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Natural History Survey
BULLETIN

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CONTENTS

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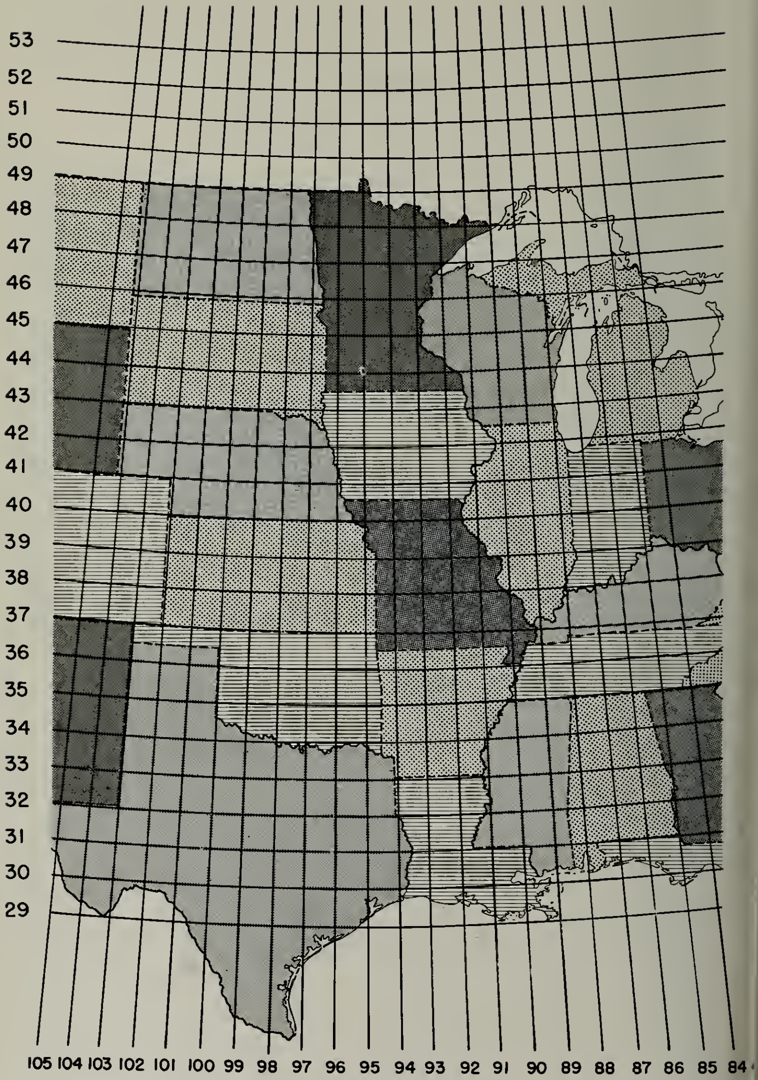

Frontispiece. — Map of central United States, including degrees of latitude and longitude as referred to in discussions of mallard and black duck band recoveries.

Migrational Behavior of Mallards and Black Ducks as Determined from Banding

Frank C. Bellrose
Robert D. Crompton

LARGE-SCALE BANDING of migratory ducks in the United States first occurred in Illinois. During the spring and fall of 1922, Frederick C. Lincoln of the U.S. Bureau of Biological Survey (now Bureau of Sport Fisheries and Wildlife) banded 1,670 mallards *(Anas platyrhynchos)* and 57 black ducks *(Anas rubripes)* at the Sanganois Duck Club, near Browning. In 1926, Lincoln again returned to the Illinois River to band 941 mallards and 27 black ducks near Bath.

We do not know why Lincoln selected this area of the nation to demonstrate the feasibility of trapping large numbers of waterfowl. It may have been because Illinois is about midway between the principal breeding and wintering grounds of the mallard, or because the state was known for its abundance of migrating mallards.

Illinois remains one of the leading states for migrating waterfowl in the nation; only a few states are frequented by larger numbers. And, as in earlier days, mallards are especially abundant. Weekly waterfowl censuses during the fall of 1965 revealed that mallards composed 65 percent of all ducks concentrated in the Illinois and Mississippi River valleys of Illinois. Before their decline in the 1950's, mallards formed an even larger proportion of the duck population. Peak numbers of mallards in these valleys have varied (1945–1966) from a high of 2,435,000 in 1955 to a low of 563,000 in 1961.

Because of the abundance and importance of mallards, this species has received the greatest attention in banding programs within the state. Prior to the entry of the Illinois Natural History Survey into the waterfowl banding program in 1939, the only large contribution to Lincoln's effort in Illinois was that of Chris Goetz. Between 1932 and 1940, he banded almost 5,000 mallards at the Duck Island Preserve near Banner in Fulton County, Illinois.

The principal duck banding program of the Survey extended from 1939 through 1952. Survey personnel have continued to band ducks, but since 1952 the bandings have been more experimental in nature, directed toward problems of homing and orientation. Nevertheless, many of the indirect recoveries from these experimental bandings can be used to analyze fall migration movements.

Personnel of the Illinois Department of Conservation and the U.S. Bureau of Sport Fisheries and Wildlife have also banded appreciable numbers of ducks in the state. To provide as much substance as possible to our analysis of duck bandings in Illinois, we have made use of band recoveries from the Department of Conservation's banding program at the Union County Wildlife Management Area, Ware, Illinois, and the Bureau's bandings as well as our own at the Lake Chautauqua National Wildlife Refuge, Havana, Mason County, Illinois, hereafter referred to as Lake Chautauqua.

To round out the analysis of mallard movements in the Mississippi Flyway, we have used band recoveries from mallards banded by the Bureau of Sport Fisheries and Wildlife at the Delta Marsh, Manitoba, Canada, and the Squaw Creek National Wildlife Refuge, Mound City, Missouri.

The objectives of the analysis presented in this paper were to determine: a) the migration patterns as shown by band recoveries from mallards and black ducks, b) the variation in migration patterns of mallards banded at various localities in the Mississippi Flyway, c) the degree of variation in migration patterns of mallards from year to year, d) the period of time mallards remain at a given area on the flyway, and e) the chronology of migration in the mallard as shown by band recoveries.

ACKNOWLEDGMENTS

We are most indebted to numerous persons for their contributions to this paper. Foremost are the many biologists who as students or recent college graduates banded thousands of ducks over the years at the several banding stations operated by the Natural History Survey.

The Survey banding program was initiated in 1939 by Arthur S. Hawkins, now with the Bureau of Sport Fisheries and Wildlife, and John M. Anderson, now with the National Audubon Society. Because of their enterprise, the program was successful in meeting early goals, and was continued in the pattern they initiated.

Robert Brough, in 1952 and 1953, hand tabulated most of the band recovery data received between 1939 and 1952, and, by so doing, made a major contribution to the analysis of data in this paper. Dr. William Starrett, Aquatic Biologist with the Survey, suggested showing the longitudinal distribution of band recoveries by mean and standard deviation.

George Arthur, Waterfowl Biologist, Illinois Department of Conservation, kindly made recovery data available on mallards banded at the Union County Wildlife Management Area. Arthur S. Hawkins provided the mallard recovery data from bandings at Delta Marsh, Manitoba.

Through the efforts of Walter Crissey, Kahler Martinson, and Earl Baysinger of the Migratory Bird Population Center, Bureau of Sport Fisheries and Wildlife, computer tabulations were obtained of the mallard recoveries from bandings at the Squaw Creek National Wildlife Refuge near Mound City, Missouri. We are grateful to the several refuge managers at Squaw Creek who banded ducks there in the period 1937–1963.

John Chattin and Arthur S. Hawkins, Bureau of Sport Fisheries and Wildlife, reviewed the paper for its biological context. Dr. H. W. Norton, Department of Animal Science, University of Illinois, reviewed the paper for data analysis. O. F. Glissendorf, Technical Editor, and Dr. Glen C. Sanderson, Head, Section of Wildlife Research, Illinois Natural History Survey, edited the paper. Richard Sheets, Illustrator for the Survey, prepared the maps and graphs.

METHODS

Type of Traps

The basic trap used in Illinois to capture dabbling ducks was 16 feet long, 8 feet wide, and 6 feet high (Fig. 1). It had V-type entrances at either end, with a holding box at one end. This trap was used primarily to capture mallards and black ducks. Usually two to four of these traps were operated at each banding station.

The traps were placed in water 6–18 inches deep and baited with grain. Whole corn was usually used as bait for attracting mallards and black ducks.

Location of Banding Stations in Illinois

Personnel of the Illinois Natural History Survey banded ducks at five principal locations in the state — Lake Chautauqua, Mason County, 1939–1944, 1947–1952, 1954–1966; McGinnis Slough, Cook County, 1940–1947; Spring Lake Division, Upper Mississippi Wildlife and Fish Refuge, Carroll County, 1946–1948; and Calhoun Division, Mark Twain National Wildlife Refuge, Jersey County, 1947–1948.

George Arthur, Illinois Department of Conservation, banded waterfowl at the Union County Wildlife Management

Fig. 1. — Banding trap used by personnel of the Illinois Natural History Survey to capture mallards and black ducks in shallow lakes and marshes.

Area, near Ware, Illinois, 1954–1966. Only indirect recoveries from mallards he banded in the 1954–1965 period are used in this report.

Fig. 2 shows the locations of these banding stations in Illinois.

Handling of Records

At the time of banding, ducks were classified as to species, sex, and, when possible, as to whether immature or adult. Data were recorded on our own field forms, and transferred to federal banding schedule forms in our office. The completed schedules were forwarded to the Bird Banding Laboratory at the Patuxent Wildlife Research Center, Laurel, Maryland, a branch of the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service.

The Bird Banding Laboratory reported each recovery of a banded bird on a 3- by 4-inch file card until 1949 when the form was changed to a "flimsy," a carbon copy of band-recovery report Form 3-624. The flimsy was revised and enlarged in 1954, and in 1961 the Bird Banding Laboratory switched to IBM cards to inform both the bander and reporter of each band recovery.

We hand tabulated data from the file cards, the flimsies, and listings of our own punched IBM cards up to 1952. Band recovery data for the 1955–1966 period for all stations were tabulated by computer at the University of Illinois.

It should be noted that frequently this report uses one set of dates for bandings and another set of dates for recoveries, because indirect recoveries occur in years following the bandings. Also, in some tabulations data were omitted for certain years when band recoveries were insufficient for analysis.

Terminology

Particular definitions have been given to certain terms by the Bird Banding Laboratory. These terms are used frequently by bird banders and are essential to understanding this text. We have slightly modified the definition of most terms, as listed below, to meet the specific needs of this study.

Adults: Ducks one year of age or older.

Immatures: Young ducks fully cap-

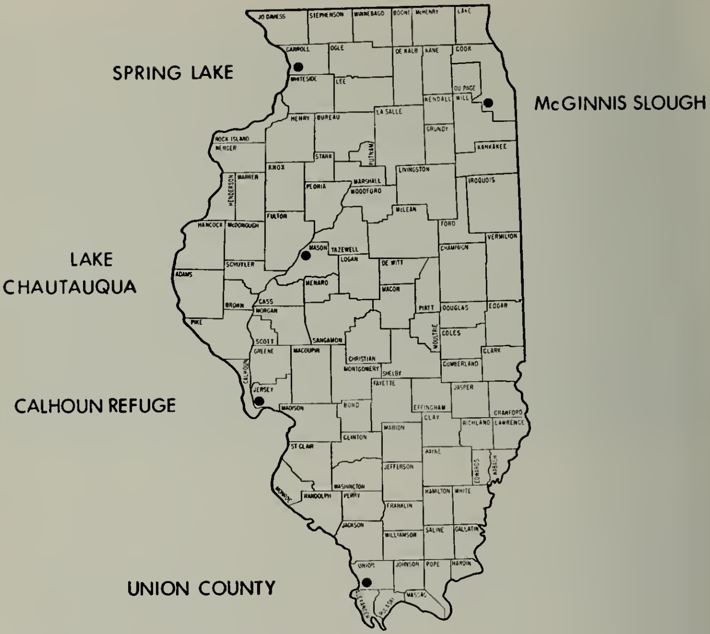

Fig. 2.—Locations of banding stations in Illinois.

able of flight but known to have hatched in the year of banding.

Recovery: A report of a banded duck killed or found dead. Over 95 percent of recoveries reported herein resulted from ducks shot by hunters. Trappers of muskrats were probably next in reporting largest numbers of banded ducks.

Direct recovery: A band recovered during the same autumn and/or hunting season as banded.

Indirect recovery: A band recovered in hunting seasons subsequent to the first.

Repeat or retrapped: The recapture of a duck within 90 days at the same trap and/or banding station where it was initially banded.

Return: The recapture of a duck at the same banding station over 90 days (usually the following fall) following initial banding.

Banding year: Our banding year started September 1 in one calendar year and ended January 15 in the next calendar year. For all practical purposes it was the hunting season in the United States and Canada, which has varied as to opening and closing dates. The closing dates in the southern zone of the United States have invariably occurred in January of the calendar year after banding but during the same banding year.

Coordinates: The latitude and longitude of a particular banding station or band recovery. A band recovery is now recorded on an IBM card by coordinates read from maps marked off in 10-minute grids.

Tabulation of Band Recoveries

At the time we first began to tabulate band recovery data in 1950, they were reported by a political or geographic designation, such as a town, county, or lake. In recording several thousand band recoveries by political designation, we found it nearly impossible to make definitive comparisons among banding stations and among years. Therefore, for species and for banding stations where large numbers of recoveries made comparisons difficult, we tabulated band recovery data by coordinates. As far as we know, this was the first use of coordinates rather than political divisions to facilitate the analysis of recovery data. Band recovery data were grouped for every 30 minutes of latitude and longitude.

IBM cards record recoveries by each degree of latitude and longitude. In both hand and computer analysis of recovery data by coordinates, degree blocks are used. For each degree of latitude, the mean of the longitudinal distribution of recoveries is determined. The mean points in each degree of latitude are connected with a line which we term an axial line. This designates the mean of the east-west distribution of recoveries within the Mississippi Flyway. The standard deviation indicates the scatter of band recoveries to the east and to the west of the mean. About two-thirds of the recoveries occur within one standard deviation of the mean. Thus, connecting the standard deviation points between each degree of latitude forms a definable geographic area, which can be depicted on a map, and can be compared with band data from other similar areas.

Our interpretation of the Mississippi Flyway (the area within the heavy lines in Fig. 3) is slightly different from that illustrated by Lincoln (1935:6). Our western border of the flyway extends from Saskatchewan to the Missouri River in central North Dakota. Then it proceeds through the middle of South Dakota and into Nebraska slightly west of the Missouri River (usually one tier of counties) to Kansas City, Missouri. It extends along county borders from Kansas City to Galveston Bay, Texas. The eastern border of the Mississippi Flyway follows state borders, the east side of Ohio, Kentucky, Tennessee, and Alabama. The relatively few band recoveries outside the flyway were not included in the analysis of recoveries by coordinates.

Throughout this study, the proportion of direct or indirect recoveries in any longitudinal-latitudinal area is equated to time. We believe there is a close relationship between the proportion of band recoveries in any geographic area (of the region delineated in this study) and the amount of time spent there by ducks during the hunting season. Thus, if indirect recoveries for a particular area amounted to 10 percent of the total recovered during a season, then we interpret this as indicating that that group of ducks spent 10 percent of the hunting season there.

RESULTS

MALLARD

Lake Chautauqua Bandings

(Our main banding effort was at the Lake Chautauqua Refuge containing a 3,700-acre shallow-basined body of water adjacent to the Illinois River. There are numerous private waterfowl clubs in the immediate area, and the most important waterfowl hunting grounds in the Illinois River valley are in an area from 10 to 20 miles downstream (southwest) from the refuge. Mallard populations on the refuge during the period of banding varied from a peak of 1,500,000 in 1944 to a low of 60,000 in 1964. Only a small number of mallards were banded prior to mid-October or after the end of November.)

Band recoveries outside of our defined limits of the Mississippi Flyway were relatively few. Fig. 3 shows all recoveries outside the defined area that resulted from banding 46,070 mallards in the periods 1939–1944 and 1947–1952 at

Fig. 3. — Direct and indirect band recoveries outside our defined limits (heavy lines) of the Mississippi Flyway from mallards trapped and banded at Lake Chautauqua, 1939–1944, 1947–1952.

Lake Chautauqua. Of the 5,408 indirect recoveries tabulated geographically from these bandings, 97.1 percent occurred within our defined limits of the flyway, 2.3 percent occurred west of the flyway and 0.6 percent east of the flyway. There were 2,713 direct recoveries tabulated geographically of which only 0.55 percent occurred west of the flyway and 0.29 percent east of the flyway.

Most of the mallard recoveries west of the Mississippi Flyway were in the Great Plains immediately west of the flyway border; only 12 were in the Far West. Recoveries of Illinois banded mallards in the Atlantic Flyway represented birds which were probably trapped as they were crossing the Mississippi Flyway on their way to wintering grounds in South Carolina, Georgia, and Florida. An average of 113,000 mallards wintered in South Carolina, 1960–1966; 5,000 wintered in Georgia; and 3,700 in Florida, and, of necessity, almost all of these ducks migrated through the Midwest to reach their destinations in these states.

The indirect recovery rate west of the Mississippi Flyway was 0.24 percent for adult drake mallards banded at Lake Chautauqua. For immature drakes the indirect recovery rate was 0.42 percent, and for hens of both age classes it was 0.21 percent. This suggests that immature drake mallards banded in Illinois during their first fall of life were more likely to occur in the Central Flyway in subsequent falls than were mallards banded initially as adults. Hens were less likely than drakes to leave the confines of the flyway.

Longitudinal Distribution. — The yearly axial lines of mallard *indirect recoveries* in the flyway from Lake Chautauqua bandings are shown grouped into three periods (Fig. 4, 5, and 6). In general, the axial lines are very similar through the span of 17 years. The greatest variation in the east-west distribution of axial lines usually occurs in the latitudes where the recoveries are fewest. These are latitudes with less waterfowl habitat than other latitudes.

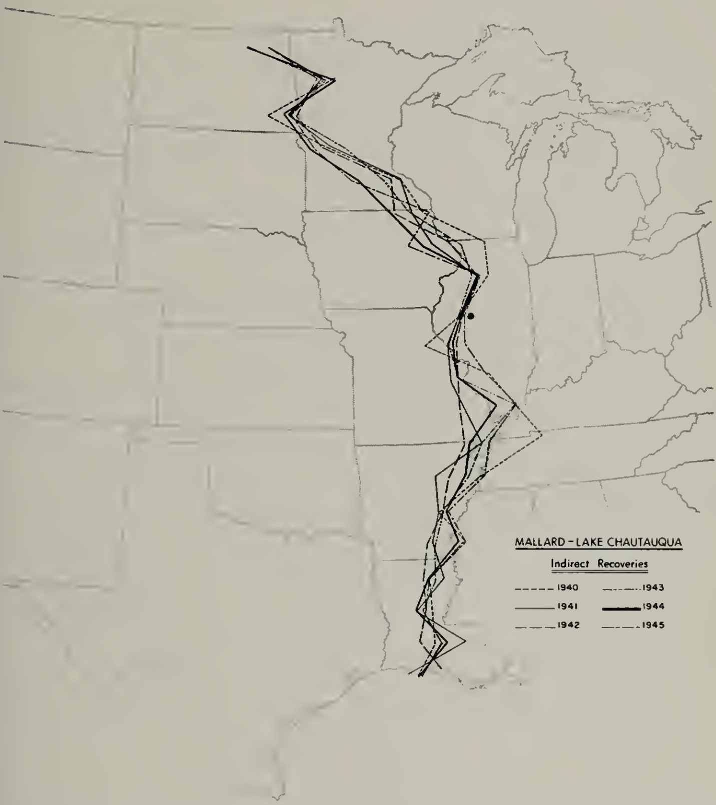

Fig. 4.— Axial lines, 1940–1945, of indirect band recoveries from mallards banded at Lake Chautauqua.

The latitude marked by the 47° and 48° parallels shows a peculiar variation in means.* In 13 of 17 years the axial lines show an abrupt swing east-southeastward, from their points of origin in northeastern North Dakota into western Minnesota, but, then, in the next zone to the south (between the 46° and 47° parallels) there is a swing back to the west, with all the mean points falling in southeastern North Dakota. This zigzag in the axial lines is apparently due to the limited distribution of mallard habitat in this zone.

It should not be inferred from the zigzag in band recoveries that the mallards shift their passage similarly. Apparently Lake Chautauqua-bound mallards pass southeastward from Saskatchewan over eastern North Dakota and western

* For all locations of areas designated by parallels and meridians, refer to frontispiece map.

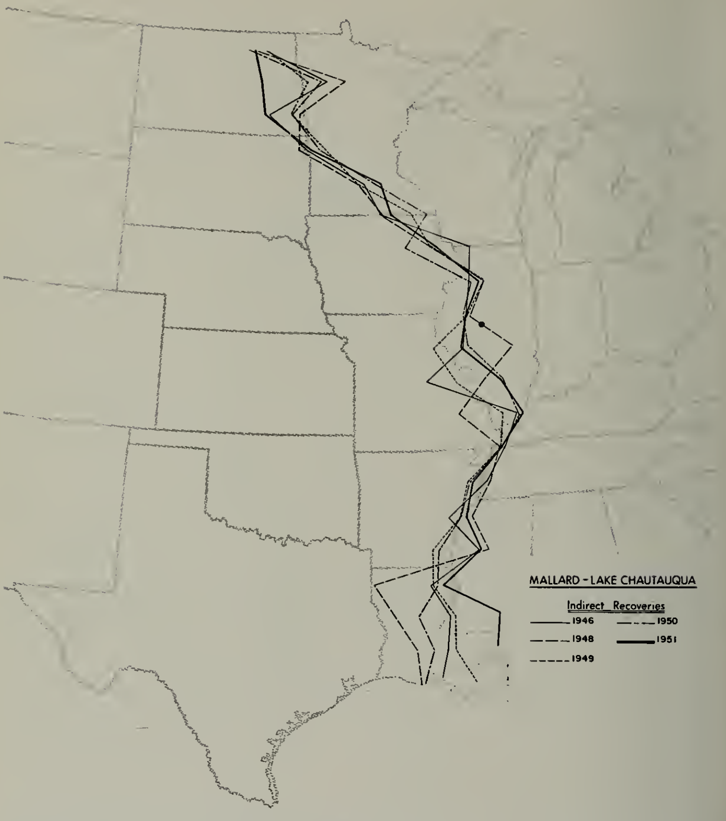

Fig. 5.—Axial lines, 1946–1951, of indirect band recoveries from mallards banded at Lake Chautauqua.

Minnesota. Many of those in the eastern elements of the migrating swarm tend to drop out in western Minnesota, whereas most of those in the western elements pass nonstop over adjacent areas in eastern North Dakota.

There is a great abundance of mallard habitat in the region of western Minnesota, and a comparative paucity of habitat in the adjacent region of east-central North Dakota. Apparently, however, in some years rains create temporary water areas on the Red River plains of North Dakota that attract elements of mallard population which previously passed nonstop; their detainment is reflected in the kill and band recoveries from the Red River Plains. Thus, particularly in 1951 and 1956, the high kill of mallards in this region of eastern North Dakota reduced the effect of the kill made in adjacent western Minnesota. The 1951 and 1956 recoveries are believed to be a more typical representation of the

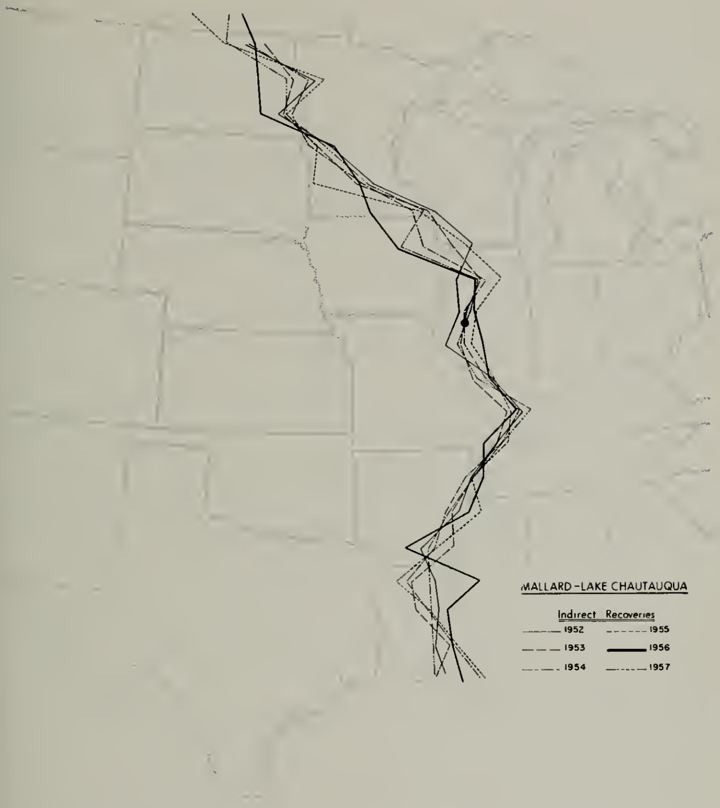

Fig. 6. — Axial lines, 1952–1957, of indirect band recoveries from mallards banded at Lake Chautauqua.

flight path taken by migrating mallards across eastern North Dakota.

In 9 of the 16 years (1940–1943, 1945, 1946, 1952, 1953, and 1955), the axial line of recoveries arrived at the Mississippi River near the border of Minnesota and Iowa. In the other 7 years (1944, 1948–1951, 1954, and 1956) the axial line arrived at the Mississippi River farther south in northwestern Illinois. We are unable to account for all of these slight shifts in axial lines in the region between the western border of Minnesota and the Mississippi River. Mass flights of ducks, largely mallards, occurred on the Upper Mississippi Wildlife and Fish Refuge during the autumns of 1940, 1946–1948, 1955, and 1956 (Green 1963:22, 24). In 3 of these 6 years (1940, 1946, 1955), the axial lines of recoveries (Fig. 4, 5, and 6) were close to the Upper Mississippi Refuge, but in 2 of the years of mass flights (1948, 1956) the axial lines fell farther west. However, by far the largest mass movements of mallards on the Upper Mississippi Refuge occurred in 1940 and 1955 (op. cit. :24), and this is reflected in the proximity of the 1940 and 1955 axial lines to the upper Mississippi River. Both the 1940 and 1955 mass migrations of mallards and other ducks were the result of unusually severe storms (Bellrose 1957:21). In our opinion, the strong northwest to west winds of these storms partially drifted large segments of Chautauqua-banded mallards east of their customary lines of flight, thereby accounting for the eastward swing in the axial lines in southern Minnesota.

There is considerable variation in the yearly east-west location of the axial lines of mallard band recoveries (Fig. 4, 5, and 6) in the lower wintering grounds. The lower wintering grounds extend south from the Arkansas River in Arkansas to the Louisiana coast. Only a small proportion of the mallards in the Mississippi migration corridor (Bellrose 1968:8) winter in this region. Consequently, the yearly shifts in east-west distribution represent only relatively small numbers of mallards. The change in location of the axial line on the lower wintering grounds for the mallard appears to be related to shifts in the availability of food. Streams flood at different times in the various watersheds, accounting for much of the shift in abundance of mallards, which are quick to move east or west to newly flooded feeding grounds.

There are two regions where the yearly axial lines are similar — in the vicinity of the banding station at Lake Chautauqua and between northern Tennessee and the Arkansas River of Arkansas. The first region emphasizes the consistent tendency each year for Lake Chautauqua mallards to return to the vicinity of their banding site. The second region emphasizes the stability of food supplies in the rice region of Arkansas where large tracts of swamp land are managed specifically for mallard hunting.

The standard deviation analysis of indirect mallard recoveries from Lake Chautauqua is shown for two periods, 1940–1954, and 1955–1959 (Fig. 7). There are only slight differences in the geographic distribution of band recoveries between these two periods, suggesting that there was no basic change in migration patterns during the two periods.

During these time periods there might have been a gradual shift in mallard populations from the Illinois to the Mississippi rivers in Illinois. Our belief was based upon relative fall populations in these two areas (Mills et al. 1966:21). But apparently the increase in mallards in the Mississippi River valley of Illinois during the 1955–1964 period over that of the 1946–1954 period (op. cit. :21) did not accrue at the expense of mallard populations customarily frequenting the Illinois River valley.

Because about two-thirds of the band recoveries occur within the lines delineating the standard deviation, these lines mark the significant limits of recoveries from the Lake Chautauqua banding station. The spread in longitudinal distribution of recoveries is greatest on the mallard breeding grounds in Saskatchewan and Manitoba, and smallest in the area of the banding station. The largest spread extends over a width of 500 miles, the smallest spread extends over a width of 70 miles, and the broad span over most of the area delineated is about 150 miles.

The distribution of individual band recoveries in Canada from mallards banded at Lake Chautauqua is given in Fig. 8. Most of these recoveries were reported by hunters and were taken during the fall. A few recoveries were obtained from fur trappers and were taken in early spring. For the most part, the recoveries were from the grassland and parkland region of southwestern Manitoba and of eastern Saskatchewan,

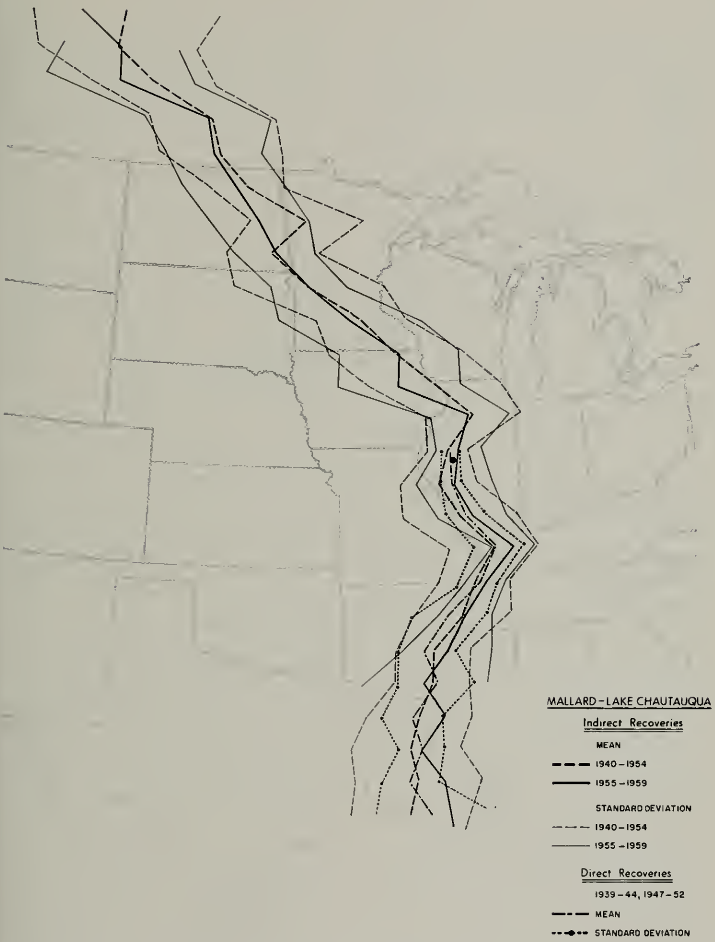

Fig. 7. — A comparison of the longitudinal distribution of indirect mallard band recoveries from Lake Chautauqua bandings for two periods, 1940–1954 and 1955–1959. The direct band recoveries for the periods 1939–1944 and 1947–1952 are also shown.

south of the Saskatchewan River.

The yearly axial lines for *direct recoveries*, 1939–1944 and 1947–1952 (Fig. 7), conform to the pattern of the indirect recovery means in the lower half of the Mississippi Flyway. However, at some latitudes there is a greater variation between years among the means of

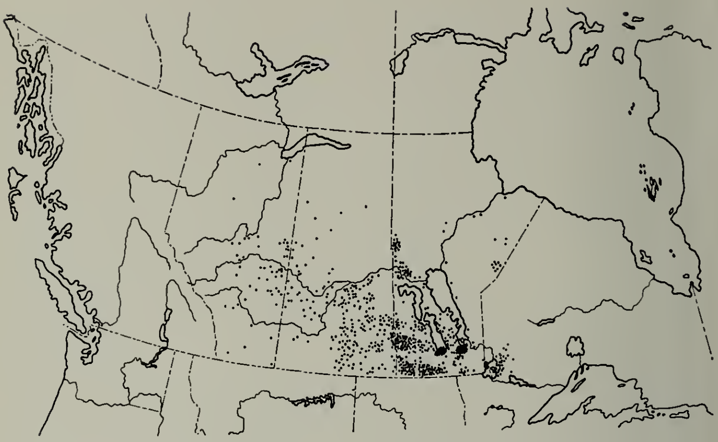

Fig. 8.—The distribution of individual indirect band recoveries in Canada, 1940–1954, from mallards banded at Lake Chautauqua.

direct as compared to those of indirect recoveries.

Yearly variation is especially evident in direct recovery means recorded between the 37° and 38° parallels. In five years (1939, 1944, 1950–1952) the axial lines fell near the mouth of the Wabash River 250 miles southeast of the banding station as a result of the unusually large number of recoveries from Hovey Lake, in the southwest corner of Indiana.

All of our information points to sizable late season departures during the fall to Hovey Lake from the Illinois River valley. Apparently in those years we banded unusually large numbers of mallards which were late migrants. Our chronology of fall-banded mallards varied from year to year depending upon trap locations, weather conditions, and availability of food.

The summary distribution of direct band recoveries, 1939–1944 and 1947–1952, by longitude mean and standard deviation is given in Fig. 7. The axial and standard deviation lines are quite similar to those for indirect recoveries in the lower half of the Mississippi Flyway. The principal difference in the distribution between direct and indirect recoveries occurs in the latitude of the banding station and the latitudes immediately to the south.

Table 1 shows the longitudinal distribution of direct and indirect mallard recoveries for the degree of latitude (40°–41°) embracing the Lake Chautauqua banding station. The means are almost identical for both direct and indirect band recoveries, being slightly to the west of the banding station, which was located within 2 miles of the 90° meridian. Both direct and indirect recoveries predominated to the southwest of the station because the more extensive hunting grounds located there biased recoveries in that direction.

The standard deviation implies that two-thirds of the recoveries occurred within an average of ±0.35 of a degree for direct recoveries and ±0.55 of a degree for indirect recoveries. Since at this latitude 1 degree of longitude equals 52.5 miles, the breadth of the standard deviation of direct recoveries was about

Table 1.—A comparison of the longitudinal distribution of direct and indirect mallard recoveries, 1939–1952, from bandings at Lake Chautauqua, Mason County, Illinois, for the degree of latitude of the banding station (40°–41°). Banding station located at about 90° longitude.[a]

	Direct Recoveries		*Indirect Recoveries*	
Year	Mean	Standard Deviation	Mean	Standard Deviation
1939	90.18	0.16	. . .	. . .
1940	90.25	0.32	90.12	0.31
1941	90.31	0.43	90.29	0.34
1942	90.17	0.38	90.30	0.32
1943	90.26	0.56	90.43	0.32
1944	90.21	0.32	90.36	0.72
1949	90.26	0.19	90.27	1.96[b]
1950	90.21	0.16	90.31	0.94
1951	90.20	0.36	90.34	0.61
1952	90.17	0.57	90.18	0.87
Average	*90.22*	*0.35*	*90.29*	*0.55*

[a] At latitude of banding station, 1 degree of longitude equals 52.5 statute miles.

[b] Omitted from average because two recoveries, one 8 degrees east of mean and the other 5.5 degrees west of mean, greatly biased standard deviation of remaining 48 recoveries.

36.7 miles and that of the indirect recoveries was about 57.7 miles. Direct recoveries represent mallards that were using Lake Chautauqua for resting and feeding, and a radius of 18.35 miles was the distance within which most mallards fed in fields and other lakes. Observations on the daily feeding flights of mallards from Lake Chautauqua confirm that most go no farther than 30 miles. Only rarely have we followed local field-feeding flocks as far as 45 miles.

The difference in longitudinal standard deviations between direct and indirect recoveries indicates that almost two-thirds of the mallards banded in previous years returned to the same longitude as Lake Chautauqua; the others that stopped at the same latitude were prone to make their migratory home in other areas, most of which were within a radius of 50 miles of Lake Chautauqua.

Latitudinal Distribution.—The longitudinal distribution of band recoveries has been appraised for Lake Chautauqua mallards by mean and standard deviation analysis. We now consider the latitudinal distribution of mallard band recoveries by comparing the proportion of band recoveries for each degree of latitude.

Table 2 shows the yearly proportion of *indirect band recoveries* for each degree of latitude between central Saskatchewan and the Gulf of Mexico, 1940–1946 and 1948–1966. In the degree of latitude including the banding station at Lake Chautauqua, the percentage of indirect recoveries varied between 10.5 and 29.3 percent.

Yearly variation in the percent of indirect mallard recoveries in the latitude of the banding station appears related first to habitat conditions and population density, and second to weather.

In the degree of latitude immediately north of the banding station, unusually large numbers of indirect recoveries were received in 1941, 1943, and 1946. Band recoveries were especially numerous along the upper Illinois River valley (1941, 1943) and the Mississippi River valley, Oquawka-Moline (1946). However, of all regions in which indirect recoveries were recorded, the largest variation from year to year occurred on the wintering grounds south of Illinois (Table 2). Eastern Arkansas north of the Arkansas River and the adjacent region of Mississippi provided most of the recoveries, amounting to 11.6 percent. In most years, there was an inverse relationship between the proportion of recoveries in the north Arkansas (35°–36°) and mid-Arkansas (34°–35°) regions. In 1950 an unusually high proportion of indirect recoveries (13.8 percent) came from the Obion River-Reelfoot Lake area of Tennessee (36°–37°).

Comparatively few indirect band recoveries came from mallards south of the Arkansas River from 1940 through 1955, except in 1940. In that year 13.8 percent of all indirect recoveries occurred in Louisiana and the adjacent

Table 2.—The number and percent of indirect band recoveries, 1940–1946 and 1948–1966,[a] for mallards banded at Lake Chautauqua, by degrees of latitude.

Degree of Latitude[b]	1940 (166)	1941 (428)	1942 (557)	1943 (519)	1944 (693)	1945 (601)	1946 (218)	1948 (128)	1949 (297)	1950 (515)	1951 (495)	1952 (587)	1953 (698)	1954 (388)	1955 (311)	1956 (261)	1957 (280)	1958 (169)	1959 (99)	1960–66 (232)	Average
56 +	0.6	0.0	0.0	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
55–56	0.0	0.7	0.0	0.4	0.2	0.0	0.0	0.8	0.0	0.4	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2
54–55	0.6	0.9	0.0	0.2	0.3	0.3	0.0	1.6	1.0	0.2	0.6	0.3	0.6	0.8	0.6	0.0	0.7	0.0	0.0	0.4	0.5
53–54	1.2	2.1	0.9	0.0	1.0	0.8	1.4	1.6	3.0	1.7	2.6	0.3	2.0	2.8	1.0	0.8	0.7	1.2	3.0	0.4	1.4
52–53	0.6	1.7	0.7	0.6	1.2	0.2	0.9	0.8	2.4	1.6	1.0	1.2	1.2	2.6	1.6	1.5	0.4	0.6	3.0	1.7	1.3
51–52	2.5	1.4	2.2	1.0	1.9	0.5	1.8	0.8	2.4	1.6	1.0	1.5	3.3	2.8	4.8	3.8	3.9	1.8	5.1	4.3	2.4
50–51	2.5	1.9	2.7	2.7	2.5	2.2	6.0	4.7	6.7	3.9	5.9	6.0	7.8	6.2	5.5	6.2	3.2	5.9	2.0	5.2	4.5
49–50	3.6	2.4	2.0	1.7	1.3	3.3	3.7	3.1	4.4	3.5	2.0	2.6	2.8	4.9	2.9	2.7	3.9	2.4	2.0	5.2	3.0
48–49	0.0	5.4	3.6	3.1	2.6	5.3	4.2	7.0	5.7	4.6	4.0	5.6	3.3	4.4	1.6	4.2	1.1	1.8	1.0	3.4	2.9
47–48	4.2	3.7	0.9	2.9	2.3	1.7	3.2	5.5	2.4	2.7	3.0	1.9	3.9	2.1	1.0	5.7	2.9	1.2	3.0	3.0	2.9
46–47	3.6	3.1	2.5	3.9	5.8	5.0	1.8	4.7	7.7	5.6	4.5	4.1	5.3	2.3	2.9	1.5	2.9	2.4	3.0	1.7	3.7
45–46	4.8	4.9	6.3	7.1	7.8	4.7	6.4	3.9	7.4	6.0	3.6	4.4	5.6	2.1	2.9	2.7	1.1	1.8	4.0	4.3	4.6
44–45	5.4	3.7	6.5	5.8	4.0	6.0	6.9	2.3	5.4	5.0	5.7	5.4	5.8	4.6	1.3	3.4	1.4	3.5	0.0	7.8	4.5
43–44	3.6	4.4	3.6	3.1	3.9	2.8	2.8	1.6	3.7	2.7	3.2	3.6	2.7	3.3	1.9	2.7	1.8	3.0	10.1	4.3	3.4
42–43	4.2	1.9	1.6	2.5	1.2	1.5	5.5	0.0	2.0	0.6	2.8	2.9	1.4	1.8	2.3	1.1	3.6	3.0	4.0	3.0	2.3
41–42	9.0	14.0	8.6	14.8	6.6	6.5	11.0	6.2	5.7	3.3	4.8	5.3	7.5	7.5	8.7	5.7	7.5	7.7	9.1	9.1	7.9
40–41[d]	19.3	20.6	19.0	16.2	21.6	21.1	15.6	12.5	16.8	10.5	19.0	25.0	16.1	19.3	27.4	18.9	29.3	19.4	21.3	23.3	19.6
39–40	5.4	6.5	9.3	5.0	4.8	2.5	4.1	2.3	3.0	4.7	8.7	5.8	8.1	9.0	7.1	6.5	5.3	2.4	5.1	3.9	5.5
38–39	1.2	2.3	2.7	2.1	1.4	2.0	1.4	1.6	0.3	2.5	2.6	1.9	1.7	2.8	2.6	5.0	6.1	8.9	2.0	3.5	2.7
37–38	0.0	0.2	1.8	1.9	3.0	3.0	1.8	3.9	1.7	4.1	4.5	5.6	3.1	3.1	6.7	3.1	6.1	11.1	7.1	3.0	3.7
36–37	1.2	0.9	3.1	2.5	3.6	4.3	0.9	5.5	6.1	13.8	8.1	3.1	4.2	4.9	5.1	4.2	9.3	8.9	5.1	3.0	4.9
35–36	2.5	8.4	5.4	2.7	4.6	6.5	6.4	11.7	3.4	10.0	4.3	3.4	4.1	3.6	4.5	8.8	4.6	5.3	3.0	3.0	5.3
34–35	7.2	1.2	9.0	7.7	9.8	9.8	8.7	10.1	3.7	4.4	5.1	4.3	2.8	3.3	4.8	6.9	2.1	5.3	7.1	3.0	5.8
33–34	3.0	1.7	0.9	1.0	2.8	3.5	0.9	2.3	1.0	2.9	0.4	1.0	1.2	2.1	0.0	1.1	1.4	1.8	0.0	0.9	1.5
32–33	1.2	2.8	1.4	4.4	2.0	1.5	0.9	1.6	1.0	0.8	0.8	0.7	0.5	0.5	0.3	0.8	0.0	0.6	0.0	0.4	1.1
31–32	3.6	0.9	2.3	2.7	1.2	1.2	1.4	0.0	0.7	0.4	0.4	0.2	0.9	0.3	0.6	0.8	0.0	0.0	0.0	0.0	0.9
30–31	4.2	1.4	1.8	1.3	1.4	1.5	1.8	1.6	1.7	0.8	0.2	1.2	0.9	1.3	1.6	1.1	0.0	0.0	0.0	0.9	1.2
29–30	4.8	0.9	1.2	2.3	1.2	2.0	0.5	2.3	0.7	1.6	0.4	2.7	2.3	1.3	0.3	0.8	0.7	0.0	0.0	1.3	1.4
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*99.2*

[a] 1947 omitted because band recoveries were insufficient for analysis.
[b] Percent determined for the midpoint between each of the two latitudes listed.
[c] Figures in parentheses represent the number of indirect recoveries analyzed by latitude.
[d] Lake Chautauqua.

region of Mississippi. This extreme proportion from the Deep South probably resulted from the worst fall storm in history, which struck the Midwest on November 11, forcing hundreds of thousands of mallards south ahead of their customary migration time.

Surprisingly, only 1.7 percent of all indirect recoveries occurred on the 3,500,000-acre coastal marsh of Louisiana. Most of the other species of dabbling ducks in the Mississippi Flyway winter on this coastal marsh, but it is apparent that wintering Illinois-banded mallards predominated in the swamp lands to the north of the coastal marshes.

The latitudinal distribution of *direct band recoveries* for mallards banded at Lake Chautauqua is shown in Table 3. The latitudes shown extend from 1 degree north (41°–42°) of the banding station (40°–41°) to the Gulf of Mexico. The yearly variation in the proportion of direct recoveries in the vicinity of the banding station varied from a low of 33 percent in 1939 to a high of 68.2 percent in 1951.

The principal reason for the yearly variation for direct recoveries in the vicinity of the banding station was variation in the chronology of banding. In those years when the proportion recovered was lowest (1939, 1941, 1942, 1943, 1944), bandings tended to be late in the fall; when the proportion recovered was highest (1940, 1949, 1950, 1951, 1952) the bandings tended to be early in the fall. Food, water, and weather conditions were other factors which influenced the yearly rate of direct recoveries near the banding station.

The percentages of direct and indirect recoveries, distributed among the latitudes from 1 degree above the Lake Chautauqua banding station to the Gulf of Mexico, are compared in Table 4. Between the 40° and 41° parallels, the location of the banding station, direct recoveries were about 1.7 times greater than indirect recoveries. However, upon considering only the 1 degree of latitude immediately above, and the 1 degree below the banding station, we find that the indirect recoveries were greater than direct recoveries. This suggests that some of the Lake Chautauqua mallards dropped out of migration immediately prior to reaching their migratory home destination of Chautauqua and that some slightly overshot their destination. In

Table 3. — The percent of direct band recoveries, 1939–1944 and 1949–1952, for mallards banded at Lake Chautauqua, by degrees of latitude.

Degree of Latitude	*1939* (100)[a]	*1940* (386)	*1941* (116)	*1942* (432)	*1943* (340)	*1944* (206)	*1949* (187)	*1950* (177)	*1951* (383)	*1952* (266)	*Average*
41–42	2.0	8.8	13.8	5.1	10.6	3.9	4.3	0.6	4.4	4.9	6.1
40–41[b]	33.0	63.7	47.4	42.8	44.1	47.1	53.5	59.9	68.2	60.1	53.7
39–40	9.0	6.0	14.6	4.9	7.0	7.3	5.9	9.6	8.9	12.8	7.9
38–39	3.0	3.6	5.2	6.5	2.6	1.9	2.7	2.3	2.9	3.4	3.6
37–38	1.0	0.8	0.9	2.8	1.5	2.9	4.8	7.3	4.4	3.4	2.9
36–37	9.0	0.8	1.7	6.0	1.8	7.3	11.8	12.4	3.7	3.7	5.0
35–36	8.0	3.1	1.7	13.9	6.2	9.2	9.1	5.7	3.9	3.7	6.7
34–35	11.0	6.2	5.2	8.3	10.6	12.6	5.9	1.1	3.1	4.9	6.8
33–34	3.0	2.1	2.6	1.1	1.8	1.9	0.0	0.0	0.5	0.0	1.2
32–33	7.0	1.8	3.4	1.4	5.3	1.5	1.0	0.0	0.0	0.8	1.9
31–32	6.0	1.0	0.9	2.3	3.2	0.5	0.0	0.0	0.0	0.4	1.3
30–31	6.0	1.3	1.7	1.9	3.8	2.4	0.5	1.1	0.0	0.4	1.7
29–30	2.0	0.8	0.9	3.0	1.5	1.5	0.5	0.0	0.0	1.5	1.2
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

[a] Figures in parentheses represent number of recoveries.

[b] Lake Chautauqua.

Table 4. — A comparison of the latitudinal distribution of direct and indirect recoveries of mallards from 1 degree north of the banding station at Lake Chautauqua to the Gulf of Mexico for the years 1939–1952.

Degree of Latitude	*Percent of Recoveries*	
	Direct	Indirect
41–42	6.1	12.8
40–41 [a]	53.7	30.8
39–40	7.9	9.9
38–39	3.6	3.3
37–38	2.9	4.7
36–37	5.0	8.0
35–36	6.7	8.4
34–35	6.8	9.9
33–34	1.2	2.6
32–33	1.9	2.8
31–32	1.3	2.0
30–31	1.7	2.2
29–30	1.2	2.6
Total	*100.0*	*100.0*

[a] Lake Chautauqua.

the zone embracing all 3 degrees of latitude including the banding station, direct recoveries were 1.3 times greater than indirect recoveries.

The implication from this comparison of direct and indirect recoveries is that about 60 percent of the mallards from bandings in previous years returned to within a 60-mile north-south zone centering on the banding station. About 80 percent of the mallards from previous bandings returned to areas within a 200-mile north-south zone centering on the banding station. These areas were primarily in the vicinity of the banding station, secondarily on the upper Illinois River above Peoria, and lastly on the lower Illinois River below Browning. Hence, about 20 percent of previously banded mallards appeared to have overflown the Illinois River valley, many continuing directly south to their principal wintering grounds.

Year in and year out, the principal wintering grounds for the mallards in the Mississippi Flyway lie between the 37° parallel and the Gulf of Mexico. Within this region, the greatest concentration of wintering mallards occurs in eastern Arkansas between the 34° and 36° parallels.

Direct recoveries south of the 37° parallel amounted to 25.8 percent while indirect recoveries amounted to 38.5 percent, almost 13 percent greater. Thus, of the 20 percent greater indirect than direct recoveries south of the banding station, 13 percent occurred on the wintering grounds. Direct recoveries on the wintering grounds were 1.5 times more frequent than indirect recoveries.

Direct recoveries indicate that there is some *reverse migration* — that each autumn some mallards move back north varying distances from the Chautauqua banding station. The longitudinal mean of these recoveries approximates the mean of indirect recoveries.

The distribution of direct recoveries by degrees of latitude north of the banding station is presented in Table 5. Of the 7.59 percent of the direct recoveries occurring north of Lake Chautauqua, 5.95 percent were within 1 degree of latitude (69 statute miles). Only three recoveries from reversed movements occurred north of South Dakota. These recoveries probably represent ducks which overshot their migratory home areas and were trapped prior to reorientation northward.

Table 5.— The latitudinal distribution of direct recoveries, 1939–1944 and 1947–1952, from mallards banded at Lake Chautauqua (40°–41°).

Degree of Latitude	*Recoveries*	
	Number	Percent
48–49	1	0.04
47–48	1	0.04
46–47	1	0.04
45–46	6	0.23
44–45	7	0.27
43–44	12	0.45
42–43	15	0.57
41–42	157	5.95
29–41 [a]	2,436	92.41
Total	*2,636*	*100.0*

[a] Recoveries from south of Lake Chautauqua.

McGinnis Slough Bandings

(McGinnis Slough is a body of water of only 300 acres situated in the southwestern part of Cook County, Illinois. It is rather isolated from other waterfowl habitat. The nearest important waterfowl hunting habitat lies on the upper Illinois River, especially from Channahon to Bureau, some 20 to 85 miles west and slightly south of McGinnis Slough. Additional small acreage of waterfowl habitat occurs in northwestern Indiana.)

Longitudinal Distribution. — A summary of *indirect band recoveries* for mallards by longitude, 1941–1951, is shown in Fig. 9. The axial and standard deviation lines show a longitudinal distribution down the flyway almost identical to that for bandings of mallards at Lake Chautauqua. The only important differences between the two stations occur between 40° and 45° of latitude, where the axial and standard deviation lines are farther east for McGinnis Slough recoveries. The slightly greater eastward swing for McGinnis Slough mallards begins in southern Minnesota and ends on the Mississippi River in west-central Illinois.

North of the McGinnis Slough banding station in the United States, the spread of band recoveries varied from a maximum of 350 miles to a minimum of 100 miles and averaged about 225 miles. South of the banding station, spread in band recoveries varied from a maximum of 270 miles to a minimum of 120 miles with an average of about 170 miles.

The standard deviation in the longitudinal distribution of band recoveries at the latitude of the McGinnis Slough banding station was 200 miles. This is more than twice the spread for indirect recoveries of Lake Chautauqua banded mallards in the vicinity of their station. The difference arises from the small size of McGinnis Slough, the paucity of hunting in its immediate vicinity, and the importance of the upper Illinois River valley for mallard hunting, some 20–85 miles to the west.

Table 6 shows the yearly variation in the mean longitude and standard deviation for indirect band recoveries occurring at the latitude of the McGinnis Slough banding station. The mean varied from 0.12 to 1.47 degrees west of the banding station during the 9-year period. The standard deviation displayed a considerable yearly variation; some years those mallards returning to the latitude of McGinnis Slough were widely dispersed, east and west, and other years they were well grouped near the station. But in general, there is evidence of a

Table 6. — Indirect mallard band recoveries, 1943–1951, by mean degree of longitude[a] and its standard deviation for the degree of latitude (41°–42°) at which the ducks were banded at McGinnis Slough, Cook County, Illinois. Station located at about 87.9° longitude.

Year	*Number of Recoveries*	*Mean Degree of Longitude*	*Degrees from Station*[b]	*Standard Deviation in Degrees*
1943	12	89.33	+1.47	2.11
1944	48	88.35	+0.79	5.10
1945	43	88.51	+0.65	1.37
1946	36	88.90	+1.04	1.57
1947	34	88.08	+0.12	0.62
1948	9	89.19	+1.33	4.75
1949	20	89.23	+1.37	0.51
1950	13	88.29	+0.43	0.32
1951	9	89.08	+1.22	0.78
Average		*88.77*	*+0.91*	

[a] 1 degree of longitude at this latitude equals about 52 statute miles.
[b]—Denotes degrees east of station, + denotes degrees west of station.

strong homing tendency for McGinnis Slough mallards. Considering the small size of McGinnis Slough and its out-of-the-way location for mallards, it is a remarkable display of return.

The longitudinal distribution of mallard *direct recoveries*, 1940–1947, for McGinnis Slough bandings, along with the distribution of indirect recoveries is shown in Fig. 9. The axial line of direct recoveries occurs from 10 to 50 miles east of that for the indirect recoveries

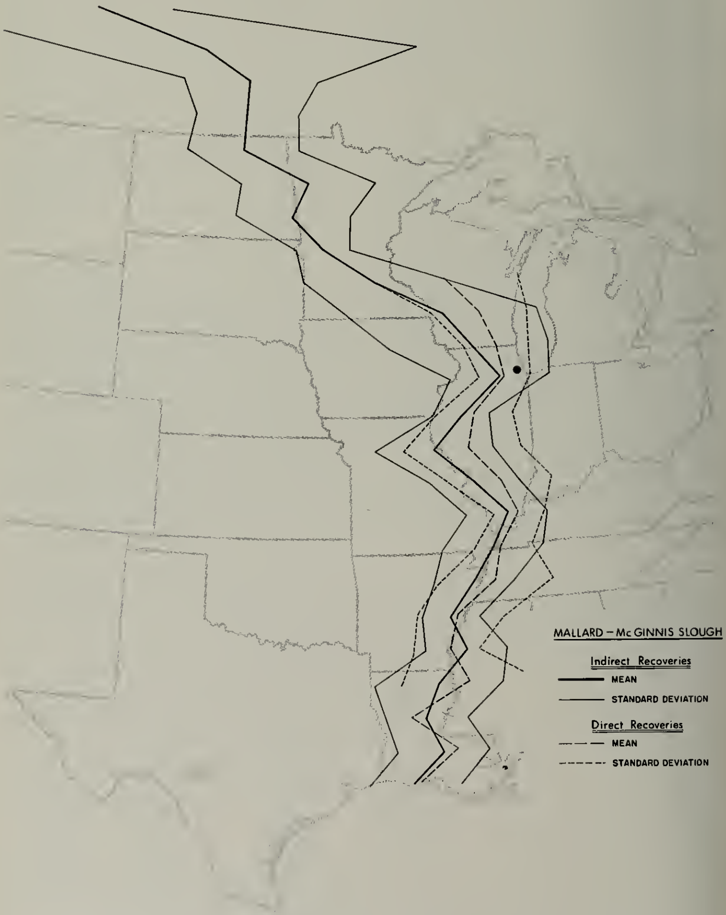

Fig. 9.—The longitudinal distribution of mallard indirect recoveries as compared with direct recoveries on the basis of mean and standard deviation lines. Mallards banded at McGinnis Slough, Cook County, Illinois, 1940–1947.

between the banding station and the main wintering grounds near Stuttgart, Arkansas. North of the banding station, the direct mallard recoveries, representing a reversed movement, tend to occur in central Wisconsin, about 50 miles to the east of the line for most indirect recoveries.

The axial line and standard deviation for the direct recoveries represent the migration corridor used by McGinnis Slough mallards between that area and the wintering grounds. The slight westward distribution of the indirect recoveries is more in keeping with the mass mallard passage through Illinois to the wintering grounds. It is evident that some mallards banded at McGinnis Slough are "captured" by other mallard population elements passing in subsequent years to the west of McGinnis Slough.

Latitudinal Distribution. — The latitudinal distribution of *indirect recoveries* for mallards banded at McGinnis Slough, 1941–1951, is given in Table 7. The percentages of recoveries by latitude are similar to those of mallards banded at Lake Chautauqua except for the difference stemming from the location of the two stations. At the latitude of McGinnis Slough (41°–42°) indirect recoveries for that station amounted to 16.8 percent. On the other hand, at this latitude for Lake Chautauqua bandings, recoveries amounted to only 7.9 percent (Table 2). And at the latitude of Lake Chautauqua, recoveries from McGinnis Slough bandings amounted to only 5.4 percent. Thus, there is evidence that each banded group of mallards tended to return to the latitude where previously banded.

Considering *direct recoveries,* mallards banded at McGinnis Slough have a recovery of 55.5 percent within the degree of latitude of the banding station (Table 8). This is close to the 53.7 percent recorded for direct recoveries from Lake Chautauqua bandings and

Table 7. — The number and percent of indirect recoveries, 1941–1951, from mallards banded at McGinnis Slough, Cook County, by degrees of latitude. Station located at about 87.9° longitude.

Degree of Latitude	*Recoveries*	
	Number	Percent
56 +	3	0.2
55–56	0	0.0
54–55	9	0.6
53–54	16	1.1
52–53	11	0.7
51–52	11	0.7
50–51	50	3.6
49–50	38	2.7
48–49	42	2.9
47–48	39	2.7
46–47	79	5.6
45–46	99	7.0
44–45	114	8.0
43–44	79	5.6
42–43	55	3.9
41–42[a]	237	16.8
40–41	77	5.4
39–40	51	3.6
38–39	28	2.0
37–38	35	2.5
36–37	70	4.9
35–36	68	4.8
34–35	89	6.3
33–34	37	2.6
32–33	17	1.2
31–32	18	1.3
30–31	24	1.7
29–30	23	1.6
Total	*1,419*	*100.0*

[a] McGinnis Slough.

reported near that station (Table 3). The distribution of direct recoveries from McGinnis Slough shows only a 9.7 percent recovery in the latitude of the Lake Chautauqua station. The distribution of direct recoveries on the principal wintering grounds of the mallard (34°–37°) is similar to that from bandings at Lake Chautauqua.

A comparison of direct and indirect recoveries from mallards banded at McGinnis Slough (recorded only for those degrees of latitude from 1 degree north of the banding station to the Gulf of Mexico) is given in Table 8. The important latitude for comparison is that of the banding station (41°–42°). Note

Table 8. — A comparison of the distribution of direct and indirect recoveries for the same latitudes from north of the banding station at McGinnis Slough to the Gulf of Mexico, 1941–1947.

Degree of Latitude	*Direct Recoveries*		*Indirect Recoveries*	
	Number	Percent	Number	Percent
42–43	48	6.7	40	6.0
41–42[a]	400	55.5	194	29.4
40–41	70	9.7	66	10.0
39–40	25	3.5	39	5.9
38–39	25	3.5	23	3.5
37–38	21	2.9	23	3.5
36–37	30	4.2	50	7.6
35–36	29	4.0	53	8.0
34–35	36	5.0	73	11.1
33–34	6	0.8	33	5.0
32–33	12	1.7	18	2.7
31–32	7	0.9	11	1.7
30–31	9	1.2	21	3.2
29–30	3	0.4	16	2.4
Total	*721*	*100.0*	*660*	*100.0*

[a] McGinnis Slough.

that the percentage for direct recoveries (55.5) is about 1.9 times greater than that for indirect recoveries (29.4) for the area of the banding station. The proportion of recoveries from the wintering grounds (29°–37°) amounts to 18.2 percent for the direct recoveries and 41.7 percent for the indirect recoveries. Thus, the proportion of indirect recoveries is about 2.3 times greater than the proportion of direct recoveries for the latitudes of the wintering grounds. The conclusion is reached that additional time on the wintering grounds accrued from overflights of McGinnis Slough and other habitats at that latitude.

Spring Lake Bandings

(Spring Lake is a shallow body of water of about 2,900 acres adjacent to the Mississippi River in Carroll County, Illinois. It is a division of the Upper Mississippi Wildlife and Fish Refuge. The banding station on this lake was about 115 miles west and 25 miles north of the one on McGinnis Slough, and 120 miles north of the Lake Chautauqua banding station. The 42nd degree of latitude passes 2 miles south of the banding station site. During the years of banding, 1946–1948, peak mallard populations on this lake varied between 15,000 and 25,000. Extensive waterfowl hunting habitat extended up and down the Mississippi River from this banding station.)

Longitudinal Distribution. — The mean and standard deviation of the longitude for each degree of latitude of all *indirect recoveries,* 1947–1952, for mallards banded at Spring Lake are shown in Fig. 10. With a few minor exceptions, the distribution of indirect recoveries is essentially the same as that for those from bandings at Lake Chautauqua and McGinnis Slough (Fig. 7 and 9). The principal exception to the general distribution pattern occurs in the latitudes adjacent to the Spring Lake banding station. There, the axial and standard deviation lines are about 100 miles west of those for McGinnis Slough, but almost identical to the lines representing the longitudinal distribution of Lake Chautauqua bandings.

Data in Table 9 show that in a 4-year period, variations in the mean longitude of indirect mallard recoveries represented distances from about 27 miles west of the station (1948) to about 23 miles east (1950). The average mean of band recoveries for the period, 1947–1950, was within 1 mile of the banding station. The standard deviation shows a rather limited dispersion longitudinally for 3 of the 4 years.

It is apparent that Spring Lake mallards, like those at the Lake Chautauqua and McGinnis Slough banding stations, were prone to return to the vicinity of the banding station in the years following their banding.

A comparison of the distribution of *direct recoveries* with indirect ones from Spring Lake bandings (Fig. 10) shows only minor differences. Standard deviation lines show that a more compact distribution of direct recoveries occurred

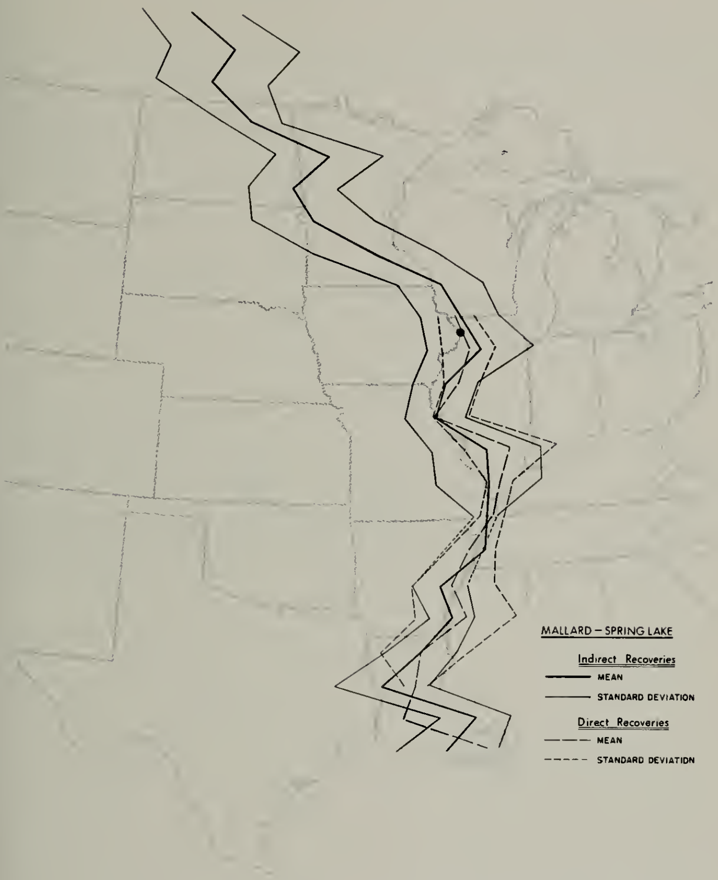

Fig. 10. — The longitudinal distribution of mallard indirect recoveries as compared with direct recoveries on the basis of mean and standard deviation lines. Mallards banded at the Spring Lake Refuge, Carroll County, Illinois, 1946–1948.

in the immediate vicinity of the banding station. South of southern Illinois there was little difference in the axial or standard deviation lines until central Louisiana, and south, a region of few recoveries.

Direct and indirect recoveries between 42° and 40° of latitude are largely from the Mississippi and Illinois River valleys, thereby accounting for the axial lines passing between these two river valleys.

The plotting of individual direct recoveries shows their distribution in the region of the Spring Lake banding sta-

Table 9.—Indirect mallard band recoveries, 1947–1950, by mean degree of longitude and its standard deviation for the degree of latitude (42°–43°) where banded at the Spring Lake, Carroll County, Illinois station. Banding station located at about 90.1° longitude.[a]

Year	*Number of Recoveries*	*Mean Degree of Longitude*	*Degrees from Station*[b]	*Standard Deviation of Recoveries*
1947	32	90.03	−0.04	1.50
1948	13	90.60	+0.53	1.75
1949	13	90.17	+0.10	2.81
1950	13	89.52	−0.45	1.91
Average		*90.08*	*+0.01*	

[a] 1 degree of longitude at this latitude equals about 51.5 statute miles.
[b]—Denotes degrees east of station, + denotes degrees west of station.

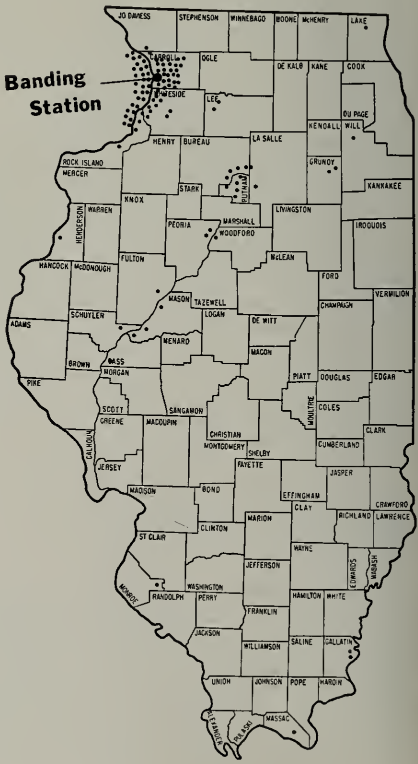

Fig. 11.—Individual direct recoveries of mallards banded at the Spring Lake Refuge, Carroll County, Illinois, during October and November, 1946.

tion (Fig. 11). Two facts are apparent — there is a cruising radius of about 25 miles around the banding station which the mallards cover in their feeding activities, and when the birds leave the area of their daily cruising range they are continuing their migratory flight. The Mississippi River valley between Muscatine, Iowa, and Alton, Illinois, supports the largest mallard concentrations in the entire Mississippi valley, yet there are few direct recoveries from this region. This indicates that mallards departing from Spring Lake in migration did not gradually move south down the Mississippi River albeit that excellent habitat was available to them. It is also evident from Fig. 11 that a sizeable contingent of Spring Lake banded mallards flew southeastward about 65 miles to the Illinois River valley near Bureau. We believe that most of these mallards had this area of the Illinois valley as their initial goal but prematurely dropped out of migratory passage at Spring Lake and were banded before continuing to their proximate goal.

Latitudinal Distribution. — The latitudinal distribution of *indirect recoveries* from mallards banded at Spring Lake is given in Table 10. Because the banding station was located only 2 miles north of the 42° parallel, approximately equal numbers of recoveries were received below and above that latitude. Therefore, at the latitude of the banding station we have combined band recoveries for 2 degrees (41°–43°) of latitude to make the data more comparable with those from other banding stations. Indirect recoveries in this delimited area amounted to 23.6 percent of the total for the flyway.

Indirect recoveries for a similar 2-degree delimited area (39°–41°) in the vicinity of the Chautauqua station (Table 2) accounted for 24.1 percent, and for McGinnis Slough (40°–42°) (Table 7) 22.1 percent, of the indirect recoveries over the entire span of migratory flight.

Table 10. — The number and percent of indirect recoveries, 1947–1952, from mallards banded at Spring Lake, Carroll County, Illinois, by degrees of latitude. Station located at about 90.1° longitude.

Degree of Latitude	*Recoveries*	
	Number	Percent
56 +	1	0.2
55–56	0	0.0
54–55	4	0.7
53–54	2	0.4
52–53	2	0.4
51–52	9	1.6
50–51	20	3.6
49–50	14	2.6
48–49	24	4.4
47–48	23	4.2
46–47	24	4.4
45–46	28	5.1
44–45	31	5.7
43–44	21	3.8
42–43, 41–42 [a]	129	23.6
40–41	43	7.8
39–40	12	2.2
38–39	14	2.6
37–38	10	1.8
36–37	33	6.0
35–36	26	4.7
34–35	34	6.2
33–34	13	2.4
32–33	11	2.0
31–32	5	0.9
30–31	4	0.7
29–30	11	2.0
Total	*548*	*100.0*

[a] Data for these 2 degrees combined because banding station located so near the 42° parallel.

Direct and indirect recoveries are compared (Table 11) for similar latitudes for mallard bandings at Spring Lake. For the 2-degree area embracing the vicinity of the banding station, the percentage of direct recoveries is about 1.7 times greater than that of the indirect recoveries. However, indirect recoveries are in greater proportion than direct recoveries in the latitudes immediately north (43°–44°) and south (40°–41°) of those latitudes adjacent to the banding station. On the principal wintering grounds of the mallard (29°–37°), the relative proportion of indirect recov-

Table 11. — A comparison of the distribution of direct and indirect recoveries for the same latitudes from north of the banding station at Spring Lake to the Gulf of Mexico, 1946–1952.

Degree of Latitude	*Direct Recoveries* Number	Percent	*Indirect Recoveries* Number	Percent
43–44	2	0.6	21	5.7
42–43, 41–42 [a]	189	60.9	129	35.1
40–41	22	7.1	43	11.7
39–40	6	1.9	12	3.3
38–39	5	1.6	14	3.8
37–38	11	3.5	10	2.8
36–37	20	6.4	33	9.0
35–36	16	5.1	26	7.2
34–35	18	5.8	34	9.3
33–34	5	1.6	13	3.6
32–33	7	2.3	11	3.0
31–32	5	1.6	5	1.4
30–31	3	1.0	4	1.1
29–30	2	0.6	11	3.0
Total	*311*	*100.0*	*366*	*100.0*

[a] Spring Lake.

eries is 1.5 times greater than is the proportion of direct recoveries. As at the previous stations, we believe that this difference resulted largely from overflights. About one-third of the living mallards which visited Spring Lake the year previous failed to stop and continued on in migration to their principal wintering grounds, where the additional time, accruing from the overflight, was spent.

Calhoun Wildlife Refuge Bandings

(The Calhoun National Wildlife Refuge is the southernmost division of the Mark Twain National Wildlife Refuge which encompasses federal refuge units along the Mississippi River between Rock Island and Alton, Illinois. The Calhoun division, embracing about 5,050 acres, includes several lakes adjacent to the Illinois River a few miles above its confluence with the Mississippi River at Grafton, Illinois. The banding station was located on Gilbert Lake, about 3 miles south of the 39° parallel in Jersey County. This is about 215 miles almost due south of the Spring Lake refuge. The Calhoun Refuge, at the time of our banding program, was host to peak mallard populations of 25,000–50,000. We banded only 1,500 mallards during late autumn seasons of 1947 and 1948. Direct recoveries were so few in number as to be meaningless. Indirect recoveries, 1948–1954, numbered 201 which provided data for limited analysis.)

Longitudinal Distribution. — The mean longitude for indirect recoveries for each degree of latitude shows an axial line from the breeding to the wintering grounds which is very similar (Fig. 12) to that found for indirect recoveries from the Lake Chautauqua, McGinnis Slough, and Spring Lake banding stations. At the latitude of the banding station, the axial line passed within a mile or two of the banding station. The axial line of recovery extends southeastward from Manitoba to the Mississippi River in northern Illinois, and then south to the Gulf of Mexico.

Latitudinal Distribution. — Indirect recoveries from mallards banded at the Calhoun Refuge have been analyzed by degree of recovery (Table 12). Because the banding station was located only 3 miles south of the 39° parallel, the recoveries were combined for 2 degrees of latitude, 1 degree north of the site and 1 degree south.

The 23.9 percent indirect recovery of bands from hunters within these 2 degrees of latitude is larger than the total percentage for any other 2 degrees. The largest sum for any other 2 degrees (44°–46°) is 14.9 percent. The indirect band recovery of mallards near the Calhoun Refuge banding site was almost identical to the indirect recoveries for mallards banded at the Spring Lake, McGinnis Slough, and Lake Chautauqua stations which returned to the respective latitudes of those stations.

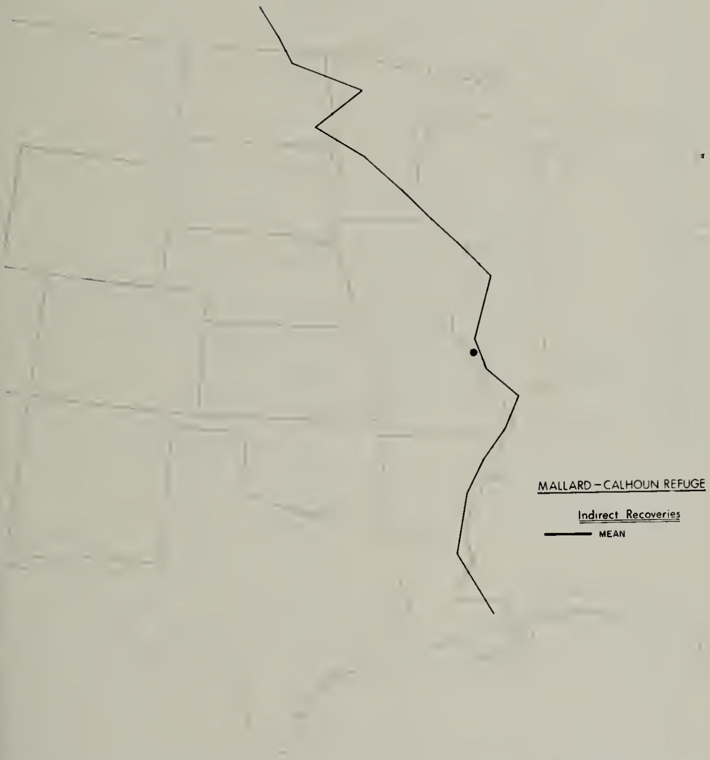

Fig. 12. — The mean line of indirect recoveries from mallards banded at the Calhoun Refuge, Jersey County, Illinois, 1947 and 1948.

Table 12. — The number and percent of indirect recoveries, 1948–1954, from mallards banded at the Calhoun Refuge, Jersey County, Illinois, by degrees of latitude. Station located at about 90.4° longitude.

Degree of Latitude	*Recoveries*	
	Number	Percent
56 +	0	0.0
55–56	0	0.0
54–55	0	0.0
53–54	2	1.0
52–53	5	2.5
51–52	3	1.5
50–51	5	2.5
49–50	6	3.0
48–49	5	2.5
47–48	5	2.5
46–47	11	5.5
45–46	14	6.9
44–45	16	8.0
43–44	11	5.5
42–43	2	1.0
41–42	2	1.0
40–41	6	3.0
39–40, 38–39 [a]	48	23.9
37–38	3	1.4
36–37	14	6.9
35–36	14	6.9
34–35	12	6.0
33–34	8	4.0
32–33	0	0.0
31–32	4	2.0
30–31	2	1.0
29–30	3	1.5
Total	*201*	*100.0*

[a] Data for these 2 degrees combined because banding station located so near the 39° parallel.

Union County Bandings

(The Union County Wildlife Management Area is located 2 miles east of the Mississippi River between Ware and Reynoldsville in Union County, Illinois. This is slightly south of midway between the 37° and 38° parallels, about 320 miles south of the Spring Lake banding station, and 105 miles south of the Calhoun Refuge banding station. Mallards at this station were banded in mid- and late winter, thereby permitting only a few direct recoveries. Because of the few direct recoveries, only indirect recoveries have been analyzed for mallard bandings at this station.)

Longitudinal Distribution.—All of the indirect band recoveries from mallards banded at the Union County station which were reported during the period 1955–1966 have been analyzed by longitudinal mean and standard deviation. Fig. 13 shows that although the axial and standard deviation lines from this banding station were similar to those presented for other banding stations in Illinois, there are some slight differences.

Whereas earlier bandings at other stations showed a recovery bias originating from hunting pressure and waterfowl habitat in northwestern Minnesota, Union County mallard data do not result in this zigzag in the axial recovery line in northern United States. The path of recoveries, as delineated by standard deviation, arrived at the Mississippi River in southern Iowa slightly south of that delineated for other Illinois stations. From the Mississippi River southward, Union County recovery data are almost identical to data for all other mallard bandings in Illinois.

Table 13 shows the yearly variation in the longitudinal mean and standard deviation for indirect recoveries in the degree of latitude encompassing the banding station. The banding station was located at about 89.35° of longitude whereas the 12-year average of the mean recoveries was 88.95°, about 40 miles east of the banding location. Intensive hunting at Hovey Lake, near Mount Vernon, Indiana, resulted in this eastward pull in mean recovery location.

In 10 of the 12 years, the mean of the band recoveries fell within 55 miles east of the station. The standard deviation embraced a breadth varying from 34 miles in 1966 to 280 in 1960. Wide yearly variation in the spread in distribution is attributed to the dispersed and relatively meager waterfowl habitat available between the 37° and 38° parallels. Nonetheless, in 9 of 12 years the standard deviation indicated that two-thirds of the recoveries at the lati-

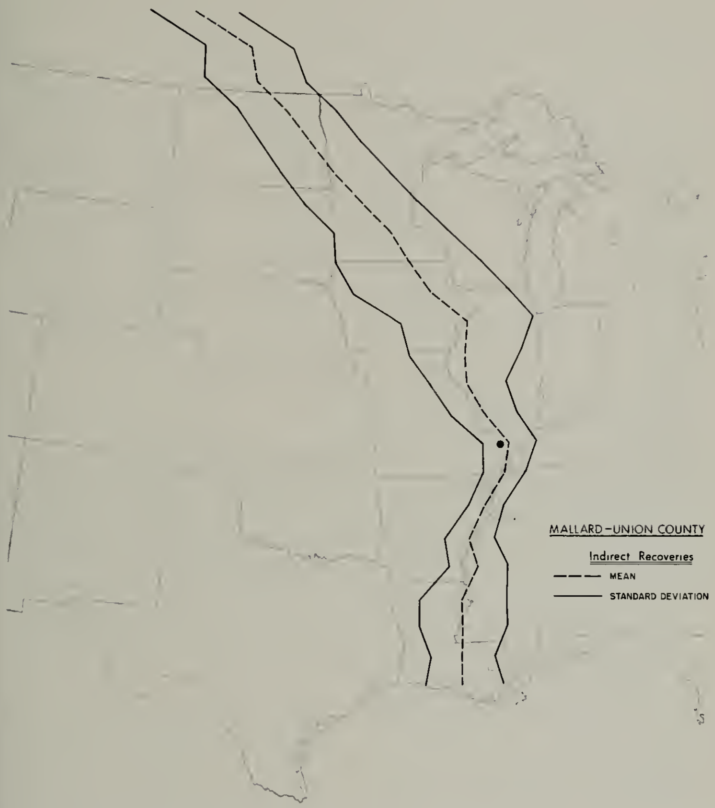

Fig. 13. — The longitudinal distribution of mallard indirect recoveries on the basis of mean and standard deviation lines. Mallards banded at the Union County Wildlife Management Area, near Ware, Illinois, 1954–1966.

tude of the banding station fell within a longitudinal span of 175 miles.

Standard deviation of indirect band recoveries from Union County is smallest from the banding station south along the Mississippi River to southern Arkansas. There the path of recoveries is only 100–140 miles wide. Standard deviation shows that the broadest recovery path is between the western border of Minnesota and the Mississippi River along the border of Illinois. In this region the delineated path is from 200 to 250 miles wide. This wide path across southwestern Minnesota and diagonally across Iowa results both from the spread in band recoveries in any one year, and from variations in the yearly mean.

Fig. 14 shows the variation in the yearly mean longitude distribution of

Table 13. — Indirect mallard band recoveries, 1955–1966, by mean degree of longitude[a] and its standard deviation for the degree of latitude (37°–38°) encompassing the Union County, Illinois, banding station. Station located at about 89.4° longitude.

Year	*Number of Recoveries*	*Mean Degree of Longitude*	*Degrees from Station*[b]	*Standard Deviation in Degrees*
1955	257	88.65	—0.70	0.75
1956	217	88.81	—0.54	1.53
1957	69	88.44	—0.91	1.15
1958	65	88.41	—0.94	1.58
1959	21	89.31	—0.04	2.38
1960	12	88.90	—0.45	2.55
1961	11	88.09	—1.26	0.75
1962	11	91.02	+2.27	5.08
1963	12	89.17	—0.18	0.54
1964	30	88.82	—0.53	1.11
1965	14	88.86	—0.49	0.52
1966	13	88.88	—0.47	0.31
Average		*88.95*		

[a] 1 degree longitude at this latitude equals about 55 statute miles.
[b] — Denotes degrees east of station, + denotes degrees west of station.

Union County mallard bandings for the recovery years, 1955–1960. For most regions of their fall passage, the band recoveries from these mallards are very similar in year-to-year distribution, but especially so along the Mississippi River from southern Illinois to southern Arkansas. The greatest divergence in the yearly axial line distribution occurred in the region between western Minnesota and the Illinois River. In this region, the 1955 axial line was farthest east and the 1957 axial line was farthest west. In 1956 the axial line of recoveries was approximately average, about midway between that of 1955 and 1957.

There were massed mallard flights each of these 3 years as described by Bellrose (1957), and Bellrose and Sieh (1960). The massed passage on November 1-2, 1955 occurred largely at night in the region between western Minnesota and the Mississippi River (Bellrose 1957:22–23). A heavy, low overcast blanketed the region and winds were strong from the west.

In contrast, the November 7, 1956 fall grand passage, through the region delineated above, occurred largely during diurnal hours (Bellrose & Sieh 1960:37–42). This migration occurred during a period when skies were overcast in the region (op. cit. 55) and winds were strong from the northwest. The great 1957 mallard passage through the region between western Minnesota and western Illinois occurred largely during the night of October 23-24 (op. cit. 53). Skies were again overcast and winds were fairly strong, but this time from the northeast.

Winds and landscape visibility may account for the divergence in the axial lines of band recoveries in 1955, 1956, and 1957 in the region from western Minnesota southeastward to the Mississippi River (Fig. 14). The 1956 grand passage is the only one of the three (1955–1957) for which band recoveries indicate that this region was crossed along customary lines of flight. The mean (Fig. 13) is based on the average of all indirect recoveries, 1955–1966. The November 7, 1956 passage occurred more extensively in daylight hours than either that of November 1-2, 1955, or October 23-24, 1957.

The 1955 axial line of recoveries between western Minnesota and the Mississippi River was from 60 to 120 miles

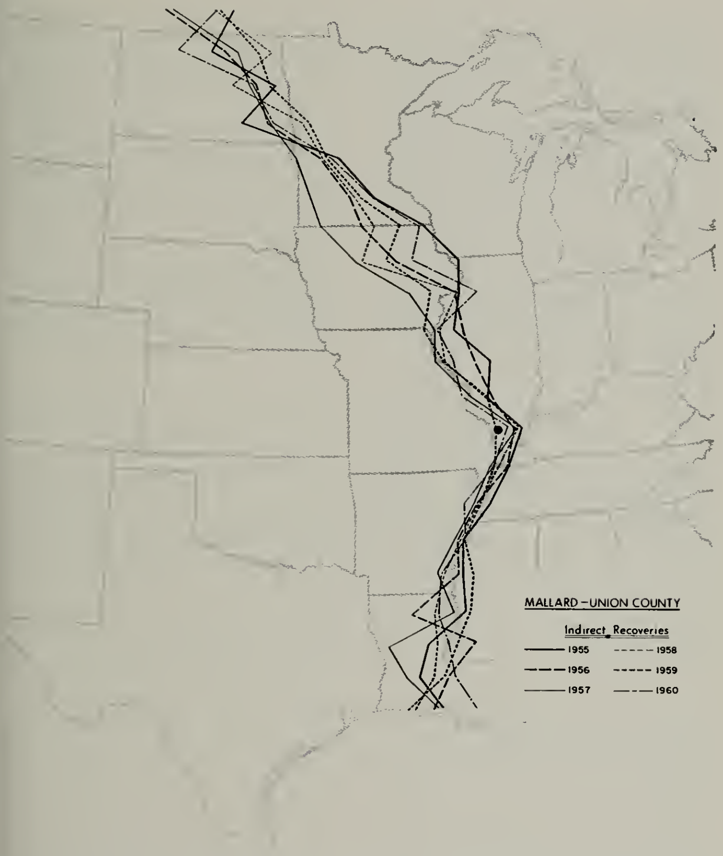

Fig. 14. — Axial lines, 1955–1960, of indirect band recoveries from mallards banded at the Union County Area, near Ware, Illinois.

east of that of 1957. In the 1955 mass flight the wind was strong from the west, while in 1957 the wind was almost as strong from the northeast. At the time of both the 1956 and 1957 mass flights, heavy, low overcast at night reduced visibility to less than a mile. The regions crossed by the passage of waterfowl in southern Minnesota and northern and eastern Iowa are devoid of salient landscape features. South of the Minnesota River, the general drainage pattern of creeks and small rivers is southeastward to the Mississippi River. When it is visible, the drainage pattern in this region provides a means of orientation. During the diurnal passage in 1956, observations made from a light aircraft by

Bellrose (Bellrose & Sieh 1960: 33, 34, 44) indicated that mallards were utilizing the larger streams of this region for navigational purposes. Nocturnal observations made by Bellrose at low altitudes from a light airplane were helpful in understanding the problems faced by migrating waterfowl at night. On nights with a low overcast, the watercourses of this region were invisible until directly below the aircraft, and woods and fields were indistinguishable. It is doubtful that on the nights of November 1-2, 1955, and October 23-24, 1957, the landscape in this region could have been used by waterfowl for prolonged orientation and/or navigation. Therefore, the variation in yearly means of longitude in the region, from western Minnesota southeastward to the Mississippi River, appears to be attributable to wind drift of migrating mallards during nights of poor visibility and strong beam winds. Landscape features were plainly visible and were used during the diurnal passage in 1956, when there was apparently no wind drift.

Latitudinal Distribution. — The latitudinal distribution of indirect mallard band recoveries from Union County is shown for the years 1955–1966 in

Table 14. — The percent of indirect mallard recoveries, 1955–1966, by latitude from bandings at the Union County banding station (37°–38°).

Degree of Latitude	*1955* (1236)[a]	*1956* (2160)	*1957* (1531)	*1958* (965)	*1959* (490)	*1960* (416)	*1961* (233)	*1962* (105)	*1963* (256)	*1964* (575)	*1965* (243)	*1966* (221)	*Average*
55–56	0.0	0.1	0.1	0.2	0.2	0.2	0.0	1.0	0.0	0.2	0.0	0.0	0.2
54–55	0.2	0.2	0.3	0.7	0.8	0.0	0.9	1.9	0.0	0.2	0.0	1.4	0.6
53–54	0.4	0.7	1.2	1.4	2.9	1.2	4.3	0.0	0.8	1.2	1.2	0.9	1.4
52–53	0.7	2.1	2.2	2.7	3.5	3.6	2.6	3.8	2.3	1.2	4.1	2.3	2.6
51–52	1.5	4.2	2.7	4.8	4.5	4.1	2.2	4.8	3.5	1.0	2.9	4.1	3.3
50–51	1.9	8.8	4.3	6.0	5.9	6.5	4.7	1.9	8.2	4.0	3.7	1.8	4.8
49–50	0.9	2.3	2.3	1.9	2.2	2.7	3.4	5.7	3.1	3.0	4.5	0.9	2.7
48–49	0.9	2.8	1.2	1.5	2.7	2.4	3.0	5.7	4.3	4.4	4.9	3.2	3.1
47–48	0.5	3.7	2.5	2.4	2.7	1.9	2.6	1.0	4.3	3.3	2.1	1.4	2.3
46–47	1.0	1.9	2.7	3.0	3.0	3.1	3.0	4.7	6.3	4.5	4.1	2.7	3.3
45–46	1.0	2.5	4.0	4.0	2.6	1.9	6.9	3.8	7.0	4.4	7.0	6.8	4.3
44–45	0.7	3.3	2.9	3.1	3.5	5.3	8.2	7.6	8.2	5.9	7.0	7.2	5.2
43–44	0.9	2.2	3.4	2.3	3.9	4.3	7.7	4.7	5.9	3.8	5.4	6.3	4.2
42–43	0.6	1.2	2.3	2.3	3.7	2.7	4.7	0.0	3.5	3.8	2.9	5.4	2.8
41–42	3.3	3.6	6.5	4.8	6.9	7.2	8.6	1.9	3.9	7.0	7.0	6.3	5.6
40–41	8.0	6.0	12.5	5.7	11.6	13.5	9.4	6.7	5.1	8.7	8.6	9.9	8.8
39–40	2.5	2.9	5.1	3.5	4.5	5.3	3.9	7.6	8.2	2.1	2.9	5.9	4.5
38–39	5.1	3.3	5.0	4.8	3.5	5.8	3.4	1.9	3.9	3.3	4.1	3.6	4.0
37–38[b]	22.5	10.4	5.6	8.7	5.7	3.4	4.7	13.3	5.1	5.4	5.8	5.9	8.0
36–37	23.9	12.2	12.3	10.3	8.4	6.7	6.4	7.6	3.5	8.5	5.4	7.2	9.4
35–36	13.2	10.2	10.0	9.5	6.3	7.9	3.4	2.8	0.8	9.9	7.0	5.9	7.3
34–35	7.0	9.3	7.1	10.0	7.8	5.8	3.0	5.7	2.5	8.5	2.1	4.1	6.1
33–34	1.2	2.2	1.5	3.0	1.4	2.4	1.3	1.0	1.2	1.4	2.1	0.4	1.6
32–33	0.5	0.6	0.5	1.4	0.6	0.5	0.0	2.9	0.4	0.7	1.6	0.0	0.8
31–32	0.2	0.5	0.3	0.9	0.0	0.2	0.4	1.0	3.5	1.0	1.2	0.0	0.8
30–31	1.0	1.3	0.5	0.6	0.2	0.2	0.4	0.0	3.1	1.2	1.2	3.2	1.1
29–30	0.4	1.5	1.0	0.5	1.0	1.2	0.9	1.0	1.6	1.4	1.2	3.2	1.2
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

[a] Figures in parentheses represent number of recoveries.
[b] Union County Refuge.

Table 14. Unlike results from previous banding stations in Illinois, smaller proportions of recoveries occurred in the latitude of the banding station. The average was only 8.0 percent for the entire period as contrasted with 19.6 percent for the return of Chautauqua mallards to the latitude of their banding station. Combining of mallard recoveries from the latitude of the Union County banding station with the latitude immediately to the south results in a 17.4 percent return. At other Illinois stations the combined recoveries of 2 degrees embracing the banding station varied from 22 to 25 percent.

The difference in return of mallards to the Union County area from that at other Illinois areas is, in our opinion, due to the differences in migration response when overflights occur. The Union County area is on the northern fringe of the main wintering grounds for the mallard in the Mississippi Flyway. We speculate that when mallards bound for the Union County area miss it, perhaps flying over on dark nights, they reach their main wintering grounds instead of their more immediate destination. Apparently because these ducks find themselves on a wintering area with which they are familiar, there is no sizeable reversal of direction. They are content to remain where they are. Banded mallards of Union County spend more time on their main wintering grounds than those banded elsewhere in Illinois. For example 22.8 percent of the indirect recoveries from Union County bandings, 1955–1966, occurred between 34° and 37° of latitude, the principal wintering area in the Mississippi migration corridor (Bellrose 1968). During the same years, only 15.7 percent of the Chautauqua recoveries occurred between the 34° and 37° parallels.

We know, from many field observations, that when mallards bypass Lake Chautauqua or some other migration stop, large numbers return to the bypassed area (Bellrose 1966:80), usually in the evening following their arrival. This reverse flight is occasionally observed on the wintering grounds in Arkansas, but it is most infrequent when compared to that observed in migration areas. Thus, we conclude that an overflight of mallards at Union County would not result in the same degree of return as when this event occurs at migration areas farther north in Illinois.

Delta Marsh Bandings

(During the fall seasons, 1947–1953, Arthur S. Hawkins of the U.S. Bureau of Sport Fisheries and Wildlife, and personnel of the Delta Waterfowl Research Station banded mallards at the Delta Marsh, Manitoba, Canada. The Delta Marsh embraces about 30,000 acres of shallow water and vegetation at the lower end of Lake Manitoba, some 60 miles west-northwest of Winnipeg, Manitoba. Most of the mallards frequenting the Delta Marsh in the fall have migrated to it from farther north. Delta Marsh is on the eastern fringe of the main breeding grounds of the mallard, and although some of the birds nest there, the bulk of the fall population is transient.)

Longitudinal Distribution. — The mean lines of the longitudinal distribution of recoveries from mallard bandings at the Delta Marsh are shown for both direct and indirect recoveries in Fig. 15.

The direct and indirect recoveries of mallards banded at the Delta Marsh show a similar longitudinal distribution; there are a few minor variations between the axial line formed by direct recoveries and the axial line formed by indirect recoveries. The close agreement between the longitudinal distribution of direct and indirect recoveries shows that after mallards have once made the flight down the flyway they conform in subsequent years to almost identical migration patterns.

The distribution of indirect band recoveries from Delta Marsh mallards,

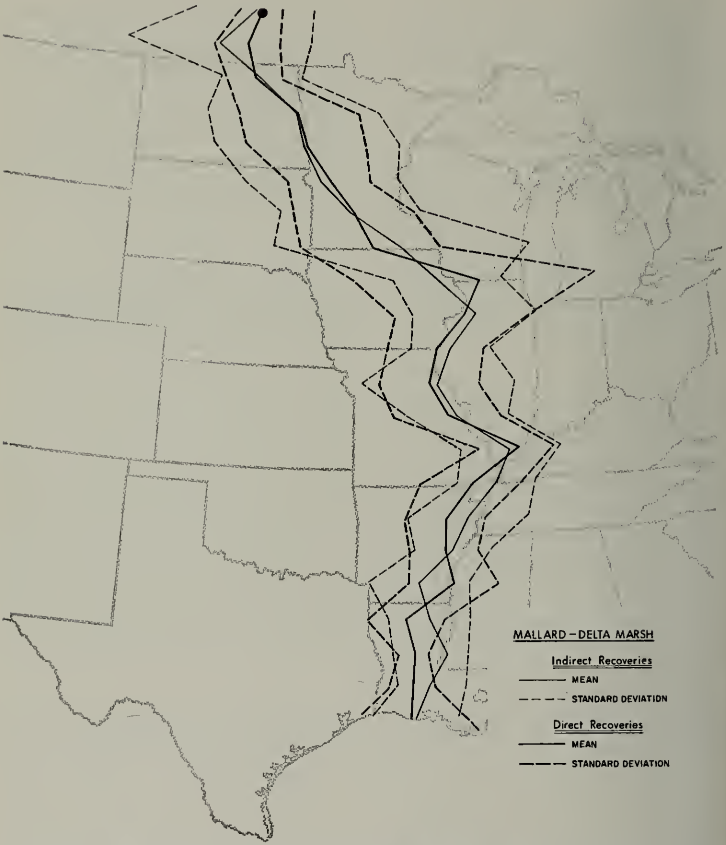

Fig. 15.—The longitudinal distribution of mallard indirect recoveries as compared with direct recoveries on the basis of mean and standard deviation lines. Mallards banded at the Delta Marsh, Manitoba, Canada, 1947–1953.

south of the Canadian border, is almost identical to that obtained from indirect recoveries of mallards banded in Illinois. The only important geographic difference between Illinois recoveries and those at Delta Marsh occurs in the region of the Delta Marsh. Recoveries from bandings of mallards in Illinois show that axial recovery lines occur west of the Delta Marsh on a northwest-southeast slant from central Saskatchewan to Illinois. Thus, mallards once having made Delta Marsh a migration stop evidently move eastward from the main stream of the southeastward passage to return to Delta. Upon departing Delta Marsh, these mallards rejoin the main stream of migrants in the Mississippi corridor by the time the border of the United States is reached.

A comparison of the longitudinal distribution of direct and indirect mallard recoveries in relation to their banding at the Delta Marsh is presented in Table 15. There are some variations in the mean longitude of indirect recoveries as compared with those for direct recoveries. In 3 of the years, the standard deviation showed a clustering of indirect recoveries around Delta almost as compact as for direct recoveries. However, in 1949 and 1952 there was a much wider dispersion in indirect recoveries.

Table 15. — A comparison of the longitudinal distribution of direct and indirect mallard recoveries, 1948–1953, from bandings at the Delta Marsh, Manitoba, Canada. Recoveries for the degree of latitude of the banding station (50°–51°). Banding station located at about 98.3° longitude.[a]

	Direct Recoveries		*Indirect Recoveries*	
Year	Mean	Standard Deviation	Mean	Standard Deviation
1948	98.54	0.50	...	...
1949	98.76	0.97	99.50	2.28
1950	98.57	0.63	97.81	0.98
1951	98.83	1.06	99.93	1.16
1952	98.89	1.36	98.86	4.30
1953	98.68	0.95	98.75	1.16
Average	*98.71*		*98.97*	

[a] 1 degree of longitude at this latitude equals about 45 statute miles.

Latitudinal Distribution. — The latitudinal distribution of both direct and indirect recoveries from mallards banded at Delta Marsh is shown in Table 16. About 40 percent of all direct recoveries occurred at the latitude of the banding station. This is substantially below the average of 55 percent for direct recoveries of Illinois bandings recovered in their home latitudes.

The distribution of direct recoveries by latitude indicates that when mallards left the Delta Marsh they migrated to many diverse places. No single latitude had a monopoly on recoveries; rather there was an astonishingly even dispersion by latitude down the flyway.

Table 16. — A comparison of the distribution of direct and indirect recoveries for the same latitudes from north of the banding station at Delta Marsh, Manitoba to the Gulf of Mexico, 1947–1953.

Degree of Latitude	*Direct Recoveries*		*Indirect Recoveries*	
	Number	Percent	Number	Percent
55–56	...	...	2	0.4
54–55	...	...	1	0.2
53–54	...	...	3	0.7
52–53	...	...	6	1.3
51–52	13	1.3	16	3.5
50–51[a]	411	39.9	87	19.2
49–50	41	4.0	20	4.4
48–49	35	3.4	20	4.4
47–48	16	1.6	12	2.6
46–47	21	2.0	9	2.0
45–46	48	4.7	24	5.3
44–45	43	4.2	21	4.6
43–44	23	2.2	19	4.2
42–43	14	1.4	13	2.9
41–42	39	3.8	17	3.8
40–41	25	2.4	13	2.9
39–40	41	4.0	19	4.2
38–39	17	1.7	7	1.5
37–38	16	1.5	12	2.6
36–37	33	3.2	26	5.7
35–36	53	5.1	21	4.6
34–35	39	3.8	37	8.2
33–34	22	2.1	9	2.0
32–33	16	1.5	7	1.5
31–32	7	0.7	4	0.9
30–31	22	2.1	6	1.3
29–30	35	3.4	23	5.1
Total	*1,030*	*100.0*	*454*	*100.0*

[a] Delta Marsh.

Indirect recoveries in the latitude of the Delta banding station (50°–51°) compose about one-fifth of recoveries for all latitudes. This is almost identical to that found for indirect band recoveries of mallards in the latitude of their respective banding stations in four regions of northern and central Illinois. It is double that found for mallards returning to the vicinity of their banding station at the Union County Refuge in southern Illinois.

A comparison of the proportions of direct and indirect recoveries (Table 16) at the latitude of the Delta Marsh banding station discloses that at this latitude direct recoveries are twice as important as indirect recoveries. Here again, as at Illinois banding stations, it is evident that only about half of the mallards visit the same latitude for comparable periods of time as in the year in which they were initially banded. This suggests that overflights occur among a sizeable proportion of previous autumn inhabitants. As noted earlier, there is some return from overflights, but apparently it is not sufficient to greatly compensate for all that pass by.

The percentage of indirect recoveries on the wintering grounds for the Delta banded mallards (29°–37°), is 1.3 times greater than for the direct recoveries. This implies that mallards which pass over the Delta Marsh spend most of the additional time gained by such passage (23 percent) on the wintering grounds rather than on migration areas between the Delta Marsh and wintering grounds in Arkansas.

Squaw Creek Wildlife Refuge Bandings

(The Squaw Creek National Wildlife Refuge covers 6,800 acres of land and water a few miles east of the Missouri River near Mound City in northwestern Missouri. At the time of the bandings, 1937–1963, Squaw Creek was the only significant concentration point for mallards along the Missouri River between Sioux City, Iowa, and Kansas City, Missouri. Because of the paucity of waterfowl habitat in this region, tremendous concentrations of mallards developed during the fall migration. In most Novembers, mallards numbered between 200,000 and 400,000, and, along with other ducks, and tens of thousands of lesser snow geese, created a tremendous congestion of waterfowl. The De Soto National Wildlife Refuge, established in 1958, is located on the Missouri River, 20 miles north of Omaha, Nebraska. Appreciable numbers of mallards did not begin to frequent this refuge until 1963.)

Longitudinal Distribution. — The longitudinal distribution of mallard indirect recoveries between central Saskatchewan and southern Louisiana is shown for Squaw Creek bandings in Fig. 16. The axial and standard deviation lines are similar in southern Canada to those for Illinois banding stations. Thus, up to this point, mallards from all the various banding stations discussed appear to originate from the same region of the central Saskatchewan plains.

South of the Canadian border, the path of band recoveries, as delineated by the longitudinal distribution of about two-thirds of them, extends on a bearing of about 155 degrees to east-central Arkansas. There the course changes to south, terminating on the Gulf Coast marshes in western Louisiana.

The zigzags in this mapped path of band recoveries (Fig. 16) are largely the result of differences in the longitudinal distribution of waterfowl habitat. The extensive waterfowl habitat along the Mississippi River from southern Minnesota to St. Louis exerts an influence on the longitudinal mean and standard deviation. Because of the influence of the Mississippi River, the axial line is pulled eastward from what is undoubtedly the true path used by this population element of mallards. For example, at the latitude of the Squaw Creek banding station, the *mean* longitude of indirect recoveries is 50 miles to the east, yet the longitudinal *median* of the indirect recoveries occurs within a few miles of the banding station.

The southern Arkansas and northern Louisiana wintering grounds area for Squaw Creek mallards is a short distance to the west of the region occupied by mallards banded at Illinois stations (Fig. 25).

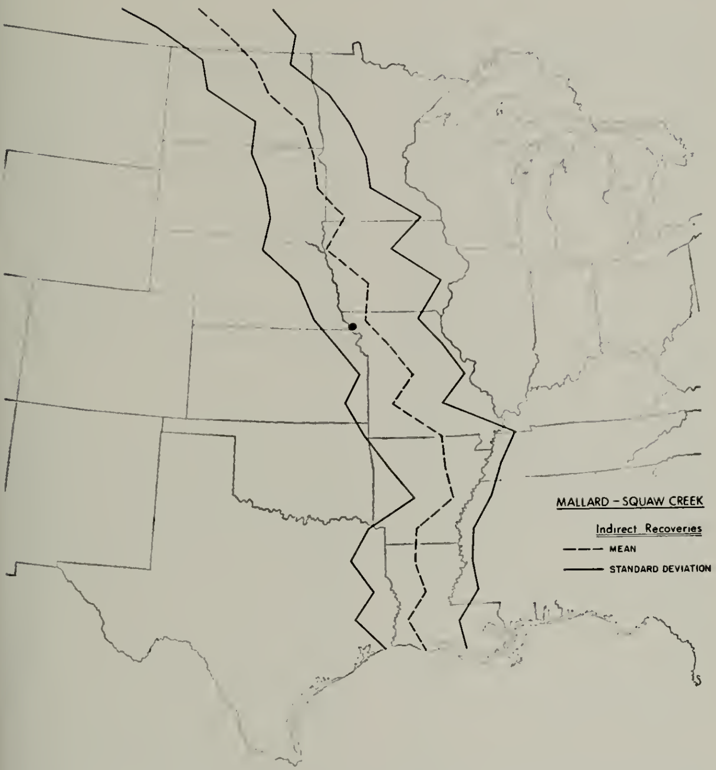

Fig. 16. — The longitudinal distribution of mallard indirect recoveries on the basis of mean and standard deviation lines. Mallards banded at the Squaw Creek National Wildlife Refuge, Holt County, Missouri, 1937–1963.

Latitudinal Distribution.—Indirect recoveries of mallards banded at Squaw Creek are rather evenly distributed down the flyway (Table 17) except at the latitude of the banding station and on the principal wintering grounds. For mallards returning to the vicinity of the banding station the indirect recovery rate at the station latitude was more than twice that for any latitude to the north. Because the banding station was located only a few miles north of the 40° parallel, we included recoveries from the adjacent degree of latitude to the south. The combined total for the 2 degrees of latitude was 16.3 percent compared to 22 to 25 percent for comparable areas at Delta Marsh, Manitoba, and the four stations in northern and central Illinois.

We believe that the lower proportion of indirect band recoveries, within the home range of Squaw Creek mallards, results from the tremendous concentra-

Table 17.—The number and percent of indirect recoveries, 1938–1966, by degrees of latitude from mallards banded at the Squaw Creek National Wildlife Refuge, Holt County, Missouri (40°–41°). Station located at about 95.3° longitude.

Degree of Latitude	*Recoveries*	
	Number	Percent
55–56	2	0.1
54–55	23	1.2
53–54	55	2.9
52–53	78	4.1
51–52	72	3.8
50–51	76	4.0
49–50	83	4.4
48–49	62	3.3
47–48	56	3.0
46–47	50	2.7
45–46	56	3.0
44–45	66	3.5
43–44	53	2.8
42–43	50	2.7
41–42	97	5.1
40–41[a]	217	11.5
39–40	91	4.8
38–39	66	3.5
37–38	39	2.1
36–37	83	4.4
35–36	126	6.7
34–35	204	10.8
33–34	42	2.2
32–33	32	1.7
31–32	21	1.1
30–31	48	2.5
29–30	39	2.1
Total	*1,887*	*100.0*

[a] Squaw Creek Refuge.

tion there. At times, the population density of mallards is so great (200 per acre of water) that the carrying capacity of the refuge is sorely overtaxed. This tremendous density probably induces many ducks to move on down the flyway sooner than if densities were less. The differences in the latitudinal distribution of indirect recoveries between Chautauqua and Squaw Creek banding stations lend credence to this contention.

Both banding stations are between the 40° and 41° parallels. All of the indirect recoveries north of this latitude amounted to 46.6 percent for Squaw Creek (Table 17) and 45.6 percent for Chautauqua (Table 2), almost identical. Yet, south of the banding station the recoveries amounted to 41.9 percent for Squaw Creek mallards (Table 17) but only 34.0 percent for Chautauqua mallards (Table 2). The differences in band recovery rates south of the respective banding stations imply differences in the relative time the mallards of each banded group spent on their principal wintering grounds. Squaw Creek mallards spent 19 percent more time on the wintering grounds than did those banded at Lake Chautauqua. It appears that Squaw Creek mallards departed after a shorter stay than customary at migration stopovers at Delta, Manitoba, and northern and central Illinois.

Black Hills Bandings

(Personnel of South Dakota's Department of Game, Fish, and Parks banded 2,144 mallards in the northern Black Hills during the winters of 1950–1951 and 1951–1952 (Drewien 1968). One banding station was located on Coxy's Lake, 7 miles northwest of Spearfish, South Dakota, the other station was on Bear Butte Lake, 7 miles northeast of Sturgis. Warm springs have enabled from 6,000 to more than 30,000 mallards (average 16,500) to winter at this northern outpost, 1963–1968.)

The latitudinal distribution of indirect recoveries from mallards banded in the Black Hills (Table 18) has been adapted from data reported by Drewien (1968). Quite different from other banding stations was the fact that 46.4 percent of the indirect recoveries from bandings in the Black Hills occurred at the same latitude as the banding station and only 22.0 percent occurred south of the banding station. The recovery rate south of the Black Hills banding station was considerably lower than the 41.9 percent south of the Squaw Creek station and the 34.0 percent south of the Lake Chautauqua station. Moreover, at the latitude of the banding station the longitudinal distribution of recoveries was confined, with only a few exceptions, to

Table 18. — The number and percent of indirect mallard recoveries by degrees of latitude from bandings during the winters of 1950–1951 and 1951–1952 in the northern Black Hills, Lawrence County, South Dakota.[a] Stations located at about 103.8° longitude.

Degree of Latitude	*Recoveries*	
	Number	Percent
55–56	1	0.3
54–55	5	1.6
53–54	9	2.8
52–53	13	4.1
51–52	9	2.8
50–51	20	6.3
49–50	16	5.0
48–49	11	3.4
47–48	3	0.9
46–47	10	3.1
45–46	4	1.3
44–45[b]	148	46.4
43–44	6	1.9
42–43	6	1.9
41–42	19	5.9
40–41	5	1.6
39–40	5	1.6
38–39	1	0.3
37–38	2	0.6
36–37	4	1.3
35–36	7	2.2
34–35	8	2.5
33–34	1	0.3
32–33	1	0.3
31–32	1	0.3
30–31	0	0.0
20–30	4	1.3
Total	*319*	*100.0*

[a] From "Recovery Analysis of Mallards Banded in the Black Hills During the Winters of 1950-51 and 1951-52," by Rod C. Drewien. Pittman-Robertson Project W-75-R-10. Report of South Dakota Department of Game, Fish and Parks.

[b] Black Hills banding station.

within the degree of longitude (103°–104°) containing the banding areas. Such distribution in the indirect recoveries points to the strong homing of mallards back to this particular wintering area. This wintering area is far north of the principal wintering grounds of the mallard. It is comparatively small, and isolated from other waterfowl habitat.

The isolated nature and northern location of this wintering area are believed responsible for the unusually large proportion of indirect recoveries in the vicinity of the banding station. Because of the limited waterfowl habitat in the Black Hills region of South Dakota, it is more essential for mallards to return to a specific locality than in regions where habitat is more widespread. Because of the northern location, latitudinal distribution is restricted to a greater degree than at other banding stations in this study. These mallards migrated over a much shorter distance to reach their winter quarters than customary for the species in the Mississippi migration corridor.

Obviously not all the mallards that wintered in the northern Black Hills during the years of banding (1950–1951 and 1951–1952) elected to winter there in subsequent years. Slightly less than one-third moved south of the Black Hills during subsequent hunting seasons. However, the single greatest concentration of recoveries occurred only a short distance south of the Black Hills along the North Platte River of western Nebraska.

Seasonal Turnover in Population

It is important to ascertain the seasonal turnover in migratory waterfowl populations as an aid in evaluating population status and determining food and space requirements of migrating populations. We analyzed direct band recoveries and repeats of banded mallards with this objective in view. Then we also analyzed the latitudinal distribution of indirect recoveries as a means of determining the time spent by mallards at a migratory area.

Direct Recoveries. — Fig. 17 shows the relationship of time following banding to direct recoveries by age and sex classes of mallards at latitudes from the Lake Chautauqua banding station south. The mean recovery of bands at the latitude of the banding station occurred from 14.9 days after banding for juvenile drakes to 17.3 days for adult drakes and 16.0 days for hens of all ages. The progression of band recoveries southward was almost linear between time

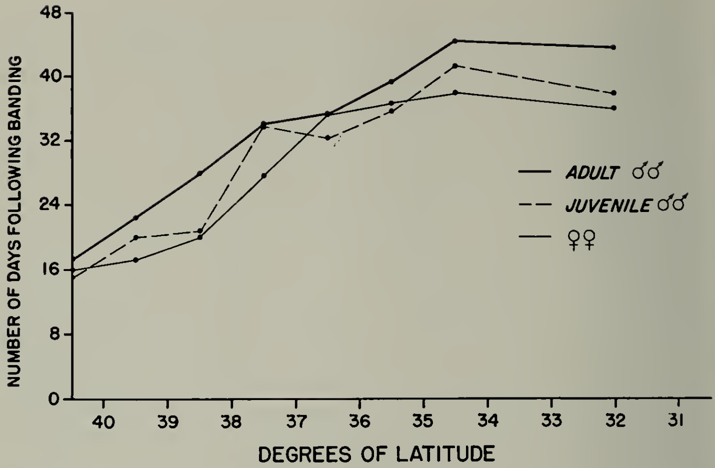

Fig. 17.—The mean southward passage of adult drake, juvenile drake, and hen mallards in relation to time as determined from direct band recoveries of ducks banded during the fall, 1939–1944, 1947–1952, at Lake Chautauqua.

and distance until the latitude of 34.5°. From that region (Stuttgart, Arkansas) southward, there was a plateau in time versus distance for all three classes of mallard band recoveries. We deduce that mallards migrating to the southern region of the wintering grounds did so by passing over the central region of the wintering grounds from a migration area between Lake Chautauqua and the wintering area.

The passage of mallards between the area of the banding station and the principal wintering grounds (Stuttgart, Arkansas, region of the Mississippi migration corridor) took varying amounts of time for the different age and sex classes. The elapsed time for adult drake band recoveries (Fig. 17) between the banding station mean and wintering grounds mean was 27 days. For juvenile drakes the elapsed time was 26 days, and for hens of all ages 22 days.

However, the percentage grouping of band recoveries based on the intensity of recovery by time versus distance (Fig. 18), shows that there is a great variation in the individual rate of passage southward—some mallards moved into northern Louisiana (33°–32°) within 6 days after bandings; other mallards were still in the vicinity of the banding station over 60 days after banding.

Fig. 18 gives the impression that rather than a methodical passage southward mallards migrate by considerable leapfrogging. That is, when a migratory movement occurs, certain elements of the mallard population fly to waterfowl habitat in the latitude immediately to the south, others continue to habitats 2 degrees southward, others continue to habitats 3 degrees southward, and so on until the southern limits of the wintering grounds are reached. Nevertheless, there is a tendency for the largest proportion of migrating mallards to drop out of southward flight at the shorter ranges while smaller proportions continue to the more extreme ranges. Thus, in Fig. 18, even with the evidence of a great spread in individual migratory

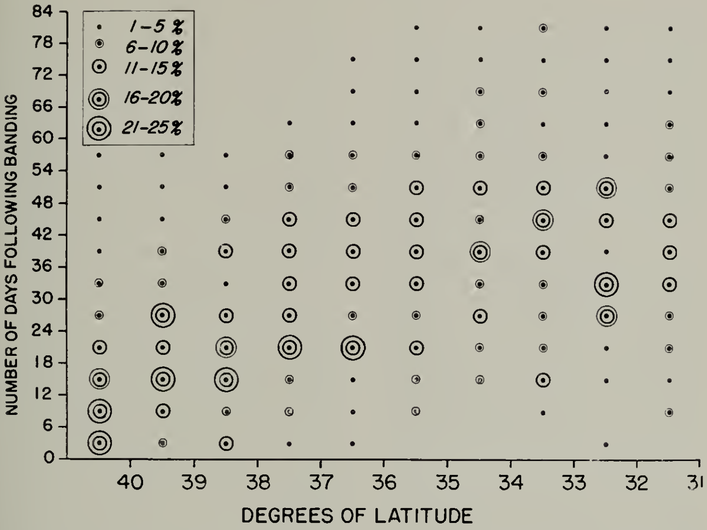

Fig. 18.—The percentage grouping of mallard recoveries, based on time versus distance, showing the variation in individual rate of passage southward. Mallards banded at Lake Chautauqua, 1939–1944, 1947–1952.

behavior, there is an evident relationship in recoveries between time and distance.

It also seems apparent that there is a seasonal relationship between time and distance traveled. Table 19 shows the mean miles per day traveled by age and sex classes of seasonally banded samples of mallards. Miles per day were derived from the distance of the banding station to location of the band recovery in relation to time.

The low rate of movement during the

Table 19.—Seasonal change in rate of passage of mallard age and sex groups from Lake Chautauqua, 1939–1944. Based on distance traveled in relation to number of days from banding for direct recoveries, and expressed in mean number of miles per day.

Week of Banding	*Adult Drakes*		*Juvenile Drakes*		*Hens*	
	Number	Miles per Day	Number	Miles per Day	Number	Miles per Day
Oct. 11–17	28	4.2	58	3.4	44	5.2
" 18–24	58	5.2	62	4.2	57	5.7
" 25–31	73	5.8	82	6.9	35	6.0
Nov. 1– 7	69	6.0	89	5.5	48	7.4
" 8–14	109	6.3	30	7.2	43	8.5
" 15–21	87	10.1	76	7.6	24	10.0
" 22–28	88	9.4	75	9.7	51	11.3
" 29–Dec. 5	34	12.0	30	14.5	26	14.2
Average		*7.4*		*7.4*		*8.5*

first 2 weeks (October 11–24) might have been partly determined by the opening of the Illinois hunting season, which occurred on either October 15 or 16 except in 1939 when it did not open until October 22. During this time period some of the banded mallards were not immediately exposed to hunting, and undoubtedly this slightly lowered the rate of daily movement. In a similar way, the rate of passage late in November was probably biased toward a higher rate by the Illinois closure of the hunting season, which occurred between December 5, 1939 and January 1, 1944. Hence, more distant mallards were likely to be shot than were mallards near the banding station.

The rate of movement of mallards as expressed for the weeks from October 25 through November 21 appears little affected by the opening or closing of the hunting season. Examining data for this period only, we find that adult drake mallards averaged 7.5 miles per day, juvenile drake mallards averaged 6.8 miles per day, and hens averaged 8.0 miles per day. Within this period, the rate of movement increased as the season progressed: adult drakes from 5.8 to 10.1 miles per day, juvenile drakes from 5.5 to 7.6 miles per day, and hens from 6.0 to 10.0 miles per day.

The departure of mallards from the immediate area of the banding station has been evaluated by two types of data: 1) a time-related shrinkage in band recoveries within the degree of latitude embracing the banding station, and 2) the interval of time between the initial banding and the last recapture of a mallard at the same banding station during the same season.

Fig. 19 shows the length of time mallards remained in the vicinity of the banding station at Lake Chautauqua, based on band recoveries of both shot and retrapped mallards. The lines of shrinkage in numbers of banded ducks within the trapping zone are curvilinear for both shot and retrapped recoveries. Because there is a curvilinear rather than a linear relationship to time, the medians show shorter time spans in the area of the banding station than do the means in Fig. 17. The median number of days, as determined for shot recoveries within the latitude of trapping, was 12.0 for adult drakes, 10.0 for

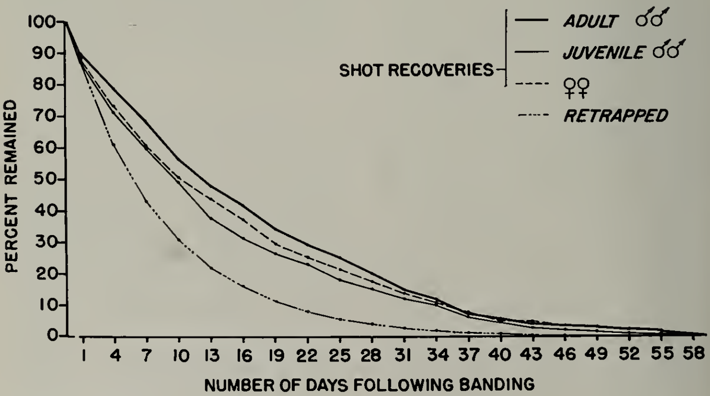

Fig. 19.—The length of time mallards remained in the vicinity of the banding station at Lake Chautauqua, based on shot recoveries from hunters and repeats of live ducks at banding traps.

hens, and 9.5 for juvenile drakes. The median number of days for the last retrapping of individual mallards of all ages and both sexes was only 6 days.

The skewing of the band recovery curves, as related to the passing of time, points to this axiom: the longer a mallard remains in the area of Lake Chautauqua, the greater the likelihood of it remaining longer. Both shot recoveries and retrap data indicate that the likelihood of departure was greatest soon after banding and decreased progressively with the passing of time.

Further analysis of banded mallards retrapped (the repeats) provides additional appraisals on the duration of time spent in the vicinity of the banding station. Tables 20 and 21 present data on the seasonal change in the mean days between banding and the last day the same individuals were recaptured. A time span of 3 weeks was provided beyond the banding dates shown in Tables 24 and 25 for ducks to be recaptured. There is evidence that early in the migration season mallards tend to remain slightly longer in the banding area than they do late in the season. This is in agreement with shot band recovery data (Table 19) which showed fewer miles per day of movement early in the migration season.

Mallard repeats at both Lake Chautauqua and Spring Lake remain in the vicinity of the banding station about 10–12 days (Tables 20 and 21). This is somewhat less than the mean span derived from shot recoveries, which was 17.3 days for adult drakes, 14.9 days for juvenile drakes, and 16.0 days for hens.

After a banded duck is released, two

Table 20. — Seasonal changes in the mean number of days mallards were last retrapped following their initial banding at Lake Chautauqua in the years 1940–1943.

Week of Banding	*1940* Number Retrapped	*1940* Mean Days	*1941* Number Retrapped	*1941* Mean Days	*1942* Number Retrapped	*1942* Mean Days	*1943* Number Retrapped	*1943* Mean Days	*Average Mean Days*
Oct. 4–10	...	...	...	...	39	13.4	...	...	13.4
" 11–27	193	9.0	...	...	82	11.3	37	12.5	10.9
" 18–24	55	9.6	...	...	264	8.3	271	13.0	10.3
" 25–31	50	14.2	...	...	162	7.7	164	10.1	10.7
Nov. 1– 7	64	13.5	39	11.8	168	7.8	138	10.6	10.9
" 8–14	40	13.9	73	11.1	...	...	270	9.0	10.3
" 15–21	58	5.4	43	9.0	...	...	...	...	7.2
Average		*10.9*		*10.6*		*9.7*		*11.0*	*10.5*

Table 21. — Seasonal changes in the mean number of days mallards were last retrapped following their initial banding at Spring Lake Refuge, Carroll County, Illinois in 1946 and 1947.

Week of Banding	*1946* Number Retrapped	*1946* Mean Days	*1947* Number Retrapped	*1947* Mean Days	*Average Mean Days*
Oct. 11–17	45	13.6	...	...	13.6
" 18–24	112	14.3	...	...	14.3
" 25–31	147	12.0	113	9.4	10.7
Nov. 1– 7	251	8.2	112	9.2	8.7
Average		*12.0*		*9.3*	*11.8*

counteracting forces affect its potential recapture; they are 1) desire to return for bait, and 2) fear of being recaptured. Apparently the fear of the trap is greater than the desire for bait because the interval of repeats is 6 days less than the interval of recoveries from shot ducks.

We can only speculate on the length of time a mallard was present in the area prior to its capture and banding. A clue lies in the difference in the span of time between recoveries of mallards shot in the vicinity of the banding station and those recaptured in the banding traps. If we assume that the banding traps are equally effective at capturing both newly arrived and previously banded mallards, then the difference in departure intervals between shot and retrapped recoveries can be employed. Band recoveries from shot mallards in the latitude of the banding station show a 6-day longer time span than do recoveries from retrapped birds. If we assume this ineffectiveness in capturing newly arrived birds, the potential sample of mallards is present on Lake Chautauqua an average of 6 days prior to initial banding. Thus with the 16 days the banded birds are present following banding there is an average span of 22 days between arrival of the birds and their departure from the area.

Analysis of indirect recoveries for population turnover, discussed below, indicates that the 6 days for the pretrap period is too low. It is probably closer to 12 days.

Indirect Recoveries.—Information on the length of time mallards remain at any single location during migration can also be derived from the relative proportion of indirect recoveries in any 1 degree of latitude. The latitudinal distribution of band recoveries reflects the time mallards spend at any specific latitude. Shooting pressure on mallards appears quite uniform geographically between southern Saskatchewan and Louisiana. This has been demonstrated by the remarkably similar band recovery rates of mallards near every banding station discussed in this paper. Therefore, within the scope of this study, the geographic distribution of recoveries broadly represents the length of time mallards spend during the hunting season in any defined geographic area.

Hunting seasons on mallards in the Mississippi Flyway of the United States during the years 1940–1960 have ranged from 92 to 107 days. The season in Canada has usually opened 10–15 days earlier than in the United States, almost always on September 15. Seasons in the United States have generally opened October 1–October 8 and closed January 8–January 15, depending upon the length of the season. Band recoveries from mallards shot in September amount to less than 5 percent of the total indirect recoveries from Illinois banding. Over the years about 95 percent of the mallard indirect recoveries have occurred over a 100-day period, October 1–January 8. Thus 1 percent in latitudinal distribution of band recoveries represents 0.95 day during the hunting season.

Equating the proportion of mallard indirect recoveries, within the latitudes of their respective banding stations, to the duration of stay in the hunting season provides data for several deductions. Lake Chautauqua mallards, 1940–1966, (Table 2) spent an average of 18.6 days (0.95 x 19.6) within the degree of latitude where banded in previous years. McGinnis Slough banded mallards (Table 7) spent an average of 15.9 days in the area of their station in years following banding. Spring Lake mallards (Table 10) spent 22.2 days within 1 degree of latitude above and below where banded in previous years. Calhoun Refuge mallards (Table 12) spent 22.7 days in subsequent years within 1 degree of latitude above and below their banding station. Union County banded mallards (Table 14) spent 16.5 days within 1 degree above and below the banding station in years following banding. Delta Marsh, Manitoba, banded mallards (Table 16) spent an average of 18.2 days in subsequent years within the same degree of latitude as their banding station.

As discussed earlier, direct band recoveries indicated that Lake Chautauqua mallards remained 22 days in the vicinity of the banding station. Indirect recovery data from the same station indicated that mallards remained 18.6 days.

However, it must be kept in mind that indirect recoveries from Lake Chautauqua were 1.5 times more numerous on the wintering grounds than were direct recoveries. This was interpreted as the result of overflights by certain groups of mallards which proceeded directly to the wintering grounds without stopping more than momentarily at one of their traditional marshes. If this is indeed the behavior that occurred, then those mallards that did halt their southward flight at their traditional marshes (as shown by direct recoveries) remained a longer period than the calculated 18.6 days (as determined from indirect recoveries). The 18.6 days represent the functional stay of the entire population at a traditional migration area, as measured by indirect recovery data. Since a certain proportion of the migrants bypassed the migration area, those that did stop (direct recovery data) more than momentarily at their traditional areas remained 1.5 times the number of days indicated by the performance of the entire population (indirect recovery data). Therefore, those mallards that did return to their traditional areas remained 1.5 x 18.6 days or 27.9 days.

We conclude that mallards in the Mississippi migration corridor remain about 28 days at each traditional migration area they use between their breeding and wintering grounds. The relative time mallards from the several banding stations in the Mississippi migration corridor remain on breeding grounds, migration areas, and wintering grounds between October 1 and January 8 is shown in Table 22. The delineation of these regions by latitude is somewhat arbitrary for there is an overlap between breeding and migration areas as well as between migration and wintering areas. However, the bulk of the mallards in the Mississippi migration corridor breed north of the 49° parallel and winter south of the 37° parallel.

Table 22.—Number of days mallards remained in three regions of the Mississippi migration corridor during the 100-day period, October 1–January 8, as determined from indirect recoveries in all years resulting from bandings at the various stations listed.[a]

Banding Station	*North of 49° (Breeding Grounds)*	*49°–37° (Migration Areas)*	*South of 37° (Wintering Grounds)*
Lake Chautauqua	13.4	64.5	22.1
McGinnis Slough	9.6	68.0	22.4
Spring Lake	9.5	65.6	24.9
Calhoun Refuge	10.5	61.2	28.3
Union County	15.6	56.1	28.3
Delta Marsh	29.7	41.0	29.3

[a] Based on latitudinal distribution of indirect band recoveries derived from Tables 2, 7, 10, 12, 14, and 16.

Each banded contingent displayed differences in the time spent in the three regions, but the time spent on the wintering grounds during this October 1–January 8 period was most uniform for all banding stations. During the 100-day period, mallards spent more time on migration areas than on breeding or wintering areas. Time on the breeding grounds varied from 9.5 to 29.7 days for the several groups, and was much the longest for Delta Marsh, Manitoba, mallards because they were transients, utilizing a marsh on the breeding grounds as a traditional migration stop.

If we accept 28 days as the period Lake Chautauqua banded mallards remained in the banding vicinity, then the 64.5 days spent on migration areas (Table 22) suggest that these birds had two or three important feeding and resting areas between their breeding and wintering grounds. This would also apply to almost all of the other banded groups except for those at Delta Marsh. Because of the longer time the Delta

Marsh mallards remained in the breeding grounds region, they had time for only one or two major migration stops between the Delta Marsh and their wintering grounds.

Seasonal Chronology

The seasonal chronology in the number of indirect band recoveries illustrates the general chronology of waterfowl migration. A comparison in Illinois of the seasonal distribution of indirect band recoveries with population estimates of mallards pointed up three differences: 1) seasonal peaks in mallard populations were higher than those shown by band recoveries, probably because bag limits asserted a greater restriction on the kill when mallards were most abundant, 2) populations of mallards were also comparatively larger after the freeze-up, usually about December 1, than indicated by band recoveries because when mallards were restricted by ice to open holes on a few large lakes the opportunity for hunting was greatly reduced, 3) some mallard migration, although usually minor, occurred prior to the opening of the hunting season. Most states in the Mississippi Flyway adjust their hunting seasons to encompass the mallard flight to the extent they can do so within the length and framework of the season set by federal regulations.

In spite of the several ways in which the seasonal distribution in band recoveries failed to conform to mallard populations in Illinois, there was sufficient agreement to indicate that broad interpretations of seasonal movements could be deduced from band recoveries. Fig. 20 illustrates the seasonal distribution of band recoveries from four geographic zones of North America.

The northern zone included North and South Dakota, Minnesota, and Wisconsin. The central zone included Iowa, Illinois, Indiana, and Missouri. The southern zone embraced all states in the Mississippi migration corridor south of the central zone. The years 1940–1946 were selected from the 1940–1952 period because of the large number of recoveries and relatively long hunting seasons in those years.

The seasonal progression of mallards southward in the Mississippi migration corridor is most apparent even though

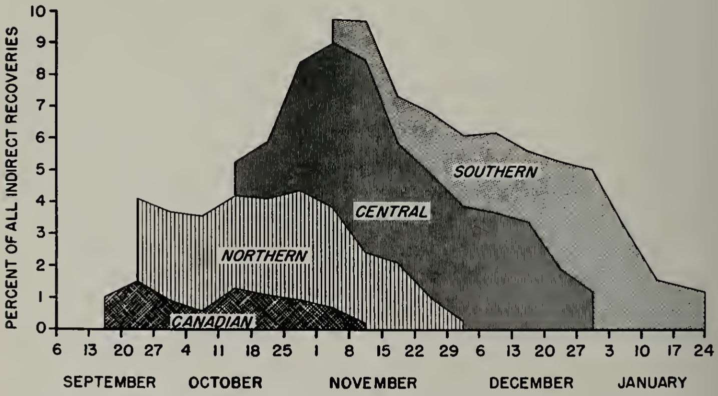

Fig. 20. — The seasonal distribution of indirect mallard band recoveries in four geographic zones of North America. Based on bandings at Lake Chautauqua, 1939–1944, and indirect recoveries, 1940–1946.

limited movements occurred during nonhunting periods. The passage of mallards into the northern zone is somewhat obscured by breeding birds already present in that zone together with an early passage into it from the Canadian zone prior to the hunting season.

Band recoveries suggest that mallard populations reached their greatest abundance in the various zones as follows: Canadian, September 20–26; northern, October 25–31; central, November 8–15; southern, December 27–January 3. The greatest time lag between periods of greatest abundance was between the central and southern zones, indicating

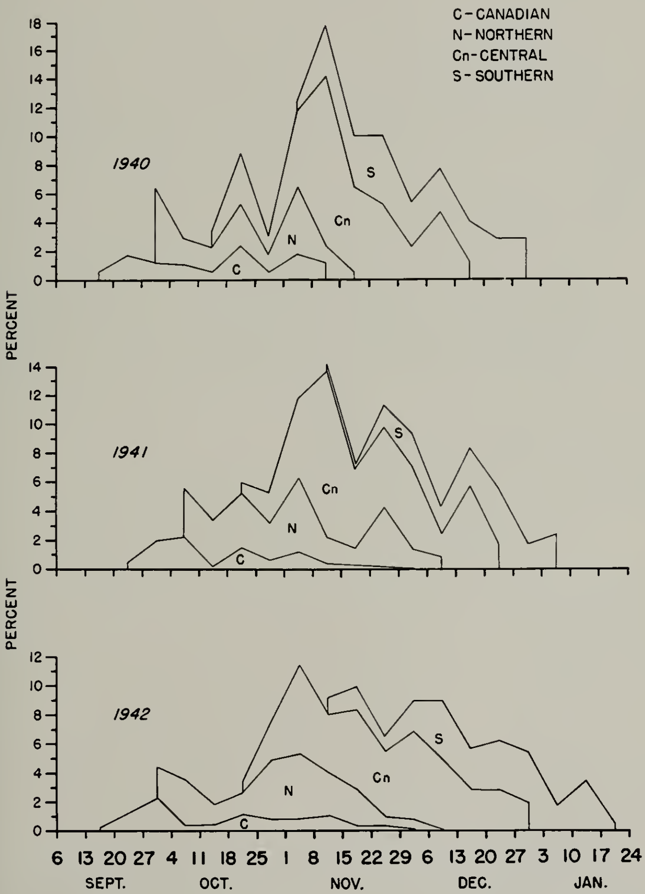

Fig. 21.—Yearly variation, 1940–1942, in the seasonal distribution of indirect mallard recoveries in four regions of North America.

that there was an early wave of migrants into the central zone which delayed departure to the southern zone.

The median period of band recoveries for the several zones was as follows: Canadian, October 11–17; northern,

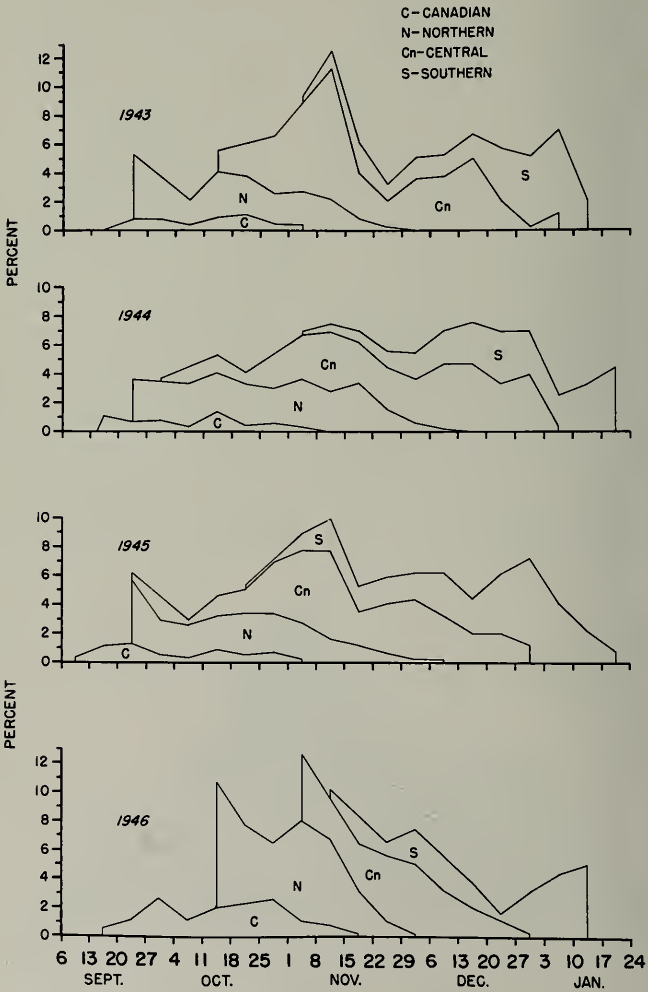

Fig. 22.—Yearly variation, 1943–1946, in the seasonal distribution of indirect mallard recoveries in four zones of North America.

October 18–24; central, November 15–21; and southern, December 13–19. Available evidence indicates that a 3½-month span occurred between the earliest passage from the Canadian zone to the last passage into the southern zone. The bulk of the southward passage occurred over a 2-month period, October 15–December 15.

In the period studied, 1940–1946, there is much variation among years in the chronology of recoveries from mallards (Fig. 21 and 22). Much of the variation in band recoveries reflects changes in the chronology of migration. Apparently the southward passage of mallards is greatly influenced by weather conditions, otherwise it would not be so variable from year to year.

Waves of migrants were most apparent in the central zone. Usually four waves were evident in that zone, three in the southern zone, and two to four in the northern zone. The primary waves of mallard migrants in the northern zone tended to center around the last week in September, with secondary waves usually centering around the second and the third weeks in October.

Largest waves of mallards tended to arrive in the central zone the first 2 weeks in November. The next largest waves, in order, tended to appear during the last 2 weeks in November and the first 2 weeks in December. Waves of migrating mallards varied so much in magnitude and time in the southern zone that it was not possible to classify their chronology. The largest waves of migrants arrived between December 2 and January 13. Waves of secondary magnitude occurred as early as November 4 and as late as December 30, and tertiary waves occurred between November 11 and January 6.

BLACK DUCK

(Illinois is on the western fringe of the black duck's range. Waterfowl censuses show a pronounced change in the abundance of black ducks between waterfowl habitats in the eastern and western regions of the state. For example, at McGinnis Slough in the Forest Preserve District of Cook County, 30 miles southwest of Chicago, black ducks were outnumbered by mallards by a ratio of 5:1. However, at Lake Chautauqua in central Illinois mallards usually outnumbered black ducks by a ratio of 50:1. Band recoveries indicate that most of the black ducks which migrate into Illinois originate from breeding grounds in the Laurentian Shield region of western Ontario. Human populations are sparse there, and as a result band recoveries are few in number and scattered. Hence, band recovery data from this region of Canada were too few to analyze for mean and standard deviation of recoveries by longitude and latitude.)

Lake Chautauqua Bandings

Between 1939 and 1952, 3,408 black ducks were banded at the Lake Chautauqua National Wildlife Refuge, Mason County, Illinois. The black ducks were trapped along with mallards in large, baited traps as previously described. Indirect recoveries have been analyzed within the United States by longitude and latitude with a view of determining the degree of homing back to the region of the banding station.

Longitudinal Distribution.—Recoveries from black ducks in the years following their banding at Lake Chautauqua have been analyzed for longitudinal mean and its standard deviation by degrees of latitude south of Canada (Fig. 23).

The axial and standard deviation lines, which denote the longitudinal distribution of the majority of the indirect band recoveries, indicate that most Lake Chautauqua black ducks moved into northwestern Minnesota from western Ontario and eastern Manitoba (Fig. 23). They passed east-southeast to the upper peninsula of Michigan and northern Wisconsin. The bulk of this population

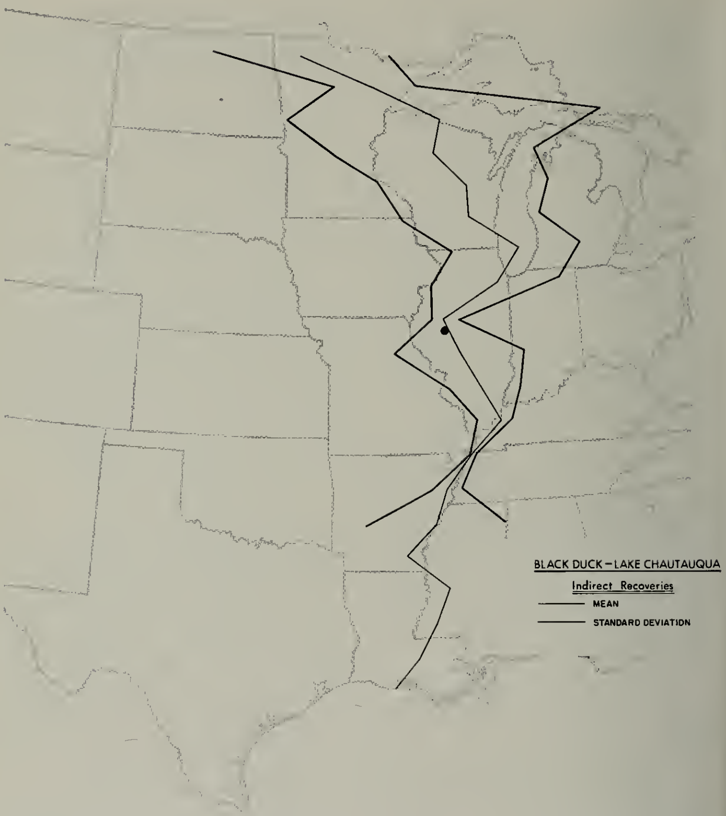

Fig. 23. — The longitudinal distribution of black duck indirect recoveries on the basis of mean and standard deviation lines. Black ducks banded at Lake Chautauqua, 1939–1944, 1947–1952.

of black ducks migrated south-southeast from north-central Wisconsin to northeastern Illinois. From that point, the center of the distribution approximated the course of the Illinois River valley to Lake Chautauqua.

Apparently on departing Lake Chautauqua most black ducks headed south-southeast for the area embracing the mouth of the Wabash River. South of this point, the axial line of recoveries was similar to the course of the Mississippi River. From Lake Chautauqua south, the distribution of black duck recoveries (Fig. 23) was very similar to that of mallards banded at the same place (Fig. 7). North of Lake Chautauqua, the indirect recoveries from black ducks were 200 or more miles east of those derived from mallards, reflecting the more eastward breeding range of the black duck.

The standard deviation lines denote a wide distribution of band recoveries in northern United States. It is assumed that this broad distribution of recoveries indicates that the Lake Chautauqua black ducks originated over an extensive breeding range. As the black ducks migrated south, toward Lake Chautauqua, the standard deviation lines converged in the area of the banding station to a breadth of only 44 miles. The spread in standard deviation for mallards at the same place was about 58 miles (Table 1).

South of southern Illinois to about Memphis, Tennessee, the standard deviation lines show very little spread in band recoveries. Beyond this point recoveries were widespread, and south of northern Mississippi they were so few in number as to be insignificant.

Latitudinal Distribution. — The latitudinal distribution of recoveries between the Canadian border and the Gulf of Mexico from black ducks banded at Lake Chautauqua is shown in Table 23.

Table 23. — The latitudinal distribution of indirect black duck recoveries, 1940–1952, from autumn bandings at Lake Chautauqua, Mason County, Illinois.

Degree of Latitude	*Number of Recoveries*	*Percent of Recoveries*
48–49	6	1.7
47–48	6	1.7
46–47	9	2.6
45–46	23	6.5
44–45	28	7.9
43–44	24	6.8
42–43	7	2.0
41–42	35	9.9
40–41[a]	128	36.3
39–40	16	4.5
38–39	4	1.1
37–38	19	5.4
36–37	12	3.4
35–36	9	2.6
34–35	17	4.8
33–34	1	0.3
32–33	1	0.3
31–32	3	0.8
30–31	4	1.1
29–30	1	0.3
Total	*353*	*100.0*

[a] Lake Chautauqua.

With 36.3 percent of the indirect recoveries at the latitude of the banding station, a very strong homing is indicated. It is also indicated that these black ducks spent about one-third of the hunting season within the United States in the vicinity of the Chautauqua refuge.

Apparently this population element of black ducks wintered farther north than did the population element of mallards banded at the same place. All indirect recoveries south of the latitude embracing the Chautauqua banding station amounted to 24.6 percent for black ducks, but 34.0 percent (Table 2) for mallards. In both mallards and black ducks, recoveries dropped off below the 34° parallel (south of the mouth of the Arkansas River).

A comparison of the latitudinal distribution of direct and indirect band recoveries is presented (Table 24) for purposes of evaluating the homing of black ducks on migration corridors. For the Lake Chautauqua bandings there was a higher percentage (60.3) of direct recoveries than indirect recoveries (51.2) at the latitude of the banding station.

Table 24. — A comparison of the latitudinal distribution of black duck direct and indirect recoveries, from ducks banded at Lake Chautauqua, 1939–1944 and 1947–1952, for 1 degree north of the banding station to the Gulf of Mexico.

Degree of Latitude	*Percent of Recoveries* Direct	Indirect
41–42	5.0	14.0
40–41[a]	60.3	51.2
39–40	9.5	6.4
38–39	5.6	1.6
37–38	2.2	7.6
36–37	6.1	4.8
35–36	6.7	3.6
34–35	2.8	6.8
33–34	0.6	0.4
32–33	0.6	0.4
31–32	0.0	1.2
30–31	0.0	1.6
29–30	0.6	0.4
Total	*100.0*	*100.0*

[a] Lake Chautauqua.

Direct recoveries were 1.18 times more frequent than indirect recoveries suggesting that only 15 percent of the black ducks failed to return to their "home" latitude. The black ducks that missed their home latitude either spent their allotted migration time in the latitude immediately north of the banding station or farther south, especially between the 34° and 38° parallels.

McGinnis Slough Bandings

(Black ducks are relatively more abundant at McGinnis Slough as a result of its more easterly location, than at Lake Chautauqua. Consequently, 4,887 black ducks were banded there during the fall seasons, 1940–1947, and this number included a large part of the total population. In the fall of 1947 the peak population of black ducks at McGinnis Slough was 1,020. Population estimates were not made in earlier years, but from cursory observation the numbers were believed to have been between 800 and 1,500 at the height of migration.)

Longitudinal Distribution.—Based on 509 indirect band recoveries, the axial line, derived from joining the longitudinal mean for each degree of latitude, does not vary much from straight north and south (Fig. 24). The axial line bisects Lake Superior, jogs to the west, and then resumes a southward direction along the west shore of Lake Michigan. Waterfowl habitat and intensive hunting along the Illinois River pulled the axial line westward from the lower end of Lake Michigan. Then suitable habitat and hunting for black ducks along the Wabash River pulled the axial line back eastward.

South of Illinois, the axial line of recoveries paralleled the Mississippi River, but was from 50 to 75 miles east of it, and a similar distance east of the axial line formed by recoveries of Lake Chautauqua black ducks.

The lines formed by standard deviation of the mean extended over a breadth of 750 miles at the Canadian border. From there south to the site of the banding station, the standard deviation lines converged to a breadth of about 100 miles. The intensive hunting along the upper Illinois River further restricted the latitudinal spread. However, south of central Illinois the longitudinal lines widened again to distances varying from 100 to 350 miles.

The longitudinal distribution of 390 direct recoveries of black ducks banded at McGinnis Slough was similar to that for indirect recoveries (Fig. 24). North of southern Illinois, the distribution of direct and indirect recoveries was almost identical. South of Illinois, standard deviation showed a wider spread in longitudinal distribution for direct than for indirect recoveries. Moreover, the axial line of the direct recoveries in this region averaged about 50 miles nearer to the Mississippi River than that of indirect recoveries.

Latitudinal Distribution. — The latitudinal distribution of indirect recoveries from black ducks (Table 25) showed that almost half of the recoveries occurred at the latitude where the ducks had been banded. However, this was only slightly higher than for wintering mallards returning to the latitude of their banding station north of the Black Hills, South Dakota (Table 18).

It is suggestive that McGinnis Slough banded black ducks returned to spend about half of the open hunting season (within the United States) in the vicinity of their former migratory home. They remained there later during the winter than did mallards, for indirect recoveries of black ducks south of McGinnis Slough amounted to 24.6 percent (Table 25) as compared with 37.9 percent for mallards (Table 7).

A comparison of direct and indirect recoveries for similar latitudes (Table 26) indicates that only 18 percent of the indigenous black ducks failed to return to the latitude of McGinnis Slough. If all had returned, the percentage of direct

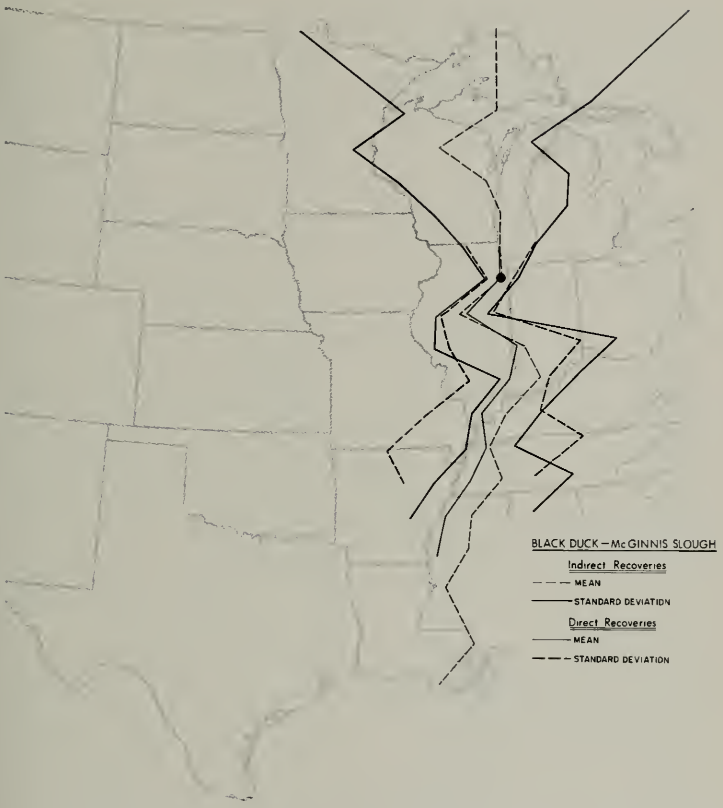

Fig. 24. — The longitudinal distribution of black duck indirect recoveries as compared to direct recoveries on the basis of mean and standard deviation lines. Black ducks banded at McGinnis Slough, Cook County, Illinois, 1940–1947.

and indirect recoveries for the latitude of the banding station (41°–42°) would be the same, inasmuch as local direct recoveries represent the time remaining during the hunting season which the ducks spent in the vicinity of the banding station.

A small proportion of black ducks (as shown by the difference between direct and indirect recoveries) either stopped at the latitude immediately north of the banding station or continued south to other areas, principally between southern Illinois and northern Mississippi.

The direct recoveries show a northward reversal of movement from McGinnis Slough. Nearly all of the black ducks went no farther than 1 degree north (Table 26). Such northward movements may represent birds searching for new feeding grounds, or those that overshot favorite stopping areas and returned.

Table 25. — The latitudinal distribution of indirect black duck recoveries (1941–1952) from autumn bandings at McGinnis Slough, Cook County, Illinois.

Degree of Latitude	*Number of Recoveries*	*Percent of Recoveries*
48–49	3	0.6
47–48	1	0.2
46–47	18	3.5
45–46	22	4.3
44–45	29	5.7
43–44	23	4.5
42–43	34	6.7
41–42[a]	254	49.9
40–41	26	5.1
39–40	12	2.4
38–39	10	2.0
37–38	15	2.9
36–37	13	2.6
35–36	14	2.7
34–35	20	3.9
33–34	4	0.8
32–33	3	0.6
31–32	0	0.0
30–31	5	1.0
29–30	3	0.6
Total	*509*	*100.0*

[a] McGinnis Slough.

Table 26. — A comparison of the latitudinal distribution of black duck direct and indirect recoveries (1941–1952) from 1 degree north of the banding station at McGinnis Slough to the Gulf of Mexico.[a] Ducks banded 1940–1947.

Degree of Latitude	*Percent of Recoveries*	
	Direct	Indirect
42–43	4.5	8.2
41–42[b]	74.7	61.6
40–41	7.6	6.3
39–40	1.0	2.9
38–39	2.1	2.4
37–38	2.4	3.6
36–37	2.6	3.2
35–36	2.9	3.4
34–35	0.8	4.8
33–34	0.5	1.0
32–33	0.0	0.7
31–32	0.3	0.0
30–31	0.3	1.2
29–30	0.3	0.7
Total	*100.0*	*100.0*

[a] Based on 381 direct recoveries and 413 indirect recoveries.
[b] McGinnis Slough.

DISCUSSION

Indirect recovery of mallards banded in Illinois provides a reasonable albeit somewhat distorted presentation of the migration corridor used by these ducks between their breeding and wintering areas. Visual sightings of migrating mallards, radar observations, and weekly waterfowl censuses (1946–1968) disclose that across Iowa the principal course of the mallard population is to the southwest of that shown by band recoveries.

Observation of migration and the relative abundance of mallards on refuge areas along the Mississippi River show that the bulk of these ducks reach this river between Muscatine, Iowa, and Clarksville, Missouri. Band recoveries, on the other hand, show the center of the migration corridor to occur at the Mississippi River farther north, mostly between northern Illinois and southern Minnesota (Fig. 25).

Band recoveries are particularly biased in the region between the Minnesota and Mississippi rivers by the paucity of habitat along the axis of the migration corridor. Yet, there is an extensive mallard habitat in marshes along the Upper Mississippi Refuge which forms the east border of this migration corridor (Bellrose 1968:8). Apparently, the banded ducks migrating along the eastern edge of the corridor come in contact with the Mississippi River farther north (thereby affording more opportunities for shooting and for recovering bands) than do the bulk of the migrants. Thus the band recoveries do not delineate the course taken by most mallards using this particular migration corridor.

A similar situation prevailed for certain Illinois bandings in the eastern North Dakota-western Minnesota region. As previously discussed, the variation in habitat resulted in a migration artifact, a zigzag in the longitudinal distribution of band recoveries.

A third region in which waterfowl

habitat biased the longitudinal distribution of mallard band recoveries was in southern Illinois and Indiana. Because of the high kill of mallards made at Hovey Lake and other areas in southwestern Indiana, compared with that made in southern Illinois, band recoveries in the Hovey Lake area were far out of proportion to known waterfowl abundance in the two areas.

Intensive hunting in the extensive waterfowl habitat along the Mississippi

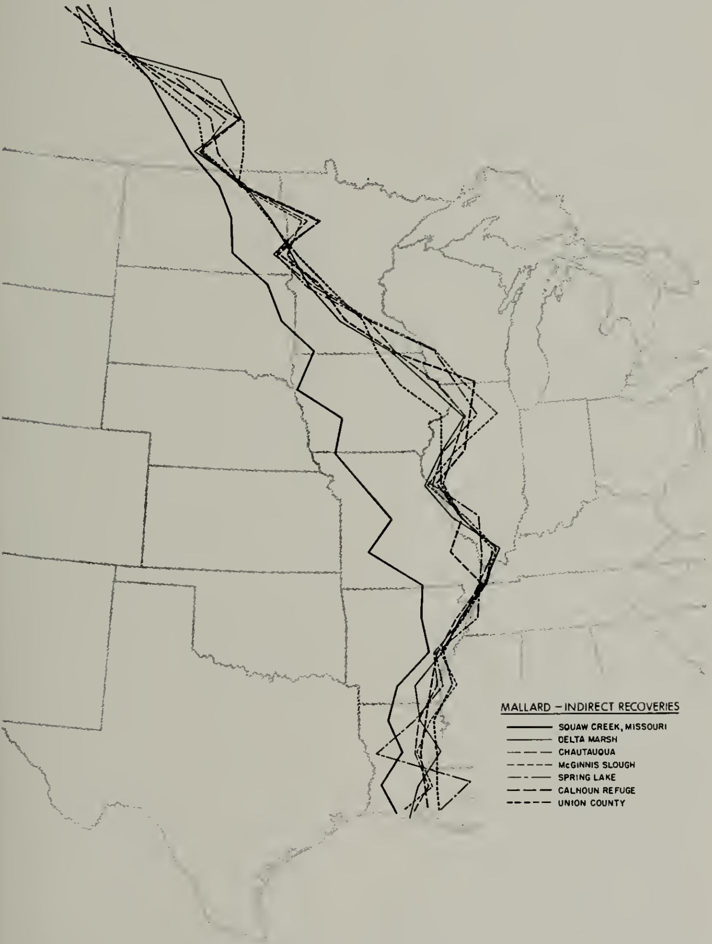

Fig. 25. — A comparison of the mean lines of indirect mallard recoveries from bandings at seven stations in the Mississippi Flyway.

River in Iowa, Illinois, and Missouri pulled the mean line of Squaw Creek indirect recoveries (Fig. 25) to the east of the Missouri River. Visual sightings of mallards in migration indicate that there is a larger passage along the Missouri River valley in western Iowa and Missouri, then eastward as far as the Mississippi migration corridor.

Outside of the above biases in band recoveries resulting from the restricted distribution of waterfowl habitat and hunters, band recoveries appear to adequately delineate the geographic distribution of mallard passage.

Biological Implications

Fig. 25 shows the uniform migration pattern exhibited by mallards banded at five stations in Illinois and at the Delta Marsh, Manitoba. The greatest difference in the mean band recovery lines occurred in the vicinity of each banding station. It is obvious that each banded group tended to break away from the main stream of migration within 100 miles of its respective home lake and take the most expedient direction to its home area. When the group departed from its home lake, the course of flight once again merged with the main stream of migration within 100 miles.

The main stream of mallards migrating to the Midwest arises in central Saskatchewan and assumes a southeasterly course primarily to the Mississippi River, secondarily to the Illinois River, and also to other waterfowl habitats. The main stream, which we have also called the Mississippi migration corridor, turns southward at the Mississippi River, the Illinois River, or some other important water area in the Midwest to reach wintering grounds largely in eastern Arkansas, western Tennessee, western Mississippi, and northern Louisiana.

Mallard bandings at Squaw Creek point to a passage of secondary magnitude from central Saskatchewan. This migration corridor arises from the same general breeding grounds as does the Mississippi migration corridor. However, it proceeds south-southeasterly rather than southeasterly to the Midwest. Because it is associated with the Missouri River, where its separation is greatest, we have termed this the Missouri River corridor (Bellrose 1968:6).

Because bait was used to attract ducks to the banding traps, some biologists have suspected that in subsequent years this attraction might have influenced the return of banded birds to the trap areas. A comparison of the distribution of indirect recoveries for both mallards and black ducks shows no discernible difference in returns to the banding area between those years in which bait was available and years in which it was unavailable. Bait was available in those years for which there were direct band recoveries for Lake Chautauqua, McGinnis Slough, and Spring Lake, Illinois bandings. Bait was unavailable in years in which there were no records of direct recoveries, for then no bandings were made at those stations. Thus, the high rate of indirect band recoveries in the vicinity of the banding station does not occur as a result of the ducks being attracted by bait.

There is increasing documentation on the homing of many species of waterfowl to particular breeding and wintering areas. In ducks, this return to opposite ends of their migration corridors applies especially to individuals having made one round trip. Although there is evidence of yearling ducks returning to their natal areas, the proportion is less than for older birds.

At the Delta Marsh, Manitoba breeding grounds, Sowls (1955:33) retrapped in subsequent years the following percentages of adult hens on their nests: pintail *(Anas acuta)* 39; gadwall *(Anas strepera)* 37; shoveler *(Spatula clypeata)* 42; blue-winged teal *(Anas discors)* 14; and mallard 13. Considering that the annual mortality rate of these species is close to 40 percent, and that the nests of some individuals were overlooked, Sowls concluded that practically all the pintail, gadwall, and shoveler hens alive returned to nest in the same area. Apparently some pioneering to new areas, possibly within a few miles, occurred among mallard and blue-winged teal hens.

Adult wood duck *(Aix sponsa)* hens in Illinois also return to their initial nesting area (Bellrose et al. 1964:671). Almost half of the hens captured on nests one year were captured in the same area the following year. An annual mortality rate of almost 50 percent points up the fact that practically every adult hen wood duck alive homed back to the same nesting area in Illinois.

At least 6.5 percent of the juvenile banded wood ducks returned to nest in the same area where they were reared (Bellrose et al. 1964:672). Banding data suggest that a high mortality occurs among immatures, which may amount to 80 percent the first year. Also many of the returning yearlings would not nest in houses, the principal source of captured birds. Hence, it is most likely that the proportion of returning yearling wood ducks was much greater than that shown by the 6.5 percent return rate.

Of 185 captive-reared juvenile hens among 5 species of ducks released during the summer at Delta Marsh, Sowls (1955:36) reported that 18 (9.7 percent) returned as yearlings. However, pen-reared juvenile ducks are known to suffer exceptionally high mortality in the wild; consequently, probably fewer than 40 of the 185 ducks had survived. As among adults, the mallard and blue-winged teal yearlings showed a lower return to the home area than did pintails, gadwalls, and shovelers.

The precise homing of buffleheads *(Bucephala albeola)* has been described by Erskine (1961:393). Of 20 hens banded on their nests in the central plateau region of British Columbia, 18 were captured in subsequent years on nests at the same lake and 2 on nests at nearby lakes. Two hens were caught in 3 consecutive years on the same nest. Four other hens were banded as young, 3 of which nested in later years at the same lake and 1 on another lake less than 1 mile away.

Mendall (1958:117) believed that in the northeastern United States homing to breeding areas occurred consistently in black ducks, ring-necked ducks *(Aythya collaris)* and wood ducks. He reported that a number of black ducks, banded as juveniles or brood females, were found during subsequent nesting seasons in the same region where they were originally captured. Circumstantial evidence of homing was the finding of several black duck nests at identical sites in succeeding years. Eight ring-necked ducks, 5 juveniles and 3 adult hens returned to nest in the same marsh where they were initially banded.

Lensink (1964) analyzed many thousands of band recoveries from ducks banded as flightless young on their rearing grounds. Band data from a region of about 48,000 square miles in southwestern Saskatchewan provided information from which Lensink (1964:19) concluded:

> ". . . (1) direct and indirect recoveries of both sexes cover essentially identical geographical areas, (2) except for the high incidence of direct recoveries near the banding station, the direct and indirect recoveries from bandings in Saskatchewan have similar distribution patterns, and (3) a highly developed homing tendency is indicated by indirect recoveries that are no more scattered from the area of banding than the direct recoveries of birds banded as locals. The tendency to return to the general region of origin is apparent among males as well as females and does not appear to have been changed by habitat deterioration during drought years."

Lensink's findings were for an extensive region of the breeding grounds, which is not comparable to homing to a specific area, such as a large marsh or a group of potholes. Nevertheless, Lensink's findings show a pronounced return of both yearling drake and hen mallards to the general area of their origin.

Waterfowl are also known to return to specific wintering areas. This is especially evident in Canada geese (Hanson & Smith 1950; Vaught & Kirsch 1966). Ducks home to their wintering grounds too, but it is not as well known. Based on the banding of 17,395 mallards at five stations in British Columbia, Munro (1943:229) reported that they ". . . return to the same wintering grounds on the Coastal Plain [British Columbia] and trap recoveries show that some return to the precise locality."

Lauckhart et al. (1961) tabulated direct and indirect recoveries of mallards banded in the Pacific Northwest. They analyzed indirect recoveries from bandings in eight regions of Washington, Oregon, Idaho, and the northern half of California. For all these banding regions, the largest number of indirect recoveries were from ducks that had returned to the respective locality of each banding station. Mallard populations were transitory in only two (eastern Idaho and northeastern California) of the eight regions where bandings occurred. The other six regions are known to be terminal wintering areas. In these six regions (eastern and western Washington, eastern and western Oregon, southwestern Idaho, central California) fewer than 5 percent of the indirect recoveries occurred south of the respective banding areas. Thus, there is ample evidence of a strong homing by mallards to specific wintering areas in the Pacific Northwest.

Mallard bandings made during the winter in the northern Black Hills of South Dakota (Drewien 1968 and Table 18) show that 22 percent of all recoveries in subsequent years were south of that wintering area. Although the data show an important return to the same wintering area, they also point up that numbers of mallards did migrate farther south in subsequent winters.

Bandings of mallards made at several stations in Illinois also show a north-south variation in wintering locations. The main wintering grounds for these ducks occurs between 34° and 37°. Indirect recoveries in that region from Chautauqua banded mallards varied from 10.5 percent in 1941 to 28.2 percent in 1950. However, in half of the years from 1940 through 1966 the variation between years was no greater than 5 percent.

At the Union County Refuge in southern Illinois, wintering mallards were banded even though the station lies just north of the principal wintering grounds, between the 34° and 37° parallels. In the years following banding at Union County, the proportion of mallard bands from the principal wintering grounds varied from a high of 44.1 percent in 1955 to only 6.8 percent in 1963. In 1963, 9.8 percent of the recoveries, an unusually high number, came from latitudes south of the 34° parallel.

Such variation in the apparent yearly abundance of Illinois banded mallards on their principal wintering grounds points to a flexible homing to specific localities. There is a strong tendency to home, but the north-south distribution is influenced by weather and food conditions. This also applies to the population of mallards wintering in the Black Hills, but, obviously, mallards in the Pacific Northwest behave differently.

Mallards in the Pacific Northwest exhibit a much greater degree of homing to specific wintering grounds than do mallards of the Mississippi migration corridor. Because of maritime influences, winter weather in the Pacific Northwest is more moderate and stable than the unstable Great Plains weather which affects most of the Mississippi migration corridor. Therefore, mallards in the Mississippi migration corridor are definitely more mobile on their wintering grounds than those of the Pacific Northwest. They need to have a flexible homing behavior to meet changing weather and habitat conditions.

On wintering grounds in the Mississippi migration corridor, ice may cover water areas some years and not others; snow may or may not cover grain fields; mast may be abundant or wanting in river swamps; river swamps may be dry in some years and flooded in others. All these conditions affect the availability of the mallard's winter food supply. To meet these conditions on their wintering grounds in the Mississippi migration corridor, mallards often leave one wintering area for other more provident areas. Nevertheless, banding data reviewed here imply that mallards have traditional wintering areas in the Mississippi migration corridor albeit flexible in extent. Banding data presented by Munro (1943:239) and Lauckhart et al. (1961:13–24) indicate that mallards in the Pacific Northwest have more rigid traditional wintering areas.

Black duck bandings analyzed by Addy (1953) show a consistent homing to specific wintering areas along the Atlantic Coast. Coastal banding stations which showed a large proportion of indirect recoveries in their vicinities and only a very small proportion to the south were stations near Newburyport and Cape Cod, Massachusetts; Long Island, New York; Chincoteague and Back Bay, Virginia; and New Holland, North Carolina.

Examples of the degree of homing to Massachusetts and Long Island stations suffice to illustrate this point. For black ducks banded during the winter at Newburyport recoveries in subsequent years amounted to 60 percent of all recoveries within a 50-mile radius of the station (Addy 1953:11). Only 3 percent of all recoveries were from areas south of New England. Bandings of black ducks during the fall at Cape Cod resulted during subsequent falls in a 52-percent recovery within a 50-mile radius of the station. The proportion of recoveries south of Cape Cod was about the same for direct and indirect recoveries, which amounted to only 8 percent from Long Island and south.

Data for black ducks banded on Long Island, New York during the fall showed that 60 percent of all indirect recoveries occurred locally. Only 9 percent of all indirect recoveries were reported south of Long Island.

Black ducks banded in the interior have been largely from the northern part of their fall and spring ranges. Without the modification of weather brought about by maritime influence, snow and ice make most of the northern interior areas untenable for large populations of wintering black ducks. Small numbers may winter, but band recoveries indicate that the bulk of the ducks migrate to more southerly areas.

This situation is exemplified by recoveries from black ducks banded at stations on Lake Chautauqua and McGinnis Slough in Illinois. Indirect recoveries south of these banding areas amounted to an identical 24.6 percent of all recoveries (Tables 23 and 25) for each station. This is a much larger southward recovery than Addy's (1953) findings for Atlantic Coast stations at about the same latitude (Cape Cod and Long Island).

When food is available we find several thousand black ducks wintering at the confluence of the Des Plaines and Kankakee rivers, only about 25 miles southwest of McGinnis Slough. However, when a deep or crusted snow makes waste corn unavailable, most or all of these ducks depart for more favorable areas to the south.

Therefore, we conclude that where weather conditions are sufficiently uniform from year to year as to make wintering food supplies consistently available, black ducks as well as mallards home to the same wintering areas. Where weather conditions during winter vary greatly in their severity, both the black duck and the mallard exhibit varying degrees of site attachment. Where conditions demand a flexible winter site attachment for survival, both mallards and black ducks have evolved such a behavior response.

A similar flexibility in homing may also apply to mallards on the breeding grounds, but adequate documentation of this is lacking. The only suggestion that mallards may sometimes seek new areas for breeding is Sowls' (1955) finding that both adult and yearling mallards showed a lower return to the Delta Marsh, Manitoba area than did several other species of ducks. Lensink's (1964) conclusion on the return of mallard ducklings to their natal region applies to a rather large region rather than a specific locality.

Less well known than the homing of ducks to breeding and wintering areas is their homing along migration routes. As discussed in this paper, mallards and black ducks return to specific localities in migrating from breeding to wintering areas. Even so, between 25 and 50 percent of the mallards and black ducks which stopped at a migration area one year fail to return to the same area the next year.

Most of the ducks that miss returning to the same area pass on to their wintering grounds. Others stop 50–100 miles short or pass 50–100 miles beyond their traditional migration area. Still others stop at marshes east or west of the one they visited the previous year.

Those ducks which fail to return to a traditional migration area but stop at other areas or continue in passage directly to their wintering grounds may do so for several reasons: 1) Individuals which have made a particular area a migration stop may be in a flock of ducks oriented to a different goal; they may be carried along by other, more dominant, members of the flight. 2) A reduction in the availability of food resources results either in continued southward passage or a pioneering in the area for new supplies. 3) Severe winds may cause migrating ducks to drift off course, or, in the case of head winds, retard migration so that birds land prematurely. 4) On dark nights, especially when low cloud decks prevail, waterfowl may pass over their goal without seeing the landscape cues necessary for pilotage.

Banding, radar surveillance, and visual sighting demonstrate that ducks may depart in migration from a particular area in several different directions. Upon departure we often see a shift in individuals and segments of flocks from one flight line to another. On occasion we have observed flocks and segments of flocks undecided as to which directional flight they should affiliate with; indecisively they have swung from one direction to another. Such behavior leads us to believe that at times individuals and even entire flocks are influenced in choice of direction by the action of more dominant groups (Bellrose 1968:13).

Waterfowl censuses and observations made over a 30-year period in the Illinois River valley show that when a reduction in food resources occurs, many ducks leave and populations decline. Ducks arriving one night and failing to find adequate food have often been observed to leave the next night. The influence of food on duck populations is evident in the sharp decline of lesser scaup *(Aythya affinis)* numbers in the Illinois River valley, following the disappearance in 1954 of their principal food, fingernail clams *(Sphaeriidae)* (Mills et al. 1966:18).

Evidence cited earlier in this paper on the yearly course of mallard band recoveries across southern Minnesota and northern Iowa indicated a drift of migrants. This occurred on nights of major mass flights with strong quartering or beam winds. The region where the suspected drift occurred is one devoid of significant landscape features.

Direct band recoveries (Table 5) and visual observations confirm that there are reversed directional movements of mallards and other ducks. We see most of these reversed flights after a large flight has arrived during the previous night; northward flights the following evening are most prevalent when low, heavy clouds blanket the sky the night the ducks arrived.

We interpret these reversed flights of ducks as being made by those flocks which either bypassed or overshot their home lakes. Our observations suggest that at times migrating flocks arrive at the Illinois or Mississippi valleys south of their goal, and they correct for their displacement by turning northward. Other observations indicate that migrating ducks miss their goal under conditions of poor visibility at night. Probably the farther ducks land from their goal, the less their desire to return. Therefore, some of those missing a migration goal continue on to the next goal, which may be either a migration area or a terminal wintering area.

The detailed homing by mallards and black ducks to specific points on the breeding, migration, and wintering grounds leads us to deduce that landscape features are important factors in their navigational system. We have frequently seen migrating ducks change directions upon sight of prominent landscape features (Bellrose 1966:79–81).

Since mallards on the average remain about 28 days at traditional fall migration areas, they have ample time to become acquainted with local landmarks. Direct recoveries show a cruising radius of about 30 miles around each traditional area, enabling the inhabitants to become familiar with a sizable region before moving on to the next traditional area.

Traditional migration and wintering areas are established by juvenile ducks visiting them for the first time in company with adults who return to the areas they visited the year before. Available evidence (Martinson & Hawkins 1968: 684–686) indicates that flocks of mallards are not made up of family units, as is the case with geese. Recoveries of ducks banded as broodmates (op. cit.: 686) have been obtained from widespread areas, evidence that they did not travel together.

If adult and juvenile ducks do not migrate together as a family unit, how do juveniles align themselves with a group of adults which visit a particular series of traditional marshes? We have good reason to believe that most flocks of ducks are composed of both adults and juveniles. Our evidence is strongest for the mallard, a species we have banded and checked in hunters' bags for nearly 20 years. In checking hunters' bags for age composition, we rarely found all one age class. Only early in the fall, when mallard migration was just getting under way, have we found flocks which were entirely adult drakes. The composition of mallard age classes in the bags was quite similar week by week through the hunting season (Bellrose et al. 1961:441). Also both banded juvenile and adult mallards show similar chronologies in their southward passage (Hickey 1951:286).

From the evidence, we conclude that juveniles migrate with older ducks of the same species. We must conjecture on how a particular group of juveniles became associated with a particular group of adults. However, it is well known that adult and juvenile mallards, and, indeed, most other species, collect in large numbers on particular staging areas on the breeding grounds immediately prior to the fall migration.

On the staging areas are birds in all stages of physiological development. As shown by the protracted period of migration from the breeding grounds, some mallards reach a migratory state 2 months in advance of others. It seems reasonable to assume that juvenile and adult mallards in the same physiological condition would begin to associate together. Unknown to us are the behavioral displays that would indicate to the participating individuals the physiological state of other birds. Owen (1968: 623–625) describes some behavioral mechanisms that apparently served to bring blue-winged teal together in groups on staging areas and prepare them for departure in organized flocks.

Since hundreds and sometimes thousands of ducks would be at the same synchrony level of migratory preparedness, chance could well determine which juveniles associated with which adults. Therefore, juveniles from the same brood (associating partly by chance with adults from different migration corridors and wintering grounds) could well migrate in a dispersed manner from the same staging area. The chance association of juveniles with adults homing to diverse migration areas is probably the reason for certain bandings on the breeding grounds showing different geographic patterns between years.

For example, Gollop & Dzubin found a difference in recoveries between the Central and Mississippi Flyways among flightless young mallards banded near Kindersely, Saskatchewan, 1953–1955.[1] In 1953 they reported 2.3 times as many recoveries in the Central as the Mississippi Flyway, in 1954 it was only 1.1 times as many in the Central Flyway, and in 1955, it dropped further to only 0.8 times as many. This variation in the banded samples of young mallards between flyways may have resulted not only from chance association with adults bound for the two flyways, but also there may have been a seasonal difference in the physiological state of the young banded in relation to the adults present.

Because the birds in each group of adults, to which juveniles become attached, utilize their own traditional migration areas, the juveniles are indoctrinated to the same sequence of areas used by their "foster parents." Then those juveniles surviving to the next fall repeat the procedure, returning to the areas they first visited. Only this time, they, as adults, escort juveniles. In this fashion, certain migration and wintering areas become traditional to long-lived individuals. By such an intrinsic form of behavior, a semblance of orderliness is maintained in the pattern of waterfowl migration. Therefore, excessively large numbers of ducks usually do not migrate to habitats of poor quality, nor do good quality habitats usually go unused.

When mallards depart from a particular area in southward migration, they do not all seek the same marsh as their next goal. A large passage from just one staging area is made up of hundreds to thousands of flocks, most of which are bound for diverse localities. However, occasionally we have observed a number of migrating flocks all following an identical path and all bound for the same destination.

An assemblage of flocks obviously migrating along the same route, and with the same goal, is almost as much an entity as individuals comprising a single flock. Because the flocks are usually strung out in a line for miles, we refer to this assemblage of flocks as a "train" flock.

In a light aircraft we have on several occasions followed the track of a train flock. Once we observed flocks of arriving mallards landing at Rice Lake, near Banner, Illinois. Flying in reverse along their line of flight for 90 miles, we passed a flock every 30 seconds to 2 minutes. We found that these migrating flocks were leaving the Skunk River valley 20 miles west of Burlington, Iowa. Some of the flocks were out of sight of each other, yet they were following an identical track east-southeast across the farm lands of Illinois to Rice Lake in the Illinois River valley. Apparently this small population of mallards was migrating as a distinct entity. We believe that they originated from the same water area and followed the same "track" to the same destination. A future challenge is to discover how a train flock originates. How were flocks with the same goal able to assemble at the same place? Banding data presented

[1] From J. B. Gollop & A. Dzubin 1957 mimeographed report with limited distribution, "Waterfowl banding — Whither goest thou?" Report to members of the Mississippi Flyway Technical Committee (now the Technical Committee of the Mississippi Flyway Council).

here show the importance of the old ducks in determining the destinations of flocks from previous visits to a particular area. Therefore, we would conclude that the flocks in a train were brought together by adults with the same migratory pattern. But how did the adults with the same migratory pattern assemble in the same flock?

Such train flock passage usually involves relatively small numbers of mallards, 1,000 to 10,000. When we have observed flights of major proportions, many different goals were involved. One of many observations was reported in a recent paper (Bellrose 1966:80): "Mallards were observed flying parallel to the Illinois River. From time to time we observed flocks from the migrating stream 'peeling off' and landing in one of the many bottomland lakes they were passing. From our knowledge of 'home lakes' provided by band recoveries, I would interpret the peeling off of particular mallard flocks as an indication that they had reached their home lake."

From examining the indirect recoveries of mallards banded at the several locations herein reported, it is apparent that home lakes are dispersed all along the migration corridor. Whereas some flocks may migrate only 100 miles to reach their next home lake, other flocks migrate 200 miles or more, and a few even up to 1,000 miles.

It should be emphasized that among waterfowl migrants, as indeed among all bird migrants, there are three classes of visitants to any specific area—"fallouts," "dropouts," and "homeouts."

The fallouts are birds forced out of the air space by unusually severe weather, such as thunderstorms, snowstorms, sleet, adverse winds, and the like. They are often forced to seek temporary refuge in habitat quite foreign to their normal activities.

The dropouts are birds which have ended their migration after a day or a night flight at such habitats as those with desirable attributes for their resting and feeding. They remain only until the following night or until the weather is favorable for continued migration.

The homeouts are birds which return to a specific area throughout their lives to spend a considerable proportion of their migration period resting and feeding before continuing in migration. We probably have banded no fallout mallards, and only a small proportion of those which are dropouts. The mallards we have banded in Illinois have been largely from those composing the homeout segment of the population.

Management Implications

The analysis of band recoveries reported in this study lends evidence to our belief that ducks migrate along definable areas of geography, smaller than flyways, which we have referred to as "migration corridors" (Bellrose 1968). What sets one migration corridor apart from others is the breadth of passage of a homogeneous segment of a waterfowl population. A homogeneous segment of a population in migration may be defined as flocks of a particular species which exhibit similar geographic and habitat affinities.

Populations of ducks from any premigratory staging area migrate to a sequence of wetland areas within corridors from 150 to 250 miles wide, as shown by standard deviations of band recoveries. Only when mallards are departing or approaching a specific area frequented the year before does the breadth become smaller.

Most species of ducks exhibit a high degree of homing to specific areas on breeding, migration, and wintering grounds, as do Canada geese *(Branta canadensis)*. It would appear, therefore, that ducks should afford the same potential regional manipulation of harvest as do geese. However, there are basic differences in flock organization between ducks and geese which operate against such management.

As discussed earlier, Canada geese migrate as family units, whereas young from the same brood of ducks are likely to disperse among different flocks (Martinson & Hawkins 1968). From many staging areas flocks of ducks may migrate along several different migration corridors. Because of some dispersal of broodmates in migration, a particular breeding area may contribute to several migration corridors, and sometimes to more than one flyway. Moreover, ducks from a specific migration corridor fan out over an extensive part of the breeding range, as illustrated by the distribution of band recoveries in Canada (Fig. 8). On the other hand, it is well known that Canada geese from a particular migration corridor breed in close proximity to each other in well-defined geographic areas.

The geographic fidelity of distinct elements in breeding populations of Canada geese makes it possible to regulate their kill along specific migration corridors. Evidence at present suggests that the kill of ducks along one migration corridor would have some degree of influence, through the breeding population, on the population status of adjacent migration corridors. This stems from the potential dispersal of a brood to more than one migration corridor. Consequently, the available evidence indicates that the duck harvest cannot be regulated on a corridor basis as precisely as it is for Canada geese.

Certain critical information is needed before establishing hunting regulations on the basis of migration corridors rather than flyways. We need to know much more about the degree of dispersal in broodmates along different migration corridors. We need to know the motivation and selection that governs the formation of flocks on premigration staging areas. We need to know, for all important staging areas, the distribution of flocks along the various migration corridors. Until we have much more information on the relationship between various units of breeding populations of ducks and migration corridors, we urge caution in establishing hunting regulations for ducks by migration corridors.

Nevertheless, the fact that there is an affinity among ducks in migration for traditional wetlands provides a new dimension in considering both habitat and population management. Because of a degree of return to specific wetland areas, we see evidence of waterfowl refuges which are overpopulated and others which are underpopulated. We suggest that an example of mallards overpopulating a refuge occurred at the Squaw Creek National Wildlife Refuge up to 1963 and an example of underpopulating a refuge occurs at the Upper Mississippi Wildlife and Fish Refuge. In order to achieve maximum efficiency in a refuge system, it is essential to distribute refuge areas according to the intensity of use along each migration corridor. How well this has been done requires further appraisal, species by species and corridor by corridor.

A population segment indigenous to a particular migration corridor could conceivably be overharvested or underharvested. If consistently overharvested, it could result in migration habitat being occupied below its carrying capacity. This would arise from the fact that fewer adults from that particular corridor would be available to attract their share of juveniles from the gathering of young on premigration staging areas. We are presuming, of course, that chance divides the juvenile ducks on the staging area equally among the available "adult guides," and, moreover, that the staging area is frequented by adults from more than one migration corridor. Potentially, at least, the corridor represented by the largest number of adult guides on the staging area would logically receive the lion's share of available juveniles.

SUMMARY

1. Recoveries from the banding of mallards at five locations in Illinois, at the Delta Marsh, Manitoba, and at the Squaw Creek National Wildlife Refuge, Missouri, were analyzed. Recoveries from black ducks banded at two stations

in Illinois were also compared as to geographic distribution.

2. The geographic distribution of band recoveries was analyzed on the basis of longitude and latitude. Comparisons of the longitudinal distribution in recoveries were made by establishing the mean and its standard deviation for each degree of latitude. Standard deviation implies that two-thirds of the band recoveries for each degree of latitude occurred within the longitudinal deviates.

3. Indirect recoveries from mallards banded at the Delta Marsh, Manitoba, and the McGinnis Slough, Spring Lake, Lake Chautauqua, Calhoun Refuge, and Union County stations in Illinois all showed the same basic geographic pattern. The principal difference in the recovery patterns from these six stations occurred about 100 miles to the north and to the south of each station. In these zones, the recoveries indicated a departure of the mallards from the main stream of passage to return to the area frequented the previous year.

4. The axis of the indirect recoveries from Illinois and Delta Marsh mallard bandings extended southeastward from east-central Saskatchewan to north-central Illinois, and then almost straight south to south-central Louisiana.

5. Indirect recoveries from mallards banded at the Squaw Creek National Wildlife Refuge, Missouri, showed a similar origin to those groups banded at the Delta Marsh and in Illinois. All banded groups of mallards seemed to have commenced their fall migration from east-central Saskatchewan. However, near the United States border, the Squaw Creek banded mallards pursued a more south-southwesterly course than those banded at the Delta Marsh and in Illinois. The east-west separation of these two bandings was greatest at the latitude of the Squaw Creek Refuge. On their principal wintering grounds in east-central Arkansas, Squaw Creek mallards were centered only 25 miles west from those of the other banded groups.

6. There are only slight differences between the longitudinal distribution patterns of direct and indirect recoveries for those latitudes and banding stations where data permit comparison. The principal difference that did occur was in the more limited east-west spread in direct recoveries. The greater spread of the indirect recoveries indicates the proportion of mallards which in years following banding passed east or west of their former migration homes.

7. The homing of mallards back to the same degrees of latitude as where they were initially banded is shown by the large indirect recovery rates at the latitudes of the respective banding stations.

8. An index to the degree of homing to the latitude of the banding station can be obtained by comparing the proportion of direct recoveries with indirect recoveries for those latitudes where both occur. At four stations where such comparisons were possible, the indication was that 50–58 percent of the banded mallards alive returned in subsequent years to the latitudes of their respective banding areas. Others undershot or overshot their former areas, showing up in latitudes immediately north or south of their previous fall migration homes.

9. Direct and indirect recoveries indicated that mallards are most abundant on the wintering grounds between the 34° and 36° parallels in eastern Arkansas and western Mississippi. Thus, mallards banded over an extensive region of the Midwest concentrated in the same general region for wintering.

10. Personnel of the South Dakota Department of Game, Fish, and Parks banded 2,144 mallards during winter in the northern Black Hills. Indirect recoveries at the latitude of the banding station amounted to 46.4 percent of the total, evidence of the large proportion of mallards that returned to their former wintering area.

11. The seasonal turnover in mallard populations during the fall at Lake

Chautauqua was analyzed on the basis of elapsed time in direct recoveries, elapsed time in repeat captures at the banding traps, and the relative proportion of indirect recoveries at any 1 degree of latitude. The proportion of band recoveries was equated with time available during the hunting season. The elapsed time of direct recoveries received from the area of the banding station was 17.3 days for adult drakes, 14.9 days for juvenile drakes, and 16.0 days for hens. Repeats of mallards in the banding traps indicated an elapsed time of 10–11 days. Indirect recoveries indicated that mallards remained in the Lake Chautauqua area for 27.9 days. It is believed that the figure derived from indirect recovery data was the most valid.

12. The chronology of mallard passage down the Mississippi migration corridor was plotted from indirect recoveries. Peaks in recoveries occurred September 20–26 in the Canadian zone, October 25–31 in the northern zone of the United States, November 8–15 in the central zone, and December 27–January 3 in the southern zone. The principal southward passage occurred over a 2-month period, October 15–December 15.

13. Black ducks were banded at McGinnis Slough and Lake Chautauqua locations, respectively, in northern and central Illinois. The black ducks banded in central Illinois commenced their southward passage largely from Ontario west of Lake Superior. Those banded in northern Illinois started their fall flight from that region of Ontario north of Lake Superior. Both groups wintered in the same region, centering around the Mississippi River south of Illinois.

14. The mean and standard deviation lines of black duck recoveries showed that with respect to longitude a large proportion returned to the areas of their banding stations. The east-west spreads in direct and indirect recoveries at the McGinnis Slough banding station were almost identical, indicating that only a few returning ducks stopped at areas east or west of there.

15. The latitudinal distribution of black ducks also showed a high degree of homing. A comparison of the direct and indirect recoveries by latitude indicated that only 15 percent more direct than indirect recoveries occurred at the latitude of Lake Chautauqua for bandings made there and 18 percent more direct than indirect recoveries at the latitude of McGinnis Slough for bandings made there.

16. In several areas of the Mississippi migration corridor the waterfowl habitat is so unevenly distributed that the mallard recoveries are biased geographically. However, in general the indirect recoveries reflected the corridor of passage between the breeding and wintering grounds.

17. The detailed homing by mallards and black ducks to specific areas on breeding, migrating, and wintering grounds points up the importance of landscape features as cues in migration.

18. It appears that traditional migrating and wintering areas become established by juvenile ducks visiting them for the first time in the company of adults who return to the areas they previously frequented.

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INDEX

Some Publications of the ILLINOIS NATURAL HISTORY SURVEY

BULLETIN

Volume 28, Article 3.—A Comparative Study of Bird Populations in Illinois, 1906-1909 and 1956-1958. By Richard R. Graber and Jean W. Graber. October, 1963. 146 p., 4 frontis., 32 fig., bibliogr., index.

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BIOLOGICAL NOTES

57.—Man's Effect on the Fish and Wildlife of the Illinois River. By Harlow B. Mills, William C. Starrett, and Frank C. Bellrose. June, 1966. 24 p., 16 fig., bibliogr.

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59.—Tables for Estimating Ages and Birth Dates of Cottontail Rabbits with Suggestions for Handling Lenses. By William R. Edwards. December, 1967. 4 p., 2 fig.

60.—Use of Feather Minerals as Biological Tracers to Determine the Breeding and Molting Grounds of Wild Geese. By Harold C. Hanson and Robert L. Jones. February, 1968. 8 p., 2 fig., bibliogr.

61.—Waterfowl Migration Corridors East of the Rocky Mountains in the United States. By Frank C. Bellrose. June, 1968. 24 p., 6 fig., bibliogr.

62.—Nightlighting: Its Use in Capturing Pheasants, Prairie Chickens, Bobwhites, and Cottontails. By Ronald F. Labisky. October, 1968. 12 p., 8 fig., bibliogr.

63.—Selected Minerals in Soils, Plants, and Pheasants: An Ecosystem Approach to Understanding Pheasant Distribution in Illinois. By Robert L. Jones, Ronald F. Labisky, and William L. Anderson. December, 1968. 8 p., 1 fig., bibliogr.

64.—The Value of In Vitro Fungicide Tests. By Dan Neely. January, 1969, 8 p., bibliogr.

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