MORTALITY RECORDS AS INDICES OF MIGRATION IN THE MALLARD

By JOSEPH J. HICKEY

This paper has been written as a critical appraisal of the banding technique in revealing autumnal migration routes of waterfowl. It has particular reference to the Mallard (*Anas platyrhynchos*) in North America. That serious technical problems now face ornithologists in summarizing the wealth of migration data available for some species of North American waterfowl must be apparent to everyone who has scanned the excellent report on banding records recently compiled by Aldrich (1949) and his colleagues in the United States Fish and Wildlife Service. It is clear from this report that banding analyses in the future will more and more summarize extensive lists of recoveries on a percentage basis. Without in any way reflecting discredit on the very useful work that has already been reported in this way, I wish to explore the potential biases present in percentages of this kind in the hope that future analyses can be carried out with increase in precision.

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To a very considerable extent, the studies of the migration of banded waterfowl have involved analyses of the distribution of mortality reports turned in by literate hunters in Canada and the United States. These are the records that will be examined in the present study. About 87 per cent of the recovery localities cited on Mallard banding cards of the Fish and Wildlife Service in 1946 I found to refer to the place where a duck was shot; the remaining 13 per cent refer to the home locality of the hunter. Because the present study does not, for the most part, break down hunters' reports below the state or provincial level, and because so few hunters buy out-of-state licenses, I feel that the potential error from reports referring to home localities has been here kept to a negligible minimum.

DISTORTIONS PRODUCED BY DIFFERENTIAL VULNERABILITY TO HUNTING

Emlen (1940) and Lack (1943, 1946) have shown that in some species of birds the young in the early part of the fall have a higher mortality rate than do adults. Hochbaum (1944:109, 159-160) has presented evidence that some young waterfowl are similarly more vulnerable to hunting than adults. Although during the past five years this phenomenon has become common knowledge among waterfowl biologists in North America, its statistical verification has awaited a report by Bellrose, Hawkins and Low (in press).

Is the percentage of banded waterfowl reported shot in a given state or province in any way affected by this greater vulnerability of young ducks to the gun? Some instructive data on this problem are set forth in table 1 which summarizes some banding work undertaken mainly by Ducks Unlimited (Canada). In this table birds banded after August 31 represent those banded for the most part during the hunting season and shot

during that same season. While the samples are too small to bring out minute differences, the results take on some meaning when they are considered in the aggregate for the two provinces of Alberta and Saskatchewan. (1) Among birds banded before September 1, 25 per cent of the 272 young were shot in the province in which they were banded, in contrast to 14 per cent of 710 adults. This difference at once leads one to suspect that the recorded percentage of young recovered to the south will tend to be less than that

Table 1

Reported Recoveries of Canadian-banded Mallards on a Percentage Basis

Where banded	Latitudinal zone where reported shot	Shot as young		Shot as adults	
		Banded before Sept. 1	Banded after Aug. 31	Banded before Sept. 1	Banded after Aug. 31
	(Size of sample)	(175)	(189)	(211)	(129)
Alberta	1. B.C.-Man.	35	29	25	29
	2. Wash.-Mich.	21	25	24	22
	3. Ore.-Ill.	23	25	27	26
	4. Calif.-Mo.	10	10	10	14
	5. Ariz.-Tenn.	5	5	4	5
	6. Tex.-Miss.	5	6	10	5
	(Size of sample)	(97)	(107)	(499)	(187)
Sask.	1. Alta.-Ont.	27	36	17	20
	2. Id.-Mich.	13	6	16	7
	3. Ore.-Ohio	21	24	23	23
	4. Calif.-Va.	9	7	10	12
	5. Ariz.-S.C.	14	14	15	18
	6. Tex.-Fla.	16	14	19	21

recorded for the adults. For latitudinal zones 4 to 6 in table 1, these statistics are 27 per cent for young birds against 37 per cent for the adults. (2) If recoveries are considered regardless of banding date, we find that 24 per cent of 568 young were reported shot in their "home" province in contrast to 16 per cent for 1026 adults. Resulting recoveries in the three more southern zones run 26 per cent for young birds and 38 per cent for adults.

Does this mean that fewer young birds than adults are shot in the South? We can approach this question separately by plotting young and adult records geographically on a percentage basis. From figure 1, in which only birds banded in Canada are considered, it would appear that relatively more immature birds than adults are shot in September and October in Canada, that during the same period relatively more adults are shot in the northern states, and that a smaller percentage of the young birds seems to be shot in the South. The two sets of percentages should imply the rate at which these two age groups are shot on their wintering grounds near the end of the season under a condition involving equal numbers of adults and of young at the start of the hunting season. (This condition is the result of our permitting 100 per cent to represent the total number of birds in each age group in the above analysis.) The possibility that young birds are markedly more wary than adults, and are less apt to be shot, near the end of the hunting season, has been thoroughly ruled out by Bellrose, Hawkins and Low (*ibid.*). We must therefore conclude that this difference between the age groups in late hunting season kill data in the South is an aberration resulting from (a) the differential vulnerability of the two age groups in the early part of the hunting season and from the percentage method of summarization or (b) differential migration by the two age groups. This last possibility surely deserves special study.

A further exploration of relative vulnerabilities to hunting can be made by comparing the monthly distribution of hunting mortality for 2883 adults (banded in Canada and the Northern States) against that of 610 juveniles banded in various parts of the continent before the start of the hunting season. This is carried out in the first half of table 2. Now in December and January, 28.3 per cent of the adults were reported shot against 21.8 per cent of the juveniles, which are now better referred to as first-year birds.

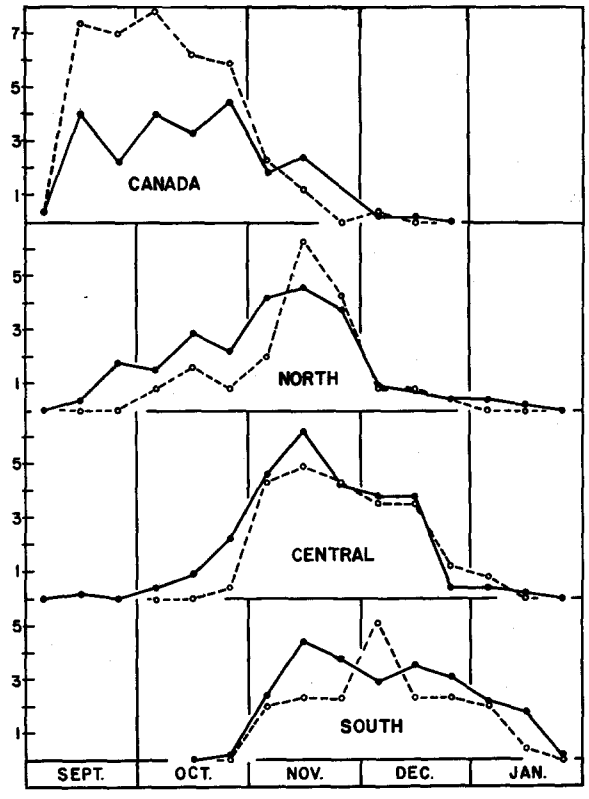

Fig. 1. Frequency polygons showing distribution of hunters' reports of Mallards banded in Canada before September of season in which they were shot; data arranged to show their mortality by ten-day periods. Solid lines represent 453 adults; broken lines 252 immature birds. Ordinate scale represents per cent of birds. "North," "Central," and "South" represent approximately equal latitudinal belts of the United States. Kills for the 31st days of October and December were omitted from total numbers of birds.

It seems a safe assumption to state that during these two months, vulnerability of first-year birds was at least as great as that of the adults. Temporarily ignoring sampling error (the confidence limits in samples like these being about 3 per cent), we can divide 28.3 per cent by 21.8 to get a correction factor of 1.30 which can be used to multiply each value in the monthly frequency distribution of hunting mortality for the immature birds. This correction in the adjusted distribution is shown in the lower part of table 2. Thus, for these particular birds (and not necessarily all Mallards), it would seem possible that

the immature birds may be twice as vulnerable to gunning in September and October as the adults are in the same period. Because the adjusted November value for the immatures rather closely approximates the actual November value for adults, I suspect that the sampling errors restricting the calculation of a correction factor here are of a minimal nature.

As a possible check on this correction factor, the Canadian banding data shown in figure 1 were recast into table 3 along with some North Dakota data to illustrate the

Table 2

Monthly Distribution of Hunting Mortality in Mallards

When reported shot		Sept.	Oct.	Nov.	Dec.	Jan.	Dec.-Jan. subtotal
Age group	No. in sample	Actual distribution by per cent					
Adults	2883	7.3	20.3	44.2	22.5	5.8	28.3
Immatures	610	11.1	33.4	33.6	19.0	2.8	21.8
		Adjusted distribution (see text)					
Adults	2883	7.3	20.3	44.2	22.5	5.8	28.3
Immatures	.....	14.4	43.4	43.7	24.7	3.6	28.3

effect of sampling a population farther south. A purely negative check on vulnerability of first-year birds to gunning is possible if we can assume (1) that immature birds are shot at least as frequently as adult birds in the Southern States and (2) that sampling errors do not seriously mar the regional frequencies here calculated. Thus 24.5 per cent for Canadian-banded adults shot in the South would be divided by 19.8 (for immatures) to give a correction factor of 1.24. When this factor is multiplied against each value in

Table 3

Geographic Breakdown of Hunting Mortality Encountered by Certain Adult and Immature Birds

Age when shot	Adult		Immature	
Place banded	North Dakota	Canada		
Size of sample	592	453	252	
Where reported shot	Percentage frequencies			Corrected (see text)
Canada	12.8	24.1	39.7	49.2
Northern States	26.4	24.1	17.5	21.6
Central States	32.3	27.4	23.0	28.5
Southern States	28.5	24.5	19.8	24.5
Total (%)	100.0	100.1	100.0	123.8

the actual frequency distribution of the 252 immatures, a corrected series (shown in the last column in table 3) gives the relative vulnerability of the two age groups in the three other regions. Thus in Canada, immature birds would appear to be about twice as vulnerable as adults. The small sample of immatures here considered does not demonstrate any marked changes in the vulnerability of those first-year birds once the birds have left Canada.

The size of the samples here considered surely restricts the conclusions one can draw on this problem, and I hesitate to claim that the approximately same results obtained by the different analytical approaches are anything more than coincidence. Both tech-

Table 4

Hunting-season Reports of Adult Mallards Banded in Western North America

Where banded		Brit. Col.	Montana	Alberta	Sask.	N. D.
Size of sample		1258	254	211	499	592
		Per cent of reports in each sample				
Where reported shot						
Zone 1	Alaska	1.4	.....	.....	.....	.....
	Brit. Columbia	44.6	2.0	0.5	.....	.....
	Washington	43.0	8.7	10.4	.....	.....
	Oregon	5.0	13.0	4.3	.....	0.3
	California	0.6	14.9	1.4	.....	0.2
Zone 2	Yukon-Mackenzie	0.2	.....	.....	.....	.....
	Alberta	3.1	11.4	20.9	2.2	2.4
	Idaho	0.6	28.3	7.1	0.8	0.3
	Nevada	0.1	1.6	0.5	.....	.....
	Utah	.....	1.6	.....	0.2	0.2
	Arizona	.....	.....	.....	.....	.....
Zone 3	Montana	0.4	15.4	8.5	1.6	1.3
	Wyoming	0.2	.....	2.4	0.6	.....
	Colorado	0.1	0.4	5.7	1.8	.....
	New Mexico	.....	.....	0.5	0.2	0.9
Zone 4	Saskatchewan	.....	1.6	1.4	10.6	6.4
	North Dakota	0.1	.....	2.4	7.2	11.4
	South Dakota	.....	.....	3.8	8.4	4.4
	Nebraska	.....	.....	7.1	4.8	4.6
	Kansas	.....	.....	0.9	3.4	3.7
	Oklahoma	0.1	.....	0.9	3.4	2.7
	Texas	0.1	0.8	7.6	9.8	4.7
Zone 5	Manitoba	0.2	.....	1.9	4.2	4.1
	Minnesota	.....	.....	1.9	5.4	5.9
	Iowa	.....	.....	0.9	3.0	6.1
	Missouri	.....	.....	1.9	4.0	4.9
	Arkansas	0.1	.....	1.9	10.6	11.6
	Louisiana	.....	.....	1.9	7.0	6.8
Zone 6	Ontario	0.1	.....	.....	0.2	.....
	Wisconsin	.....	.....	0.9	0.4	2.0
	Illinois	0.1	.....	1.4	6.0	10.9
	Kentucky	.....	.....	.....	.....	0.2
	Tennessee	.....	.....	0.5	0.8	0.9
	Mississippi	.....	.....	0.5	1.4	1.3
Zone 7	Michigan	.....	.....	.....	0.2	0.3
	Indiana	.....	0.4	.....	0.4	.....
	Ohio	.....	.....	.....	0.2	.....
	Alabama	.....	.....	.....	0.4	0.7
	Virginia	.....	.....	.....	0.2	.....
	South Carolina	.....	.....	.....	.....	0.7
	Georgia	.....	.....	.....	0.2	.....
	Florida	.....	.....	.....	0.2	.....

Table 5

Hunting-season Reports of Adult Mallards Banded in Interior North America

Where banded		Man.	Minn.	Wis.	Ill.	Mo.	Ark.	La.
Size of sample		194	112	99	1718	220	277	498
		Per cent of reports in each sample						
Where reported shot								
Zone 1	Alaska	.....	.....	.....	0.06	.....	.....	0.2
	Misc. Canada	.....	.....	.....	0.2	.....	.....	0.4
	Oregon	.....	.....	.....	.....	.....	0.4	.....
Zone 2	Alberta	.....	0.9	.....	0.9	3.6	1.8	3.4
	Idaho	.....	.....	1.0	0.2	.....	.....	.....
	Nevada	.....	.....	.....	0.06	.....	.....	.....
	Utah	.....	.....	.....	.....	.....	0.4	0.2
Zone 3	Saskatchewan	1.5	0.9	1.0	2.2	5.0	5.1	5.2
	Montana	.....	.....	.....	0.1	0.5	0.7	0.2
	Colorado	.....	1.8	.....	.....	.....	0.4	1.5
Zone 4	Manitoba	**17.5**	1.8	4.0	4.7	2.3	6.1	6.0
	North Dakota	8.3	5.4	2.0	3.7	5.5	4.7	4.8
	South Dakota	1.4	1.8	3.0	3.3	4.5	5.1	4.6
	Nebraska	1.0	2.7	.....	0.9	3.6	2.9	2.4
	Kansas	1.0	0.9	.....	0.7	2.7	1.1	2.0
	Oklahoma	1.4	3.6	.....	0.4	4.1	1.4	1.8
	Texas	5.7	4.5	1.0	1.4	8.2	2.2	3.0
Zone 5	Minnesota	15.5	**25.9**	17.2	15.2	8.2	11.6	13.9
	Iowa	5.2	1.8	2.0	4.9	6.8	4.7	5.2
	Missouri	5.7	5.4	.....	2.2	**13.2**	1.8	5.2
	Arkansas	9.3	11.6	3.0	8.6	11.4	**27.1**	9.0
	Louisiana	5.7	6.2	4.0	5.3	8.2	6.5	**13.1**
Zone 6	Ontario	0.5	.....	1.0	0.7	.....	0.7	0.4
	Wisconsin	1.0	3.6	**30.3**	6.9	0.9	1.4	3.4
	Michigan	0.5	.....	3.0	1.7	.....	.....	0.4
	Illinois	9.8	13.4	13.1	**25.0**	7.7	8.3	11.6
	Indiana	.....	.....	2.0	1.9	0.5	0.4	0.2
	Ohio	1.0	0.9	2.0	0.5	.....	.....	0.2
	Kentucky	0.5	0.9	2.0	0.7	.....	0.7	0.2
	Tennessee	2.1	0.9	1.0	3.1	0.9	2.2	0.6
	Mississippi	4.1	2.7	.....	3.1	0.5	2.5	1.2
	Alabama	0.5	1.8	3.0	0.6	.....	.....	.....
Zone 7	Quebec	.....	.....	1.0	.....	.....	.....	.....
	New York	.....	.....	.....	.....	.....	.....	0.2
	Pennsylvania	.....	.....	.....	0.06	.....	.....	.....
	New Jersey	.....	.....	.....	0.06	.....	.....	.....
	Virginia	.....	.....	1.0	.....	.....	.....	.....
	North Carolina	.....	.....	.....	0.1	.....	.....	.....
	South Carolina	0.5	0.9	1.0	0.2	0.5	.....	.....
	Georgia	.....	.....	.....	0.4	0.5	.....	.....
	Florida	.....	.....	1.0	.....	.....	.....	.....

niques should be re-applied with larger samples. A much more positive approach to this problem depends on analyses of recovery rates, which can of course be broken down regionally as well as month by month.

BAITED BIRDS AS RANDOMIZED SAMPLES OF REGIONAL POPULATIONS

In summarizing banding recoveries of waterfowl, either in migration studies or game-management analyses, it may properly be asked if adult birds banded by baited trapping represent adequately randomized samples of regional populations. This question is explored in tables 4 and 5 for adult birds banded before September 1 or in some year previous to the one in which they were reported shot. In 9 out of 12 cases, *more Mallards were shot in their "home" state or province than in any other state or province.* In two other cases, divergences from this generalization were minimal. For Saskatchewan-banded birds, Arkansas recoveries equalled those of the home province; for North Dakota-banded birds, they exceeded that of the home state by 0.2 per cent. In the one nonconforming sample (Montana), the banding station was less than 50 miles from the critical state boundary (Idaho). From this I conclude that these banded samples are not typical of large regional or flyway population units of Mallards; each one of them tends to be peculiarly "conditioned" by the birds' previous experience. In the southern part of the Mississippi Valley, we have an Illinois population unit of Mallards, a Missouri one, an Arkansas one, and a Louisiana one. It is obvious that most birds that were trapped for banding purposes in the past were caught because they were baited and spent some time in the vicinity of the banding station. While it is not evident from this study that they returned to that station or its vicinity, it is certainly implied that they tended to return to the same state and that they spent more time there than in neighboring states or were more easily shot in the state or province in which they were banded. This bias is a warning that even with large-scale banding operations, one cannot place complete confidence in unqualified statements that given percentages will appear in particular zones. The fact remains, however, that banded adults are reported with relative consistency in areas away from the point of banding. Thus, in tables 4 and 5, adult birds were reported in Missouri, Arkansas, and Louisiana with the following percentages: from Saskatchewan—4, 11, and 7 per cent; from North Dakota—5, 12, and 7; from Manitoba—6, 9, and 6; and from Minnesota—5, 12, and 6. It seems to me probable that correction factors can be worked out for individual banding stations to remove bias introduced by "conditioning," but I did not attempt any in the present study.

In recent years, the United States Fish and Wildlife Service has utilized drive traps as a means of capturing both young and adult ducks for banding in Canada. By eliminating baiting, this technique opens up a fresh approach to the problem of banding representative samples of waterfowl populations and to analyses of their migratory behavior.

In general, the adult recoveries set forth in tables 4 and 5 conform to the migration analyses of Lincoln (1933) and Hawkins (1949). Contradictory results may be noted in the small number (27) of waterfowl banded in western Montana and recovered in California according to Lincoln (1933:134); I am at a loss to explain his result and am forced to regard it as a *lapsus*. (Some additional data on Montana-banded Mallards are also presented in table 7.) Cartwright's (1945) description of a previously unrecognized migration route from Alberta to California, which was reported for two other species, seems to have been an indirect correction of this oversight. Hawkins' (1949) report that 7 per cent of an Alberta sample of Mallards was recovered in Michigan should have read 0.7 per cent (A. S. Hawkins, *in litt.*).

To Munro (1943), banding and observational data from British Columbia have sug-

gested that "Mallard populations in general are definite associations, nesting in the same localities, migrating together, and wintering together in the same areas from year to year." This hypothesis could not be tested thoroughly in the course of my study. The possibility should also be mentioned that an aggregation of birds nesting in some area in the North may leave there en masse and the individuals proceed to their wintering grounds at different rates of travel. Thus, observations on migration in southern Canada might support Munro's hypothesis of migration by aggregations while observa-

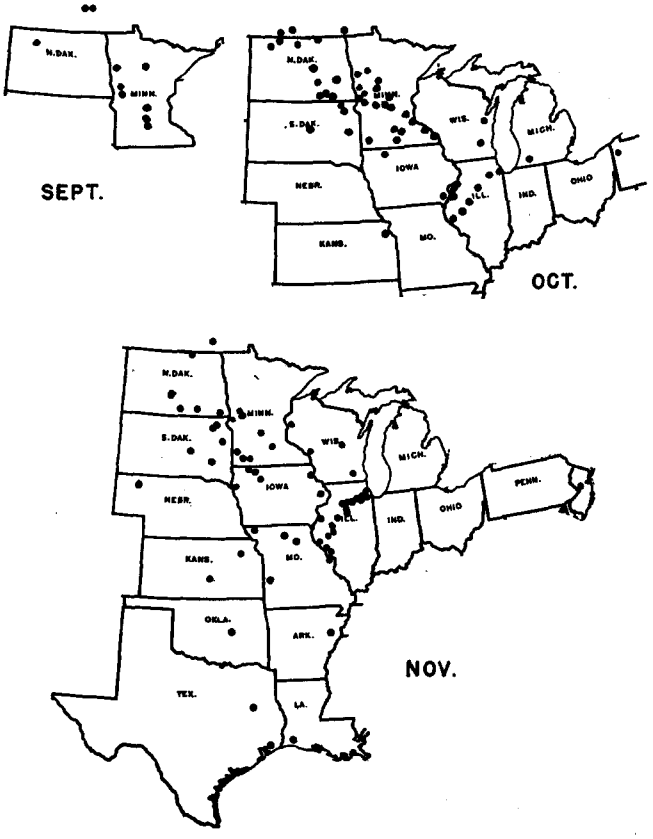

Fig. 2. Geographic distribution of returns of some adult Mallards reported shot in September, October, and November, 1944; all individuals banded in 1943 at McGinnis Slough, northeastern Illinois (Mann, Thompson, and Jedlicka, 1947).

tions in Oregon, Nebraska, and Illinois would contradict it if the birds dispersed more and more as they migrated south.

One test of this hypothesis is illustrated in figures 2 and 3, in which the recoveries of Mallards (banded in northeastern Illinois in 1943) are followed month by month throughout a full hunting season. One should notice here the width of the front on which the birds travelled and the probable duration of the "aggregation" they made up.

Although my initial impression of these maps was that the front was a wide one, I finally concluded that "width" here requires some definition. If one is willing to overlook an aberrant 10 per cent of the population that scatters widely, it can be said that

most of these birds moved within a channel approximately 250 miles wide. This is about the width of Iowa and, for a powerful flyer like the Mallard, this seems to me to be a reasonably narrow migration route. Despite the distortions in the data produced by the length of the legal hunting season, it is evident, however, that these Mallards were strung out in a long arc from Manitoba to the Gulf Coast during the autumn. The final test of migration by definite aggregations in waterfowl perhaps depends on a re-analysis of the data according to the time the birds were banded.

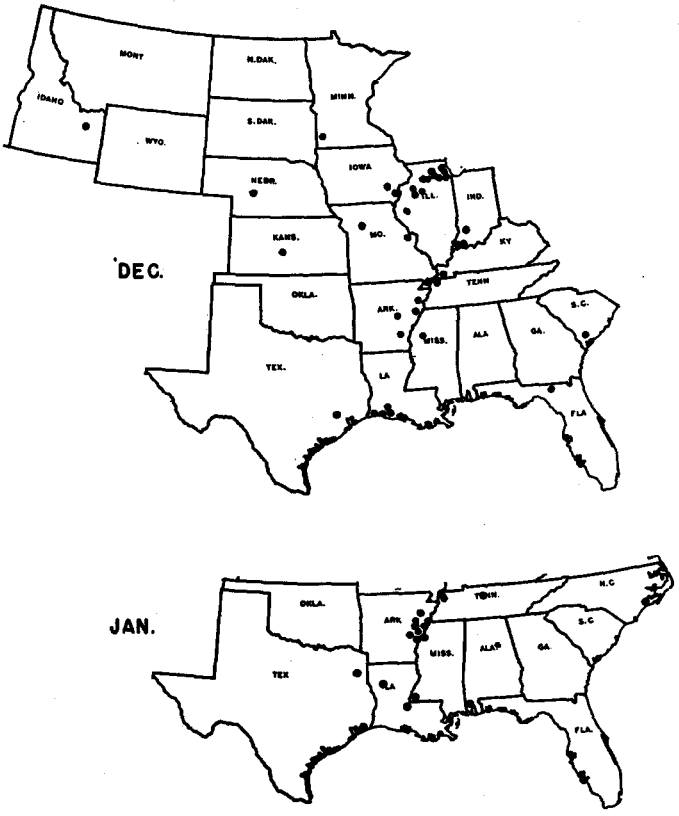

Fig. 3. Distribution of adult Mallards reported shot in December, 1944, and January, 1945. Original data from Mann, Thompson, and Jedlicka (1947), as in figure 2.

It is worth noting that the "conditioning" associated with baited traps is a behavior pattern that shows up in hunting-season records, and its effects should not be expected in spring distributions on birds on their breeding grounds. Table 6 demonstrates this situation. While sampling errors affect the percentages both vertically and horizontally in a table like this, provincial differences in, say, shooting of waterfowl in spring (or reporting of bands) may only affect the distributions horizontally. Sampling errors aside, the ratios implied vertically apparently represent preliminary indices of the distributional gradients existing at these latitudes. To make them statistically reliable, some large-scale banding programs would have to be carried out. In order to give greater meaning to analyses like that of table 6, it would be particularly helpful if these programs could be carried out on wintering populations.

Table 6

Breeding Season Recoveries of Some Winter-banded Mallards

Where banded	Number banded	Per cent recovered in May and June			
		Alta.	Sask.	Man.	Ont.
Kansas-Oklahoma	73	36	42	21	1
Mo., Ark., and La.	55	16	44	34	5
Illinois	149	12	28	43	17

DISTORTIONS PRODUCED BY DIFFERENT BANDING DATES

Aldrich *et al.* (1949:2) have pertinently distinguished between "direct" and "indirect" recoveries. Direct recoveries in their report involve recaptures of birds during the migration period in which they were banded. Since their technique frequently groups birds banded during the breeding season with those banded during the hunting season, it is of some interest to examine the possible effects that banding dates have on the frequency of recoveries reported in various states and provinces. I have attempted to do this by breaking down some recovery data into birds banded before September 1 and those banded after August 31 (table 1). (More divisions of the data would be useful in larger-sized samples.)

Among young birds, significant differences were absent in the two rather small-sized samples examined. Among adult birds, these differences were absent in those from Alberta and present to a minor degree in the Saskatchewan-banded samples studied here. In this last group, birds banded before September 1 appear to have had an equal oppor-

Table 7

Autumnal Distribution of Hunters' Reports of Male Mallards Banded in Montana in 1927

Size of sample	414	254	239
When reported shot	Same year	Later years	See text
Where reported shot	Per cent of reports in each sample		
British Columbia	.....	2.0	.....
Alberta	.....	11.4	.....
Saskatchewan	.....	1.6	.....
Montana	29.2	15.4	18.1
Idaho	29.7	28.3	33.2
Washington	15.2	8.7	10.2
Oregon	16.2	13.0	15.3
California	8.7	14.9	17.5
Miscellaneous	1.0	4.8	5.6

tunity to disperse both east and west as well as to undergo something of a full measure of hunting pressure in the northern tier of states. Those banded after August 31 presumably represented a residue of the birds left in Saskatchewan; they did not disperse appreciably to the east and west, and their lingering in Saskatchewan seems to have subjected them to less hunting pressure in the northern tier of states.

It is of course obvious that, south of Canada, banding dates late in the hunting season should lead to no direct recoveries in Canada. In a purely preliminary exploration of this situation, I separated 414 direct recoveries from 254 indirect recoveries of

668 unaged male Mallards banded by F. H. Rose in western Montana during the fall of 1927. Even when all the Canadian recoveries are dropped from consideration, as in the last column of table 7, several interesting differences between the two types of recoveries compel notice: they are decreases in the percentage of reports for Montana and Washington in indirect recoveries and increases in the percentage reported for California. It seems to me quite probable that these differences arise from the fact that the birds recovered directly were not aged at the time of banding and must have in-

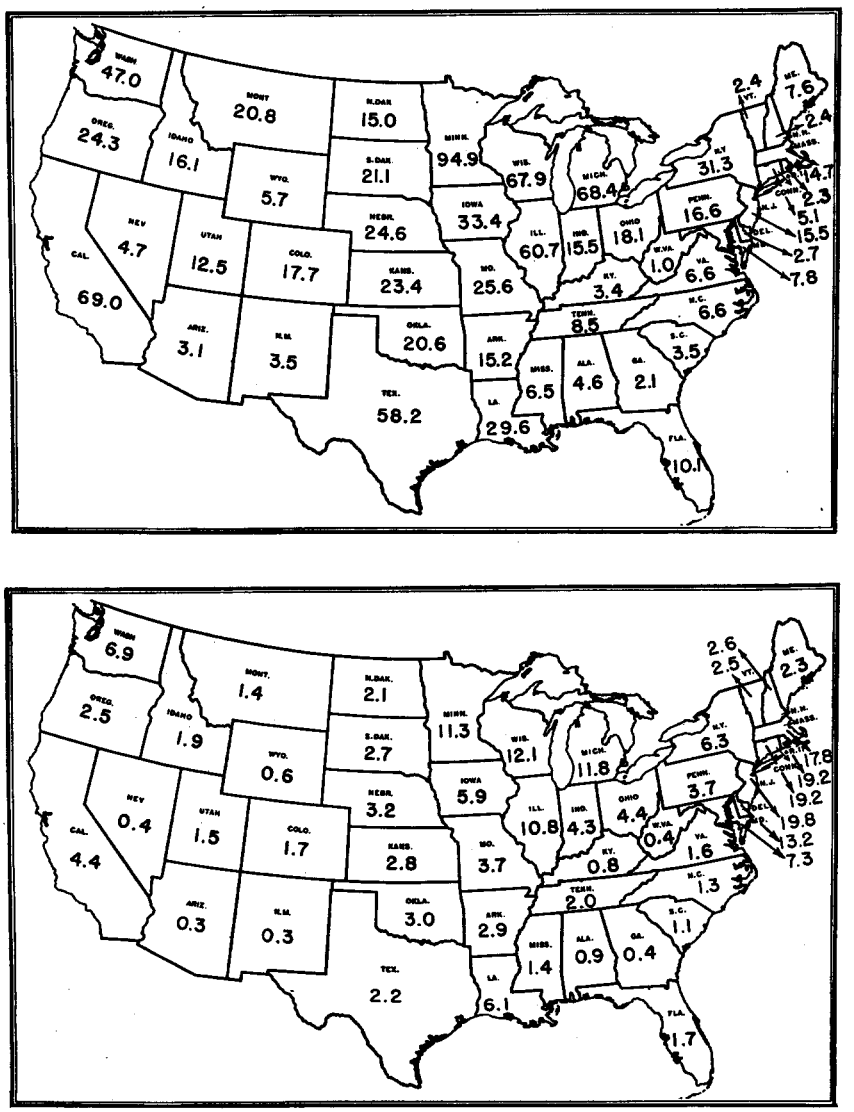

Fig. 4. Upper map, mean number of Federal duck stamps (in thousands) sold annually in each state, 1934–44. Lower map, 10-year duck-stamp sales, 1934–44, divided by the total area in square miles of each state and multiplied by 10.

cluded an important number of young birds. The samples here considered can scarcely be taken as an adequate test of the effect of banding dates, but they do serve to illustrate the degree of variation that can be expected from this source.

DISCUSSION

It is obvious that regional differences in shooting pressure could bias the geographic distribution of waterfowl recoveries. This is using the term shooting pressure not only in the sense of guns afield per unit area, but also as the equivalent of some index of hunting effort or efficiency (the mean number of days afield for each hunter, facilities such as hunting clubs or public shooting grounds, and the like).

One national index of duck-hunting pressure is the number of duck stamps annually sold by the United States government. With the help of unpublished tabulations furnished me by F. C. Lincoln and A. C. Martin, I mapped the mean number of duck stamps sold in each state over a ten-year period, from 1934 to 1944 (fig. 4, upper map).

Differences in the numbers of duck stamps sold in adjacent states are well known and quite considerable. Thus, in Florida and Georgia, nearly identical in size, duck stamps averaged 10,106 for the former and 2109 for the latter over a ten-year period. Illinois has averaged 60,677; Iowa with a similar size has averaged 33,360.

To get some idea of the relative densities of duck hunters, I next divided this mean number by the number of square miles in each state. The resulting distribution is summarized in table 8. The 14 states that averaged the most number of duck stamps per

Table 8

Average Number Duck Stamps Sold Per Square Mile

Number of stamps per square mile	Number of states
Less than 0.1	8
0.11–0.20	10
0.21–0.30	10
0.31–0.40	3
0.41–0.50	3
0.51–1.98	14

square mile from 1934 to 1944 were Iowa, New York, Washington, Maryland, Louisiana, Delaware, Illinois, Michigan, Minnesota, Wisconsin, Massachusetts, Rhode Island, and New Jersey. The geographic spread of these data can be seen in figure 4 where each value has been multiplied by ten. This index of hunting pressure suggests superficially that uncorrected mortality reports of banded waterfowl might minimize the occurrence of ducks in some states like Oregon and exaggerate it in other regions like Minnesota, Wisconsin, Michigan, and Illinois or on the Atlantic Coast from Massachusetts south to Delaware or Maryland.

A few moments' reflection will convince one, I think, that this index is too crude to justify any such inferences without supporting evidence from the field. It is probably quite true that annual fluctuations in duck-stamp sales are useful indicators of changing hunting pressure on waterfowl, but the geographic distribution of these stamps is something more complex. Federal duck-stamp sales in each state are fundamentally mass notices of anticipation to hunt waterfowl. These mass notices result from the availability of promising hunting areas and from the size of the human population in each state. Figure 4 must indirectly reflect the presence of waterfowl concentration areas as well as variations in the distribution of the human population in the United States. Aside from a potential bias associated with the acquisition of duck stamps by philatelists,

these reasons make duck-stamp densities a tenuous and uncertain tool in the analysis of waterfowl banding recoveries. A much more pertinent correction factor would seem to be the density of human population in each state.

Other banded birds that apparently are shot mostly by duck hunters include the Double-crested Cormorant (*Phalacrocorax auritus*) and the White Pelican (*Pelecanus erythrorhynchos*). For recoveries of these species, the above arguments clearly do not

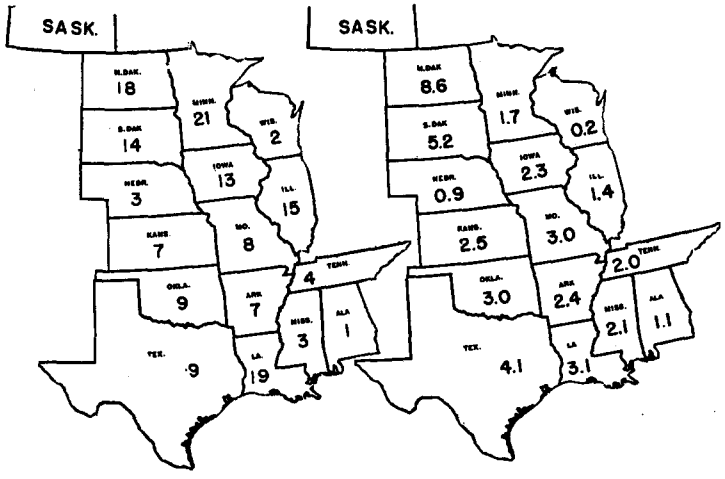

Fig. 5. Left, distribution of Double-crested Cormorants banded in Saskatchewan and later reported in the fall hunting season. Right, same data divided by the density of duck-stamp sales as shown in figure 4 (lower map).

hold, and for them duck-stamp analyses would seem to be pertinent. In figure 5, I have mapped some autumnal reports of Double-crested Cormorants banded by Fred G. Bard in Saskatchewan and later reported shot (by persons who may or may not have been hunters). The west to east gradient effect appears among the corrected recoveries in four out of six instances, minimizing the frequency of birds shot in Minnesota and in the states east of the Mississippi River. It seems to me that the adjusted distribution of these recoveries has fully as much plausibility as that of the raw data, but both analytical techniques leave much to be desired in the test here considered.

SUMMARY AND CONCLUSIONS

A review of over 6800 autumnal recoveries of the Mallard in North America develops the following points:

1. Relative geographic distributions (state and provincial frequencies expressed as a per cent of all recoveries reported) are more biased when young birds are included in the samples being studied than when adults alone are considered. The early-season vulnerability of these immature birds to hunting exaggerates their relative distribution in the North and underestimates their presence in the South.

2. In years subsequent to their banding, more Mallards have been shot in their home state or province than in any other state or province; samples of these waterfowl studied thus far have been trapped by baiting and do not appear to be randomized samples of large regional populations.

3. The hypothesis that Mallard populations in general are definite associations re-

mains unproven; in one sample banded in Illinois most of the birds migrated on a front about 250 miles wide.

4. Percentage distributions of "direct" recoveries will vary at least occasionally according to the dates on which the birds were banded.

5. As Munro (1943) has indicated, less than 6 per cent of the adult Mallards marked in British Columbia (banded mostly near Chilliwack) are shot south of Washington; this is in contrast to about 25 to 30 per cent of a sample banded in western Montana. There evidently are at least two major population units of this species on the Pacific Seaboard.

6. Small samples of Mallards recovered in the Prairie Provinces in May and June suggest that Mallards from Alberta pass through or reach Kansas-Oklahoma, Missouri-Arkansas-Louisiana, and Illinois in the proportions of 4, 2, and 1; for Saskatchewan birds these ratios are roughly 4, 4, and 3; for Manitoba birds, 2, 3, and 4; and for Ontario Mallards, 1, 5, and 15.

7. While the geographic distribution of banded cormorants and pelicans reported shot in the fall apparently can be corrected for regional differences in hunting pressure as indicated by Federal duck stamp sales, similar data for waterfowl can not.

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