

MASSED WATERFOWL FLIGHTS IN THE MISSISSIPPI FLYWAY, 1956 AND 1957

FRANK C. BELLROSE AND JAMES G. SIEH

ALMOST every year in the Mississippi Flyway there is one waterfowl flight that is greater in scope and magnitude than all others. Some refer to it as the "grand passage" of waterfowl. This great movement usually occurs during the first week of November, but it may be earlier or later. In 1957, this spectacular duck migration occurred from October 23-25; in 1956, it occurred from November 6-8; in 1955, it occurred from October 31 to November 3.

The 1955 grand passage of waterfowl was discussed in an earlier paper (Bellrose, 1957). The present paper largely concerns the grand passage of waterfowl in 1956 and 1957. Although the 1956 and 1957 flights were not so large as the one in 1955, they were still of unusual scope and magnitude in the Mississippi Flyway. They are discussed here not so much because of their size, but primarily because of the unique complementary observations made in Iowa and in Illinois.

The 1955 massed waterfowl flight was well documented on its passage from Canada to Louisiana (Bellrose, 1957). Therefore, in discussing the 1956 and 1957 grand passages of waterfowl we have attempted to provide only a sketchy documentation of the over-all flights in favor of more detailed descriptions of the movement through Iowa and Illinois.

Studies of waterfowl movements are productive of information on three aspects of migration: (1) the mechanics of migration including routes, speed, altitude, and flock behavior; (2) the problem of navigation; and (3) the weather conditions responsible for initiating migratory movements.

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GRAND PASSAGE OF 1956

Extensive Observations.—The prelude to the 1956 grand passage began late in the afternoon of November 5, when at Bismarck, North Dakota, C. H. Schroeder (letter, July 29, 1957) of the Game and Fish Department reported scattered flocks of ducks flying southward. Before sunrise on November 6,

Schroeder heard ducks flying overhead, and at daylight he observed a "sky full of ducks," moving southeast. Most of the ducks were Mallards (*Anas platyrhynchos*), but flocks of Pintails (*A. acuta*), Gadwalls (*A. strepera*), Green-winged Teals (*A. carolinensis*), Shovelers (*Spatula clypeata*), Lesser Scaups (*Aythya affinis*), Canvasbacks (*A. valisineria*), Ring-necked Ducks (*A. collaris*), Redheads (*A. americana*), Buffleheads (*Bucephala albeola*), and Ruddy Ducks (*Oxyura jamaicensis*) also were observed.

W. G. Leitch of Ducks Unlimited telegraphed that on the morning of November 6, 1956, there was an appreciable movement of ducks through and out of southern Manitoba.

At Fergus Falls, Minnesota, Joseph Hopkins (letter, March 11, 1957), U. S. Game Management Agent, reported a mass migration of ducks, which appeared about 11:00 a.m. (C.S.T.) on November 6. The flight was still in progress at sunset. Late in the afternoon many Mallards dropped out of the passing throng to alight on local lakes. On the morning of November 7, Hopkins observed numerous high flying flocks of ducks heading south-southeast whenever there was a break in the low overcast. Several flocks of Whistling Swans (*Olor columbianus*) were observed migrating at a high altitude. The waterfowl flight continued through the afternoon and was still in progress at dark.

There was no indication of the mass migration in the area of Minneapolis, Minnesota, until 9:00 a.m. (C.S.T.) on November 7. At that time, J. D. Smith (letter, August 15, 1957) and others of the U. S. Fish and Wildlife Service noticed long strings of Mallards passing over that city, heading in a southeasterly direction. The flight continued until between 3:30 and 4:00 p.m. In the morning and early afternoon, duck flocks were observed at 3- to 5-minute intervals. Later in the afternoon, however, flocks passed by at intervals of 10 to 15 minutes. Most of the duck flight occurred at about 2000 feet, but during the afternoon the flight dropped progressively lower until by 3:30 p.m. the flocks were at 800 to 1000 feet.

Similar observations were made at Swan Lake, near New Ulm, Minnesota, 60 miles southwest of Minneapolis. There, W. G. Hoerr, local duck hunter, reported (letter to A. H. Hochbaum, January 21, 1957) that ducks showed up from the northwest about 9:00 a.m. on November 7. From that time until 3:30 p.m., when the flight ceased, Mr. Hoerr could see large flocks of ducks through breaks in the clouds and/or when the snow abated. The flight consisted mostly of Mallards and Lesser Scaups. About 10 per cent of the observed ducks dropped into Swan Lake, and the others continued in a southeasterly direction.

R. A. McCabe (letter, March 18, 1958), of the University of Wisconsin, reported this duck flight as follows:

"On the morning of November 7, 1956, I hunted at Mud Lake, between Lake Waubesa and Kegonsa, 5 miles south of Madison, Wisconsin. On this particular body of water the shootable duck flight was mediocre but about 9 o'clock that morning, and for at least 1 hour, there was a phenomenal movement of birds in a northwest-southeasterly direction. I would say there were about 75 per cent divers and 25 per cent dabblers and that they were about 1,500 feet more or less, in the air."

At the Fountain Grove Wildlife Area in north-central Missouri, C. T. Shanks (letter, August 27, 1957) noted the first migrating flock at 11:00 a.m. on November 7. His account of the flight follows:

"Another group of birds came by about 10 minutes later. Both of these flocks were relatively low when I saw them, about 500 feet By the time I reached the blind at about 12:30, these low flying flocks were passing overhead about every 3 minutes. Upon reaching the blind I noticed for the first time a large migration of birds which was occurring at a much higher altitude. These high flyers were just under the clouds and were about constant, one flock directly behind the other. I estimated this flight at about 3,000 feet. They were moving out of the northwest and continuing on in a southeasterly direction.

"At about this same time flocks of gadwalls began coming in to land 100 to 150 yards out from my blind, drinking, and immediately taking to the air. According to my counts there were, on the average, 75 gadwalls landing in this area every 2 minutes. However, since they were departing so quickly there were never more than 200-300 birds on the water at any one time. It is interesting to note that they all landed exactly in the same spot. This gadwall flight continued in this manner for approximately 2 hours, which, figuring 75 every 2 minutes, calculates to 4,500 birds landing during this 2 hour period.

"During this same period, there were just as many low flying flights which passed on without stopping so that I feel it is safe to say that 9,000-10,000 gadwalls came by this particular spot between 12:30 and 2:30 p.m. This gadwall flight seemed to stop as suddenly as it started, and was replaced by an even heavier flight of mallards. The mallard flight continued for the remainder of the afternoon. By nightfall the Fountain Grove Area, which was devoid of ducks that morning, was covered with mallards."

The vanguard of the flight arrived in Tennessee, according to P. B. Smith (letter, July 19, 1957), formerly of the Tennessee Game and Fish Commission, late in the afternoon and evening of November 7. The main flight occurred all through the day of November 8, when it was reported from numerous places throughout the state.

Smith reported that he had never seen so many ducks arrive in Tennessee in so short a time. Illustrating the magnitude of the flight, he cited the two-day kill of ducks on the West Sandy hunting area: On opening day, November 7, 400 hunters averaged 0.12 ducks per man; on November 8, hunters averaged 2.1 ducks per man.

In Arkansas, the flight was first noticed at the Big Lake National Wildlife Refuge in the northeast corner of the state about 3:30 p.m. on November 7. According to D. M. Donaldson (letter, July 24, 1957) of the Arkansas Game and Fish Commission, the flight continued until dark and through most of the

following day, November 8. Upon conducting an aerial survey, Donaldson found 15,000 Mallards on the Big Lake Refuge on November 8, where only a few Mallards had occurred before. Near Weiner, Arkansas he observed the duck flight coming in from the north at altitudes from 2000 to 2500 feet. The flight was made up almost entirely of Mallards.

The vanguard of this great duck flight arrived in Louisiana at noon on November 7, 1956, according to R. K. Yancey (letter, August 5, 1957) of the Louisiana Wildlife and Fisheries Commission. The flight was detected throughout the state by a great number of observers. Yancey was in northeastern Louisiana on November 7 and observed ducks migrating at 300 to 400 feet all across that section of the state. However, he noted that the largest movements occurred along river courses. At Lake Pontchartrain in southeast Louisiana, John Newsom, Federal Aid Coordinator with the Commission, saw large numbers of ducks arrive during the afternoon of November 7.

The flight into Louisiana continued over the next two days and brought at least 1,200,000 ducks into the state, including the first major arrivals of Mallards and diving ducks. Green-winged Teals, Gadwalls, and Pintails also arrived in large numbers. As these northern ducks moved in, the bulk of the Blue-winged Teal (*Anas discors*) population which had been present departed from the state.

Iowa-Illinois Observations.—The earliest indication of a waterfowl flight in Iowa was reported by F. A. Heidelbauer (pers. comm.) of the Iowa Conservation Commission. Late in the morning of November 6, he was flying from Des Moines to Sioux City, Iowa, when two flocks of Mallards were encountered flying southeast at 1500 feet. During an afternoon aerial reconnaissance he observed a flock near Sioux City, which also was flying southeast at 1500 feet.

At 9:30 a.m. on November 7, Heidelbauer began to see migrating ducks as soon as he left the Sioux City airport. Over the Missouri River ducks were seen in an unending stream from a few hundred feet to 5000 feet above the river. Later it was learned that the flight first appeared at Onawa, Iowa, about 8:00 a.m. Migrating flocks were made up largely of Mallards, Lesser Scaups, and Redheads. The flight continued throughout the day, but by the morning of November 8 it was over.

At Spirit Lake, Iowa, Sieh first noted a few flocks of migrating Mallards at 9:00 a.m., November 7. By 9:30 a.m. the number of passing flocks had increased until ducks were constantly in view. The flight direction was to the south-southeast, and virtually all ducks passed over without stopping at local lakes.

Seth Shepard (pers. comm.) made counts of duck flocks he could see from a window of the Biology Station at Spirit Lake. In one hour, between 9:30

and 10:30 a.m., he counted 45 flocks averaging 67 ducks per flock, for a total of 3083 birds. At nearby Pleasant Lake during a 2-hour period (1:30 to 3:30 p.m.) Thomas Moen and Seth Shepard counted 90 flocks averaging 92 ducks per flock for a total of 8,311 ducks, or 4,155 per hour. The count was made of all waterfowl crossing an imaginary vertical plane, with the observers facing to the east.

At Trumbull Lake, 20 miles southeast of Spirit Lake, William Basler (pers. comm.) similarly counted 86 flocks, totaling 5,160 ducks, passing over in an hour (1:30 to 2:30 p.m.). The flight began to taper off by 3:00 p.m. in northwestern Iowa, and by 4:00 p.m. it was practically over.

Sieh obtained a "cross-section" of this flight through northern Iowa by driving east from Spirit Lake on state route No. 9 to Osage, a distance of 128 miles. The trip was made from 12:55 to 3:40 p.m. During this 2¾-hour period, 11,925 ducks in 193 flocks (4155 birds per hour) were observed crossing the highway in front of the car. The flocks were moving largely in a south-southeast direction as far east as Thompson, but farther east, between Thompson and Osage, the flight was largely to the southeast.

Table 1 shows the distribution of the waterfowl flight between Spirit Lake and Osage. The route taken across northern Iowa crossed the upper reaches of several rivers which flow to the southeast, but little relationship between the rivers of northern Iowa (Fig. 1) and the magnitude of the flight is indicated. For the most part the flight of waterfowl was passing over the fields of northern Iowa in an evenly distributed pattern. However, eastward from Lakota to Osage, the magnitude of the flight was somewhat reduced.

Accompanied by Norman White, pilot, Bellrose had been aviating up the Mississippi River Valley for five hours before sighting the first migrating duck flocks at 2:00 p.m. on November 7 near Wapello, Iowa. By 2:15 p.m., when Muscatine, Iowa, was reached, the duck flight was appreciably greater.

At Muscatine, flocks of Mallards were observed arriving at the Mississippi River from the north and northwest. Several flocks arriving from the northwest were observed to alter course 30 to 40 degrees to move southward down the bluff of the Mississippi River Valley, some 3 to 4 miles east of the river channel. A smaller number of flocks continued on a southeast course, over the fields of Illinois, apparently bound for the Illinois River Valley.

The airplane was flown northwest from Muscatine into the stream of migrating ducks. A zigzag course was pursued; each leg of the course was about 25 miles in length and centered on the Cedar River.

On the three legs of the course, each bisected by the Cedar River, counts of flocks revealed one per minute within a belt of 5 miles on each side of the river valley as opposed to one flock per two minutes farther away from the valley.

TABLE 1
NUMBERS OF DUCKS SEEN CROSSING ROUTE 9 BETWEEN SPIRIT LAKE AND OSAGE, IOWA,
ON NOVEMBER 7, 1956

City	Time P.M.	Miles Travelled	Number of Ducks	Ducks per Minute	Ducks per Mile
Spirit Lake	12:55				
Superior	1:03	6	1100	138	183
Estherville	1:15	8	575	48	72
Armstrong	1:37	18	3007	137	167
Swea City	1:46	9	1310	146	146
Lakota	2:00	12	1369	86	114
Thompson	2:22	18	1690	77	94
Forest City	2:35	14	495	38	35
Hanlontown	2:54	14	1077	57	77
Manly	3:05	9	790	72	88
Osage	3:40	20	510	15	26
Total	2¾ hours	125	11,923		
Average				71	94

At Iowa City the airplane was headed south via Mt. Pleasant to Argyle, Iowa. For 11 miles, from Iowa City to Riverside, the course was adjacent and parallel to the Iowa River. In that stretch flocks of ducks were cutting across the Iowa River Valley at an angle of 40 degrees as they pursued their southeast direction of flight.

South of Riverside the magnitude of the flight began to lessen (Table 2). Also, the flight direction of the migrating birds gradually but steadily shifted from southeast at Riverside, to generally east-southeast from there to Mt. Pleasant, and to generally east from there to Argyle. Near Argyle, two flocks of ducks were observed flying southeast down the Des Moines River Valley.

At Argyle, Iowa, the airplane's course was once again altered, this time to east-southeast toward Havana, Illinois. At the Mississippi River numerous flocks of ducks were seen descending to the river, joining rapidly-forming rafts of birds which had not been present several hours earlier.

Between the Mississippi River and Havana flocks of ducks were observed at intervals flying largely either south or southeast. The magnitude of the flight was considerably less than it was in Iowa (Table 2).

The altitude of each flock of ducks was recorded on the entire aerial trip. Over the Mississippi River Channel south of Muscatine, flocks of Mallards and Ring-necked Ducks were observed at from 400 to 600 feet. Over land during mid-afternoon flocks were observed at altitudes from 2100 to 3500 feet; the bulk of the birds, however, were flying at 2400 to 2800 feet. Most of the flight was 700 to 1100 feet below the continuous cloud layer; a few

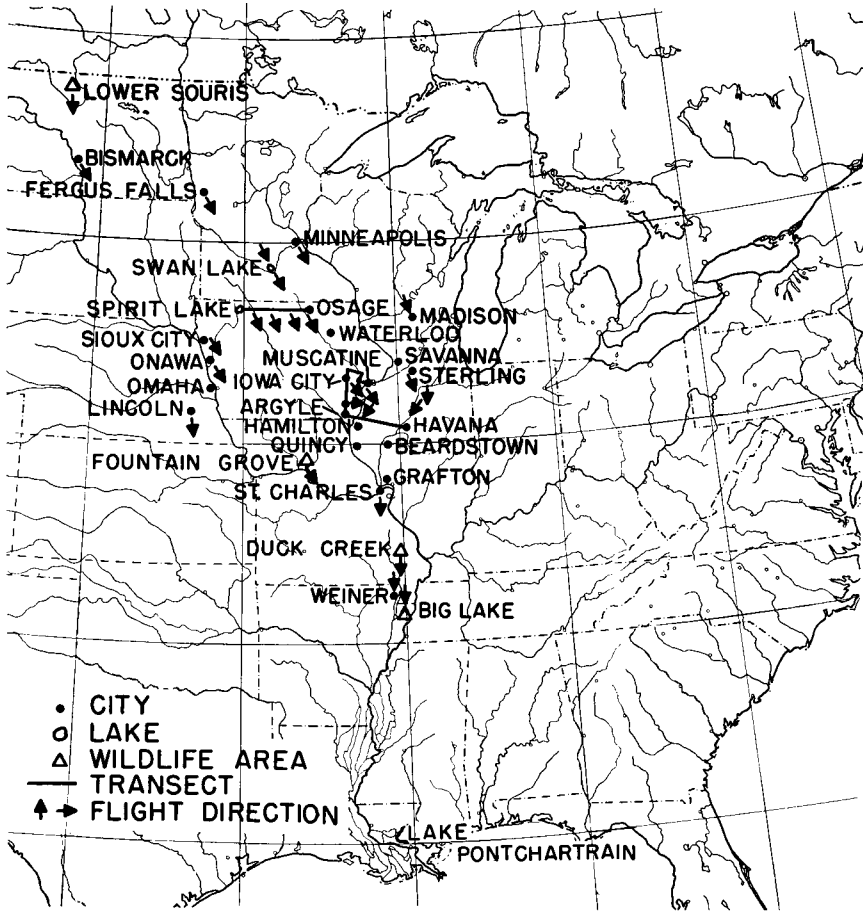


FIG. 1. Places of observation and direction of movement of two waterfowl flights, November 6-8, 1956 and October 23-25, 1957. Car and aerial transects were made of the 1956 flight in Iowa and Illinois.

flocks were observed from time to time disappearing momentarily into the base of low clouds.

As the afternoon waned, it was apparent that the flight of waterfowl descended to lower altitudes (Table 2). The last flocks, at dark, were only 500 feet above the ground.

Observations made elsewhere in Illinois aid in further delineating the November 7, 1956, duck flight. At the Spring Lake National Wildlife Refuge, near Savanna, R. V. Wade (oral comm.) noted that the flight arrived

TABLE 2

NUMBERS AND FLIGHT ALTITUDES OF DUCKS SEEN FROM AN AIRPLANE IN EAST-CENTRAL AND SOUTHEASTERN IOWA AND WEST-CENTRAL ILLINOIS ON NOVEMBER 7, 1956

City	Time P.M.	Miles Travelled	Number of Ducks	Ducks per Minute	Ducks per Mile	Average Altitude
Willow Jct.	2:45					
West Liberty	2:55	14	540	54	39	2800
Bennett	3:05	19	600	60	32	2300
Iowa City*	3:25	32	1140	57	36	2400
Riverside	3:52	11	360	51	33	2200
Ainsworth	4:00	13	300	38	23	2100
Olds	4:07	11	240	34	22	2400
Mt. Pleasant	4:15	13	180	23	14	2700
St. Paul	4:23	13	180	23	14	2300
Argyle	4:33	16	180	18	11	2000
Ferris**	4:41	13	240	30	19	1800
Colchester**	4:53	19	240	20	13	1600
Table Grove**	5:05	20	120	10	6	1100
Havana**	5:20	20	180	12	9	500
Total	2 hrs. 15 min.	214	4500			
Average				33	21	

*Landed at Iowa City airport for 20 minutes

**Cities in Illinois, others in Iowa

there about 1:30 p.m. Most of the ducks came from the northwest, but some came from the north, following the Mississippi River Valley. The bulk of the ducks continued to the southeast. It is probable that this line of flight was observed late in the afternoon of November 7, by Charles Wheat at Sterling, Illinois, about 25 miles southeast of Spring Lake. He reported (letter, June 11, 1957) that for one and one-half hours during late afternoon he saw flock after flock of Mallards passing over, heading between southeast and south-southeast, which would take these birds to the big bend of the Illinois River at Bureau, where the principal duck habitat of that famous waterfowl area begins.

The waterfowl flight was not evident on November 7 south of central Illinois. At the mouth of the Illinois River, Edward Davis (oral comm.) of the U. S. Fish and Wildlife Service did not see any migrating waterfowl until the morning of November 8, when a spectacular flight was observed. The flight continued there until early afternoon. Slightly over 100 miles farther down the Mississippi River Valley, George Arthur (oral comm.) of the Illinois Department of Conservation observed the duck flight moving down the Mississippi River Valley all day on November 8.

On the morning of November 8, White and Bellrose left the Havana, Illinois, airport at 8:00 a.m. Immediately, migrating flocks of ducks were visible

on a course 1 to 5 miles east of the Illinois River Valley. An occasional flock detached itself from the south-moving stream of birds to fly west into a strong wind. Upon reaching one of the numerous lakes or marshes the flock descended to join others already at rest on the water.

By the time the aerial observers reached Meredosia, 45 miles south-southwest of Havana, the flight stream of ducks had practically disappeared, as the bulk of the migrating birds had steadily descended to the intervening waters. Inasmuch as local observers reported a large movement of ducks into the Illinois River Valley all through November 8, it was apparent that the bulk of the birds arriving at the Illinois River during the period had temporarily ceased migrating southward.

At Meredosia the airplane was turned away from the Illinois River Valley and headed west for the Mississippi River at Quincy, Illinois. During the 45-mile flight over land, three flocks of Mallards, aggregating 280 birds, were observed flying east at altitudes of 700 to 1000 feet.

Once more White and Bellrose headed their plane up the Mississippi River Valley. A moderate flight of Mallards and diving ducks was encountered (Table 3) up to Hamilton, Illinois. From that city northward in the Mississippi River Valley, only small and scattered flocks were observed flying south. Two flocks, aggregating 130 Mallards were observed flying north, in the opposite direction to the rest of the flight.

TABLE 3

NUMBERS AND FLIGHT ALTITUDES OF DUCKS MOVING DOWN THE MISSISSIPPI RIVER VALLEY
AS SEEN FROM AN AIRPLANE ON NOVEMBER 8, 1956

City	Time A.M.	Miles Travelled	Number of Ducks	Ducks per Mile	Average Altitude
Quincy	10:10				
Hamilton	10:40	35	1000	29.0	1100
Burlington	11:15	40	145	3.6	900
Muscatine	11:45	50	245	4.9	900
Rock Island	12:00	25	50	2.0	1500

GRAND PASSAGE OF 1957

Extensive Observations.—The 1957 grand passage of waterfowl began in western Saskatchewan on October 22. In an unpublished report, J. L. Nelson of the Saskatchewan Wildlife Branch and Alex Dzubin of the Canadian Wildlife Service state that at Kindersley, Saskatchewan, flocks of 25 to 300 Mallards, with some Pintails and Lesser Scaups, were observed flying southward. The migration occurred under extremely poor visibility as a result of blizzard conditions which caused the birds to fly only 100 to 200 feet above the ground.

In the western part of Saskatchewan the peak of the duck and goose exodus occurred from mid-day on October 22 to mid-day on October 23; in the eastern part of the province it occurred largely during the afternoon of October 23. An aerial survey on October 27, 28, and 29, disclosed that waterfowl north of the snow belt (north of Saskatoon, Saskatchewan) were present in their former numbers, whereas in the snow belt south of Saskatoon only a relatively few ducks were found, the bulk having departed. Freezing temperatures were common in all areas, so Nelson and Dzubin believed that snow was the factor primarily responsible for the exodus of waterfowl from southern Saskatchewan.

At Delta, Manitoba, Frank McKinney of the Delta Waterfowl Research Station reported (telegram, October 24) that there was a mass migration through the Delta Marshes on October 24, with the local ducks departing that evening, under a clearing sky.

In North Dakota at the Lower Souris National Wildlife Refuge, Merrill Hammond, refuge biologist, reported (telephone conversation, 12:00 Noon, October 24) that the mass migration began there at 7:30 a.m., October 24. The flight continued strong until 10:00 a.m. with an intensity equal to or greater than the spectacular flight on November 1, 1955. He observed a few flocks of Pintails in the flight, but the bulk of the flight was composed of Mallards. The birds passed at the rate of 2000 to 3000 per minute. The flight was headed due south at the Lower Souris Refuge.

Previous to the mass flight of ducks, Hammond reported that Gadwalls left the refuge in the evening of October 23; they left Whitewater Lake, Manitoba in the evening of October 22.

The mass flight arrived at Swan Lake, New Ulm, Minnesota, at 8:00 a.m., October 24, according to W. G. Hoerr (letter to A. H. Hochbaum, October 25, 1957). The flight continued until 2:30 p.m., and during that time Mr. Hoerr reported that everywhere one looked in the sky there were large flocks of ducks and geese, almost all of which passed over without stopping. This was the largest flight he had ever seen so early in the autumn. Although most of the duck flocks were Mallards, there was an intermingling of Pintails, Lesser Scaups, Redheads, and Canvasbacks; the geese were Canada Geese (*Branta canadensis*) and Snow Geese (*Chen hyperborea*).

On the previous day, October 23, Hoerr reported a small flight of ducks at Swan Lake, commencing about 11:30 a.m. and continuing through the day, with flocks arriving at 30- and 60-minute intervals. On October 25, the day after the mass flight, there were only a few flocks of migrating ducks, which appeared in the afternoon.

Although Lincoln, Nebraska, lies 40 miles west of the Mississippi Flyway in the Central Flyway, its proximity suggests that observations made there

reflect the waterfowl flight down the western side of the Mississippi Flyway.

George Schildman (letter, April 25, 1958) of the Nebraska Game, Forestation and Parks Commission provided some observations. After hearing geese passing over the Wildlife Building in Lincoln during the morning of October 24, Clarence Newton and he spent the afternoon observing the migration from a hilltop, 5 miles north of Lincoln. Schildman's graphic description of the flight follows:

"Strong northerly winds, and heavy overcast skies with occasional light drizzle characterized the weather. When we first arrived we started to keep a record of the strings of moving birds. In about 10 minutes we had 9 of geese and 13 of ducks. At this point by using binoculars, we could see about 10 separate bunches of birds at one time, and one which I called geese turned out to be gulls on the second look. From then on we stopped counting because of the difficulty in identifying the more distant flocks, and the rapidity in which groups of birds were moving in and out of view. It is impossible to even guess at the number of flocks we observed that afternoon. In addition to the ducks and geese, many flocks of gulls, small groups of shorebirds, and eagles and hawks passed—all going south. Several times I scanned the horizon and counted in excess of 10 flocks of moving birds.

"At 4 o'clock the flight was over. I checked my watch at 4:07 when it dawned on me that we had seen little in the last few minutes. We stayed until sundown (about 5:20) and observed only 6 or 8 flocks in the last hour and a quarter. A light streak appeared in the overcast on the western horizon about 4 o'clock.

"I went back the next morning about sunrise, and observed only one large bunch of ducks and another small group of eight. The weather had cleared during the night, and, with it, we had our first hard freeze of the year."

In southeast Missouri at the Duck Creek Wildlife Area, George Brakhage (oral comm.) of the Missouri Conservation Commission observed the start of the waterfowl flight at 9:00 a.m., October 25. The flight continued through the rest of the day, but only a few flocks were observed the following day. About 90 per cent of the southward flying flocks passed by without stopping. Some 6000 Mallards did stop at Duck Creek, and 8000 at the adjacent Mingo National Wildlife Refuge.

Seventy-five miles south of Duck Creek, David Donaldson of the Arkansas Game and Fish Commission (letter, December 16, 1957) reported that the duck flight arrived at the Big Lake National Wildlife Refuge at 11:00 a.m. on October 25. He considered it to be only a small flight of waterfowl.

A flight of 500,000 ducks arrived in Louisiana on the night of October 24 and during the day and night of October 25, according to M. M. Smith (letter, March 10, 1958) of the Louisiana Wildlife and Fisheries Commission. The flight was made up of large numbers of divers and smaller numbers of most species of dabbling ducks.

Iowa-Illinois Observations.—The earliest observation of the 1957 spectacu-

lar waterfowl flight in Iowa was made by Conservation Officer Gerald Jauron, who reported (pers. comm.) that a sizeable duck flight was starting at 12:20 p.m. on October 23 along the Missouri River north of Council Bluffs. On October 24, in the same area, he witnessed the largest day-long waterfowl migration he had ever seen. The flight continued there on October 25 but in reduced volume. The ducks came from the north, flying south down the Missouri River Valley.

At Spirit Lake, Iowa, Sieh first observed the migration at 9:10 a.m., October 24, when a flock of 50 Mallards appeared. From that time until dark, flocks of ducks passed by the Biology Station, but they were much less numerous than on November 7, 1956. An all-day count yielded 131 duck flocks and 17 goose flocks, totaling 2962 ducks and 976 geese. Ducks passed at the rate of 37.8 birds per hour, with the flight twice as large in the afternoon as in the morning. The duck flight was to the south-southeast, but the goose flight was largely to the southwest.

Twenty miles southeast of Waterloo, Iowa, along the Cedar River, P. D. Kline (letter, October 29, 1957) of the Iowa Conservation Commission made counts of migrating ducks and geese for an hour in early afternoon on October 24, and again for an hour later in the afternoon. The count from 12:45 to 1:45 p.m. amounted to 1810 ducks in 15 flocks; and from 4:09 to 5:09 p.m., 340 ducks in 8 flocks. All of the ducks were migrating in a southeasterly direction; some goose flocks were also headed southeast, but other geese were flying to the south and southwest.

In central Illinois the flight arrived at the Chautauqua National Wildlife Refuge at 1:00 p.m., October 24. From that time until 4:00 p.m., 34 flocks of Mallards, 2 flocks of Blue (*Chen caerulescens*) and Snow Geese, and 1 flock of Canada Geese were observed alighting in the lake.

At 4:45 p.m. the refuge manager, Arthur Hughlett, and Bellrose climbed the refuge's 99-foot observation tower. A census revealed that there were about 5000 newly-arrived Mallards on the lake. Other flocks of Mallards were observed swinging into the lake from the northeast, steadily increasing the size of the rafts of birds resting on the water. At first, flocks were dropping into the lake at the rate of one per minute, but as darkness approached the tempo increased and flocks of ducks were alighting at the rate of one every 10 seconds.

As great as was the number of waterfowl which stopped at Lake Chautauqua that evening, it represented only a part of the flight south. Many flocks could be seen streaming by from $\frac{1}{2}$ to 2 miles east of the Illinois River Valley. A large part of this flight, however, is believed to have taken place above the almost solid overcast, for in looking south through rifts in the cloud layer, more ducks could be seen in a limited area above the clouds than below. At

one time, through a break in the overcast, four large flocks of migrating waterfowl were visible in the binocular field. Over 200 flocks containing about 25,000 ducks were observed flying past the observation tower from 4:45 to 5:30 p.m.

By dark it was estimated that 30,000 Mallards, plus several thousand Lesser Scaup, Ring-necked Ducks, and Canvasbacks had alighted on Lake Chautauqua. Two additional flocks of Blue and Snow Geese had also dropped into the lake.

On the Mississippi River at Dallas City, Illinois, Harry Canfield, a life-long duck guide, reported (oral comm.) that the waterfowl flight arrived there late in the afternoon of October 24, continued apparently into the night, and ended at 2:00 p.m. on October 25. He considered the flight to be larger than that of November 7, 1956, but not so large as the November 2, 1955, duck flight.

Canfield noted on October 25 that several dozen flocks of ducks were flying north at extremely high altitude, at a time when the bulk of the flight was moving south down the Mississippi River Valley.

On October 25, with Norman White as pilot, Bellrose aviated down the Illinois River Valley from Havana to Grafton, Illinois, and up the Mississippi River Valley from Grafton to Rock Island, Illinois. During the aerial survey, it was noted that from Havana to Beardstown migrating waterfowl flocks (Table 4) were east of the Illinois River Valley at altitudes of 1500 to 1800 feet, with the cloud layer at 1800 to 2000 feet. Between Beardstown and Grafton waterfowl flocks were in the eastern part of the valley, but they appeared to be following it. Above Beardstown, three flocks were observed flying north against the wind at 1500 feet.

TABLE 4

NUMBERS OF DUCKS MOVING SOUTH IN THE ILLINOIS AND MISSISSIPPI RIVER VALLEYS AS SEEN FROM AN AIRPLANE ON OCTOBER 24, 1957

City	Miles Travelled	Number of Ducks	Ducks per Mile
Havana	—	—	—
Beardstown	30	600	20
Meredosia	15	180	12
Grafton	60	900	15
Clarksville	55	1200	22
Quincy	50	3000	60
Hamilton	35	1200	34
Burlington	40	800	20
Muscatine	50	600	12

TABLE 5
A 2-DAY CHANGE IN WATERFOWL POPULATIONS OF THE LOWER ILLINOIS AND MISSISSIPPI
RIVER VALLEYS FROM GRAFTON, ILLINOIS, TO MUSCATINE, IOWA, IN 1956

Species	November 7	November 8	Per Cent of Change
Mallard	257,000	704,000	+63.5
Black Duck	1,500	6,400	+76.6
Gadwall	900	1,600	+43.8
Pintail	29,000	4,500	-84.5
Green-winged Teal	10,800	4,400	-59.3
American Widgeon	8,600	4,400	-48.9
Shoveler	400	400	00.0
Ring-necked Duck	4,700	83,000	+94.3
Canvasback	520	3,000	+82.7
Lesser Scaup	13,500	127,000	+89.4
Ruddy Duck	150	30	-80.0
Total	327,070	938,730	+65.2

Near St. Charles, Missouri, three flocks of geese and two flocks of ducks were observed leaving the Mississippi River where it bends to the east. The waterfowl flocks were pursued a short distance on their southward line of flight until it was ascertained that their course was to the west of St. Louis.

The intensity of the waterfowl flight in the Mississippi River Valley on October 25 (Table 4), the second day of the 1957 grand passage, was greater than it was on November 8 (Table 3), the second day of the 1956 grand passage. On the second day of the 1956 and 1957 aerial surveys, the waterfowl flight declined in magnitude above Hamilton, Illinois.

A measure of the magnitude of the massed waterfowl flights which arrived in Illinois on November 2, 1955, November 7, 1956, and October 24, 1957, is shown in Fig. 2. The figures were obtained by Bellrose from periodic aerial surveys of waterfowl populations in Illinois.

The 1955 grand passage resulted in an increase of 775,000 ducks in the Illinois River Valley; the 1956 grand passage resulted in an increase of 600,000; and the 1957 grand passage in an increase of 225,000. The species composition of the 1956 and 1957 flights is indicated by Tables 5 and 6. As in 1955, Mallards made up the bulk of the flight population, but, unlike the 1955 flight, the largest proportionate increases in local population as a result of the 1956 and 1957 massed flights occurred in Lesser Scaups, Ring-necked Ducks, and Canvasbacks.

Population figures reveal that there was a pronounced exodus of ducks from the Illinois and Mississippi River valleys concurrent with the arrival of the northern birds. In 1956, the principal species departing were the Pin-

TABLE 6

WATERFOWL POPULATION CHANGES ON LAKES IN THE ILLINOIS RIVER VALLEY FROM PEKIN TO HAVANA, ILLINOIS, ON THREE DAYS IN 1957

Species	October 22	October 24	October 25	Per Cent of Change
Mallard	6,900	19,100	111,500	+ 82.9
Black Duck	380	655	675	+ 3.0
Gadwall	45	85	1,100	+ 92.3
Pintail	500	1,500	500	- 66.6
Green-winged Teal	1,800	1,250	650	- 48.0
American Widgeon	3,650	1,010	2,800	+ 63.1
Shoveler	70	60	50	- 16.7
Ring-necked Duck	0	0	10,000	+100.0
Canvasback	0	0	500	+100.0
Lesser Scaup	0	0	6,500	+100.0
Total	13,345	23,660	134,275	+ 82.4

tail, Green-winged Teal and American Widgeon (*Mareca americana*) (Table 5). In 1957, the Pintail and Green-winged Teal departed in large numbers (Table 6) .

MECHANICS OF MIGRATION

The piecing together of visual records of the directions taken by migrating waterfowl supplement information on flyway routes provided by band-recovery data. Band recoveries do not fix as finitely as visual records, specific routes of passage in any geographic area.

An analysis of the flight directions reported for November 1-3, 1955 (Bellrose, 1957:20), and those of November 6-8, 1956, and October 23-25, 1957 (Fig. 1), adds materially to the available knowledge on routes taken by waterfowl in the Mississippi Flyway.

From the plains of Saskatchewan and Manitoba to Illinois the general direction of flight was between south-southeast and southeast. In the area between northern (latitude 42°30') and south central Illinois (latitude 39°), there was a great wheeling movement as the bulk of the flight turned from a southeasterly direction to a southerly one. It appeared as if the Mississippi River played a major role in changing the course of the migrants, with the Illinois River playing a secondary role and other bodies of water, such as the Chain-of-Lakes in northeastern Illinois, tertiary roles. In other states, significant bodies of water might serve in a similar fashion.

The key role that certain water areas may serve in altering direction of flight was illustrated by the fact that duck flocks changed their course from

southeast to south when they arrived at the Mississippi River near Muscatine, Iowa. Although other duck flocks continued in flight to the southeast, observations made of the November 2, 1957, flight and other flights indicated that they changed to a more southerly direction at the Illinois River. On the basis of observation on past flights, such migrating flocks as those observed by McCabe in Wisconsin are thought to have shifted to a southerly direction in the Chain-of-Lakes region in northeastern Illinois.

There was a strong flight of waterfowl down and adjacent to the Missouri River Valley in Iowa. Because the bulk of the movement did not turn east at Kansas City, Missouri, to follow the Missouri River, the plausible conclusion was that the flight continued in a south-southeasterly direction over the Ozark Mountains to wintering grounds in Arkansas and Louisiana.

Sieh did not observe any tendency for migrating waterfowl to follow rivers when he crossed northern Iowa on November 7, 1956. Duck flocks were dispersed all across the northern part of the state (Table 1). Farther down the flight lines, where the streams were larger, Bellrose's observations indicated that migrating waterfowl were more abundant within 5 miles of the Iowa and Cedar Rivers, which flow from northwest to southeast; however, he found ducks migrating across all of southeastern Iowa (Table 2). It appeared that as the rivers became larger, there was a tendency for the ducks to use them as guide lines, but only when river courses paralleled the lines of flight. Migrating waterfowl appeared to depart from river guide lines whenever they were inconvenient to follow, as exemplified by flocks leaving the Mississippi River above St. Louis to fly straight south.

The migrating flocks observed flying southward between the Mississippi and Illinois rivers (Fig. 1) may well have turned south at some point on the Mississippi River directly north of the place where they were observed. At three different latitudes duck flocks were observed heading directly east from the Mississippi River toward the Illinois River; again these birds may have used some point on the Mississippi to alter their line of flight.

Flocks observed flying north at the same altitude as the stream of south-bound migrants are thought to be ducks which arrived at the Mississippi River at a point south of the desired one. These ducks would appear to have recognized their displacement from land marks, and used them as a means of returning to their haunts of other years.

In aviating inland from the Mississippi River between Iowa City and Argyle, Iowa, on November 7, 1956, it was obvious that the direction of duck flight changed from southeast to east by the time Mt. Pleasant was reached. Apparently most flocks headed directly toward the Mississippi River as darkness approached. From an altitude of 2500 feet the river was barely

discernible 20 to 30 miles away, and apparently as the birds saw it, they swung east toward it. Most ducks appeared to be halting their flight for part or all of the night when they reached the river.

The waterfowl passage on November 7, 1956, was on a front of at least 250 miles. The first migrants formed a line which at 9:00 a.m. was farthest south near Omaha, Nebraska, and slanted abruptly to the north-northeast, extending at least as far as Minneapolis, Minnesota. The location of the front line of migrants is derived from observations of the first ducks which appeared in the Missouri River Valley at Onawa, Iowa, at 8:00 a.m., at Spirit Lake, Iowa, at 9:00 a.m.; at Swan Lake near New Ulm, Minnesota, at 9:00 a.m.; and at Minneapolis, Minnesota, at 9:00 a.m. (Fig. 1). Thus the western terminus of the flight line in the Mississippi Flyway was about 200 miles south of the eastern segment of the flight line at Minneapolis.

The apparently greater progress southward in the west segment of the flight over the segments farther east no doubt stems from the fact that these mass waterfowl migrations often start from the western plains of Canada ahead of those from the eastern plains. This was recorded on the October 31–November 3, 1955, flight (Bellrose, 1957:19), and on the October 22–25, 1957, flight. In 1957, the passage peaked between the noons of October 22–23 in western Saskatchewan, and during the afternoons of October 23 in eastern Saskatchewan and October 24 farther east at Delta, Manitoba.

Counts made in Iowa at Spirit Lake, across northern Iowa from Spirit Lake to Osage (Table 1), and in eastern Iowa (Table 2) on November 7, 1956, indicate that that flight was much greater in the western part than in the eastern part of the Mississippi Flyway. Even though observations were made from fixed points, from a car, and from a plane the results were roughly comparable because all counts were made at an approximate right angle to the line of flight. Thus a moving observer would not tend to expand or compress the magnitude of the flight as long as observations formed a cross-section; his zone of observation would remain of comparable size.

Rate of Movement.—During the 1956 grand passage certain observers were in a position to notice the first major wave of migrating ducks reaching their locality. They also reported the flight directions which made it possible to project probable lines of flight.

A comparison of the arrival of ducks at selected points, 250 to 270 miles apart and along projected lines of flight, makes it possible to roughly compute the speed of the 1956 mass migration through the Midwest.

Ducks observed passing over Swan Lake near New Ulm, Minnesota, at 9:00 a.m., on November 7, and moving in the direction of Muscatine, Iowa, were probably representative of the birds which reached that area at 2:15 p.m. It is about 260 miles from Swan Lake to Muscatine, and the ducks appeared

to cover this distance in $5\frac{1}{4}$ hours for an average flight speed of 50 mph. The flight which passed Minneapolis, Minnesota, probably represented the same section of the migration which reached Savanna, Illinois, $5\frac{1}{2}$ hours later and some 250 miles to the southeast for a speed of 45 mph. The Mallards that reached Sumner, Missouri, at 2:30 p.m. were probably in the section of flight which passed Spirit Lake, Iowa, at 9:00 a.m. These ducks probably travelled 270 miles in $5\frac{1}{2}$ hours, for a speed of 49 mph.

Amazing though it seems, it is probable that ducks which left central Saskatchewan during the day on October 23, were the ones which arrived in Louisiana the night of October 24. This indicates a continuous flight for about 36 hours covering some 1500 miles (± 200 miles) for an average speed of 40 mph.

Both the 1956 and 1957 grand passages of waterfowl arrived in Louisiana at almost the same time as in Illinois, even though central Louisiana is some 600 miles south of central Illinois. The fact that ducks did not appear in eastern Arkansas until the following day, strongly suggests that the early arrivals in Louisiana flew 150–200 miles west of the Mississippi River, on a south-southeast course. Probably these flights crossed western Iowa during the afternoon and night. The flocks Heidelberg observed in migration on the afternoon of November 6, 1956, in western Iowa probably represented this pulse of the flight. Apparently Jauron saw the start of this segment of the 1957 flight at 12:20 p.m. on October 23, when it began to pass down the Missouri River Valley near Onawa, Iowa. The segment of the grand passage observed at Bismarck, North Dakota, and Fergus Falls, Minnesota, on the morning of November 6, 1956, may represent part of this passage which reached Louisiana on November 8.

Altitude.—Under high overcast skies on November 7, 1956, ducks were found migrating from 2100 to 2800 feet over the farm lands of Iowa (Table 2). As darkness approached, the ducks dropped lower and lower until at dark they were only 500 feet above the ground. A similar decline in altitude with the waning of the day was also observed near Minneapolis, Minnesota. There Donald Smith estimated that flocks of waterfowl descended from 2000 feet in mid-day to 800–1000 feet late in the afternoon.

On November 8, 1956, migrating flocks were found from 900 to 1500 feet above the Mississippi River (Table 3), and in the same area on October 24, 1957, they were found at altitudes varying from 1100 to 1700 feet. Over Arkansas, they were recorded at 2000 to 2500 feet. In western Iowa, several flocks were recorded at 1500 feet on November 6, 1956.

Weather Conditions.—Weather conditions associated with the November 6–7, 1956, waterfowl flight from the northern Great Plains region were under the influence of a moderate low which, on November 5, moved north-north-

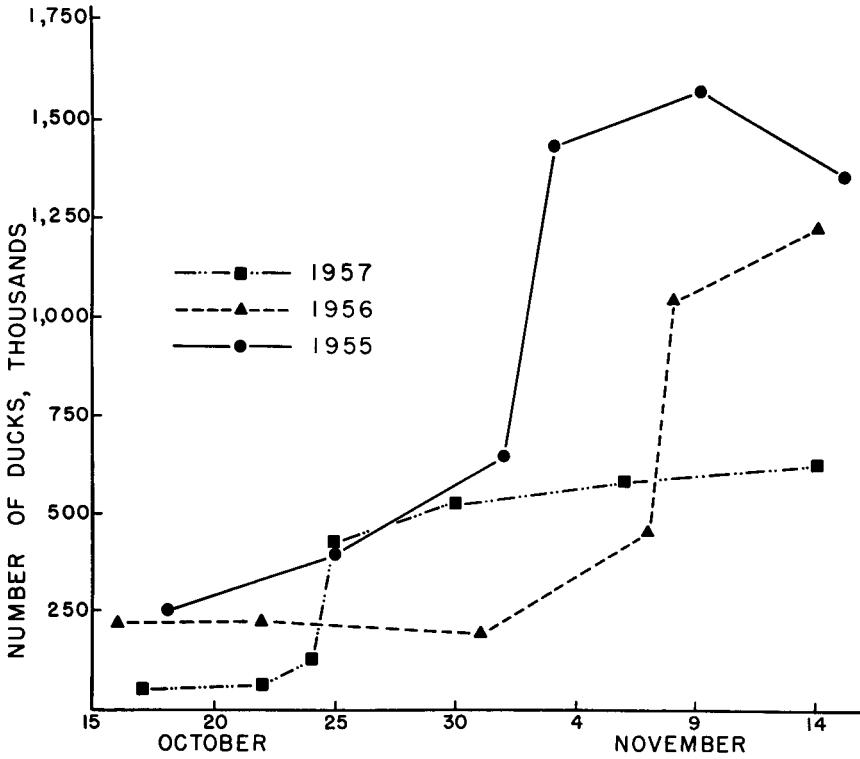


FIG. 2. Changes in the waterfowl population of the Illinois River Valley resulting from a mass migration in each of the three years, 1955-1957.

west from western Iowa to center in southwestern Manitoba by 12:30 a.m. on November 6.

Apparently as the low pressure area passed through North Dakota, it, or the weather associated with it (Fig. 3), induced some movement of ducks out of that state, beginning late in the afternoon of November 5. By the morning of November 6, much larger numbers of ducks were reported moving through central North Dakota, western Minnesota, and southern Manitoba.

The weather map for 12:30 a.m. (C.S.T.) on November 7 (Fig. 4) shows that the low pressure area had deepened slightly and had become extended to form a trough from southeastern Ontario to James Bay. Weather associated with this low consisted of falling temperature; overcast skies through eastern Ontario, Manitoba, eastern Saskatchewan, and south through Minnesota, North and South Dakota; falling snow in a belt from eastern Ontario, through

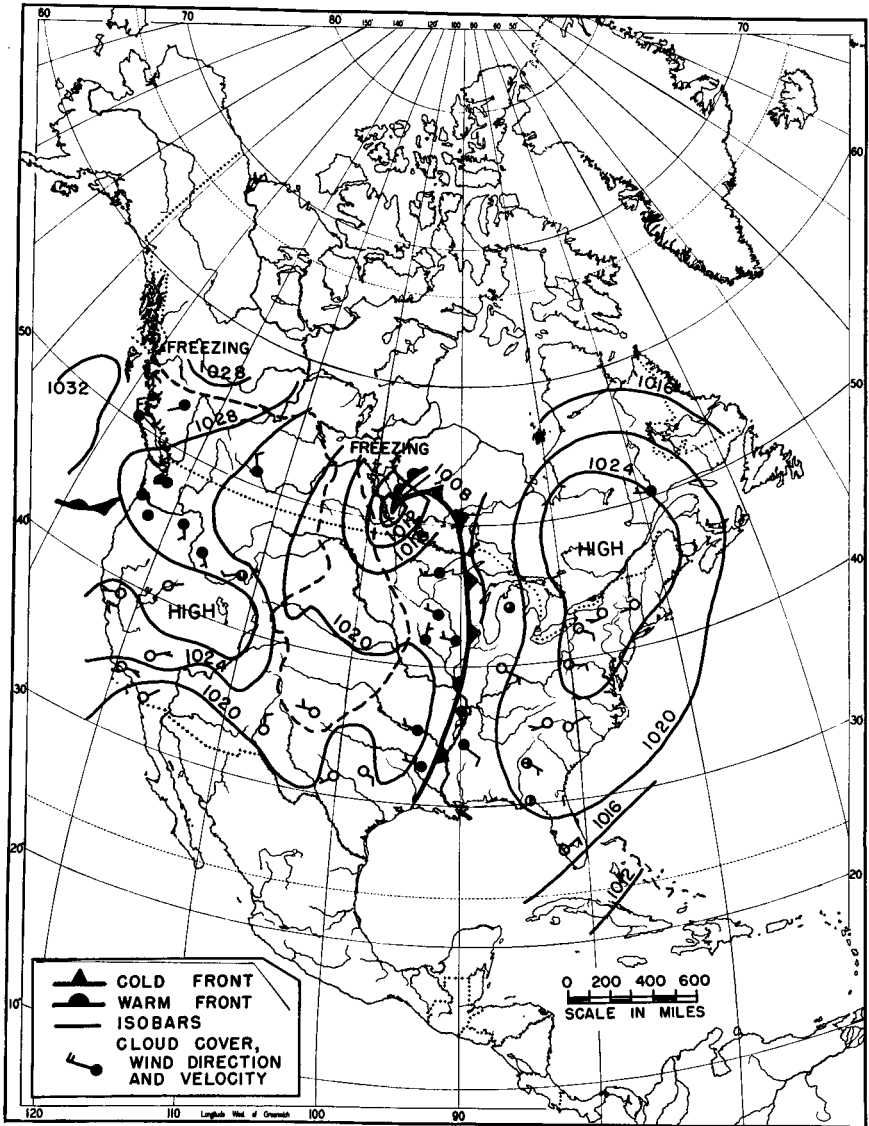


FIG. 3. Weather conditions as of 1:00 a.m. (C.S.T.), November 6, 1956, according to the United States Weather Bureau.

southern Manitoba to central Saskatchewan; and winds from the northwest in the northern Great Plains region.

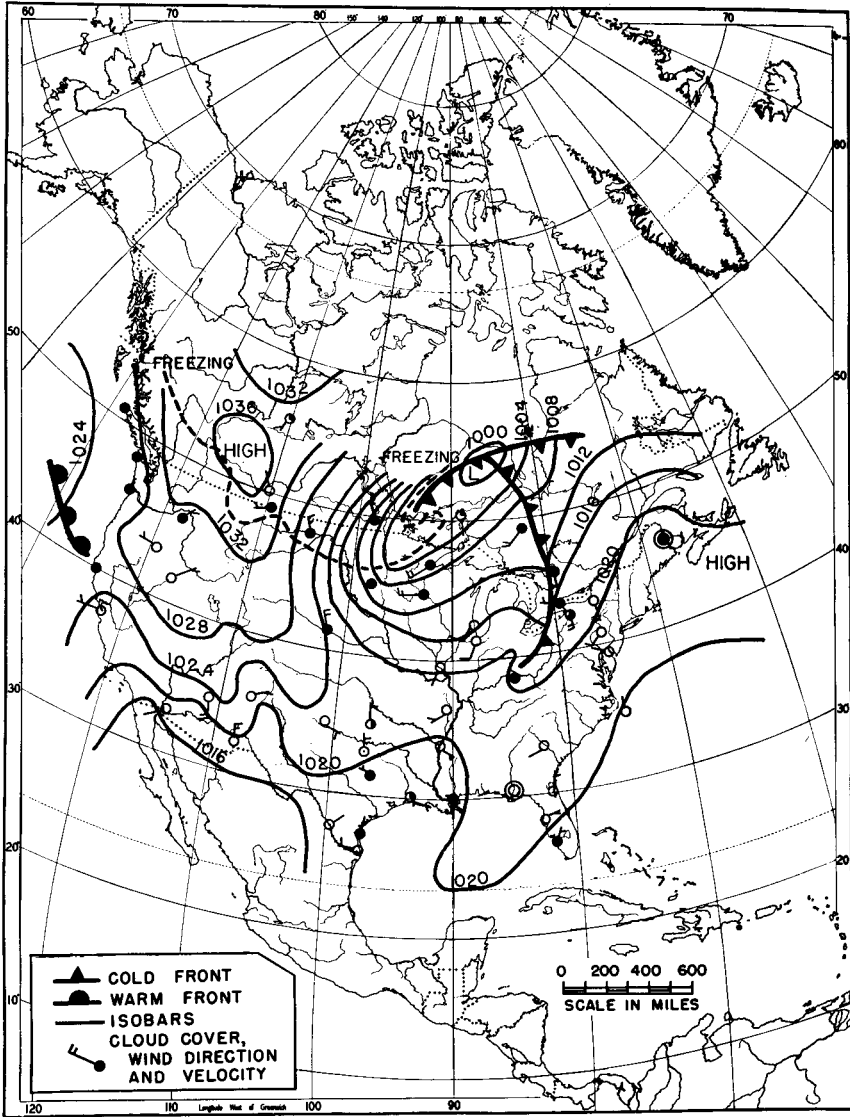


FIG. 4. Weather conditions as of 1:00 a.m. (C.S.T.), November 7, 1956, according to the United States Weather Bureau.

Daily weather records at Winnipeg, Manitoba, show (Fig. 5) that on November 5, 1956, the minimum temperature rose slightly but fell 6 degrees

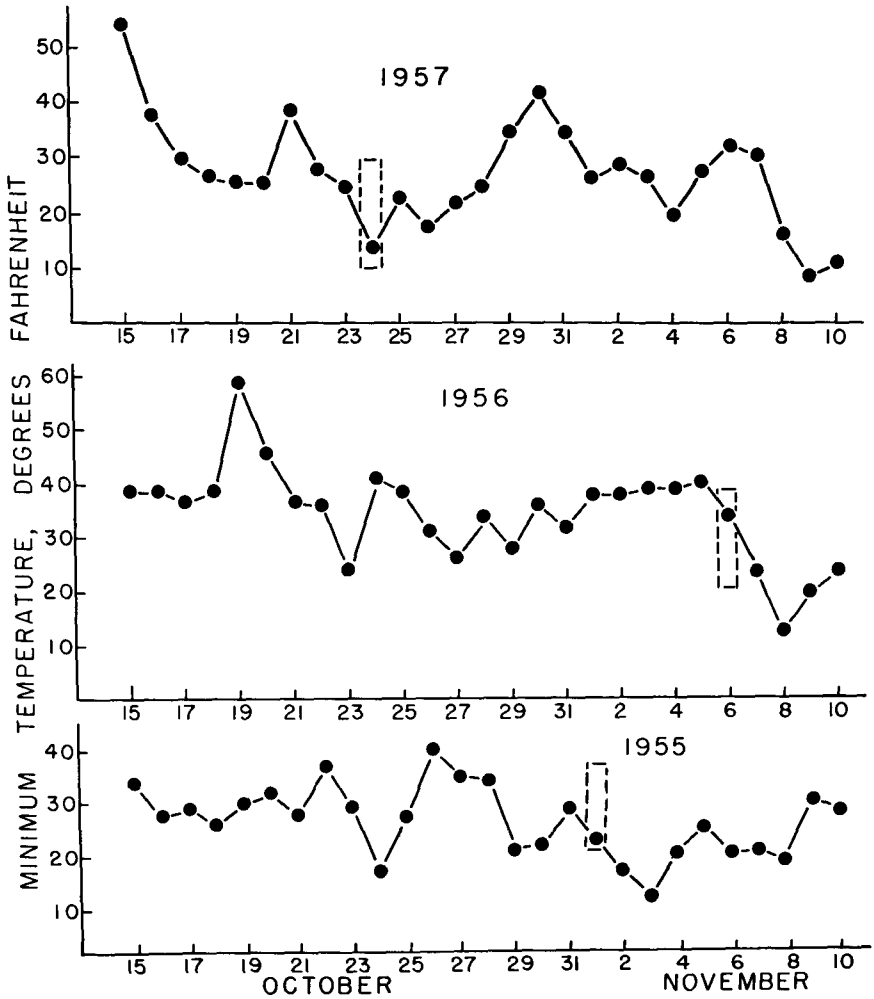


FIG. 5. The minimum daily temperature from October 15 through November 10, 1955-1957, at Winnipeg, Manitoba, Canada. Vertical bar designates day flight started from southern Manitoba.

on November 6, 8 degrees on November 7, and 11 degrees on November 8, when a low temperature of 13 degrees was reached. Daily weather records of Saskatoon, Saskatchewan, 450 miles northwest of Winnipeg, show (Fig. 6) that temperatures as low as 4 degrees above zero occurred there as early as October 29, followed by a slight warming trend on October 31, near zero on

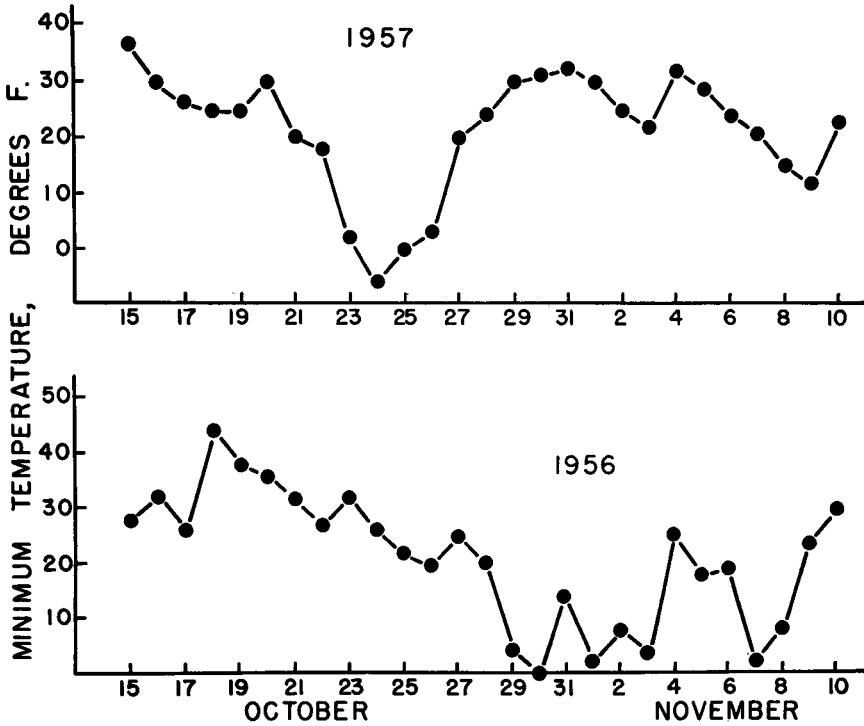


FIG. 6. The minimum daily temperatures from October 15 through November 10, 1956 and 1957, at Saskatoon, Saskatchewan, Canada.

November 1 and 2, a strong warming trend on November 4, 5, and 6, followed by a return of cold air on November 7.

Moderate flights of ducks which arrived in Illinois on October 31 and November 3 (not indicated by population data because of departure of other ducks, Fig. 2) were probably triggered by the cold air which penetrated the Saskatoon, Saskatchewan, area on October 29 and November 1. Because this cold air did not extend as far southeast as Winnipeg (Fig. 5), the bulk of the ducks which may have departed from the Saskatoon area at that time probably halted their migration north of the border.

They were then in position to become affected by the weather (produced by the low pressure area moving north from Iowa) which brought storm conditions to southern Manitoba and Saskatchewan on November 6 and 7. As indicated by temperature and wind changes at Winnipeg (Table 7), the flight probably started from this region about midnight on November 6, when

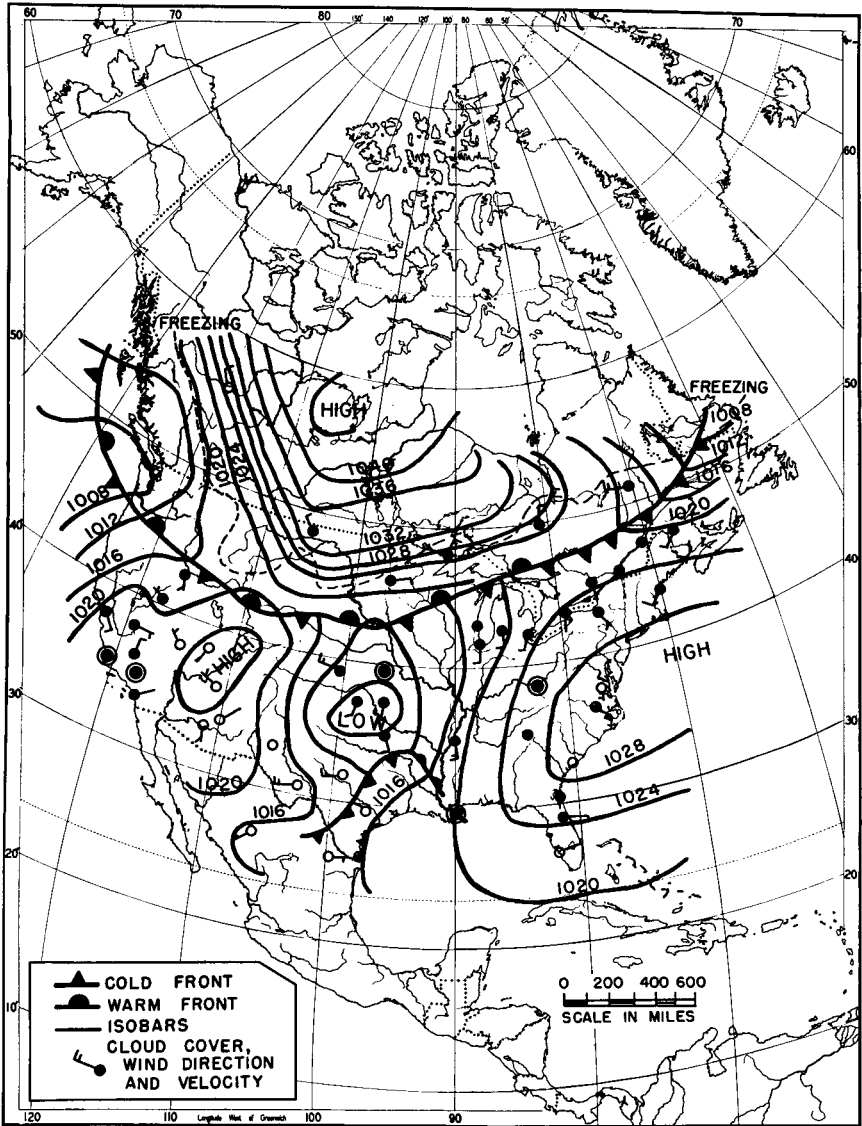


FIG. 7. Weather conditions as of 1:00 a.m. (C.S.T.), October 23, 1957, according to the United States Weather Bureau.

the wind shifted from north to northwest and increased in velocity. Temperatures fell slowly but steadily, reaching a low of 13 degrees at Winnipeg on November 7.

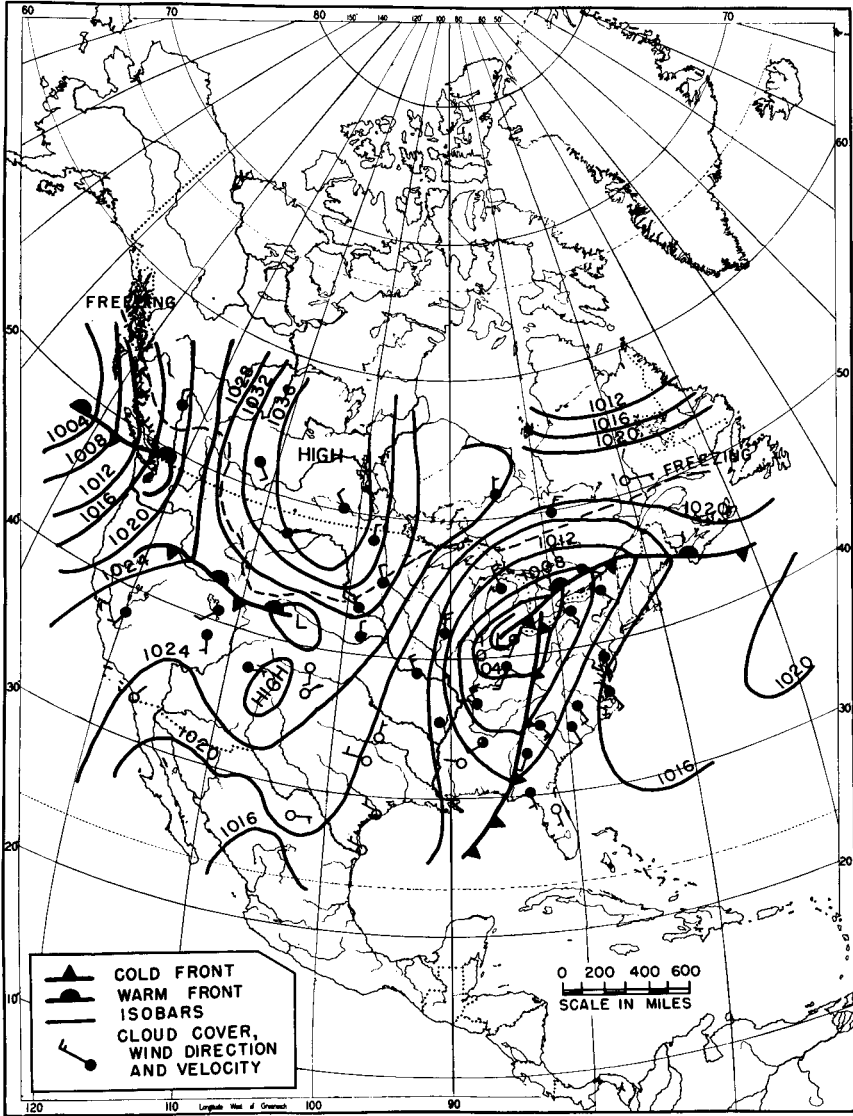


FIG. 8. Weather conditions as of 1:00 a.m. (C.S.T.), October 24, 1957, according to the United States Weather Bureau.

The 1957 grand passage started in western Saskatchewan about mid-day on October 22, in eastern Saskatchewan during the afternoon of October 23, and in Manitoba probably about midnight, October 23.

TABLE 7

WEATHER CONDITIONS¹ AT WINNIPEG, MANITOBA, NOVEMBER 6-7, 1956, AND OCTOBER 23-24, 1957

Hour of Day	1956		1956		1957		1957	
	November 6 Temp.	November 6 Wind	November 7 Temp.	November 7 Wind	October 23 Temp.	October 23 Wind	October 24 Temp.	October 24 Wind
1	38	S 26	31	NW27	28	NE18	25	NW17
3	37	S 25	28	NW25	27	NE17	26	NW 8
6	37	S 20	25	NW27	26	NE16	25	NW14
9	36	S 19	25	NW26	27	NE15	29	NW20
12	36	S 9	26	NW27	31	NE19	32	NW21
15	36	SW 7	27	NW25	27	NE19	36	NW19
18	36	N 8	26	NW24	26	NE17	30	NW14
21	35	N 16	25	NW13	27	NE16	26	NW14
24	33	NW24	17	W10	25	NE17	24	NW16

¹Temperature in degrees Fahrenheit; wind direction; and velocity in mph.

This flight of ducks from Canada started when a very large and strong high pressure area moved southeast from the Yukon Territory of Canada to northern Alberta, where it was centered at 6:00 a.m. (C.S.T.) on October 22. By 6:00 a.m. on October 23 (Fig. 7) the high pressure area had moved farther southeast to central Saskatchewan, and from there it moved slowly southward on October 24 (Fig. 8), reaching the United States-Canadian border by 6:00 a.m. on October 25.

A cold front moving south through Wyoming, South Dakota, Minnesota, and Wisconsin on October 22 stalled and partially disappeared on October 23, when a moderate low moved northeastward to Missouri, and on to Lake Ontario by October 24 (Fig. 8).

On October 22, snow fell most of the day in Alberta, southern Saskatchewan, southern Manitoba, and Montana; and rain fell in the northern plains states and in the Midwest. The entire northern Great Plains was under obscured or overcast skies. In that region winds were largely from the northeast and east at 15-25 mph.

Snow continued to fall through the morning of October 23 in southern Alberta, southern Saskatchewan, the southwest corner of Manitoba, and northern Montana. Snow showers occurred in North Dakota and rain fell through much of the Midwest. Skies were obscured or overcast through most of the northern Great Plains and the Midwest. In the Great Plains and north-central United States winds were mainly from the northeast at 15-25 mph, shifting to the north as the day progressed.

During the morning of October 24, snow continued to fall in North Dakota and scattered snow storms occurred in Minnesota and South Dakota. Skies became clear in the prairie provinces, and as the day progressed the clearing extended southward through North Dakota and Minnesota. Skies were largely overcast in the Midwest during the morning, and the overcasting increased as the day progressed. In Manitoba and Saskatchewan winds were largely westerly early in the day, shifting to northwest later in the day as the high pressure moved farther south in Saskatchewan.

The high pressure area, with its clockwise flow of air, began bringing continental arctic air into Alberta on October 21. This cold air mass moved into Saskatchewan and northern Montana on October 22, and into North Dakota during the afternoon of October 23. On October 24, the cold air mass moved to South Dakota and thence eastward to Wisconsin.

This cold air mass produced a similar sequence in temperature decline at both Saskatoon, Saskatchewan, and Winnipeg, Manitoba (Figs. 5 and 6). However, as might be expected, the temperature decline during the period of October 21–24 was more severe at Saskatoon than at Winnipeg. The -6°F . reported at Saskatoon was an unusually low temperature for the season.

Calculating the time of the waterfowl flight on October 24 from its appearance in the Midwest suggests that ducks may have started migrating from southern Manitoba about 1:00 a.m. on that date. About that time the wind shifted from northeast to northwest (Table 7). The temperature which had dropped 6 degrees since noon, remained at or near 25°F . through the early morning hours.

Effect of Weather on Mass Flights.—An analysis of weather conditions occurring at the time of the massed waterfowl flights on October 31–November 3, 1955 (Bellrose, 1957:21–24), November 6–8, 1956, and October 23–25, 1957, points to several similar and dissimilar weather conditions in association with the three flights.

Barometric Pressure.—Two massed waterfowl flights (1955 and 1956) occurred as a result of weather conditions associated with low pressure areas, and one massed flight (1957) was initiated by weather conditions produced by a high pressure area. It is difficult to assess the role of barometric pressure alone as a factor in triggering waterfowl flights. The low center passing through North Dakota on November 5, 1956, may have resulted in some ducks migrating in advance of storm conditions. Certainly, the peaks of the 1955 and 1956 massed flights were more directly associated with weather conditions than with low pressure, and the 1957 flight was definitely not the result of low pressure.

Atmospheric Conditions.—The massed flights in all three years were associated with overcast skies which prevailed over almost the entire north-

ern Great Plains and south through the Midwest. In the Midwest we observed massed flights in the daytime only under overcast skies.

For example, November 7, 1956, began as a clear day in Illinois. By 1:30 p.m., a solid overcast moved in from the northwest along the Mississippi River.

At 2:30 p.m., the front line of migrating ducks appeared, as previously described, at Muscatine, Iowa. Both the duck flight and overcast skies persisted until darkness. On other occasions we have observed duck flights to end shortly before or after the overcast passed regardless of the time of day.

All three flights originated when snow was falling extensively on the plains of Canada. Usually the snow had been falling for several hours, or longer, before the first migrating waterfowl were observed. The importance of snow as a factor in large scale waterfowl migrations is apparent in Nelson's and Dzubin's October, 1957, observations of the almost complete exodus of ducks from the snow belt south of Saskatoon, Saskatchewan, as opposed to ducks remaining in customary numbers north of there.

Observations made on the Pink-footed Goose (*Anser brachyrhynchus*) in central Iceland by Jones and Gillmor (1955:163) led them to conclude that snow was the most important factor in their fall departure. They stated: "The two departures in the two snows were forced departures. . . . The geese which left in the second snow were actually leaving on their migration to Britain. Some arrived the same day as they left, others the next day. . . . Temperature alone seems to have very little effect on geese."

Wind.—In the three massed duck flights studied, the wind was never unfavorable on the northern Great Plains when the migrations started. At the time of the November 1, 1955, flight winds were largely westerly through southern Manitoba and North Dakota (Bellrose, 1957: 15, 22); they were more northerly to the north and west of there. Although farther south in the Mississippi Flyway wind direction was flanking or adverse, winds in Manitoba and Saskatchewan, where a large part of the migration originated, were partially to fully favorable.

Early migrants on the November 6–8, 1956, movement experienced flanking winds for the most part. However, winds became exceedingly favorable by November 7, and it seems evident that the bulk of the flight developed with the shift in wind to the northwest (Table 7), which would provide a tail wind.

Again on the October 22–24, 1957, mass movement from the plains, winds were flanking in the early stages of the migration, but the winds shifted more and more to a favorable northwest direction as the day of October 24 progres-

sed. The bulk of the flight appears to have developed from Manitoba about the time the wind shifted from northeast to northwest (Table 7).

Wind apparently was a factor in reducing the magnitude of a waterfowl flight on October 24, 1955. About equally low temperatures prevailed on that same day in 1955 and 1957 (Fig. 3). Although there was a flight from the northern plains on October 24, 1955, it was much below the proportions of the one on October 24, 1957. One difference in the weather conditions was the wind, which on October 24, 1955, at Winnipeg, Manitoba, was light and from the west, southwest and south.

Temperature.—All three of the waterfowl flights under discussion occurred when temperatures were in the process of dropping to lows of 17° on November 2, 1955; 17° on November 7, 1956; and 24° on October 24, 1957, at Winnipeg, Manitoba (Fig. 5 and Table 7). Data recorded on weather maps indicate that temperatures on the southern plains of Saskatchewan dropped to similar minimums 12 to 24 hours ahead of Winnipeg on the occasion of all three duck flights. In 1956, temperatures dropped to seasonal lows at Saskatoon, Saskatchewan, several days ahead of the change at Winnipeg, but in the 1957 period temperature changes were similar in chronology at both cities.

Analysis of Weather Factors and Mass Migration.—Three spectacular waterfowl flights in as many years resulted from storm conditions on the northern Great Plains. The elements responsible for the storms were created by low pressure areas in two years and a high pressure area in one year.

The weather elements which appeared to contribute to these massed flights were: extensive overcast skies, falling snow, fairly strong winds which were partially or entirely favorable in the areas where the flights originated, and falling temperatures which in southern Manitoba declined at least to the low 20's. A cold front was involved in the 1955 massed flight, but not in those of 1956 and 1957.

SUMMARY

1. Spectacular waterfowl flights, sometimes referred to as "grand passages," occurred in the Mississippi Flyway on October 31–November 3, 1955; November 6–8, 1956; and October 23–25, 1957.
2. The massed waterfowl flight of 1955 was discussed in detail in an earlier paper; the present paper discusses the flights of 1956 and 1957, with particular emphasis on their passages through Iowa and Illinois.
3. Observers at numerous places from southern Manitoba to Louisiana reported the movements of waterfowl. The 1956 massed flight was first noted passing through southern Manitoba and in the vicinity of Bismarck, North Dakota, and Fergus Falls, Minnesota, during the morning of November 6.
4. The "leading edge" of one pulse of the flight reached Onawa, Iowa, on the Missouri River at 8:00 a.m., November 7, 1956, and Spirit Lake, Iowa, New Ulm and Minneapolis, Minnesota, at 9:00 a.m. Migrant flocks continued en masse

- over these points until the flight slackened appreciably at each location about 3:30 p.m.
5. Counts of flocks migrating in the region of Spirit Lake, Iowa, indicated a passage of 3083 ducks per hour from 9:30 to 10:30 a.m., and 4155 ducks per hour from 1:30 to 3:30 p.m.
 6. A "cross section" of the waterfowl passage on November 7, 1956, through northern Iowa was obtained by driving eastward from Spirit Lake to Osage, a distance of 128 miles. Ducks crossed this line of observation at the rate of 4260 birds per hour from 12:55-3:40 p.m.
 7. A cross section of the waterfowl passage through east-central Iowa was obtained from a light airplane. At the Mississippi River near Muscatine, Iowa, the "leading edge" of the flight appeared at 2:15 p.m., November 7, 1956. The waterfowl flight was observed as the plane took a zigzag course to Iowa City and thence south parallel to the Mississippi River to Argyle, Iowa, and eastward to Havana, Illinois. Ducks crossed the line of flight in Iowa at the rate of 2520 ducks per hour, and in Illinois at the rate of 996 ducks per hour.
 8. The vanguard of this massed flight arrived in Louisiana at noon on November 7, 1956, and continued for two days, bringing at least 1,200,000 ducks into that state.
 9. The 1957 grand passage of waterfowl began in western Saskatchewan on October 22, where it peaked that afternoon and the following morning; in eastern Saskatchewan the flight occurred largely during the afternoon of October 23; and at Delta, Manitoba, it took place largely on October 24.
 10. In North Dakota at the Lower Souris National Wildlife Refuge mass migration commenced at 7:30 a.m. on October 24, 1957, and continued strong until 10:00 a.m. It appeared at Swan Lake, Minnesota, at 8:00 a.m. and continued there to 2:30 p.m.
 11. A segment of the grand passage appeared on the Missouri River in western Iowa at 12:20 p.m. on October 23, 1957. However, farther east in Iowa the flight did not appear until October 24, reaching Spirit Lake at 9:10 a.m. It continued through the day, but the rate of flight was only 378 ducks per hour, about one-sixth of the magnitude of the 1956 flight.
 12. Although a few migrating ducks appeared in central Illinois at 1:00 p.m., October 24, 1957, the main body of migrants arrived at 4:45 p.m. and continued into the night. During the period it was estimated that 25,000 ducks passed the Chataouqua National Wildlife Refuge and a slightly larger number dropped into the lake.
 13. The 1955 grand passage of waterfowl resulted in an increase of 775,000 ducks in the Illinois River Valley; the 1956 grand passage resulted in an increase of 600,000 ducks; and the 1957 massed flight in an increase of 225,000 ducks in that area.
 14. A half-million ducks were estimated to have arrived in Louisiana on the night of October 24, and the day and night of October 25, 1957.
 15. Flight directions recorded during the spectacular flights of 1955, 1956, and 1957 were generally between south-southeast and southeast from the plains of Saskatchewan and Manitoba to Illinois. Certain water areas may serve a key role in altering direction of flight as indicated by flocks shifting from southeast to south when they arrived at the Mississippi River Valley.
 16. The waterfowl passage on November 7, 1956, was on a front more than 250 miles in length, extending from near Omaha, Nebraska, north-northeastwardly to Minneapolis, Minnesota, and probably in both directions beyond those points.

17. The mass migration of October 31–November 3, 1955, and October 23–October 25, 1957, progressed southward in the west ahead of the east in the Mississippi Flyway probably because migrations started from the western plains of Canada ahead of those from the eastern plains corresponding with weather impetus. Counts on November 7, 1956, indicate that the flight was much greater in the western segment than in the eastern segment of the Mississippi Flyway.
18. A series of observations during the grand passage of 1956 indicate a ground speed from 45–50 mph. Ducks leaving central Saskatchewan on the day of October 23, 1957, suggest a continuous flight to Louisiana, a distance of 1500 (± 200) miles for an average speed of 40 mph.
19. Arrivals in 1956 reached Illinois and Louisiana within a few hours of each other, strongly suggesting that the early arrivals in Louisiana flew 150–200 miles west of the Mississippi River, and were ahead of flight segments migrating farther east before they turned south.
20. The altitude of migrating ducks over the fields of Iowa and Illinois varied from 1500 to 2800 feet during the day. As darkness approached, flocks of ducks dropped lower to a minimum of 500 feet.
21. The weather responsible for the three massed duck flights was created by low pressure areas in two years and a high pressure area in one year. The weather elements associated with the flights were: extensive overcast skies, falling snow, fairly strong winds which were partially or entirely favorable in areas where the flights originated, and falling temperatures which in southern Manitoba declined to the low 20's.

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