, increased "edge effect" on long thin plots, and unmeasured annual changes in visibility for the helicopter components of both survey methods. However, for most points of discussion there is no information to either support or refute the claims, so they are not definitive in deciding how to proceed. Nevertheless they are mentioned here to acknowledge that significant questions remain unanswered.

There have been constraints, both of time and of money, that have made it difficult to determine the optimal design and implementation of the BDJV survey program. At the outset it was necessary to set in motion a program leading immediately to a survey that would meet the objectives of the joint venture. However, throughout the investigation, additional questions about survey methodologies have arisen. Even had we been aware at the outset of all the significant questions, there was not enough money to address them all. Even those hypotheses that were tested suffered from low power because of small samples.

The purpose of this report is to describe the results from the five year experimental survey program, to compare the results of the two survey methods in an area where both were conducted, and to demonstrate the costs associated with surveys using different designs.

Methods and Results:

1. Helicopter Plot Survey

To meet the stated objective, the original survey design called for a total of 229 plots (each 100 km^2) distributed among the provinces/states as follows: Ontario - 44, Quebec - 83, New Brunswick - 25, Nova Scotia - 25, Newfoundland - 25, and Maine - 27. The total cost was $ 560 K (Cdn). The survey was conducted on each plot according to the Standard Operating Procedures as described in the BDJV Operational Plan. The survey is conducted when the ratio of the number of drakes with hens to that of unattended drakes is approximately 1:1. Flight conditions are restricted to certain limits to reduce variability in counts caused by weather. The helicopter must be a Bell 206 equipped with bubble windows and either straight high skids or pop-out floats. The survey is conducted so as to cover all habitat likely to hold either waterfowl or loons and to obtain as accurate a count as possible based on a single visit. General rules describing habitat-specific permissable flight paths, speed and altitude are followed. All waterfowl were counted and the social structure of groups was recorded. Birds were recorded by sex, when possible, and identified as singles, or as belonging to pairs, groups or flocks.

Following three years of experimentation, the sample sizes were reevaluated to determine whether savings could be realized, while still meeting the goals of precision. Using an optimal allocation technique (based on per plot costs and standard errors in the various regions) Collins estimated costs associated with goals of different coefficients of variation (cv) (see Section 4). Based on these analyses, the samples in Ontario and Quebec were reduced to 25 and 50 plots respectively, and were expected to still achieve the stated precision goal. This reduced the total number of plots being surveyed to 175. The cost of the helicopter survey in 1993 was $ 409K (Cdn), which represented a reduction of $ 151 K (Cdn) (or 27%).

The results of the reduced sample were reviewed to ensure that, in addition to costs being reduced, the objective had also been met. Table 1 shows the results of trend analysis for 1990-1994 for the area being sampled by the helicopter survey. For black ducks, the number of indicated pairs declined significantly in Newfoundland, Quebec and Maine, whereas the total number of indicated birds declined in Ontario, Quebec and Maine (Table 1). Black ducks showed no significant trends in the other provinces. Indicated pairs of ringnecked ducks declined in Newfoundland and Quebec. Total individuals declined in Maine, as well as in the Newfoundland and Quebec. Mallards showed no significant trends (Table 1).

For some purposes, such as weighting of banding data, it is necessary to have an index to the actual population density throughout the survey area. Table 2 shows the index for the total population (with standard errors) of black ducks under the current sampling scheme. The coefficients of variation remained within the required limits. Plots of the population index over time are shown in Figure 1.

Because it is important to be able to compare densities among areas, an experiment was conducted to evaluate the variability of counts among different helicopter survey crews. The experimental design is shown in Table 3. In 1993, an experienced test crew from Quebec conducted counts on plots surveyed by each of two other Quebec crews (12 plots) and the usual Ontario crew (6 plots). In addition, 6 of the plots were surveyed twice by the test crew. ANOVA (Table 4) showed no significant differences for the plot x crew interaction for any species. Significant differences existed among crews for black ducks and hooded mergansers.

Further examination of specific differences (using Satterthwaite t-tests) showed that the test crew did not differ in comparison to the other crews from Quebec, but did differ in comparison to the Ontario crew (Table 5). If the estimated Plot*Crew variance component was negative then comparisons among crews were done using the error term in the ANOVA table. The comparability of the three Quebec crews was tested further by running a similar ANOVA using only the Quebec crews. No significant crew effects were detected (Table 6). Appendix A shows a calculation of the power of this test.

It was concluded that, within a region (Quebec), all teams used essentially the same survey method. However, to permit comparison of densities among regions, survey techniques must be similar among the "regions". To address the differences among regional crews for black ducks and hooded mergansers, further standardization of the survey technique took place in 1994. All crews used aerial photographs to update the topographic maps used for navigating and recording data. All crews used the same number of observers, and the number required was dependent on the complexity of the habitat. The pilot was not used as an observer. All crews used the same type of helicopter to allow for similar visibility.

The second experiment shown in Table 3 was conducted in 1994. The objectives were to: i) to measure the interobserver variability of the test crew in comparison to a usual Atlantic Region crew, and ii) to measure whether the improved operating procedures introduced this year reduced the among observer variability measured in the 1993 experimental survey. The test crew from Quebec surveyed 10 plots in Ontario (including the 6 surveyed in 1993), and 10 plots in Nova Scotia.

The observer differences among the test, regular Ontario and regular Nova Scotia crews in 1994 were tested for significance using a paired t-test separately for each province (Table 7). There was a significant ($p<0.05$) difference for black ducks between the test crew and the usual crew in Nova Scotia. No other significant differences were found.

The results of 1993 and 1994 experimental plots which were run in both years were combined to examine the effect of the improved operating procedures. Six plots were run in both years by the same two observers, and the test crew did replicate counts in 1993 (Table 3). The data were analyzed using an analysis of variance as described in Appendix B.

For black ducks the differences among the crews changed significantly ($p<0.05$) between the two years of the study. The results of paired t-tests between crews done separately for each year are shown in Table 8. There was a significant ($p<0.05$) difference between the crews in 1993 but the difference was not significant ($p>0.05$) in 1994. This indicates that the standardization of methodology was effective at reducing the differences among the crews. The average difference between crews was 13.7 in 1993 but only 4.3 in 1994.

For mallards, there was a significant ($p<0.05$) difference between the crews in 1993 but not in 1994 (Table 8), however the test crew obtained a lower count in both years. For ring-necked ducks there was no significant difference between the crews in either year, however, again the test crew obtained a lower count in both years.

To estimate the components of variability, the relative replicate, Plot*crew and Crew variabilities were estimated by considering the appropriate variance components as random in the ANOVA model, estimating the variance components and dividing by the mean. This provides a measure of the magnitude of these variances relative to the mean. The results of these calculations are shown in Table 9 and details of how each component were calculated are given in the footnotes to the table. The comparable values for the 1993 experiment are also shown for comparison.

2. Fixed-wing Aircraft Transect Survey

The fixed-wing waterfowl breeding population survey was conducted according to the "Standard Operating Procedures for Aerial Waterfowl Breeding Ground and Habitat Surveys in North America; 1987" (USFWS and CWS 1987). In the 40 years of conducting this aerial survey it has been refined and improved to provide annual breeding population indices covering changes over a major portion of the duck breeding range in North America. This waterfowl breeding population survey design has received three critical statistical reviews over the 40 year period (Bowden 1973), (Bowden 1984) and (Smith 1995).

The survey strata were selected as geographic units encompassing similar habitat and waterfowl densities. Transect locations within each stratum were selected using a systematic sample with a random start. The transects run east-west and spacing varies between 14 miles (23 km) and 40 miles (64 km) based on expected waterfowl densities and the homogeneity of the habitat.

Ducks are counted from aerial transects by both the pilot-biologist and an observer. The counts are adjusted upward to account for birds that are not observed by the fixed-wing crew. Visibility corrections were first attempted using ground crews in southwestern Ontario. The attempt did not prove productive because of habitat, terrain, and difficulties with access. Helicopters have been used to obtain corrections in boreal forests of Western Canada and Alaska. This method was chosen was chosen to obtain visibility corrections for stratum 51. In 1991-92 a total of 33 segments were selected on transects in stratum 51. These segments were selected based upon data obtained in 1990. In all cases the transect was flown first by the fixed-wing and then flown using the helicopter which followed the same day, or within two days. The helicopter crew was provided 7 1/2 min. quadrat maps with the transect and segment boundaries marked. In all cases the helicopter was flown at a speed and altitude such that the observers could search all of the transect segment and identify all waterfowl observed. The waterfowl data was recorded using the same technique as found in the SOP.

In 1993 two fixed-wing aircraft were flown and two helicopters were used to obtain visibility correction factors for comparison of the two fixed-wing aircraft. Crew #1 had flown the area for four years, while crew #2, although a experienced crew, had not flown the area previously. In 1994 additional visibility corrections were obtained for crew #2.

Total indicated birds per 100 km^2 (Table 10) and precision differed among species; this is a measure of the relative variation in abundance among strata. New York had large numbers of mallards while Quebec had more black ducks. These figures are uncorrected for visibility bias. Visibility correction factors did not differ for an aerial crew across years but did differ for some species among crews (Table 11; mallard $X^2_1=5.43$, $\underline{P}=0.02$; Ring-necked duck $\chi^2_1=6.1$, $\underline{P}=0.01$). These results are consistent with previous helicopter visibility analyses in western Canada (Smith 1995). Population estimates, mean counts times visibility correction, and associated precision are presented in Table 12.

3. Analysis of data from the northern Ontario area of survey overlap (stratum 51)

Data collected from helicopter plots and from fixed-wing transects located in the stratum 51 area of overlap were analyzed to (1) detect differences between surveys in patterns of estimated population indices over time, and (2) estimate numbers of plots and transects needed to detect a population decline of given size with high confidence. From either survey, the basic data available in year i for mallard, black duck, and ring-necked duck populations were sample size n_i (number of plots or transects), estimated density $\hat{x}_i$ (indicated birds/100 km^2), and $\hat{\sigma}_{\hat{x},i}$, the standard error of $\hat{x}_i$. For the fixed-wing survey, annual estimates of visibility bias correction $\hat{r}_i$ and its standard error $\hat{\sigma}_{\hat{r},i}$ for each species were also available. Fixed-wing estimates, adjusted for visibility bias, were then calculated as $\hat{a}_i = \hat{x}_i\hat{r}_i$ with standard error $\hat{\sigma}_{\hat{a},i} = (\hat{r}_i^2\hat{\sigma}_{\hat{x},i}^2 + \hat{x}_i^2\hat{\sigma}_{\hat{r},i}^2 - \hat{\sigma}_{\hat{x},i}^2\hat{\sigma}_{\hat{r},i}^2)^{0.5}$.

Test of non-parallel trend between surveys. Values of $\hat{r}_i$ for Jim Goldsberry were averaged for the years 1991-1993. The mean value and its standard error were used to calculate $\hat{a}_i$ and $\hat{\sigma}_{\hat{a},i}$ for years 1990-1993. Fred Roetker conducted the fixed-wing survey in 1994, and $\hat{a}_{94}$ and $\hat{\sigma}_{\hat{a},94}$ were calculated from visibility bias estimates specific to him for that year. For each species, a pooled value of $\hat{\sigma}_{\hat{x},i}$ for the helicopter survey was calculated as $\hat{\sigma}_h = (\sum\hat{\sigma}_{\hat{x},i}{}^2/5)^{0.5}$. Test of non-parallel trend between surveys was performed by calculating the quantity

$$Q = (\mathbf{Cx})'(\mathbf{C\Sigma C'})^{-1}(\mathbf{Cx}), \tag{1}$$

where $\mathbf{x}$ is the vector of estimated densities from both surveys, $\Sigma = \hat{\sigma}_h^2\,\mathbf{I}$ ($\mathbf{I}$ is the identity matrix), and $\mathbf{C}$ is the contrast matrix

$$\begin{bmatrix} 1 & -1 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \\ 1 & 0 & -1 & 0 & 0 & -1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & -1 & 0 & -1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & -1 & -1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

If densities are normally distributed with variance $\hat{\sigma}_h^2$, then Q is distributed as χ_4^2 (Sauer and Williams 1989). A more conservative (less powerful) test of non-parallel trends was also obtained by using $\Sigma = \mathrm{diag}(\mathbf{v})$, where $\mathbf{v}$ is the vector of estimated density variances.

There was no evidence to suggest that trends for mallard ($P \geq 0.437$) or black duck ($P \geq 0.366$) were non-parallel between surveys (Table 13). Strong evidence of non-parallel trends was discovered for ring-necked duck ($P \leq 0.007$, Table 13). Fixed-wing surveys detected an approximate doubling of ring-necked duck density during years 1992 and 1993 whereas helicopter surveys did not.

Sample size estimation. The desired objective of each survey is the detection of a 2.6% annual decrease in the study-wide population, at 90% confidence in a 5-year period (i.e., a 10% decrease detectable over 5 years). For regions within the study area, objectives are not as stringent (e.g., detection of a 2.6% annual decrease with 80% confidence in 10 years). Given a time series of density estimates and standard errors for a region, we assumed that a test for trend would take the form of (1), employing an appropriate linear contrast vector $\mathbf{c}'$.

Sample sizes were estimated in the following simulation study. For density estimates $\hat{x}_i$ and standard errors $\hat{\sigma}_{\hat{x},i}$ obtained in either survey, the pooled mean squared error of $\hat{x}$ was calculated as $\hat{\sigma}_P^2 = \sum \hat{\sigma}_{\hat{x},i}^2 n_i(n_i - 1) \,/\, \sum(n_i - 1)$. The mean squared error from a linear regression of $\hat{x}_i$ on year was denoted $\hat{\sigma}^2$, an estimate of the annual variability of x around the expected value of x. To model the hypothesis of negative trend, a vector $\mathbf{x}$ of density values $\{x_1, x_2, \ldots, x_k\}$, $k = (5, 7, 10)$, was created such that $x_3 = \bar{\hat{x}}$ and $(x_{i+1} - x_i)/x_1 = -0.025$ (hence, $[x_5 - x_1]/x_1 = -0.10$). Because density and variance are approximately proportional to each other, a vector $\mathbf{v}$ of density variance values $\{\sigma_1^2, \sigma_2^2, \ldots, \sigma_k^2\}$ was created in a similar manner such that $\sigma_3^2 = \hat{\sigma}_P^2$ and $(\sigma_{i+1}^2 - \sigma_i^2)/\sigma_1^2 = -0.025$. Given a survey, a species, a time period k, and a sample size $n = (5, 10, \ldots, 1000)$, random vectors $\tilde{\mathbf{x}}$ were iteratively drawn from the distribution $N(\mathbf{x}, \mathrm{diag}[\mathbf{v}/n + \hat{\sigma}^2])$. Quantity Q in (1) was calculated, with $\mathbf{x} = \tilde{\mathbf{x}}$, $\Sigma = \mathrm{diag}(\mathbf{v}/n)$, and

$$\mathbf{C} = \mathbf{c}' = \begin{cases} \{0, 1, \ldots, (k-1)\} - (k-1)/2, & k = 5, 7 \\ \{-9, -7, \ldots, 9\}, & k = 10, \end{cases}$$

and Q was compared to $\chi_1^2(0.05)$. The proportion of 5000 iterations where $Q \geq \chi_1^2(0.05)$ was the estimate of power for the given conditions. The smallest value of n yielding a proportion at least as great as the stated power was taken as the estimate of sample size.

Simulation of fixed-wing surveys incorporating visibility bias adjustment was carried out as above with the following alterations. For a survey with visibility rate r and coefficient of variability CV_r, $\mathbf{x} = \{x_1 r, x_2 r, \ldots, x_k r\}$. Vector $\mathbf{v}$ was created as before using $\sigma_3^2 = r^2 \hat{\sigma}_P^2/n + \bar{x}^2 (r^2 CV_r^2) - \hat{\sigma}_P^2 (r^2 CV_r^2)/n$. Quantity $\hat{\sigma}^2$ was calculated as the mean squared error from a linear regression of $\hat{d}_i$ on year. Random vectors $\tilde{\mathbf{x}}$ were then drawn from the distribution $N(\mathbf{x}, \mathrm{diag}[\mathbf{v} + \hat{\sigma}^2])$, and Q was calculated with $\Sigma = \mathrm{diag}(\mathbf{v})$.

The objective of detecting a 2.6% population decline in a 5-year period with reasonable (≥0.8) power appears unrealistic using density indices available from either survey (Table 14). For mallard and black duck, seven years is not a long enough period to detect a decline with 90% confidence at reasonable ($n \leq 400$) levels of sampling.

Estimated sample sizes for the fixed-wing survey, assuming no variability in visibility rate, were consistently lower than for the helicopter survey for the same objectives. Within survey type, the helicopter survey was more powerful for monitoring black duck and ring-necked duck than for mallard. In the fixed-wing survey, trends for ring-necked duck were estimated with somewhat higher power than for either mallard or black duck.

When variability in visibility bias is included in fixed-wing survey estimates, detection of the trend is impossible at any reasonable sample size or power, even over a 10-year period and with relatively high precision for visibility bias ($CV_r = 0.1$). In fact, $\hat{\sigma}_{a,i} \rightarrow \hat{x}_i^2 \hat{\sigma}_{r,i}^2$ as $n \rightarrow \infty$, thus power reaches a maximum for any sample size when $\hat{\sigma}_{r,i}^2$ is fixed. Power may be increased either by increasing the precision of the visibility bias estimate through more intensive secondary sampling or by seeking ways to eliminate the need for visibility adjustment altogether through increased standardization of procedure.

4. Costs

a) Helicopter Plot Survey:

Using an optimal allocation technique (based on per plot costs and standard errors in the various regions) Collins estimated costs associated with goals of different coefficients of variation (cv) (Collins, 15 February 1992).

Cost per sample unit

The simplest cost function would be to assume that cost is proportional to the number of plots. For each region, the current total cost (C) would be divided by the current number of plots (N) to give the cost per sample unit (C_U). The estimated cost to survey n samples would be:

$$C^1(n) = n\ C_U$$

However, this approach ignores the fact that as the sample size is reduced, the average distance between plots will increase and hence, on a per plot basis, the ferrying time between plots will increase. If the plots were laid out in a straight line, then the distance travelled between plots would be approximately constant no matter how many plots were sampled. Let T_F denote the current total time spent ferrying in the current survey and T_S denote the current average time spent on a plot. The cost per unit time would be $C_T = C\ /\ (T_F + N_S T)$. The estimated cost to survey n samples would be:

$$C^2(n) = (T_F + n\ T_S)$$

It is unrealistic to assume that ferrying time will be constant for all sample sizes. The plots are not in a straight line and the most direct path to the next plot will not be found by flying over the skipped plots. A correct cost function lies somewhere in between the two functions outlined above. An approximation of how ferrying time changes with sample size was estimated using a simulation of random points within a circle. The length of a path from the centre of the circle through a set of n points and back to the centre was calculated. The path was determined sequentially by always moving to the nearest available point which had not been visited. The simulation resulted in a function d(n) which gives a path length for a set of n points. Using this measure of how ferrying time increases with sample size the cost to survey n samples would be:

$$C^3 = C_T \; (T_F \; d(n)/d(N) \; + \; n \; T_S)$$

Optimum Allocation

Let $V^j(n_j)$ and $C^j(n_j)$ denote the variance and cost for a sample of size n_j in stratum j. If the sample size were increased by a small amount e then the marginal decrease in variance per unit cost would be:

$$M_j(n_j+e) = \frac{V_j(n_j) - V_j(n_j+e)}{C_j(n_j+e) - C_j(n_j)}$$

At an optimum allocation of the n_j the marginal decrease in variance per unit cost will be constant over all strata.

The optimum allocation for cost function $C^3(n)$ was calculated using a stepwise allocation procedure. The procedure was initialized by assigning 1 observation to each stratum and the sample size was then built up sequentially by assigning each additional sample unit to the stratum which gave the maximum reduction in overall variance per unit cost. Continuing in this manner the allocation moved toward a solution in which the marginal decrease in variance is constant over all strata.

Table 15 summarizes the costs and associated coefficients of variation, for a survey whose goal is to provide estimates of trend in each province/state. Further analysis showed that the samples in the Atlantic provinces and in Maine could be reduced, if we were willing to accept "regional", rather than "provincial" trends. For instance, Table 16 presents the costs and associated coefficients of variation for a survey whose goal is to provide a trend for the two Maritime provinces (of course, one would then add the costs from the above table for Ontario, Quebec, Maine and Newfoundland). Table 17 presents the same information for a survey whose goal is to provide a trend for the four eastern jurisdictions combined (plus the additional costs of the surveys in Ontario and Quebec).

Collins (December 1992) suggested some other alternatives for reducing the cost of the helicopter plot survey:

- i) take a random sample of the current sample and continue to monitor these plots each year (provides the most precise estimate of year to year change),
- ii) take a completely new random sample of plots each year (provides the most reliable estimate of the average over several years), or
- iii) use a sample selection which rotates among the available plots retaining a portion of the same plots but also discarding and introducing new plots each year (provides the most precise annual estimates through combining data from the previous year). This method could achieve the same level of precision, but with a sample that was 17% smaller.

b) Fixed-wing Aircraft Survey:

Developing a fixed-wing survey for eastern Canada

Two issues need to be addressed in developing a fixed-wing survey for eastern Canada. First, bias must be addressed, in determining if (or when) visibility adjustments must be applied to the fixed-wing counts. Second, the power of the survey in testing specific hypotheses must be estimated.

When must visibility adjustments be applied to survey data?

No survey method for counting black ducks in eastern Canada provides a census. Both helicopter and fixed-wing counts only provide an index to total population over areas to be surveyed. Consequently, the air-ground (actually air-helicopter) visibility adjustments used for the black duck surveys only act to adjust the level of the fixed-wing index to that of the helicopter index (Table 13). This adjustment of level of the index provides no information on either (1) the real population size or (2) population changes (if the adjustment is not time-specific). The adjustment only has value if the helicopter index is less affected by some factor that influences the fixed-wing index, in which case the adjustment eliminates the bias associated with the factor. For example, the fixed-wing counts may be more affected by observer differences than the helicopter-based counts. In this case, the visibility adjustment would eliminate the observer differences. The paired-observer fixed-wing experiments conducted in 1993 appear to suggest that these observer differences do exist among fixed-wing surveys. Unfortunately, the experimental helicopter surveys indicate that observer differences also occur among helicopter survey crews.

Testing for differences among visibility rates

Data collected from the fixed-wing survey can be used to directly address the question of whether the fixed-wing-helicopter visibility rates differ among survey crews. Analyses presented elsewhere provide evidence that visibility rates differ among 2 crews for mallards and ring-necked ducks. The test for crew differences associated with black ducks was not significant ($\underline{P} = 0.55$). These results provide equivocal evidence that visibility rates differ among fixed-wing crews, if the assumption is made that the helicopter bias is constant. Consequently, a conservative approach would be to estimate visibility rates by crew to facilitate comparisons among crews. Unfortunately, visibility rates estimated with helicopters tend to be very imprecise, and greatly increase the costs of the survey. Inasmuch as similar observer differences in detection of black ducks have been documented for helicopter plot surveys, a reasonable strategy for optimization of fixed-wing surveys would be to not incorporate visibility adjustments in the optimization, but add on a fixed cost for helicopter subsampling of segments by crew area to provide a test for crew differences.

What criteria should be used for optimization of fixed-wing surveys?

In earlier analyses (Sauer et al., Unpublished Memo), a fixed-wing survey was optimized based on precision of mean yearly indexes. Several levels of visibility adjustment were considered, from stratum-specific estimates to no adjustment. Costs varied greatly, depending on the amount of visibility adjustment.

In this analysis, an alternative criterion, that of power to detect population change, was used as the optimization criterion. In addition, visibility rates have been shown to affect both helicopter and fixed-wing surveys, suggesting that observer differences by crews should be monitored but only incorporated into the analysis when demonstrated to differ among areas.

Cost of fixed-wing surveys

Goldsberry (unpublished memo) has estimated costs per segment as $ 17.73 (US-per diem) + $64.24 (US-aircraft costs) ≈ $82.00. These numbers were calculated to incorporate cross-country time and travel from home base to home base, and apply throughout the survey area.

Needed number of transects

In this analysis, information from Table 14 is used as pilot data to indicate minimum levels of precision needed. This information has several limitations associated with the area it represents and the sample from the area. First, it assumes that densities and variances from that area are representative. Second, it assumes that transect sizes (in terms of number of transects) are representative of the entire region. Both of these assumptions are probably invalid, and future analyses will incorporate more realistic estimates of these quantities.

Results from Table 14 suggest that 115 transects would be needed to attain a power of 0.9 to detect the -10%/5-yr change over a 10 year period when visibility is treated as a constant. Goldsberry (unpublished memo) has allocated samples for 115 transects over the present extent of the black duck survey areas and the lake states of Michigan and Wisconsin. Table 18 contains a list of these transects and the number of segments in each. A total of 876 segments occur in the survey, leading to a total yearly cost estimate of $70,956 (US). Three crews would be needed to complete this survey.

Visibility adjustments

Given the possibility of crew differences in visibility rates, some experimental work would be needed to estimate an initial visibility rate for each crew. This work could be either a helicopter-based visibility correction or a replicate fixed-wing survey to directly estimate crew differences.

Discussion:

Helicopter Plot Survey

The helicopter plot survey achieved a black duck population index for the entire survey area with an average coefficient of variation of about 5%. For individual regions, the coefficient of variation varied from a high of 28% in Maine to a low of about 7% in Quebec. These estimates of precision met the objectives of the BDJV, even following reduction in the size of the sample in Ontario and Quebec.

The experimental helicopter plot surveys demonstrated that, within a region, survey crews operate using techniques sufficiently similar that differences in counts could not be detected. Observers that trained together were able to achieve counts that were statistically similar. It also showed that there are differences in survey methodology among regions. It is clear that there is a need for standardized training of observers, and that a bank of qualified observers needs to be developed.

Fixed-wing survey

Precision of the estimates from the fixed-wing survey for eastern Canada (strata 51-56 combined) are very similar to the precision of fixed-wing surveys in northern Manitoba and northern Saskatchewan with average coefficients of variation of 15 and 17% respectively for mallard estimates (considering similar sized areas). Although densities of mallards in northern Manitoba and Saskatchewan are 2 to 3 times those of eastern Canada the precision of the average number of ducks observed was very similar; it follows that the variances of the visibility correction factors were also similar. There is little information available to accurately assess what the precision would be for black duck estimates from a fixed-wing survey encompassing all black-duck areas. Areas currently covered in eastern Canada by the fixed-wing survey, except for stratum 51, are areas with low black duck and high mallard densities. The precision of the fixed-wing estimates increases with inclusion of larger areas. It is probable that the precision of black-duck estimates would compare favorably with that of most species surveyed in boreal forest areas in the western Canadian survey (coefficients of variation likely in the low to mid teens for the total area and approaching 20% on a province basis). The precision would probably be poorer than estimates from prairie-parkland areas in the north central U.S. and southern central Canada (coefficients of variation below 10%).

Visibility correction is an important component that needs to be considered with regard to the fixed-wing surveys. Helicopter strip transects for conducting pseudo-censuses appear to be a workable substitute for true censuses as conducted in western surveys. Visibility bias appears to differ among fixed-wing crews making helicopter correction necessary in order to permit valid spatial comparisons. However, visibility for a crew does not appear to change much temporally once the crew is 'trained and familiar' with the survey. It should be possible to realize substantial savings by only scheduling helicopter work to correspond with changes in fixed-wing crews. This also points toward the need to keep changes in fixed-wings crews to a minimum.

Comparison of Surveys

Point estimates from the fixed-wing survey with visibility correction and the helicopter plot survey are similar for black ducks and mallards in the area of experimental overlap. The habitat within stratum 51 is typical boreal forest and falls within the high density black duck breeding area as described earlier.

Estimates from fixed-wing surveys with visibility correction are by their nature less precise than estimates without visibility correction. This occurs because correction is needed to address a source of bias and the precision of the visibility correction factors must be included as a component of the total variance of the estimates. Thus one might expect estimates from the fixed-wing survey to be less precise than those from the helicopter plot survey. This is apparent in the comparisons within strata 51.

Additional biases of the two surveys are unknown. For the helicopter plot survey, differences in procedures both annually and geographically have made temporal and spatial comparisons difficult. A standardized operating procedure has been developed but inconsistencies still remain. Variations in procedures during the initiation of the survey occurred; this was to be expected as all surveys have start-up and growing pains. The fixed-wing survey had the advantage of a long history. However the helicopter portion of the visibility correction estimation is not a census, and thus also may be affected by annual changes in detection probabilities; this differs from western prairie Canada where ground crews are able to annually census segments. It is useful to remember that even helicopter surveys have detection probabilities below 0.8 (Bowden 1977); this leaves much room for potential biases to be present.

The use of precision as a comparison criterion between the fixed-wing and helicopter surveys should also consider how the data will be used and the costs associated with different levels of precision. Additional considerations include the need for consolidation of a survey of waterfowl populations in eastern Canada with the broader provincial, national, flyway, and international scales, as well as the need to continue the ongoing evaluation of the Eastern Habitat Joint Venture which relies in part on the current helicopter plots.

Recommendations:

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TABLES AND FIGURES

Table 1: Route regression analysis of breeding pairs and total individuals, 1990-1994, using only the plots that have been surveyed in all years. *From Collins (September 13, 1994).*

Species	Variable	Stratum	Number of Plots	Estimated Trend	Annual Change Factor	Estimated p-value
ABDU	IP	NF	25	-0.1799	0.8353	0.0001 *
		PQ	43	-0.1733	0.8409	0.0001 *
		ME	25	-0.0987	0.9060	0.0127 *
		NB	25	-0.0406	0.9603	0.5496
		NS	25	-0.0281	0.9722	0.3984
		ON	25	-0.0197	0.9805	0.4965
		TOTAL	168	-0.1291	0.8789	0.0001 *
	TI	PQ	43	-0.1382	0.8710	0.0001 *
		NB	25	-0.1376	0.8714	0.1451
		NF	25	-0.0932	0.9110	0.0311 *
		ON	25	-0.0840	0.9195	0.0071 *
		ME	25	-0.0578	0.9439	0.5281
		NS	25	-0.0173	0.9829	0.6633
		TOTAL	168	-0.1094	0.8964	0.0001 *
RNDU	IP	NF	25	-0.3209	0.7255	0.0001 *
		NB	22	-0.2125	0.8086	0.3910
		PQ	43	-0.0987	0.9060	0.0082 *
		ON	25	-0.0155	0.9846	0.7158
		NS	24	-0.0062	0.9938	0.8903
		ME	23	-0.0061	0.9940	0.8972
		TOTAL	163	-0.1229	0.8843	0.0001 *
	TI	NB	23	-0.2837	0.7530	0.1738
		ME	24	-0.1642	0.8486	0.0007 *
		NF	25	-0.1282	0.8797	0.0014 *
		PQ	43	-0.0688	0.9335	0.0228 *
		ON	25	-0.0496	0.9516	0.1587
		NS	25	0.0215	1.0217	0.5872
		TOTAL	165	-0.0780	0.9250	0.0001 *
MALL	IP	NB	11	-0.1118	0.8943	0.5235
		ME	20	-0.0565	0.9451	0.4195
		NS	13	-0.0455	0.9555	0.7542
		ON	25	0.0131	1.0131	0.5692
		PQ	42	0.0510	1.0523	0.3091
		NF	5	0.1645	1.1788	0.4712
		TOTAL	116	0.0222	1.0225	0.3163
	TI	NB	11	-0.1233	0.8840	0.4909
		ME	20	-0.0515	0.9498	0.4949
		NS	13	-0.0475	0.9536	0.7965
		ON	25	-0.0011	0.9989	0.9638
		PQ	42	0.0601	1.0619	0.2530
		NF	6	0.1325	1.1416	0.4991
		TOTAL	117	0.0143	1.0144	0.5353

ABDU - American Black Duck MALL - Mallard RNDU - Ring-necked Duck
IP - Indicated Pairs TI - Total Individuals

Table 2: Estimates of the total population of black ducks (indicated pairs and total individuals) with standard errors. *From Collins (September 13, 1994).*

Year	Stratum	Number of Plots	Indicated Pairs	Total Individuals
90	ME	25	6814 ± 1193	15174 ± 3407
	NB	25	8187 ± 2060	20926 ± 7026
	NF	25	16947 ± 2314	27581 ± 4275
	NS	25	7102 ± 829	14013 ± 1678
	ON	25	38649 ± 4115	70094 ± 7603
	PQ	43	84137 ± 7502	153605 ± 13924
	TOTAL		161835 ± 9215	301393 ± 18268
91	ME	25	6226 ± 1188	20116 ± 5595
	NB	25	5096 ± 899	9132 ± 1551
	NF	25	21063 ± 4492	36089 ± 8370
	NS	25	8095 ± 969	16381 ± 2141
	ON	25	40034 ± 4287	91427 ± 9668
	PQ	43	74312 ± 6680	132294 ± 12059
	TOTAL		154826 ± 9292	305438 ± 18634
92	ME	25	5247 ± 877	15522 ± 4112
	NB	25	7157 ± 1088	12481 ± 1982
	NF	25	13173 ± 1890	22435 ± 3700
	NS	25	8497 ± 1209	22510 ± 3876
	ON	25	43636 ± 4599	88934 ± 9079
	PQ	43	67531 ± 5812	129250 ± 10387
	TOTAL		145240 ± 7869	291132 ± 15487
93	ME	23	5064 ± 798	15358 ± 4632
	NB	25	8473 ± 984	14972 ± 1906
	NF	25	9125 ± 1343	20583 ± 4011
	NS	25	7060 ± 817	15091 ± 1870
	ON	25	42804 ± 3821	78544 ± 8008
	PQ	43	44559 ± 3782	97975 ± 10152
	TOTAL		117086 ± 5743	242523 ± 14555
94	ME	25	4768 ± 810	13106 ± 4391
	NB	25	7328 ± 1196	13389 ± 2123
	NF	25	10772 ± 1887	23121 ± 6201
	NS	25	6996 ± 832	14950 ± 1676
	ON	25	38649 ± 3235	74250 ± 6973
	PQ	43	48019 ± 4045	94654 ± 8389
	TOTAL		116532 ± 5759	233469 ± 13566

Table 3: Experimental design to evaluate variability in counts among helicopter crews.

Plot	1993				1994		
	Test Crew	Usual-ON	Usual-PQ-1	Usual-PQ-2	Test Crew	Usual-ON	Usual-NS
ON 14	X	X			X	X	
ON 15	X	X			X	X	
ON 17	XX	X			X	X	
ON 19	X	X			X	X	
ON 24	XX	X			X	X	
ON 26	X	X			X	X	
ON 21					X	X	
ON 22					X	X	
ON 25					X	X	
ON 28					X	X	
PQ 6	X		X				
PQ 7	X		X				
PQ 10	XX		X				
PQ 24	X		X				
PQ 34	X		X				
PQ 47	XX		X				
PQ 9	XX			X			
PQ 20	XX			X			
PQ 36	X			X			
PQ 48	X			X			
PQ 49	X			X			
PQ 64	X			X			
NS 26					X		X
NS 27					X		X
NS 28					X		X
NS 30					X		X
NS 31					X		X
NS 32					X		X
NS 45					X		X
NS 46					X		X
NS 47					X		X
NS 50					X		X

X - denotes an observation, and XX - denotes a duplicate observation

Table 4: Summary of results of ANOVA *(from Collins, 23 November 1993)*.

Species	plot	crew	plot x crew
black duck	*	*	
black duck (prs)	**	**	
hooded merganser	**	**	
mallard	**		
green-winged teal	**		
common goldeneye	**		
ringnecked duck	**		

* - significant (p<0.05) ** - significant (p<0.01)

Table 5: Comparison of results for the test crew with results of usual crews in 1993 *(from Collins, 23 November 1993)*.

	Test Crew compared with:		
Species	Usual-ON	Usual-PQ-1	Usual-PQ-2
Black Duck (total)	-13.7**	-3.5	-1.3
Black Duck (pairs)	-7.7*	0.8	0.7
Hooded Mergansers	-14.3*	-5.2	4.8
Mallards	-5.2*	2.3	0.2
Green-winged Teal	0.6	-0.4	1.2
Common Goldeneye	-3.8	0.8	-4.8
Ring-necked Duck	-4.0	2.9	0.6

Table 6: ANOVA for Quebec crews *(from Collins, 23 November 1993)*.

Species	Plot	Crew	Plot*Crew
Black Duck (total)			
Black Duck (pairs)		**	
Hooded Mergansers		*	
Mallards	*		
Green-winged Teal		*	
Common Goldeneye		*	
Ring-necked Duck		*	

Table 7: Mean counts by species and observer and probability level for the paired t-test comparing observers, 1994.

Species	Nova Scotia			Ontario		
	Test Crew	Regular Crew	Prob.	Test Crew	Regular Crew	Prob.
Black Duck	30.0	42.1	0.03 *	24.9	23.6	0.77
Mallard	0.9	0.8	0.85	7.0	8.7	0.27
Ring-necked Duck	13.2	12.5	0.66	31.3	34.6	0.36

Table 8: Mean of average counts by observer and year for the 6 plots measured in Ontario in both 1993 and 1994.

Species	1993			1994		
	Test Crew	Regular Crew	Prob.	Test Crew	Regular Crew	Prob.
Black Duck	27.3	31.7	0.01 *	23.0	27.3	0.39
Mallard	8.7	10.3	0.02 *	5.2	8.7	0.10
Ring-necked Duck	35.2	36.8	0.30	28.3	35.2	0.12

Table 9: Coefficients of variation for replicate counts and among-crew variability.

Species	Replicate CV (%) 1993 (a)	Replicate CV (%) 1994 (b)	Crew * Plot Variability CV (%) 1993 (c)	Crew * Plot Variability CV (%) 1994 (d)	Crew Variability (%) 1993 (e)	Crew Variability (%) 1994 (f)
Black Duck	23	10	21	29	0	18
Mallards	48	41	14	0	0	43
Ring-necked Duck	34	16	0	17	0	9

(a) - 100 (MS(E))/Mean
where MS(E) is the mean square for error from the ANOVA in 1993.

(b) - 100 MS(E)/Mean
where MS(E) is the mean square for error from the ANOVA in Tables B3 and B4.

(c) - 100 Sqrt((MS(Crew*Plot)-MS(E))/1.107)/Mean
(set to zero when negative)
where MS(Crew*Plot) and MS(E) are the Crew*Plot mean squared error and error terms from the ANOVA.

(d) - Ontario data for 1993-94 used because no estimate of pure error was available for Nova Scotia.
100 Sqrt((MS(Crew*Plot)-MS(E))/2.107)/Mean
(set to zero when negative)
where MS(Crew*Plot) and MS(E) are the Crew*Plot mean squared error and error terms from the ANOVA in Table B3.

(e) - Quebec Data only.
100 Sqrt((MS(Crew)-MS(Crew*Plot))/6.544)/mean
(set to zero when negative)

(f) - Ontario 1993-94 data used because variance components could not be estimated for Nova Scotia.
- For black ducks and ring-necked ducks the Crew and Year by Crew effects were considered random and the expected mean squares in Table B1 b) were recalculated. The relative crew variance was estimated as
100 Sqrt((MS(Crew)-MS(Crew*Plot)-MS(Crew*Year)+MS(E))/12.571)/Mean
where MS(Crew), MS(Crew*Plot), MS(Crew*Year) and MS(E) are the Crew, Crew*Plot and Crew*Year mean squared errors and error terms from the ANOVA in Table B3.
- For mallards the Crew and Year by Crew effects were considered random and the expected mean squares in Table A1 c) were recalculated. The relative crew variance was estimated as:
100 Sqrt((MS(Crew)-MS(Crew*Plot))/12.706)/Mean
where MS(Crew) and MS(Crew*Plot) are the Crew and Crew*Plot mean squared errors from the ANOVA in Table B3.

Table 10. Total indicated birds per 100 km^2 (mean [$\bar{x}$], pooled standard error [$\hat{\sigma}$], and coefficient of variation [CV]) in fixed-wing surveys conducted by one crew (Jim Goldsberry and Pete Polus), by survey stratum and over all strata, for 3 duck species, 1990-1993[a]. Estimated densities are not adjusted for undercounting bias.

		N transects		Mallard			Black duck			Ring-necked duck		
Stratum		min	max	$\bar{x}$	$\hat{\sigma}$	CV	$\bar{x}$	$\hat{\sigma}$	CV	$\bar{x}$	$\hat{\sigma}$	CV
51	Ontario N	6	6	12.30	2.66	0.22	14.47	2.54	0.18	14.51	2.43	0.17
52	Ontario C	4	4	30.19	11.76	0.39	10.73	2.95	0.27	13.35	8.44	0.63
53	Ontario E	4	4	61.18	22.63	0.37	6.78	2.77	0.41	0.64	1.05	1.64
54	Ontario S	9	10	68.16	20.54	0.30	5.49	2.75	0.50	12.39	6.07	0.49
55	New York	5	5	102.78	14.63	0.14	16.45	5.25	0.32	3.04	2.43	0.80
56	Quebec	9	11	29.25	8.53	0.29	33.97	15.96	0.47	5.13	6.24	1.22
Survey-wide[b]		37	40	26.64	9.78	0.37	15.70	6.61	0.42	12.04	5.05	0.42

[a] Goldsberry flew 22 of 40 transects in 1994.
[b] Weighted by stratum area.

Table 12. Population estimates (mean [$\bar{x}$], pooled standard error [$\hat{\sigma}$], and coefficient of variation [CV]) from fixed-wing surveys, by survey stratum and over all strata, for 3 duck species, 1990-1994. Density estimates are expanded to the stratum area, then are adjusted for an undercount (visibility) bias determined for each survey pilot in each year[a].

Stratum			Mallard			Black duck			Ring-necked duck		
Name - Area (100 km^2)			$\bar{x}$	$\hat{\sigma}$	CV	$\bar{x}$	$\hat{\sigma}$	CV	$\bar{x}$	$\hat{\sigma}$	CV
51	Ontario N	2038	69908	18184	0.26	68496	17582	0.26	112541	27577	0.25
52	Ontario C	732	64752	25766	0.40	19930	5905	0.30	51141	42333	0.83
53	Ontario E	110	20299	7509	0.37	2924	2183	0.75	593	844	1.42
54	Ontario S	317	62046	20108	0.32	4573	2329	0.51	19782	13449	0.68
55	New York	107	30678	7289	0.24	4016	1474	0.37	1682	1065	0.63
56	Quebec	563	49596	16404	0.33	39005	20809	0.53	11760	14015	1.19
Survey-wide		3867	297280	42160	0.14	138944	28096	0.20	197499	54145	0.27

[a] Visibility correction applied to density estimates in all strata in all years, except stratum 51 in 1994, was a 3-year (1991-1993) pooled adjustment determined for Jim Goldsberry. The adjustment applied to stratum 51 in 1994 was determined for Fred Roetker.

Table 11. Visibility corrections (air counts, mean [$\bar{x}$], standard error [$\hat{\sigma}$], and coefficient of variation [CV]) for 3 duck species, by aerial crew and cooperating state.

	Mallard				Black duck				Ring-necked duck			
Source	air	$\bar{x}$	$\hat{\sigma}$	CV	air	$\bar{x}$	$\hat{\sigma}$	CV	air	$\bar{x}$	$\hat{\sigma}$	CV
JG 1991	38	1.68	0.67	0.40	44	1.59	0.51	0.32	25	5.00	1.08	0.22
JG 1992	45	2.84	0.70	0.25	40	2.88	0.72	0.25	40	3.83	1.18	0.31
JG 1993	48	3.65	0.98	0.27	55	2.76	0.79	0.29	76	4.16	0.96	0.23
JG-pooled	131	2.80	0.46	0.16	139	2.42	0.42	0.17	141	4.21	0.64	0.15
FR 1993	120	1.46	0.32	0.22	44	3.45	0.88	0.26	141	2.24	0.40	0.18
FR 1994	77	1.81	0.31	0.17	44	2.86	0.75	0.26	44	3.00	0.63	0.21
FR-pooled	197	1.59	0.24	0.15	88	3.16	0.57	0.18	185	2.42	0.34	0.14
Michigan[a]	2266	4.08	N/A	N/A	14	1.36	N/A	N/A	33	12.06	N/A	N/A
Wisconsin[b]	N/A	1.89	N/A	N/A	N/A	5.25	N/A	N/A	N/A	5.25	N/A	N/A

[a] helicopter-based counts, pooled over farm/urban and forest strata, 1992-1994 (source: J. Martz, pers. commun.).
[b] ground-based counts, northern Wisconsin, pooled over 1992-1994 (source: 1994 Waterfowl Breeding Population Survey for the Lakes States, unpubl. rep.).

Table 13. Comparison of abundance indices (TIB/100km^2) for stratum 51[a] by survey type, and test of non-parallel trends[b] in indices, for 3 duck species. Fixed-wing indices are adjusted for visibility bias.

	Helicopter plots				Fixed-wing transects				
Species -Year	n	$\hat{x}$	$\hat{\sigma}$	CV	n	$\hat{x}$	$\hat{\sigma}$	CV	Mean
Mallard									
1990	34	24.94	4.00	0.16	6	21.68	6.84	0.32	23.69
1991	34	31.47	5.41	0.17	6	38.57	10.05	0.26	35.02
1992	34	32.76	5.40	0.16	6	46.90	12.84	0.27	39.83
1993	18	24.89	5.00	0.20	6	30.60	6.32	0.21	27.75
1994	18	21.94	4.53	0.21	6	33.77	6.73	0.20	27.86
pooled		27.20	4.90	0.18		34.31	8.92	0.26	30.83
test of non-parallel trend: $\chi_4^2 = 3.775$, $P = 0.437$ ($P = 0.694$)[c]									
Black Duck									
1990	34	24.21	2.64	0.11	6	26.84	5.59	0.21	25.52
1991	34	40.35	3.32	0.08	6	45.04	11.35	0.25	42.69
1992	34	40.71	4.60	0.11	6	35.84	9.54	0.27	38.27
1993	18	39.44	4.32	0.11	6	32.38	6.99	0.22	35.91
1994	18	34.44	3.44	0.10	6	27.96	8.50	0.30	31.20
pooled		35.83	3.73	0.10		33.61	8.63	0.26	34.72
test of non-parallel trend: $\chi_4^2 = 4.308$, $P = 0.366$ ($P = 0.814$)									
Ring-Necked Duck									
1990	34	38.94	4.86	0.12	6	27.31	7.34	0.27	33.13
1991	34	34.44	2.87	0.08	6	46.81	7.72	0.16	40.62
1992	34	43.44	4.45	0.10	6	78.69	18.26	0.23	61.07
1993	18	35.72	5.32	0.15	6	91.60	19.11	0.21	63.66
1994	18	35.50	6.39	0.18	6	31.73	10.16	0.32	33.61
pooled		37.61	4.91	0.13		55.23	13.53	0.25	46.42
test of non-parallel trend: $\chi_4^2 = 64.52$, $P < 0.001$ ($P = 0.007$)									

[a] Helicopter plots in stratum 51 are (ONT) 9, 11, 13-37, and 40-46.
[b] Test is of the form $Q = (\mathbf{Cx})'(\mathbf{CC}')^{-1}(\mathbf{Cx})\hat{\sigma}_h^{-2}$, where $\mathbf{C}$ is a 4-row contrast matrix, $\mathbf{x}$ is the vector of mean indices from both surveys, and $\hat{\sigma}_h$ is the pooled standard error from the helicopter survey. If mean indices are assumed normally distributed with variance $\hat{\sigma}_h^2$, then Q is distributed as χ_4^2.
[c] P-value for contrast that incorporates year and survey-specific variances.

Table 14. Estimated number of samples (plots or transects) required to detect change of -10%/5-yr in densities (TIB/100 km^2) of 3 duck species in helicopter and fixed-wing surveys conducted over 5, 7, and 10-yr periods, at 3 levels of statistical power.

Survey	Period (yr)	Mallard			Black Duck			Ring-necked Duck		
		0.5[a]	0.8	0.9	0.5	0.8	0.9	0.5	0.8	0.9
Helicopter plot	5	495	*[b]	*	125	985	*	220	860	*
	7	195	630	*	60	275	690	80	240	385
	10	65	165	265	20	65	120	30	70	100
Fixed-wing (VR_h, 0)[c]	5	50	505	*	50	490	*	90	430	*
	7	35	300	*	30	215	660	35	115	205
	10	20	100	265	15	50	115	15	30	45
Fixed-wing (VR, 0.1)	5	*	*	*	*	*	*	*	*	*
	7	*	*	*	*	*	*	*	*	*
	10	40	*	*	35	*	*	35	*	*
Fixed-wing (VR, $\overline{x}_{cv}$)	5	*	*	*	*	*	*	*	*	*
	7	*	*	*	*	*	*	*	*	*
	10	*	*	*	*	*	*	*	*	*

[a] Power level: probability of rejecting H_o (no trend) when H_o is false.
[b] >1000
[c] Notation (*A*, *B*) for fixed-wing surveys denotes visibility rate *A* applied with CV_A = *B*. VR_h is the helicopter:fixed-wing ratio of mean densities and is used to scale fixed-wing estimates of $\overline{x}$ density and $\hat{\sigma}_{\overline{x}}$ for comparison with helicopter plot data: these ratios are 2.21 (mallard), 2.48 (black duck), and 2.59 (ring-necked duck). VR and $\overline{x}_{cv}$ are the average visibility rate and its CV estimated from helicopter ground counts: these values are (2.80, 0.16) (mallard), (2.42, 0.17) (black duck), and (4.21, 0.15) (ring-necked duck).

Table 15: Estimated coefficients of variation and cost for various sample sizes for Maine (ME), New Brunswick (NB), Nova Scotia (NS), Newfoundland (NF), Quebec (PQ) and Ontario (ON). Costs are shown in thousands. *From Collins (February 1992).*

N	ME		NB		NS		NF		PQ		ON	
	CV	Cost	CV	Cost	CV	Cost	CV	Cost	CV	Cost	CV	Cost
5	.60	13.5	.40	6.2	.41	20.3	.29	7.9	.27	32.3	.25	20.3
10	.43	21.9	.29	10.1	.29	34.7	.20	13.3	.19	49.0	.18	32.4
15	.35	29.3	.23	13.5	.24	48.1	.17	18.3	.15	62.4	.15	42.7
20	.30	36.4	.20	16.8	.21	61.2	.14	23.2	.13	75.4	.13	52.8
25	.27	43.3	.18	20.0	.18	74.0	.13	28.0	.12	87.6	.11	62.5
30									.11	99.0	.10	71.7
35									.10	110.2	.10	81.0
40									.09	121.0	.09	89.0
45									.09	131.2		
50									.08	141.7		
55									.08	151.3		
60									.08	161.6		
65									.07	171.2		
70									.07	180.9		
75									.07	189.9		
80									.07	199.1		

Table 16: Estimated coefficients of variation and cost for various sample sizes for Nova Scotia (NS) and New Brunswick (NB) combined. Costs are shown in thousands. *From Collins (February 1992).*

N	Equal Weighting Allocation				Area Weighting Allocation			
	NS	NB	CV	Cost	NS	NB	CV	Cost
5	2	3	.340	8.1	2	3	.340	8.1
10	5	5	.240	14.1	4	6	.241	13.7
15	7	8	.196	18.8	6	9	.196	18.4
20	10	10	.170	23.5	8	12	.170	22.7
25	12	13	.152	27.5	11	14	.152	27.2
30	15	15	.139	31.9	13	17	.139	31.1
35	17	18	.128	35.8	15	20	.129	35.1
40	20	20	.120	40.0	17	23	.120	39.0
45	22	23	.113	43.8	19	26	.113	42.8
50	25	25	.107	48.0	21	29	.108	46.7

Table 17: Estimated coefficients of variation and cost for various sample sizes for Nova Scotia (NS) and New Brunswick (NB) combined. Costs are shown in thousands. *From Collins (February 1992).*

N	Equal Weighting Allocation						Area Weighting Allocation					
	NF	NS	NB	ME	CV	Cost	NF	NS	NB	ME	CV	Cost
40	10	10	10	10	.164	80.1	20	6	8	6	.158	94.2
45	12	11	11	11	.155	88.7	22	7	9	7	.149	103.0
50	13	12	13	12	.147	95.2	24	8	10	8	.141	111.5
55	14	14	14	13	.140	102.2	27	8	11	9	.134	121.5
60	15	15	15	15	.134	109.2	30	9	12	9	.129	130.7
65	17	16	16	16	.129	117.6	32	10	13	10	.124	138.9
70	18	17	18	17	.124	123.9	34	11	14	11	.119	147.1
75	19	19	19	18	.120	130.5	37	11	15	12	.115	156.7
80	20	20	20	20	.116	137.5	39	12	16	13	.111	164.8
85	22	21	21	21	.113	145.8	42	13	17	13	.108	173.8
90	23	22	23	22	.109	151.8	44	14	18	14	.105	181.8
95	24	24	24	23	.106	158.3	47	14	19	15	.102	191.1
100	25	25	25	25	.104	165.3	49	15	20	16	.100	199.0

Table 18. List of transects (first number) and segments (second number) for a proposed fixed-wing survey of eastern Canada and northeastern United States.

North-central Ontario

5101	13
5102	13
5103	13
5104	13
5105	13
5106	13

Central Ontario

5201	8
5202	11
5203	11
5204	10

Eastern Ontario

5301	1
5302	2
5303	3
5304	4
5305	4

Southwestern Ontario

5401	1
5402	3
5403	6
5404	8
5405	3
5406	4
5407	4
5408	5
5409	4
5410	1

Northern New York

5501	1
5502	1
5503	3
5504	3
5505	5

Southern Quebec

5601	7
5602	7
5603	7
5604	9
5605	8
5606	6
5607	3
5608	2
5609	1

Northern Ontario

5701	12
5702	12
5703	11
5704	9
5705	8
5706	8

Northern Michigan

5801	7
5802	8
5803	7
5804	5
5805	2
5806	1
5807	6
5808	16
5809	6
5810	1

Southern Michigan

5901	9
5902	9
5903	6
5904	9
5905	10
5906	10
5907	10
5908	10
5909	10
5910	7
5911	2
5912	1

Quebec

6801	8
6802	10
6803	25
6804	26
6805	27
6806	27
6807	26
6808	18
6809	15
6810	14

Prince Edward Island

6501	1
6502	4
6503	1

New Brunswick

6301	5
6302	8
6303	10
6304	8
6305	8
6306	7
6307	5
6308	6

Nova Scotia

6401	2
6402	4
6403	5
6404	5
6405	8
6406	8
6407	9
6408	5
6409	3
6410	5

Labrador

6701	7
6702	8
6703	4

Newfoundland

6601	9
6602	9
6603	1
6604	2

Maine

6201	8
6202	10
6203	10
6204	9
6205	8
6206	8
6207	8
6208	6
6209	5
6210	5

APPENDIX A: POWER OF THE EXPERIMENTAL HELICOPTER PLOT SURVEY *(from Collins, 4 February 1994)*.

The counts on a single plot could be modeled by:

$$y_{ij} = u + c_i + e_{ij}$$

where y_{ij} denotes the j-th count done by crew i,
u denotes the overall average count,
c_i denotes the effect of crew i,
e_{ij} denotes the random deviation of the j-th count for crew i.

Let σ_e^2 denote the variance of replicate counts done by the same crew on the same plot and σ_c^2 denote the among-crew variability of counts done by different crews.
Define $R = \sigma_c^2 / \sigma_e^2$ (i.e. the ratio of the among-crew to the within-crew variance). The power of the test can be calculated in terms of R.

The power of the 1993 experiment to detect differences among the 3 Quebec crews was calculated as follows. The analysis was done using only the 28 observations taken in Quebec and using a model with no plot*crew interaction term. Thus the test for crew effect was done using an F test with 2 degrees of freedom in the numerator and 14 degrees of freedom in the denominator. The power of this test is described in the following table:

R	Power
1.0	0.53
1.2	0.62
1.4	0.69
1.6	0.75
1.8	0.80
2.0	0.84

Thus, this experiment had an 84% chance of detecting among-crew variability which was twice the replicate variability. There was a 53% chance of detecting a crew effect which was the same size as the replicate variability.

APPENDIX B: ANOVA TABLES FOR 1993-94 ONTARIO DATA *(from Collins, 12 September 1994)*.

The data were analyzed using the model

$$y_{hijk} = \mu + \alpha_h + \beta_i + (\alpha\beta)_{hi} + \gamma_j + (\alpha\gamma)_{hj} + (\beta\gamma)_{ij} + e_{hij} + f_{hijk}$$

where y_{hijk} denotes then k-th replicate observer by crew j on plot i in year h,
μ denotes the overall mean,
α_h denotes the effect of year h,
β_i denotes the effect of crew i,
$(\alpha\beta)_{hi}$ denotes the interaction of crew and year,
γ_j denotes the effect of plot j,
$(\alpha\gamma)_{hj}$ denotes the year by plot interaction,
$(\beta\gamma)_{ij}$ denotes the crew by plot interaction,
e_{hij} denotes the deviation of the individual year by crew by plot from the model and
f_{hijk} denotes the deviation of the individual replicate from the model.

In the analysis of the above model the plot,year by plot interaction and the two deviation terms were considered random while the year, crew and year*crew interaction were considered fixed. The expected mean squared error terms are shown in Table B1.

The factors multiplying the Var(YCP) term in the expected mean squared error are close to identical and similarly the terms multiplying the coefficients for Var(YP) and Var (PC) hence the F-tests for the Year and Crew were calculated by dividing the appropriate mean square error term by the mean squared error for the year by plot interaction. The test for plot effect was done using a synthesized F-test using the YEAR*PLOT, CREW*PLOT and YEAR*CREW*PLOT mean squared error terms.

The results of the analysis of this model are shown in Table B2. For both Black Ducks and Ring-necked ducks the Mean square for (Year*Crew*Crew) was less than the mean square for error. Hence this term was discarded from the model and the analysis was redone. The appropriate expected mean-squared error terms are shown in Table B1 and the results of the analysis are shown in Table B3. The test for plot effect was done using a synthesized F-test using the YEAR*PLOT, CREW*PLOT and Error terms.

For Black Ducks there was a significant Year by Crew interaction indicating that the difference between the two crews changed between years. The two crews were compared separately each year using a paired t-test. There was a significant Crew by Plot interaction For Ring-necked Ducks there was no indication of Year or Crew differences.

In the full model analysis (Table B2) for Mallards, the mean square for the (Year*Crew*Plot) was greater than that for error but nonsignificant but the mean squared errors for Year*Plot and Crew by Plot were less than that for error. These three error terms were dropped from the model and the analysis was redone. The expected mean squares are shown in Table B1 but all terms are compared against the mean-square for Error. The results of the analysis are shown in Table B4. There was a significant difference among crews.

Table B1: Expected mean squared error terms

a) Full Model

Source	Type III Expected Mean Square
YEAR	Var(E) + 1.044 Var(YCP) + 2.087 Var(YP) + Q(Y,YC)
CREW	Var(E) + 1.044 Var(YCP) + 2.087 Var(CP) + Q(C,YC)
YEAR*CREW	Var(E) + 1.044 Var(YCP) + Q(YC)
PLOT	Var(E) + 1.047 Var(YCP) + 2.094 Var(CP) + 2.094 Var(YP) + 4.19 Var(P)
YEAR*PLOT	Var(E) + 1.047 Var(YCP) + 2.094 Var(YP)
CREW*PLOT	Var(E) + 1.047 Var(YCP) + 2.094 Var(CP)
YEAR*CREW*PLOT	Var(E) + 1.047 Var(YCP)

b) Model discarding (Year by Crew by Plot) interaction

Source	Type III Expected Mean Square
YEAR	Var(E) + 2.095 Var(Y*P) + Q(Y,Y*C)
CREW	Var(E) + 2.095 Var(C*P) + Q(C,Y*C)
YEAR*CREW	Var(E) + Q(Y*C)
PLOT	Var(E) + 2.107 Var(C*P) + 2.107 Var(Y*P) + 4.213 Var(P)
YEAR*PLOT	Var(E) + 2.107 Var(Y*P)
CREW*PLOT	Var(E) + 2.107 Var(C*P)

c) Model discarding (Year by Crew by Plot) , (Year by Plot) and (Crew by Plot) interactions

Source	Type III Expected Mean Square
YEAR	Var(E) + Q(YEAR,YEAR*CREW)
CREW	Var(E) + Q(LEADER,YEAR*CREW)
YEAR*CREW	Var(E) + Q(YEAR*CREW)
PLOT	Var(E) + 4.3 Var(PLOT)

Table B2: Results of full model ANOVA.

Black Ducks

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	0.6957	0.6957	0.03	0.8712
LEADER	1	507.1304	507.1304	4.42	0.0894
YEAR*LEADER	1	136.3478	136.3478	34.99	0.0020
PLOT	5	1682.9156	336.5831	2.50	0.1378
YEAR*PLOT	5	119.5357	23.9071	2.39	0.3207
PLOT*LEADER	5	573.1494	114.6299	11.46	0.0822
YEAR*PLOT*LEADER	5	19.4838	3.8968	0.39	0.8289
Error	2	20.0000	10.0000		
Corrected Total	25	3087.3846			

Mallards

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	3.92391	3.92391	0.76	0.4233
LEADER	1	119.83696	119.83696	41.33	0.0014
YEAR*LEADER	1	4.79348	4.79348	0.25	0.6361
PLOT	5	134.54140	26.90828	Negative	
YEAR*PLOT	5	25.82711	5.16542	0.83	0.6272
PLOT*LEADER	5	14.49594	2.89919	0.46	0.7887
YEAR*PLOT*LEADER	5	94.58685	18.91737	3.03	0.2668
Error	2	12.50000	6.25000		
Corrected Total	25	409.38462			

Ring-necked Ducks

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	57.9239	57.9239	1.52	0.2730
LEADER	1	186.5326	186.5326	1.93	0.2239
YEAR*LEADER	1	11.8370	11.8370	0.69	0.4428
PLOT	5	4910.3011	982.0602	8.32	0.0101
YEAR*PLOT	5	191.0284	38.2057	0.75	0.6583
PLOT*LEADER	5	484.3531	96.8706	1.89	0.3812
YEAR*PLOT*LEADER	5	85.2817	17.0563	0.33	0.8610
Error	2	102.5000	51.2500		
Corrected Total	25	6015.5385			

Table B3: Analysis discarding Year by Plot by Crew interaction

Black Duck

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	0.6670	0.6670	0.03	0.8729
CREW	1	508.2861	508.2861	4.36	0.0911
YEAR*CREW	1	136.4448	136.4448	24.19	0.0017
PLOT	5	1696.0079	339.2016	6.38	0.1391
YEAR*PLOT	5	117.7162	23.5432	4.17	0.0445
CREW*PLOT	5	583.0079	116.6016	20.67	0.0005
Error	7	39.4838	5.6405		
Corrected Total	25	3087.3846			

Ring-necked Duck

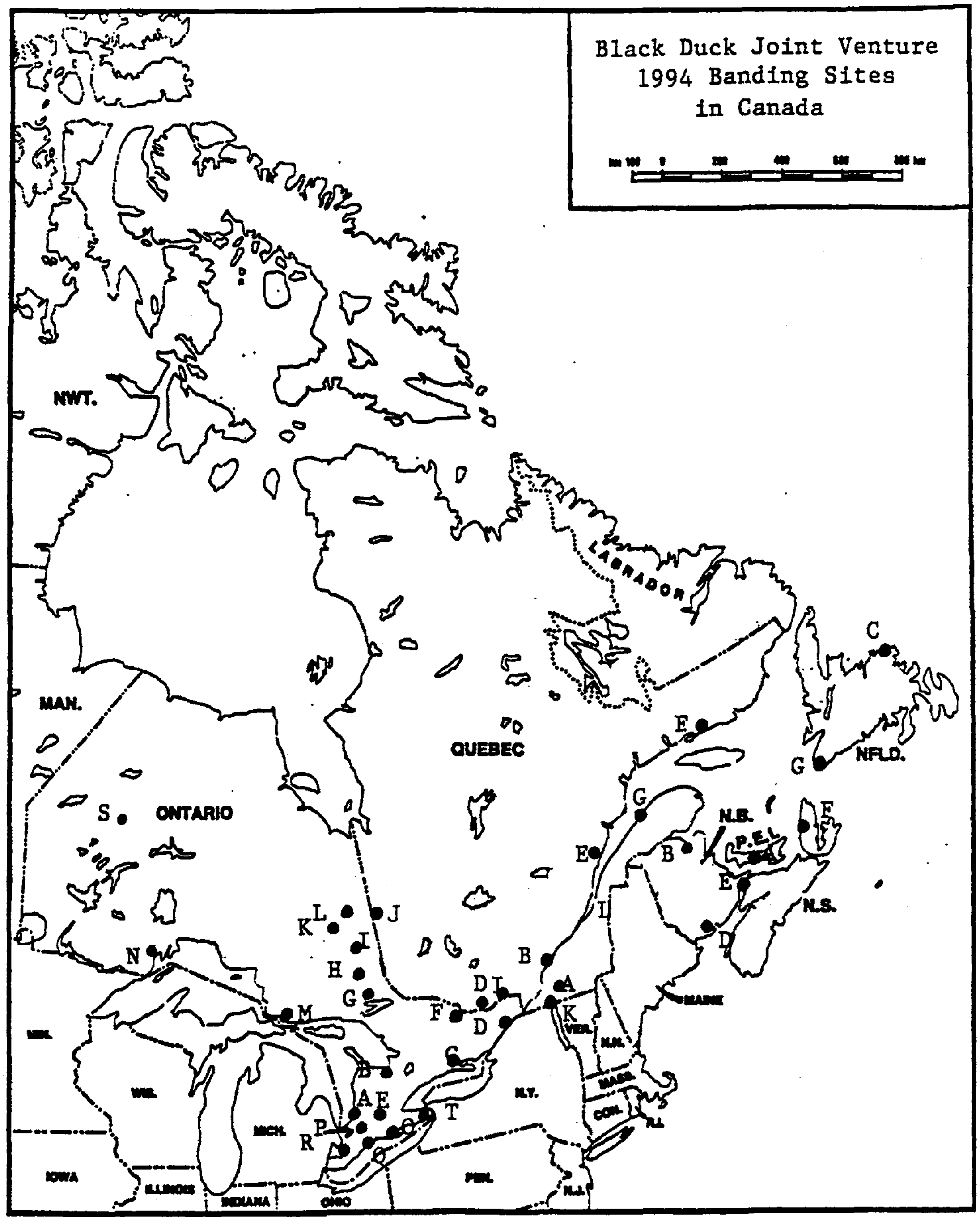
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	56.4287	56.4287	1.50	0.2747
CREW	1	190.4049	190.4049	1.96	0.2200
YEAR*CREW	1	11.1112	11.1112	0.41	0.5404
PLOT	5	4981.4350	996.2870	5.12	0.0136
YEAR*PLOT	5	187.6433	37.5287	1.40	0.3305
CREW*PLOT	5	484.6350	96.9270	3.61	0.0620
Error	7	187.7817	26.8260		
Corrected Total	25	6015.5385			

Table B4: Analysis discarding (Year by Plot by Crew), (Year by Plot) and (Crew by Plot) interactions

Mallards

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	3.88903	3.88903	0.46	0.5086
CREW	1	122.11452	122.11452	14.32	0.0015
YEAR*CREW	1	4.96746	4.96746	0.58	0.4558
PLOT	5	133.36991	26.67398	3.13	0.0350
Error	17	145.00509	8.52971		
Corrected Total	25	409.38462			

Appendix G



Ontario

A Wingham
B Midhurst
C Napanee
D Cornwall
E Cambridge
F Pembroke
G North Bay
H Temagami
I Kirkland Lake
K Timmins
L Cochrane
M Blind River
N Thunder Bay
O Long Point
P Oxford + Komoka
Q Aylmer
R Lake St. Clair
S Nikip Lake
T Niagara

Quebec

A Granby
B Lac St. Pierre
C La Pocatiere Bay
D Thurso
E Escoumins
F Baie John Beetz
G Rimouski
H Contrecoeur Island
I Rigaud
J Lake Parent
K Missisquoi Bay
L Montmagny

Atlantic Region

A PEI
B Bathurst, NB
C Terra Nova Nat. Park
D St. John River, NB
E NS/NB Border Marsh
F Cape Breton, NS
G Codroy, NF

CWS ATLANTIC REGION BANDING REPORT

1994 Preseason Banding Report by: M.C. Bateman and R.W. Daury

Banding Station Location: Atlantic Region

Crew Members: D. Patterson, C. Gunn, O. Dewberry, D. Thompson, L. Willett, J. Castiday, B. Barrow, J. Gillan, P. Gunn, D. Sears, and G. Brinson.

Results: Note that when age and sex were not given for all individuals, the total also includes birds not included in the other columns.

Species	*AHYM*	*AHYF*	*HYM*	*HYF*	*LM*	*LF*	*Total*
Black Duck	239	243	930	665	98	75	2250
Mallard	34	36	93	68	27	28	286
Mallard x Black Duck	2	1	9	4	7	0	23
Wood Duck	93	27	6	0	0	0	126
Northern Pintail	0	5	41	41	4	10	101
Ringnecked Duck	1	10	13	11	49	44	128
American Wigeon	2	4	12	20	39	41	118
Blue-winged Teal	34	22	133	144	96	80	509
Green-winged Teal	22	41	227	259	12	18	579
Canada goose	7	8	13	13	0	0	43
Gadwall	0	0	0	1	21	17	39
Shoveler	0	0	4	2	1	1	8
Total							4210

Comments: Because the black duck breeding population on PEI is being carefully monitored, the two banding stations there will be continued. The station at Terra Nova National Park, NF will be discontinued as large numbers of black ducks are not expected. The Codroy, NF station has been a long term monitoring station, but it may have to be moved as a result of poaching problems.The Cape Breton, NS station will be relocated in 1995, having captured more than 1000 black ducks in this area. The station at Bathurst, NB will be continued, as will the station in the NS-NB border marshes.

NB BANDING REPORT

1994 Preseason Banding Report by: Susan Bowes, Fish & Wildlife Branch, NB

Banding Station Location: St. John River between Fredericton and Gagetown, New Brunswick

Crew Members: Susan Bowes, Rhonda McLaughlin, Eric Wall.

Results: Note that when age and sex were not given for all individuals, the total also includes birds not included in the other columns.

Species	*AHYM*	*AHYF*	*HYM*	*HYF*	*LM*	*LF*	*Total*
Black Duck	48	71	364	276	9	9	777
Mallard	22	19	52	48	3	4	148
Mallard x Black Duck	4	5	21	17	0	0	47
Wood Duck	93	14	11	8	0	1	127
Northern Pintail	0	0	3	1	0	0	4
Ringnecked Duck	0	0	0	2	0	0	2
Blue-winged Teal	0	6	11	13	0	0	30
Green-winged Teal	13	12	30	16	0	0	71
Total	180	127	492	381	12	14	1206

Comments: water levels were ideal for bait-trapping this season. The project will continue to operate in 1995, focusing on those sites at which trapping is consistently successful. We will continue to expand the project into new marshes in the region in an effort to increase success, with particular emphasis on black ducks.

CWS QUEBEC REGION BANDING REPORT

1994 Preseason Banding Report by: P. Dupuis

Banding Station Location: Quebec Region

Crew Members: G. Couture, M. Castilloux, M. Bourque, M. Labonte, J. Hurtubise, M. Paquin, P. Messier, R. Angers and R. Smith (Fondation les oiseleurs du Quebec), J.-F. Giroux (University of Quebec at Montreal), R. Gladu (Pourvoirie Lac Saint-Pierre),M. Fortin and M.-F. Poirier (Lake Boivin Interpretation Center), S. Marois and J. Landry (Theatre educatif des migrations), Y. Desjardins, M. Charette, S. Lemay, Y. Lemay, N. Bergeron, J. Sauro, A. Cote, S. Hamel, and J. Langlais.

Results: Note that when age and sex were not given for all individuals, the total also includes birds not listed in the other columns.

Species	*AHYM*	*AHYF*	*HYM*	*HYF*	*LM*	*LF*	*Total*
Black Duck	194	175	489	345	12	8	1224
Mallard	640	291	1192	887	14	26	3052
Mallard x Black Duck	15	9	25	23	0	0	72
Hooded Merganser	0	0	0	4	0	0	4
Wood Duck	326	26	75	36	1	3	467
Northern Pintail	3	15	40	26	1	1	86
Redhead	0	0	2	2	0	0	4
Lesser Scaup	1	0	0	1	0	0	2
Ringnecked Duck	0	3	10	11	1	2	27
American Wigeon	0	0	4	3	1	3	11
Blue-winged Teal	11	16	67	83	0	2	179
Green-winged Teal	220	154	621	438	1	1	1436
Common Goldeneye	0	0	2	3	0	0	5
Gadwall	7	5	12	23	9	10	66
Shoveler	0	1	5	1	2	1	10
Total							6645

Table 1: Banding Results for Ontario - 1994. Includes all birds banded under programs or stations in Ontario that were at least partially supported by the Atlantic Flyway Cooperative Banding Program.

STATION	Mallard	Black Ducks	Mallard Black Hybrid	Wood Duck	Blue-Winged Teal	Green-Winged Teal	Ring-Necked Duck	OTHER*	TOTAL
NIAGARA	77	1			6	2			86
ALYMER	21			116	20	1			158
CAMBRIDGE	1276	33	10	24	816	15	6	38	2,218
WINGHAM	869	18	2	60	129	13			1,091
MIDHURST	947	62	4	11	66	1		44	1,135
NAPANEE	379	14	8	15	6			5	427
CORNWALL	851	54	6	22	3	5		2	943
PEMBROKE	47	11	2	16	4	2			82
THUNDER BAY	457	170	2	3	7	25	1	25	690
TIMMINS	22	26						2	50
KIRKLAND LAKE	457	74	4	3	103	11		2	654
TEMAGAMI	39	218	12	10				3	282
BLIND RIVER	33	21		2	1				57
COCHRANE	86	18	2	1					107
NORTH BAY	323	78	48						449
AIR BOAT	169	22	1	54	92	28	67	33	466
CWS - LONDON	1904	45	11	406	1562	127	0	12	4,067
TOTALS	7,957	865	112	743	2,815	230	74	166	12,962

Other: Cambridge-1 pintail, 37 redhead; Midhurst-7 pintail, 1 redhead, 36 Canada geese; Cornwall-2 pintail; Napanee-5 widgeon; Thunder Bay-5 pintail, 5 widgeon, 13 goldeneye, 1 bufflehead, 1 pintail-mallard cross; Timmins-2 Am. Widgeon; Kirkland Lake-2 common goldeneye; Temagami-1 pintail, 2 common mergansers;Air Boat Project-19 widgeon, 11 hooded mergansers, 3 northern shoveler; CWS-London 11 pintail, 1 lesser scaup.

U.S.F.W.S. BANDING REPORT

1994 Preseason Banding Report by: Fred Roetker, USFWS

Banding Station Location: Nikip Lake, Ontario

Crew Members: Steve Bierle (Univ. Montana), Glenn Harris (Cameron Prairie NWR), Bill Maynard (Region II USFWS).

Results: Note that when age and sex were not given for all individuals, the total also includes birds not included in the other columns.

Species	*AHYM*	*AHYF*	*HYM*	*HYF*	*LM*	*LF*	*Total*
Black Duck	8	0	1	0	0	0	9
Mallard	30	30	148	157	12	8	385
American wigeon	1	1	17	6	12	9	46
Northern Pintail	5	3	5	7	0	0	20
Ringnecked Duck	1	1	0	0	0	1	3
Blue-winged Teal	0	0	12	9	0	1	22
Northern Shoveler	0	0	1	2	0	2	5
Green-winged Teal	1	7	43	21	1	1	74
Total							564

U.S. BANDING REPORT

<u>1994 Preseason Banding Report by</u>: Jerry Martz and Pat Corr

<u>Banding Station Location</u>: throughout Michigan, Wisconsin and the northeastern Atlantic Flyway States.

<u>Results</u>: Note that when age and sex were not given for all individuals, the total also includes birds not listed in the other columns.

State	*Black Duck*	*Mallard*	*Hybrid*
Michigan	338	1298	
Wisconsin	0	7	
Maine	383	204	4
New Hampshire	32	120	0
Vermont	78	577	12
Massachusetts	113	575	5
Rhode Island	30	120	
New York	157	3672	
Pennsylvania	87	3531	
New Jersey	105	818	
Maryland	580	264	
Total	1834	11178	21

Appendix H

1. Project Title: Beaver pond management assessment program: Long term monitoring of waterfowl and non-waterfowl populations on beaver ponds in eastern Ontario.

Investigators: T. Shane Gabor, Research Biologist, Institute for Wetland and Waterfowl Research c/o Ducks Unlimited Canada, and Henry R. Murkin, Research Scientist, Institute for Wetland and Waterfowl Research c/o Ducks Unlimited and Adjunct Professor, Department of Renewable Resources, McGill University.

Objectives: The objectives of the study are:

1. To determine waterfowl (primarily black duck, mallard, wood duck and hooded merganser) density changes on managed and unmanaged beaver ponds.

2. To determine the abundance and habitat use of selected non-waterfowl species on landscapes with managed and unmanaged ponds.

3. To compare beaver abundance and distribution and habitat change resulting from beaver activity on managed and unmanaged landscapes.

General Description of the Study: In 1993, a long-term monitoring program was initiated to evaluate changes in waterfowl densities and habitat quality on landscapes with and without beaver pond management in eastern Ontario. Aerial pair surveys will be conducted for a 5 year period to determine the effects of beaver pond enhancement on waterfowl productivity and non-waterfowl abundance and habitat use. Beaver abundance, distribution and their effect on habitat quantity and quality will be determined annually.

Report on Progress (for ongoing work): In 1993 and 1994, aerial pair and brood surveys were conducted on the study areas. Aerial photography was employed to determine habitat use. Data from the 1994 field season is currently being analyzed and will be forwarded to the BDJV upon completion.

Partners: Black Duck Joint Venture
Ducks Unlimited Canada
Institute for Wetland and Waterfowl Research
Ontario Ministry of Natural Resources

Funding Received to date:
Black Duck Joint Venture 1994 - $10,000
Black Duck Joint Venture 1993 - $10,000
IWWR c/o Ducks Unlimited Canada 1994- $51,000
IWWR c/o Ducks Unlimited Canada 1993- $105,311

Beginning Date: Mar. 1, 1993
Ending Date: Dec. 31, 1997

2. Project Title: Increasing mallards decreasing black ducks: The role of reproductive success and competition.

Investigators: Mark Petrie, Ron Drobney, Daniel Sears

Objectives: 1) Estimate clutch size, nest success, hen success and duckling survival of mallards and black ducks.
2) Estimate survival of mallard and black duck females in the breeding, rearing and postreproductive periods.
3) Remove mallards to determine if mallards and black ducks compete.

General Description of the Study: Both mallard and black duck females were captured in the pre-laying period and fitted with surgically implanted radio transmitters. Marked birds were used to provide estimates of clutch size, nest success, hen success and survival of ducklings and adult females during the breeding period. In addition, mallard pairs were removed from selected wetlands to determine the role of competition in the decline of the black duck.

Report of Progress: To date, no difference in reproductive success has been detected for mallards and black ducks breeding sympatrically in western New Brunswick. Results of the mallard removal study indicate mallards and black ducks compete for available breeding habitat.

Partners:
1) Black Duck Joint Venture
2) New Brunswick Department of Natural Resources
3) Delta Waterfowl and Wetlands Research Station
4) Canadian Wildlife Service

Funding:
1994 - $45,000
1993 - $54,800
1990 - 1992-$104,000

Beginning Date: May, 1990

Ending Date: August, 1994

3. Project Title: *Impacts to Regional Waterfowl Populations of Wetland Restoration on Atlantic Dykeland Soils.*

Investigators: J. Bruce Pollard, Research Biologist, Institute for Wetland and Waterfowl Research, Keith McAloney, Provincial Biologist, and Andrew MacInnis, Area Biologist, DUC

Objectives: Evaluate the response of waterfowl populations in a regional context, to the securement and development of an impounded wetland complex. Supplemental waterfowl objectives include habitat-specific productivity and species-specific habitat selection. Additional objectives include the documentation of multi-species benefits of wetland development and management.

General Description of the Study: Intensive indicated breeding pair and brood surveys will be conducted on a 250 km^2 landscape surrounding a wetland development complex (Belle Isle Marsh). Waterfowl breeding effort and production will be monitored over a five year post-development period, initiated in 1993. Wetland specific data on pair and brood use and apparent brood success will provide information directly relevant to stated BDJV priorities. Impacts to passerine, wetland-obligate, small mammal, upland game bird and furbearer populations will also be assessed.

Report of Progress: Comprehensive pre-development waterfowl IBP and brood data collected in 1991/92 indicated relatively little variation in these parameters in the two years. Pre-impoundment (baseline) data for other species were also collected in 1991/92. In the first two post-development years (1993 and 1994), Black Duck indicated breeding pairs increased by approximately 17.7% and 36.5% over pre-impoundment levels. Observed Black Duck broods declined by 1.3% and 74.7% in 1993 and 1994 respectively.

Partners: Black Duck Joint Venture, Canadian Wildlife Service , Ducks Unlimited Canada, Eastern Habitat Joint Venture, Nova Scotia DNR, Canada Employment and Immigration, Institute for Wetland and Waterfowl Research

Funding Received in 1994/95:

1994: IWWR - $48 000 + Technical Assistance
BDJV - $12 700
EHJV - $10 000
CWS - $10 000 + Technical Assistance
NS DRN - $3 650 + Technical Assistance
DUC - $4 200 + Technical Assistance

Beginning Date: (post-development phase) April 1993

Ending Date: December 1997

4. Project Title: Characterization of breeding habitats for the American Black Duck using LANDSAT TM satellite images.

Investigator(s): Daniel Bordage, Marcelle Grenier et Nathalie Plante (CWS-Quebec)

Objectives: To develop large scale characterization of boreal forest habitats and to elaborate models of habitat use by breeding Black Ducks. Characterization and models will be used to locate high potential sites for breeding and to evaluate impacts of large scale projects such as hydro-electric development and forest cutting. Habitat maps and models of habitat use will help analysis of results of the breeding pair survey monitoring program.

General Description of the Study: The study area for the Black Duck Joint Venture breeding pair monitoring encompass 535 000 km^2 of boreal forest in Quebec. With such large territory and low densities of birds (15 pairs/100km^2), satellite images to characterize and models habitats proved to be an efficient tool. By combining habitats characterized by remote sensing and data from the survey program we can develop statistical models of habitat use by Black Ducks. These models permit estimation of the probability of observing Black Duck pairs by considering habitats for every square kilometre of the satellite image. Simulations could then be made by modifying water area (impoundment impacts) and forest cover (clear cutting) to estimate new probabilities of observing birds. Different maps and databases are also produced: habitat identification and distribution; potential for breeding; distribution of birds resulting from models.

Report of Progress (for ongoing work): The CWS published results of part of this study as "Grenier, M., D. Bordage and N. Plante. 1994. Remote sensing: a useful complement to waterfowl distribution surveys over vast areas. Can. J. Remote Sensing 20(2): 162-170 (in French). This means that we now have a tool for locating good habitat for Black Duck breeding pairs over vast areas of remote boreal forest (approximately 100 000 km^2 has been analyzed to-date. Locating good breeding sites for Black Ducks is only the first step toward sustainable and appropriate population management actions. To get the exact picture we should study mechanisms (including interactions with Mallards) that result in the observed distribution of Black Ducks.

Partners: Ducks Unlimited (Quebec office)

Funding received in 1993/94 and previous years:
$25 000 from BDJV and $5 000 from DU in 1994/95;
$25 000 from the BDJV in 1993/94;
$43 000 from BDJV and $15 000 from EHJV in 1992/93;
$21 000 from BDJV in 1991/92.

Beginning Date: November 1991

Ending Date: 1997

BLACK DUCK JOINT VENTURE
ANNUAL
RESEARCH REPORTING FORM

PROJECT NUMBER: BDJV94____________

PROJECT TITLE: Productivity of sympatrically breeding black ducks and mallards on wetlands of forested and agricultural landscapes in Maine.

PROJECT INVESTIGATOR(S): Jerry R. Longcore, Daniel G. McAuley, Lewis Boobar, National Biological Service, Northeast Research Group, Orono, ME.

OBJECTIVES: See BDJV Progress Report for 1992 for detailed objectives, but the general objective was to determine if various aspects of productivity of sympatric black duck and mallard productivity on an agricultural landscape and on a boreal forest landscape were different and to relate to vegetative and water chemistry variables. A secondary objective was added to collect data on type and extent of black duck and mallard interactions during the courtship period.

GENERAL DESCRIPTION OF STUDY: Brood production of black ducks and mallards will be determined in an agricultural landscape and a boreal forest landscape using telemetry. Characteristics of brood-rearing wetlands will be related to production. Wetlands will be observed during courtship period to determine use by breeding pairs of black ducks and mallards.

REPORT OF PROGRESS: During the 1994 field season 59 wetland sites were monitored by quite observation and 114 black duck and 63 mallard broods were counted. Mean brood size of Class IIc-III broods was 4.57 ± 0.24 ($\underline{n} = 95$) for black ducks and 5.00 ± 0.43 ($\underline{n} = 52$) for mallards. Mean brood sizes of mallard and black ducks that occurred together on a wetland or on all wetlands of the study area were not different. Hatching dates for black ducks preceded that of mallards. Twenty-nine wetlands were observed for about 100 hours in May; 66 interactions of black ducks and mallards were recorded. Most interactions were with conspecifics, displacement of birds was infrequent (10 of 32 instances when both species were present) with black ducks and mallards displacing each other about equally. Eight wetlands (4 per landscape) were sampled for invertebrates by sweep net and activity trap. Invertebrate samples were sorted and identification is underway. All study wetlands were mapped and classified and water samples collected and analyzed.

PARTNERS: Maine Department of Inland Fisheries and Wildlife
Canadian Wildlife Service, New Brunswick

ANNUAL FUNDING LEVEL: $100,700

BEGINNING DATE OF THIS PROJECT: April, 1993 (field work)

ENDING DATE EXPECTED: December, 1996.