Progress Notes

Disponible également en français

No. 149, January 1985

The large-scale impact of agriculture on ducks in the Prairie Provinces, 1956–81

by H. Boyd[1]

Abstract

Changes in duck numbers and production in the Prairie Provinces are compared with quinquennial agricultural census statistics and annual estimates of crop areas and production, to examine why the severe local damage known to be caused by wetland drainage and destruction of nesting cover affected regional duck populations relatively little until very recent years. The Canada Land Inventory (CLI) classification system shows that areas with high capability for waterfowl use and the best agricultural land overlap extensively. Perhaps for that reason, most waterfowl production in southern Canada takes place on poorer land, which is less intensively farmed. In the Prairie Ecozone (Continental Prairie Wetland Region) duck numbers and production have fluctuated widely in response to climatic effects on the extent of surface water, but have also decreased as total cropland and wheat acreage have increased. In the Boreal Plains (Transitional Mid-Boreal Wetlands) similar changes have occurred. Mallard have decreased with increased wheat-growing in Saskatchewan, but increased with increased wheat acreage in Manitoba.

Introduction

In Canada, as elsewhere, "reclamation" of wetlands and other features of the extension and intensification of agriculture have transformed the landscape in ways that are detrimental to ducks and other water birds. Detailed local studies have shown major reductions in numbers of breeding ducks and in nesting success, though duck numbers in the agricultural areas of southern Canada remain higher than those in most parts of the USA and Europe. The purpose of the inquiry reported here was to see whether measures of association between large-scale changes in agriculture and in waterfowl populations yield results consistent with those from intensive local studies, and whether they suggest additional topics for detailed study that might be helpful in predicting the prospects for ducks and in identifying ways of ameliorating the harmful impacts of farming on water birds. Southern Canada is matched only by parts of the USA as an area where such investigations are possible, because of the existence of runs of annual data on duck numbers and production as well as of agricultural statistics, which can be assembled by ecological zones as well as by political ones.

There are more difficulties in identifying and matching ecological zones than in dealing with units such as provinces, census divisions, or hunting zones. Political boundaries are sharp lines, mostly corresponding to easily identified topographical features. Ecological boundaries are usually fuzzy, often with extensive transitional areas, so that any selected line is almost as arbitrary with respect to biological systems as are the political limits. Thus quantitative studies at the levels of aggregation I have used here must generally be of low accuracy and precision, permitting only weak inferences to be drawn, and not well adapted to testing hypotheses. Despite these inherent limitations, large-scale studies are important constituents of the data base for managing waterfowl on a national and international scale.

[1] CWS, Ottawa, Ontario K1A 0E7

Materials and methods

Ducks

Estimates of the number of ducks in May in the southern Prairie Provinces have been made each year since 1955 by the US Fish and Wildlife Service (USFWS), using aerial strip transects, described by Martin *et al.* (1979). The strata used are shown in Figure 1(a). The same areas are sampled again in July to obtain indices of the numbers of broods hatched and of potential breeders not yet with broods.

The National Harvest Survey (NHS) and Species Composition Survey (SCS), conducted annually by CWS since 1967, provide indirect measures of regional duck abundance in the hunting season. Duck numbers are not necessarily related to local breeding densities and success, because much movement of birds takes place in late summer, including moult migrations of adults (chiefly males) and post-fledging scattering (often northward) of juveniles.

The NHS and SCS also provide indices of production, in the form of the proportion of wings taken from young birds. Because young ducks tend to be less wary than older ones, the kill survey exaggerates the preponderance of young birds in the population, but not always to the same extent, their relative vulnerability varying much more in some regions than in others (Boyd and Cooch 1983). The harvest surveys and their reliability have been described in detail by Cooch *et al.* (1978).

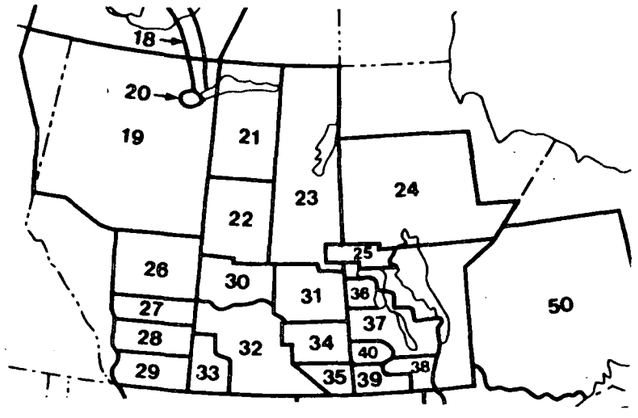
Habitat

The CLI has classified areas in the settled parts of Canada with respect to their *capability* for agriculture and for waterfowl use, among other ratings. It did not identify current use, but showed where soil, water, climate, topography, and other edaphic factors encourage or discourage farming or the presence of waterfowl. In 1979, the Lands Directorate of Environment Canada undertook, at the request of CWS, an analysis of the extent of overlapping of those two potential uses of land. The results are too complicated to be effectively displayed by mapping without the use of overlays, but I have used tabular summaries at the provincial level here to identify regional differences

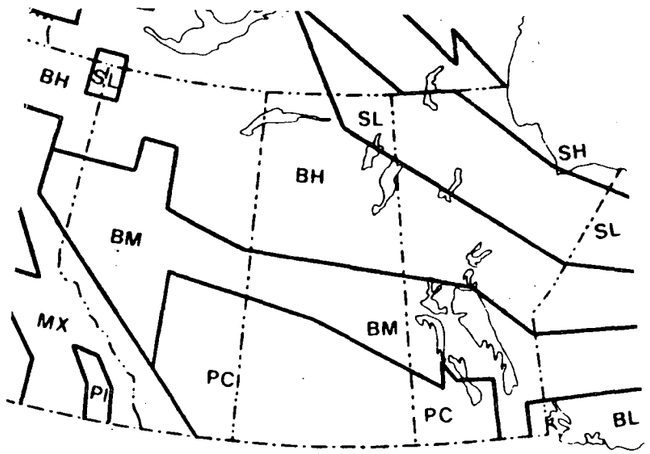
Environment Canada Environnement Canada
Canadian Wildlife Service Service canadien de la faune

Figure 1
Maps of the Prairie Provinces of Canada

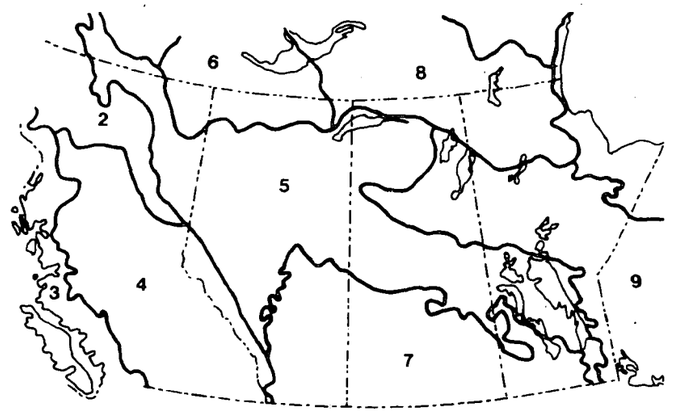
(a) STRATA FOR AERIAL WATERFOWL BREEDING POPULATION AND PRODUCTION SURVEYS



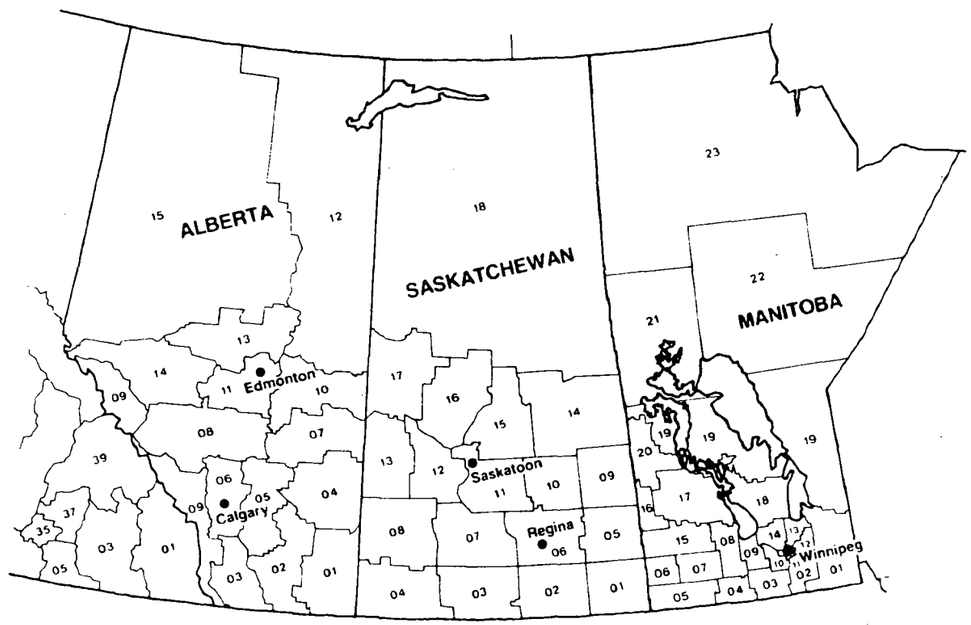
(b) WETLAND ZONES



(c) TERRESTRIAL ECOZONES



(d) 1981 CENSUS DIVISIONS



in the relative abundance of different categories and the potential conflicts in use that they suggest.

Two other habitat mapping systems recently developed by the Lands Directorate are also used here: the Wetland Regions of Canada (1981) and the Terrestrial Ecozones of Canada (1982). The relevant parts are illustrated in Figures 1(b) and 1(c). CWS has developed computer programs for assembling harvest survey data for wetland regions (Blain and Wendt 1983), and Statistics Canada has developed programs for assembling agricultural and demographic data by terrestrial ecozones, for use in a report on the state of the Canadian environment (P.M. Bird and D.J. Rapport, in prep.).

Agriculture

The agricultural data used here are those compiled by the Agriculture Statistics Division of Statistics Canada from the national quinquennial censuses (Statistics Canada 1982*a, b*), and from their annual sampling estimates of crop areas and production (Statistics Canada 1975 and 1983). The annual estimates are made only for entire provinces. The quinquennial data are also published for individual census divisions (Fig. 1 (d)), with boundaries that have been changed over time with the distribution of the human population, so that long-term comparisons at sub-provincial levels are sometimes confused. The accuracy and precision of these data are presumably greater than those of the waterfowl surveys and the determination of ecozone and wetland regional areas, but their relevance to those features of the landscape to which ducks respond is open to question.

Analysis

It is the mosaic of water, woodlands, farmland and, perhaps above all, "unused" land that determines suitability for occupation by ducks, with different requirements for nesting, brood-rearing, moulting, and occupancy in late summer and fall. Because the rolled-up statistics lack detail, they must be expected to be of low explanatory power. I have limited the methods used here to simple ranking and correlation. Of course, even high correlations do not demonstrate the existence of causal relationships. A more important deficiency is that a great many of the variables known to affect duck use at the local level are either unlikely to be reflected at all in the few surrogate state variables that are available, or likely to be largely cancelled out by others. Thus the results can be no more than indicative at best. Despite these formidable limitations, several seemingly clear results emerge.

Results

Waterfowl and agricultural capability

Table 1 records the amount of land in each of the Prairie Provinces rated in the CLI as having high capability for breeding and staging waterfowl, and high soil capability for agriculture. It also records the total area of each province and the area being farmed in 1981 (Statistics Canada 1982*b*). Potential waterfowl staging areas, chiefly large marshes (lakes having been excluded from the land inventory), clearly form a very small fraction of the total area. They are, at the same time, of critical importance to waterfowl and of minor importance to agriculture on the large scale. That does not mean that they are not threatened by agricultural improvement schemes. But it does mean that their destruction is unlikely to be detectable from the changes in land use shown by the quinquennial agricultural censuses.

Land with high waterfowl breeding capability is less than half as abundant as land with high soil capability for agriculture, being especially scarce in Manitoba. Even in Saskatchewan, land of high waterfowl capability amounts to less than 14% of the province, whereas 33% of Saskatchewan and 20% of the total Prairie Provinces have high soil potential for agriculture.

Traditionally it has been assumed that the economic value of land is much higher for agriculture than for waterfowl production, and that agriculture will therefore be pre-emptive. The extent of overlap between potentially good agricultural and waterfowl production land is consequently of crucial importance. Table 2 summarizes the relevant information. About 25% of the best agricultural land is also of high waterfowl potential, compared with nearly 33% of Class 2 and 23% of Class 3 agricultural land. Put another way, it must be expected that at least 25% of the potential waterfowl production areas have already been lost to agriculture, up to 33% in Saskatchewan and 20% in the other two provinces.

Harm done by agriculture to waterfowl breeding areas is not to be measured solely by the conversion of wetlands to croplands, important though that process is. Changes in practices on existing agricultural land can also have important effects, not always detrimental, on the extent of edges around water-bodies and fields and the quality of other potential nesting cover, on the likelihood of nests on cropland surviving the passage of cultivating or grass-cutting machinery, and so on. These detailed practices are not recorded in the standard agricultural statistics. The amount of summerfallow is recorded, but summerfallow is generally considered as nearly useless for nesting ducks.

The substitution of one crop for another, for example, growing rape and other oilseeds instead of cereals, may affect availability. Because the possible impacts of such changes on waterfowl cannot be defined quantitatively, it would be unprofitable to explore all the changes in absolute and relative abundance of crops that have been recorded since 1956. The approach I have adopted here is to ascertain what changes in duck numbers and production seem to have occurred in different regions, and then to look for agricultural changes associated with substantial population changes. If parallel changes in agriculture have taken place in regions where duck populations have not changed, the possibility of demonstrating linkage between observed changes in farming and in numbers of ducks will be diminished.

Duck survey strata, ecozones, wetland regions, and census divisions

The agricultural land of the prairies falls into two terrestrial ecozones, the Boreal Plains (BP) and the Prairies (P); and two wetland regions, the Continental Prairie (PC) and Mid-Boreal (BM). The wetland regions have been further sub-divided, the Prairie into Aspen Parkland (PCa) and Grassland (PCg), and the Mid-Boreal into Continental (BMc) and Transitional (BMt), but the boundaries of these sub-regions are so complex and their separateness so incomplete that it has seemed best to use only the larger aggregates. The published boundaries of the ecozones and the wetlands regions do not correspond exactly (see Figs. 1 (b) and 1 (c)), but the differences are small in relation to the coincidences between the great bulk of the areas defined, so that BP ≅ BM and P ≅ PC. The extent of their correspondence with the USFWS aerial survey strata (for duck populations) and Statistics Canada census divisions (for people and agriculture data) is shown in Table 3.

Numbers of ducks, ducklings, and ponds

Table 4 shows that in recent years there were estimated to be 8–18 million ducks present in May in the Prairie Ecozone, and another 4–7 million in the Boreal Plain Ecozone. The Mallard is the most important species, both numerically and for its interrelationships with farming, as it may cause damage to unharvested crops, especially wheat, when field-feeding in the fall. Other dabbling ducks nest like the Mallard on the ground near water, and the Pintail may also be involved in crop damage. Diving ducks (Aythyini) feed in, and nest over, water rather than on land, so that their responses to crop changes are unlikely to be as direct as those of the dabbling ducks, though they may be affected by changes in water quantity and quality due to run-off and agricultural effluents.

It is much more difficult to estimate the numbers of ducklings produced each year than the size of the adult population, ducklings being harder to find, nesting and brood-rearing being protracted, and many young ducks dispersing as soon as they can fly. Thus the estimates of 1.2–3.1 million unfledged ducks in the Prairie and 1.2–1.4 million in the Boreal Plain ecozones in mid July are small in relation to the corresponding number of adults, and are of use only as annual indices, rather than as absolute estimates of abundance.

An alternative way of dealing with duck numbers that is of greater analytical use is to convert the estimates to densities (ducks per km^2). Tables 5 and 6 record densities in the 6 most recent years in which full agricultural censuses were made: 1956, 1961, 1966, 1971, 1976, and 1981. In the Prairie Ecozone (Table 5), Mallard densities varied between 5 and 21, those of all other dabbling ducks (6 or 7 species) from 10 to 47, diving ducks from 1 to 10, and all ducks (including some other species, such as Ruddy Ducks and White-winged Scoters) from 16 to 76 per km^2.

In the Boreal Plains, Mallard densities varied from 1 to 18, other dabblers from 1 to 42, diving ducks from 1 to 10, and total ducks from 4 to 71. The densities in the Alberta portion of the ecozone were lower than those further east, due to the presence in northern Alberta of large tracts of country less suitable for ducks than the north-central parts of Saskatchewan and Manitoba.

Tables 4–6 show that duck numbers have fluctuated widely since 1956. The cropland areas shown in Table 4 have changed very much less. The major reason for the changing numbers of ducks is the large fluctuation in numbers of ponds and sloughs, due to changes in rainfall. The rows in Table 4 labelled "May ponds" provide an index of surface water abundance, derived from the numbers recorded during the aerial waterfowl surveys. (Ponds have not been recorded in northern Alberta.) It is important to allow for the association of ducks with ponds when examining the impact on ducks of increased cropland and changes in crops and their yields.

Crop areas and duck numbers

Table 4 shows that from 1971 to 1981 the total area of cropland increased from 22.5 to 24.0 million ha in the Prairies and from 3.7 to 4.3 million ha in the Boreal Plains, more than half of each area being in Saskatchewan, and the amounts in Manitoba being relatively small (13.7% of the Prairies, 7.1% of the total Boreal Plain crop area). Analysis for the three most recent census years (1971, 1976, 1981) suggests that, in both ecozones (Tables 5–7), increases in cropland and areas of wheat have been associated with decreases in duck numbers, especially those of dabbling ducks. Diving ducks in the Boreal Plains of Saskatchewan and Manitoba were positively associated with increasing crop areas. Brood numbers were not strongly associated with crop areas.

The longer run of agricultural census years (1956–81) cannot at present be matched against waterfowl data broken down by ecozones, so that only comparisons between province-wide data can be made for the full period. These confirm (Table 8) the negative correlation between dabbling duck numbers and areas of wheat. They also show that increases in the extent of improved pasture (not known for each ecozone separately) have coincided with decreases in ducks, particularly in Saskatchewan, even though the area of improved pasture still forms a relatively small part of the total farmed area. Numbers of broods and the mean size of broods have both fallen while farming has expanded and intensified. Most of the significant correlations remain large after partialling out the strong positive correlations between pond numbers and duck numbers and success.

Given the poor fit between crop yields and areas seeded, it is not surprising that there are no significant associations between indices of duck production and crop yields.

Summerfallow as such is of very little use to breeding waterfowl, because it fails to provide cover for nesting. It is surprising to find statistically significant positive correlations between the extent of summerfallow and duck and brood numbers in the Prairie and Boreal Plains ecozones in 1971, 1976, and 1981 (Table 7) and between Mallard numbers and summerfallow in Alberta in 1956–81 (Table 8), while for the 6 census years 1956–81, dabbling duck and brood numbers in Saskatchewan and Mallard numbers in Manitoba showed negative correlations with the extent of summerfallow (Table 8, 9). These contradictory findings are probably explicable in terms of the different trends in the extent of summerfallowing that

have become evident since 1970 (a year in which there was an isolated peak in summerfallow) in all three provinces. A.J. Macaulay (pers. commun.) has pointed out that the rate of abandonment of the practice of summerfallowing in southern Manitoba and central Alberta has been considerably higher than it has been anywhere in Saskatchewan. Thus the recent decline in duck numbers evident in all three provinces has coincided with decreasing summerfallow in Alberta and Manitoba, and with no clear change in Saskatchewan (Fig. 2).

Discussion

One of the objectives of intensive agriculture is to increase yields per unit area by using more prolific varieties, more fertilizers, herbicides to reduce unwanted weeds, and so on. These gradual gains are relatively hard to detect in the Prairies by quinquennial sampling, because the effects of adverse weather (especially drought) in particular years can so readily wipe out the anticipated gains. Thus the annual series for crop yields are as erratic as those for duck numbers, perhaps for related reasons. Duck numbers in May and areas seeded for crops both reflect occupancy or use decisions based both on current habitat stocks and on anticipated performance. (The farmer's decisions also involve economic considerations that can be ignored by ducks.) The farmer makes a judgement about the likelihood of favourable growing and ripening conditions. The duck must somehow assess the likelihood that the area in which it chooses to nest will provide good conditions for rearing a brood. Adequate summer rainfall is important to both.

The numbers of broods in July and the numbers of ducks in May are highly correlated. The correlations between wheat yields and areas seeded are poor. This suggests either that ducks make better judgements than farmers or that their task is a much easier one, because ducks are mobile and farmers are not.

The results of this exploratory investigation are satisfactory, to the extent that they indicate associations between agricultural growth and duck decline that are consistent with the results of detailed field studies. Whether they are useful depends on whether they suggest lines of inquiry not raised by previous field studies. In that respect, the most interesting results appear to be those from Saskatchewan, with the largest amounts of cropland and of wheat, where additional wheat-growing seems to have had little additional impact on ducks, but where additions to improved pasture and to summerfallow have been more clearly associated with reductions in ducks and in duck production (the latter in relation to summerfallow only). When we recall that the overlap between high capability for waterfowl and for agriculture is half as great again in Saskatchewan as in Alberta and Manitoba (Table 2), this may mean that deterioration in prairie duck populations must be expected to continue in the 1980s and 1990s, irrespective of the extent and intensity of drought and of the kinds of farming being practised. But this ecozone analysis is more discouraging than earlier studies (Boyd 1981*a, b*) because it suggests that changes in "marginal farming" are a greater threat to ducks than changes in farming on the best agricultural land.

Acknowledgements

I am indebted to S. Blain and J.S. Wendt for devising the programs to assemble and retrieve NHS and SCS data by ecozones, and to A.J. Macaulay, J.H. Patterson, and J.S. Wendt for critical comments on drafts.

References

Blain, S.; Wendt, J.S. 1983. Waterfowl hunting activity and kill of ducks and geese in Wetland Regions of Canada, 1969–1981. Program documentation. Can. Wildl. Serv. Manuscr. Rep.

Boyd, H. 1981*a*. Prairie dabbling ducks, 1941–1990. Can. Wildl. Serv. Prog. Notes No. 119:1–9.

Boyd, H. 1981*b*. A fair future for prairie ducks; cloudy further north. Trans. 46th North Am. Wildl. and Nat. Resour. Conf. (1981):85–93.

Boyd, H.; Cooch, F.G. 1983. Duck numbers and duck hunting in southern Alberta, 1975–82, and their implications for waterfowl management. Can. Wildl. Serv. Prog. Notes No. 140:1–24.

Cooch, F.G.; Wendt, J.S.; Smith, G.E.J.; Butler, G. 1978. The Canada Migratory Game Bird Hunting Permit and associated surveys. Can. Wildl. Serv. Rep. Ser. No. 43:8–39.

Martin, F.W.; Pospahala, R.S.; Nichols, J.D. 1979. Assessment and population management of North American migratory birds. Pages 187–239 *in* Cairns, J.; Patil, G.P.; Waters, W.E., eds. Environmental Biomonitoring, Assessment, Prediction and Management. Int. Co-op. Publ. Fairland, Md.

Statistics Canada. 1975. Handbook of agricultural statistics. Part I. Field Crops. Cat. 21-516. Occas. 189 pp.

Statistics Canada. 1982*a*. 1981 Census of Canada–Agriculture–Field Crops. Cat. 96-912.

Statistics Canada. 1982*b*. 1981 Census of Canada–Agriculture–Land Use. Cat. 96-916.

Statistics Canada, Agriculture Statistics Division. 1983. Handbood of field crop statistics, 1952–53 to 1982–83. Distrib. in printout form only.

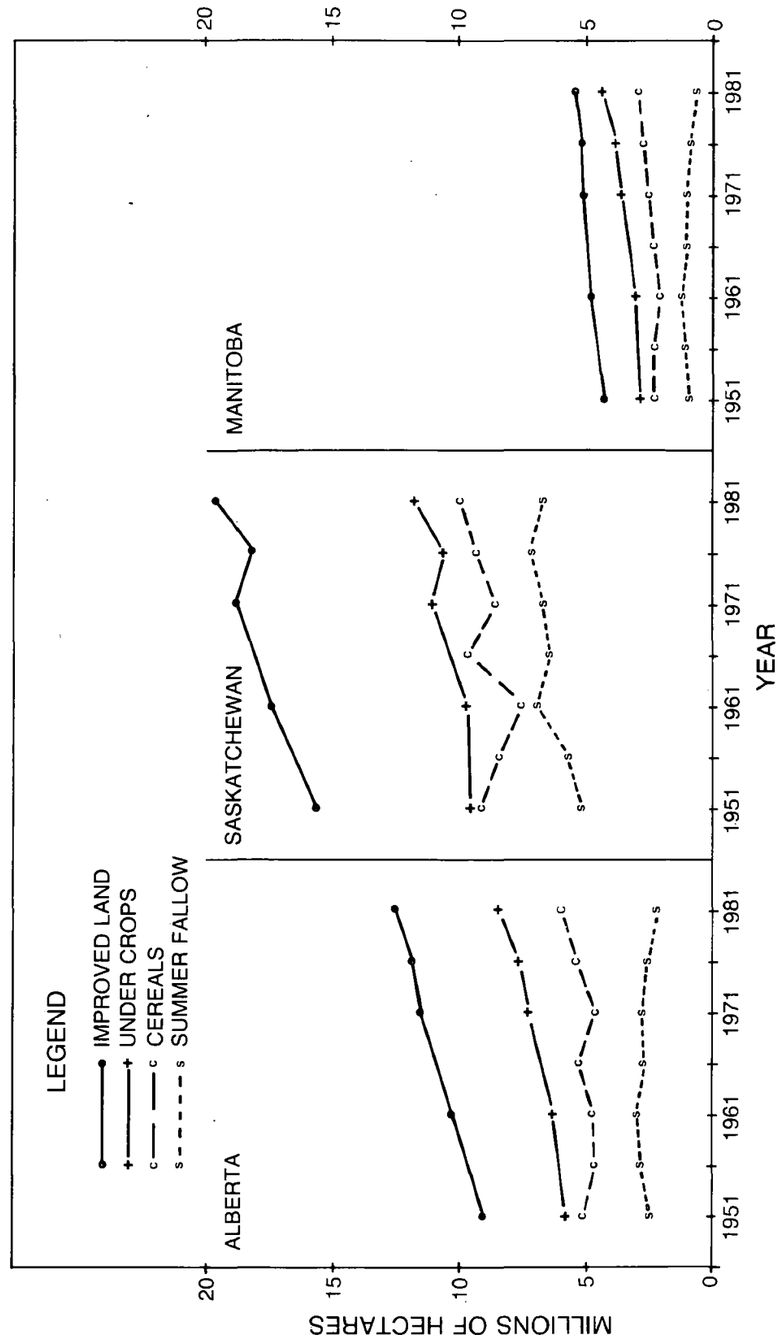


Figure 2
Areas of crops and summerfallow in the Prairie Provinces, 1951–81

Table 1
Areas in Prairie Provinces rated in the CLI as having high capability for waterfowl breeding (classes 1–3, except 3M) and staging (classes 1S, 2S, 3S, 3M), and high soil capability for agriculture (classes 1–3)

Province	High waterfowl capability				High agricultural capability		Total farm area, 1981		Total land area
	Breeding		Staging						
	km²	%*	km²	%	km²	%	km²	%	km²
Alberta	45 860	7.2	250	0.04	112 910	17.7	191 090	29.9	638 230
Saskatchewan	82 510	14.5	840	0.15	191 170	33.5	259 470	45.5	570 110
Manitoba	15 930	2.9	120	0.02	57 020	10.4	76 160	13.9	547 700
Total	144 350	8.2	1210	0.07	361 100	20.6	526 720	30.0	1756 040

* Percent of total land area.

Table 2
Association between lands of high capability for breeding waterfowl and soil capability for agriculture in Prairie Provinces. Waterfowl classes 1, 2, and 3 (except 3M) classified as "high capability"

Province	High agricultural capability				Lower agric. capability	Total high waterfowl cap.
	Class 1	Class 2	Class 3	Total		
Alberta	127*	888	1 393	2 408	2 178	4 586
Saskatchewan	426	2 881	2 749	6 056	2 195	8 251
Manitoba	5	867	286	1 158	440	1 598
Total	558	4 636	4 428	9 622	4 813	14 435
Total area agric. class						
Alberta	799	4 125	6 367	11 291	28 512	
Saskatchewan	1 256	7 398	10 463	19 117	15 261	
Manitoba	213	2 991	2 498	5 202	7 749	
Total	2 268	14 514	19 328	36 110	51 522	
High waterfowl cap. % of agric. class						
Alberta	15.9	21.5	21.9	21.3	7.6	
Saskatchewan	33.9	38.9	26.3	31.7	14.4	
Manitoba	2.4	29.0	11.4	20.0	5.7	
Total	24.6	36.9	22.9	26.6	9.3	

* Hectares in thousands.

Table 3
Equivalence of terrestrial ecozones, wetland regions, waterfowl survey strata, and census divisions in the three Prairie Provinces

Province	Ecozones	Wetland regions	Survey strata area		Census divisions	Total area	Farmed area
Alberta	BP	BM	19,20	42.9*	08, 11-15	46.6*	6.7*
	P	PC	26-29	16.6	01-07, 10	14.1	12.3
Saskatchewan	BP	BM	30,31	10.3	14-17	9.7	5.5
	P	PC	32-35	16.2	01-13	22.0	20.5
Manitoba	BP	BM	36-38	7.2	12-16, 18-21	14.9	2.8
	P	PC	39-40	2.9	03, 10, 17	4.6	4.3
Total		BM		60.5		71.2	
		PC		35.7		40.7	

* Hectares in millions.

Table 4
Summary of duck and agricultural statistics for the Prairie and Boreal Plain ecozones in Alberta (A), Saskatchewan (S), and Manitoba (M) for 1971, 1976, and 1981

Ecozones	1971				1976				1981			
	A	S	M	Total	A	S	M	Total	A	S	M	Total
Prairie												
Ducks in May												
Mallard	1871*	1 947	145	3 963	1454	1 996	283	3 733	752	947	156	1 855
Other dabblers	4129	4 752	402	9 283	3248	5 367	856	9 471	1553	3 048	281	4 882
Diving ducks	474	377	138	989	1251	724	251	2 226	277	696	165	1 138
All ducks	6446	7 115	760	14 321	6015	8 171	1434	15 620	2628	4 771	696	8 095
July broods	1151	1 341	151	2 643	1568	1 372	116	3 056	569	495	151	1 215
May ponds	609	2 372	412	3 393	830	1 586	410	2 826	281	625	83	989
Crop areas												
Wheat	1219†	4 810	959	6 988	2049	6 454	1418	9 921	2342	6 941	1435	10 718
Summerfallow	2305	5 783	1002	9 090	2112	6 303	832	9 247	1803	5 990	528	8 321
Total cropland	6047	13 190	3248	22 485	6414	14 139	3319	23 872	6553	14 394	3051	23 998
Boreal Plain												
Ducks in May												
Mallard	642	1 454	141	2 237	395	1 030	253	1 678	624	753	156	1 533
Other dabblers	1236	2 237	376	3 849	650	1 514	424	2 586	1349	1 343	327	3 019
Diving ducks	1146	359	151	1 656	810	425	228	1 463	1054	454	270	1 778
All ducks	3097	410	697	4 204	1910	2 988	955	5 853	3180	2 571	907	6 658
July broods	473	799	122	1 394	463	836	119	1 418	720	413	122	1 255
May ponds	—	731	397	—	—	615	393	—	—	315	132	—
Crop areas												
Wheat	175	419	51	645	217	709	104	1 030	369	889	125	1 383
Summerfallow	531	919	61	1 511	518	900	89	1 507	422	687	68	1 177
Total cropland	1474	1 960	236	3 676	1679	2 210	305	4 194	1763	2 218	325	4 306

* Duck numbers in thousands.
† Hectares in thousands.

Table 5
Duck and pond densities (per km^2) in May in the Prairie Ecozone of Alberta, Saskatchewan, and Manitoba in quinquennial agricultural census years, 1956–81

Province	1956	1961	1966	1971	1976	1981
Mallard						
Alberta	10.8	8.2	9.3	11.2	8.7	5.7
Saskatchewan	21.4	5.3	6.8	12.0	12.3	4.6
Manitoba	13.4	5.3	5.0	5.0	9.9	5.4
Other dabblers						
Alberta	20.7	15.3	20.6	24.2	19.5	18.3
Saskatchewan	47.5	16.3	19.8	29.4	33.2	9.6
Manitoba	18.1	20.7	26.1	14.0	29.8	9.8
Diving ducks						
Alberta	4.2	3.5	3.4	2.8	7.5	4.2
Saskatchewan	5.8	3.0	1.3	2.3	4.5	1.6
Manitoba	5.8	9.5	4.5	4.8	8.7	5.8
All ducks						
Alberta	36.4	27.4	34.3	38.7	36.1	28.6
Saskatchewan	76.4	24.7	31.3	44.0	50.5	16.2
Manitoba	39.0	39.2	38.6	26.5	50.0	23.9
Ponds						
Alberta	6.2	4.1	4.9	3.7	5.0	3.8
Saskatchewan	12.6	1.9	8.3	10.6	9.8	1.7
Manitoba	15.2	5.8	14.0	14.4	14.3	2.9

Table 6
Duck and pond densities (per km^2) in May in the Boreal Plain Ecozone of Alberta, Saskatchewan, and Manitoba in quinquennial agricultural census years, 1956–81

Province	1956	1961	1966	1971	1976	1981
Mallard						
Alberta	1.1	4.3	1.2	1.5	0.9	1.5
Saskatchewan	18.3	7.8	8.5	14.2	10.0	7.3
Manitoba	4.9	2.3	2.5	2.0	3.5	2.7
Other dabblers						
Alberta	3.0	6.9	3.5	5.2	1.5	3.2
Saskatchewan	42.5	14.6	19.7	21.8	14.7	13.1
Manitoba	4.5	5.1	7.2	5.0	5.9	4.6
Diving ducks						
Alberta	2.6	5.3	2.7	2.7	1.9	2.5
Saskatchewan	9.9	3.7	2.8	3.5	4.2	4.4
Manitoba	1.6	2.2	1.6	2.1	3.2	3.8
All ducks						
Alberta	7.9	17.7	8.1	7.2	4.5	7.4
Saskatchewan	71.4	26.7	31.3	39.9	29.1	25.0
Manitoba	11.1	10.6	12.8	9.7	13.3	12.7
Ponds						
Alberta	NR*	—	—	—	—	—
Saskatchewan	7.1	2.4	6.1	7.1	6.0	3.1
Manitoba	8.7	3.7	7.6	5.6	5.5	1.8

* Not recorded.

Table 7
Correlation between numbers of ducks and broods and areas of cropland, wheat, and summerfallow in the Prairie and Boreal Plain ecozones of the Prairie Provinces, 1971–81. The signs (+, −) of those coefficients significant at the 10% level or better are shown

Province	Prairie Ecozone			Boreal Plains Ecozone		
	Cropland	Wheat	Summerfallow	Cropland	Wheat	Summerfallow
All ducks						
Alberta	−	−	+			
Saskatchewan				−	−	
Manitoba				+	+	+
Prairie Provinces			+	−		
Mallard						
Alberta	−	−	+			
Saskatchewan				−	−	+
Manitoba						+
Prairie Provinces			+	−	−	
Other dabblers						
Alberta	−	−	+			
Saskatchewan				−	−	
Manitoba						
Prairie Provinces			+			
Diving ducks						
Alberta						
Saskatchewan		+	+	+		−
Manitoba		+	+	+		
Prairie Provinces						
Broods						
Alberta				+		−
Saskatchewan						+
Manitoba						−
Prairie Provinces		+				+

Table 8
Correlation between ducks and broods in the Prairie Provinces and changes in areas of cropland, wheat, improved pasture, summerfallow, and numbers of ponds in May. Data from 6 quinquennial census years 1956–81. Coefficients entered only if significant at 10% level

Province	Total cropland	Wheat	Improved pasture	Summerfallow	May ponds
All ducks					
Alberta		−0.660			
Saskatchewan				−0.690	0.826
Manitoba					
Prairie Provinces					0.902†
Mallard					
Alberta		−0.757*		0.714*	
Saskatchewan		−0.651		0.654	0.837
Manitoba				−0.671	
Prairie Provinces					0.873†
Other dabblers					
Alberta		−0.623			
Saskatchewan				−0.698	0.858
Manitoba					
Prairie Provinces					0.758*
Diving ducks					
Alberta					
Saskatchewan					
Manitoba		0.684			−0.665
Prairie Provinces					
Broods					
Alberta			−0.700		0.833*
Saskatchewan				−0.638	0.881
Manitoba	−0.752	−0.689	−0.891		
Prairie Provinces					0.906†

* $p < 0.05$.
† $p < 0.01$.

Table 9
Significant correlations of numbers of ducks and broods with areas of cropland, 1956–81, with and without partialling out of numbers of May ponds. Sign on right of column indicates large *r* after partialling out ponds

Ducks	Wheat				Improved pasture				Summerfallow			
	Alta.	Sask.	Man.	All	Alta.	Sask.	Man.	All	Alta.	Sask.	Man.	All
Mallard	− −	−		− −		−	−		+	−		
Other dabblers	− −			− −		− −				−		
Diving ducks			+		+	− −						
All ducks	−(−)		+			(−)−				−		
Brood numbers			− −		−		− −	−		−		−
Brood size				−	−			−		−	+	