SANDHILL CRANE STUDY IN THE CENTRAL FLYWAY

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

Special Scientific Report—Wildlife No. 113

United States Department of the Interior, Stewart L. Udall, *Secretary*
Stanley A. Cain, *Assistant Secretary for Fish and Wildlife and Parks*
Fish and Wildlife Service, Clarence F. Pautzke, *Commissioner*
Bureau of Sport Fisheries and Wildlife, John S. Gottschalk, *Director*

SANDHILL CRANE STUDY IN THE CENTRAL FLYWAY

By

Raymond J. Buller, Wildlife Biologist

Special Scientific Report--Wildlife No. 113
Washington • December 1967

CONTENTS

SANDHILL CRANE STUDY IN THE CENTRAL FLYWAY

By Raymond J. Buller, Wildlife Biologist

Abstract.–Fall-migrating sandhill cranes arrived at congregation sites in southern Canada and in the States of the Central Flyway between late July and early October. Sandhills peaked at about 100,000 birds at way stations in Saskatchewan during the fall of 1962. A similar peak was recorded at stateside way stations during the fall of 1964. Footprint measurements indicated that the lesser sandhill was by far the most numerous subspecies at way stations in Montana, North Dakota, South Dakota, and Colorado. These measurements also indicated that flocks stopping over in Wyoming, Kansas, and Oklahoma contained a significant number of the Canadian sandhill or the greater sandhill or both. A selective collecting program indicated that the footprint measurement technique overemphasized the incidence of the greater sandhill at way stations in North Dakota and South Dakota. Whooping cranes and sandhills were occasionally observed together during the early part of the fall migration. At times, fall-migrating sandhills fed on standing and harvested grain crops in Canada and in the States of the Central Flyway, but seldom were depredations considered serious.

Cranes (the family Gruidae) are protected internationally under the migratory bird conventions between the United States and Canada (1916) and between the United States and Mexico (1937). Hunting of migratory birds in the United States is regulated by the Migratory Bird Treaty Act (40 Stat. 755; 16 U.S.C. 703) which gives effect to the international treaties.

The treaty with Canada in 1916 listed "Gruidae or cranes, including little brown, sandhill, and whooping cranes." Subsequently, the little brown and sandhill cranes were shown to be subspecies of a single species (Oberholser, 1921), and it was shown also that there are intermediates between the lesser and greater subspecies. The "little brown crane" is now called the lesser sandhill crane and the "sandhill crane" is now called the greater sandhill crane. The intermediate population has been described and named the Canadian sandhill crane (Walkinshaw, 1965). Another subspecies in the United States, the Florida sandhill crane, is outside the concern of this report.

A general closed season was established on all cranes in the United States, May 20, 1916, and remained in effect until January 1, 1961, when a 30-day season was authorized on lesser sandhill (little brown) cranes in eastern New Mexico and western Texas. Sandhill cranes have been hunted in Mexico for years. During the fall of 1959, Saskatchewan farmers were permitted to shoot these birds under general crop depredation orders.

This report summarizes the results of the 4-year (1962–65) study designed to determine the feasibility of extending the hunting of lesser sandhill cranes to other States of the Central Flyway. An earlier paper summarized the results of the first 3 years of the study (Buller and Boeker, 1965).

This report is possible because of the efforts of many individuals throughout the Central Flyway who painstakingly collected data for the study. I am especially grateful to Alex Dzubin, W. R. Miller, and W. J. D. Stephen, Canadian Wildlife Service, for supplying data from the Prairie Provinces; to U.S. Game Management Agents W. Ashton Brann, Harry A. Jensen, David W. Fisher, R. E. Meyer, Loren J. Bonde, Charles R. Hayes, H. B. Lyman, and Alfred J. Robinson, Jr., for coordinating the study within their assigned districts; to Research Biologist Jerome H. Stoudt for collecting many of the cranes; and to numerous national wildlife refuge managers and State technicians for supplying fall migration and population data and footprint (midtoe) measurements.

HISTORY OF STUDY

For many years the Central Flyway Waterfowl Council requested an open season on sandhill cranes. In 1960, the National Flyway Waterfowl Council joined the Central Flyway Council in its request for consideration of a limited season on lesser sandhill cranes in the United States. The Saskatchewan Department of Natural Resources and the Canadian Wildlife Service recommended favorable consideration of the Councils' proposal. Studies by Aldrich and Burleigh (1958), Huey (1960), and Allen (1952) concluded that few, if any, greater sandhill cranes or whooping cranes occur in the proposed hunting area in eastern New Mexico and extreme western Texas. In view of these considerations, the Secretary of the Interior authorized the first hunting season on lesser sandhill cranes in these portions of New Mexico and Texas.

The first lesser sandhill crane season was held in eastern New Mexico, January 1 to 30, 1961. Texas was unable to participate at that time since cranes were not classed as game birds by State statute. This was followed by 30-day seasons in Alaska (September 1-30) and in New Mexico and West Texas (November 4-December 3) in 1961. Similar seasons have been authorized in succeeding years with minor changes. The area open to hunting in New Mexico and Texas was enlarged slightly, and the hunting period in Alaska was increased to 45 days during the 1964-65 waterfowl season. Residents of Saskatchewan and Manitoba have been permitted limited seasons on sandhill cranes each year since 1964.

Harvest data obtained during the 1961 lesser sandhill crane seasons in New Mexico and Texas (Boeker, Aldrich, and Huey, 1961; Boeker, Huey, and Uzzell, 1962) prompted the Central Flyway Waterfowl Council to request an enlargement of the hunting area at its August 1962 meeting. The resolution proposed that the Council and the Bureau explore the feasibility of extending the season to other States of the flyway. It was agreed that before this proposal could be accepted it would be necessary to firmly establish that enlargement of the hunting area would not jeopardize the endangered whooping cranes.[1]

These internationally famous birds have been sighted in Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Saskatchewan, and Alberta during fall migration. Sandhill cranes stop over in many of these same areas.

Another consideration of extending the range of the lesser sandhill crane hunting season concerned the incidence of the rare greater sandhill crane.[1] The greater race was present in collections of cranes made by T. D. Burleigh in the Horsehead Lake region of south-central North Dakota during the fall of 1959 and 1960. The possibility that this race may be present in other areas favored by fall-migrating lesser sandhills was also recognized.

OBJECTIVES

The objectives of this study were--

1. To determine the number, time of arrival, and departure of sandhill cranes throughout the Central Flyway (New Mexico and Texas excluded) during fall migration.

2. To locate the major congregation areas of sandhill cranes in the Central Flyway during the fall migration.

3. To determine the racial composition of sandhill crane flocks in the Central Flyway during the fall migration.

4. To correlate data concerning the fall migration of sandhill cranes and whooping cranes in the Central Flyway.

5. To locate and document crop depredations by sandhill cranes during the fall migration.

[1] The whooping crane is classed as endangered and the greater sandhill as rare in Rare and Endangered Fish and Wildlife of the United States, U.S. Bureau of Sport Fisheries and Wildlife, Resource Publication 34, July 1966.

PLAN OF STUDY

Standard waterfowl survey techniques were used to gather data for objectives 1, 2, 4, and 5. Information pertaining to the racial composition of fall-migrating cranes (objective 3) was obtained from a selective collecting program and a recently developed field technique which involves measuring footprint impressions.

In 1960 and 1961, 302 sandhill crane footprint measurements were obtained on Bitter Lake and Bosque del Apache National Wildlife Refuges in New Mexico (U.S. Bureau of Sport Fisheries and Wildlife, 1961). Measurements were made from the posterior edge of the ball of the foot to, but not including, the claw of the anterior end of the midtoe. At Bitter Lake, a known wintering area for sandhill cranes which are almost exclusively lessers, 160 measurements ranged from 76 mm. to 95 mm. in length and averaged 86.5 mm. At Bosque del Apache, a wintering area for sandhills which are predominantly greater, 142 measurements ranged from 100 mm. to 123 mm. and averaged 111 mm.

These data suggested that footprint measurements could be used to grossly separate the greater sandhill crane from the lesser race. But the Canadian race confounds the issue. Footprint measurements known to be from this race are not available. Consequently, the possibility exists that this subspecies is included with either the greater or the lesser race or both when they are separated on the basis of footprint measurements alone.

RESULTS OF STUDY

Fall migration

Fall-migrating sandhill cranes were observed at congregation areas (sometimes called way stations or stopover areas) in southern Canada and in the northern States of the flyway between late July and early October (fig. 1). Migration data indicated that first migrants are erratic and sometimes over-fly congregation sites in Saskatchewan en route to sites in McLean, Kidder, and Stutsman Counties, North Dakota. From there the migration proceeds in a more orderly fashion to the wintering grounds in New Mexico and Texas.

First arrivals reached congregation sites in Alberta, Saskatchewan, and Manitoba between early August and mid-September. Earliest observations of migrants reaching the Grassy Island-Gooseberry-Sound Lake region near Consort, Alberta, and the Kindersley District, Saskatchewan, occurred from late August to mid-September. They were preceded by migrants reaching the Last Mountain-Quill Lakes region of south-central Saskatchewan and the Big Grass Marsh area of Manitoba in the forepart of August. Fall migrants reached Montana and southeastern Wyoming 1 or 2 months later.

Migrating sandhills arrived in Kidder and Stutsman Counties and the Turtle Lake region of McLean County, North Dakota, between mid-July and mid-September. That segment of the population which used the Missouri River between Montana and the Nisson Bottoms east of Williston arrived the latter part of September.

Sandhill cranes arrived in the Pollock-Mobridge area of South Dakota about September 10 each year. The DeGrey area was used as a way station until it was inundated in 1964 by Big Bend Reservoir. Fall-migrating sandhills rarely stopped over in Nebraska.

First arrivals reached Prewitt Reservoir (Washington County), Bonny Reservoir (Yuma County), and the Arkansas Valley, Colorado, between mid-September and mid-October. Arrivals at Kirwin and Quivira National Wildlife Refuges, Kansas, and Salt Plains and Washita National Wildlife Refuges, Oklahoma, occurred between early October and late November.

In most instances the fall migration proceeds at a leisurely pace, and the numbers found at congregation sites build up over a period of several weeks. Sandhills depart Canadian way stations in mid-October. Departures from congregation sites within the States occurs throughout November and the forepart of December. The fall migration is sometimes hastened by late fall and early winter storms.

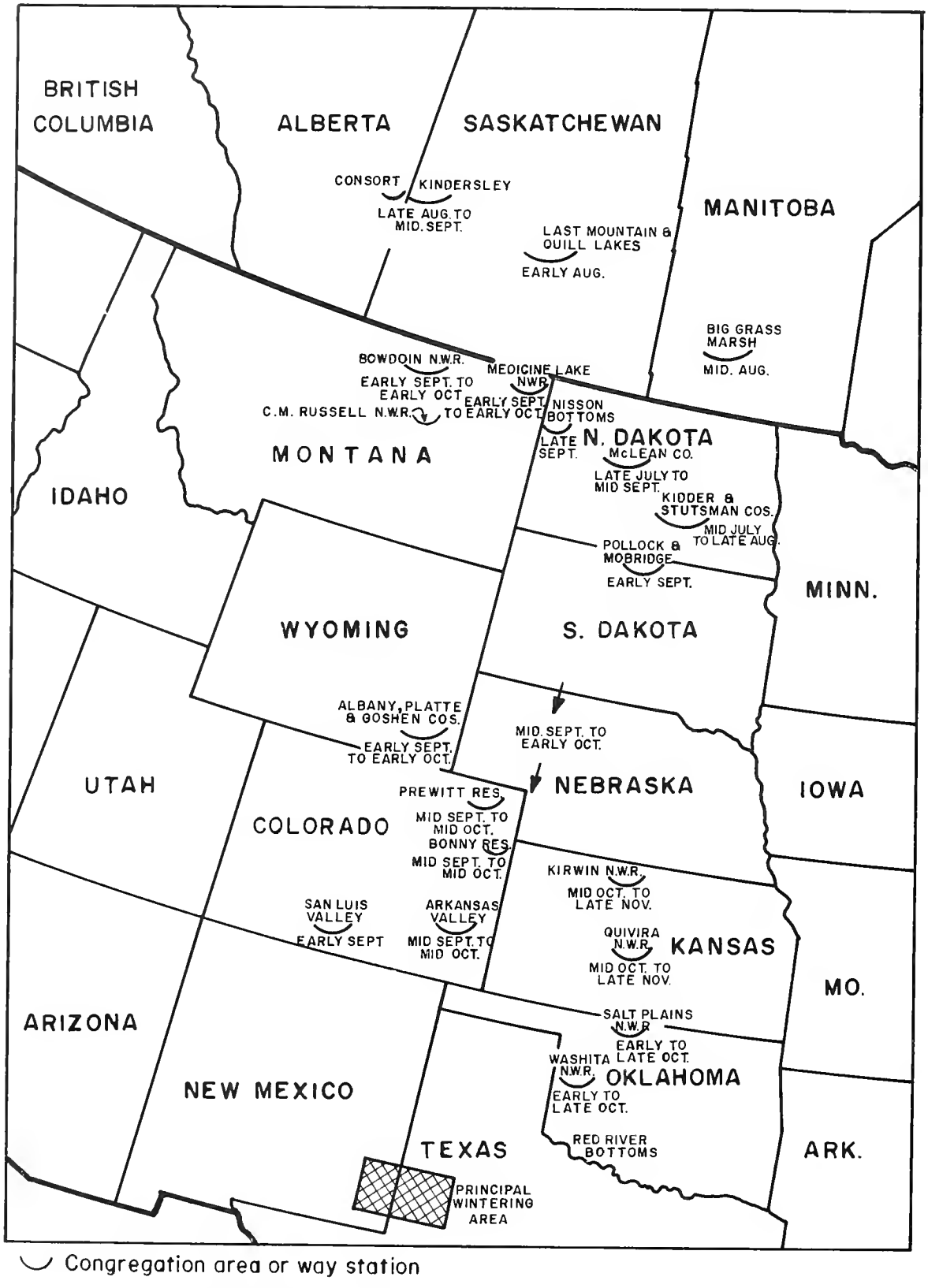

Figure 1.--Sandhill crane arrival dates at congregation sites, 1962-65.

Peak populations at congregation sites

Peak populations of sandhill cranes at fall congregation sites were recorded 3 to 8 weeks after the arrival of the first migrants (table 1). Peak numbers differed between years as did the period of use and length of stopover.

In 1962, an estimated 100,000 sandhills were recorded at the Saskatchewan congregation sites the last week of September. Peak numbers using the Last Mountain-Quill Lakes complex fluctuated between 7,000 in 1963 and 35,400 in 1965. Cranes using the Big Grass Marsh area of Manitoba ranged from 3,200 to 5,000 birds.

The greatest number of cranes stopping over in Kidder and Stutsman Counties, North Dakota, ranged between 8,000 and 16,000 birds. Sandhills using the McLean County way station peaked at 7,000 in 1964.

Migrating sandhills stopping off at way stations in Montana peaked at 5,000 to 17,500 birds. Departures in 1962 and 1963 ranged from early November to early December.

Similarly, Wyoming did not host large numbers of fall-migrating sandhills. Reservoirs in Albany, Platte, and Goshen Counties served as way stations for 1,600 to 6,000 birds.

Table 1.--Peak populations at fall congregation areas

Location	1962		1963		1964		1965	
	Date	Number	Date	Number	Date	Number	Date	Number
Alberta:								
Grassy Island	-	-	10/9	3,000	-	-	-	-
Saskatchewan:								
Kindersley District	9/23-29	50,000	9/25-10/2	13,000	-	-	-	-
Last Mtn.-Quill Lakes	9/23-29	25,000	10/11	7,000	-	-	9/6	35,415
So. Saskatchewan R.	9/23-29	25,000	-	-	-	-	-	-
Manitoba:								
Big Grass Marsh	-	3,200	9/5	4,000	9/3	5,000	9/28	4,420
Montana:								
Bowdoin NWR	11/9	4,500	10/20-26	5,000	10/8	3,000	10/11	5,000
Medicine Lake NWR	10/12-18	2,000	10/23	1,000	10/15	10,000	9/25	250
C. M. Russell NWR	-	-	-	-	10/11	4,500	-	-
North Dakota:								
Kidder & Stutsman Cos	10/20	8,000	10/12-22	12-15,000	10/5	16,000	10/20	14,000
McLean County	-	-	9/26	4,800	11/2	7,000	9/8	2,000
South Dakota:								
Mobridge-Pollock	10/28	11,000	10/30	12-18,000	10/17	9,500	-	3,500
Nebraska:								
Western portion	-	-	10/30	3,000	10/10	1,200	10/15	2,750
Wyoming:								
Southeastern portion	-	-	10/21	1,600	10/9	5-6,000	-	-
Colorado:								
Prewitt Reservoir	10/18	20,300	11/1	20,000	-	-	10/9	5,000
San Luis Valley	-	-	-	-	10/4	3,000	9/15	3,000
Arkansas Valley	-	-	10/20	2,000	10/12	500	10/17	1,000
Kansas:								
Kirwin NWR	-	-	11/7	250	-	-	-	-
Quivira NWR	-	-	11/6	810	10/6	1,850	-	-
Oklahoma:								
Washita NWR	-	-	12/6-14	7,000	11/25	15,000	10/16	3,000
Salt Plains NWR	-	-	11/6	2,000	10/20	7,900	10/9	2,600
Red River (Jackson Co.)	-	-	-	-	11/1-15	7,500	10/20	600
Cimarron River (Major Co.)	-	-	-	-	11/1-15	2,500	-	-

Fall migrants using the Mobridge-Pollock way station in South Dakota peaked at about 18,000 in 1963. In 1965, 3,500 birds was the greatest number recorded in that area.

Western Nebraska is not an important way station for fall-migrating sandhills. The peak number of birds stopping off ranged from 1,200 to 3,000, and then only for a few days.

Sandhills using Prewitt Reservoir, Colorado, peaked at about 20,000 birds in 1962 and 1963. In 1962, these birds stopped off for about 1 week, whereas the 1963 migration used this way station for about 4 weeks. The 1964 and 1965 fall migrations practically bypassed Prewitt Reservoir, with but 5,000 birds stopping overnight in 1965. Bonny Reservoir and the Arkansas Valley serve as way stations for smaller numbers (500 to 2,000) of migrating sandhills. Kansas way stations also host small numbers of cranes.

Congregation sites in Oklahoma were used both as way stations and wintering areas by various segments of the migrating population. In 1963 and 1965, the sites were used primarily as way stations, and the population peaked at 2,000 to 7,000 birds. Aerial surveys conducted between October 1964 and January 1965 indicated that the population peaked at about 30,000 in early November (Gilliam, 1966). During the last 2 weeks of December 1964, 14,000 cranes were counted in western Oklahoma. Of these birds, 4,000 wintered on Washita National Wildlife Refuge.

Population surveys which were conducted 1 to 2 days before the season in those portions of New Mexico and Texas open to the hunting of lesser sandhill cranes indicated a population ranging from 185,000 to 214,000 birds in late October, 1962 through 1965.

Racial composition of migrating sandhill cranes

A total of 3,981 sandhill crane footprints (midtoe) were measured as an aid to determining the racial composition. These were obtained on refuges, lakes, reservoirs, sloughs, sandbars, mud flats, and grainfields within the areas of greatest use (table 2). These measurements indicate that the cranes[2] using the principal way stations in the Central Flyway have the following composition:

Bowdoin National Wildlife Refuge and vicinity, Montana (294 measurements): 73% lesser; 27% greater.

Kidder and Stutsman Counties, North Dakota (960 measurements): 86% lesser; 14% greater.

McLean County, North Dakota (279 measurements): 92% lesser; 8% greater.

Campbell and Walworth Counties, South Dakota (726 measurements): 97% lesser; 3% greater.

Goshen County, Wyoming (157 measurements): 59% lesser; 41% greater.

Prewitt Reservoir, Colorado (550 measurements): 100% lesser.

Arkansas Valley, Colorado (147 measurements): 92% lesser; 8% greater.

Kirwin and Quivira Refuges, Kansas (347 measurements): 50% lesser; 50% greater.

Washita Refuge, Oklahoma (200 measurements): 68% lesser; 32% greater.

Salt Plains Refuge, Oklahoma (137 measurements): 50% lesser; 50% greater.

Red River bottoms, Oklahoma (142 measurements): 77% lesser; 23% greater.

Measurements obtained during August, September, and October in Kidder and Stutsman Counties, North Dakota, were analyzed to determine whether the races of sandhill cranes show different migration patterns. Of 277 measurements obtained in August and September, 18% fell within the range of the greater race; of 683 obtained in October, 13% fell within the range of this race. This indicates that the sandhill crane population that occurs in Kidder and Stutsman Counties during October may contain fewer greaters than the August and September population.

[2] The number of Canadian sandhills that may be included in these measurements is unknown.

Table 2.--Sandhill crane footprint measurements at fall congregation areas

Location	Date	Assumed to be--					
		Lesser sandhills			Greater sandhills		
		Number	Range in mm.	Average in mm.	Number	Range in mm.	Average in mm.
Montana:							
Bowdoin NWR	Oct. 1963	56	80-95	90.7	78	96-116	103.3
10 mi. S. Bowdoin NWR	Oct. 1965	158	71-91	81.6	2	96	96.0
North Dakota:							
Kidder & Stutsman Cos.	Oct. 1962	262	74-95	85.8	23	96-103	101.8
Do	Sept. 1963	91	71-95	86.3	12	96-105	98.9
Do	Oct. 1963	261	71-95	86.1	32	96-103	100.4
Do	Aug. 1964	7	76-91	84.4	1	97	97.0
Do	Sept. 1964	129	63-95	82.6	37	96-110	100.2
Do	Oct. 1964	74	72-95	88.8	31	96-103	98.7
McLean County	Sept. 1964	136	68-95	85.1	17	96-104	99.2
Do	Oct. 1964	105	73-90	82.6	5	97-99	98.6
Do	Fall 1964	15	78-92	85.9	1	100	100.0
South Dakota:							
Campbell & Walworth Cos.	Sept. 1962	112	68-92	80.5	-	-	-
Do	Oct. 1963	243	68-95	82.5	12	96-103	100.6
Do	Nov. 1963	63	74-95	86.3	2	98	98.0
Do	Sept. 1964	17	73-93	85.9	3	96-98	96.6
Do	Oct. 1964	268	68-95	85.7	6	96-100	97.1
Wyoming:							
Goshen County	Oct. 1963	47	70-95	87.1	3	98	98.0
Do	Oct. 1964	45	87-95	92.6	62	96-115	101.1
Colorado:							
San Luis Valley	Oct. 1962	-	-	-	42	95-113	102.3
Prewitt Reservoir	Oct. 1962	100	74-95	85.4	-	-	-
Do	Oct. 1963	300	72-95	85.6	-	-	-
Arkansas Valley	Nov. 1963	135	59-95	84.5	12	96-104	99.8
Prewitt Reservoir	Oct. 1964	100	74-95	85.0	-	-	-
Do	Oct. 1965	50	74-97	85.0	-	-	-
Kansas:							
Phillips County	Nov. 1963	20	74-94	89.6	89	96-114	102.2
Stafford County	Oct. & Nov. 1964	154	81-95	91.2	84	96-106	98.6
Oklahoma:							
Custer County	Nov. 1963	93	73-95	87.8	7	96-98	96.7
Do	Dec. 1964	43	85-95	92.2	57	96-112	100.1
Jackson County	Fall 1964	31	81-95		7	96-128	
Alfalfa County	Oct. & Nov. 1965	69	80-95	90.0	68	95-119	100.4
Jackson County	Nov. 1965	78	76-95	89.0	26	95-130	104.0

The possibility that the footprint measurement of juvenile greater sandhills might fall within the range of those of the lesser was also investigated, since this could render the footprint measurement technique invalid for separating races. At Monte Vista National Wildlife Refuge, Colorado, midtoe measurements were obtained from 11 greater sandhills hatched from eggs gathered at Malheur National Wildlife Refuge, Oregon. Measurements obtained at 49 to 57 days of age ranged from 97 to 108 mm. (average 103.6 mm.). At 79 to 88 days of age, the measurements ranged from 98 to 112 mm. and averaged 106.4 mm. (Knoder, 1964). It was concluded, therefore, that the footprint measurement technique can be used to grossly distinguish juvenile as well as adult greater sandhill cranes from lesser sandhills.

Stephen, Miller, and Hatfield (1966) concluded that there was too much overlap in the measurements (mean weights and mean values for total length, tarsus, midtoe, bill, and culmen) between adult females and adult males taken at Last Mountain Lake, Saskatchewan, to make these values useful in sex determination. Moreover, they concluded that sex differentiation was essential for taxonomic purposes. I agree that sex determination as well as diagnostic measurements are desirable

for classification purposes, but this in no way detracts from the fact that midtoe measurements provide a usable field technique for the gross separation of greater and lesser sandhill cranes. This contention is supported by the midtoe measurements obtained at Monte Vista, Bosque del Apache, and Bitter Lake Refuges.

Data on the racial composition of fall-migrating sandhill cranes are also available from a selective collecting program during and preceding the study. Birds were collected with a high-powered rifle equipped with a telescopic sight, and the collector was instructed to take only the "larger-appearing birds." Therefore, the birds collected during the study do not represent a random sample of the population. This selective technique probably resulted in the collection of proportionately more greater sandhills than normally occur in this population.

Because of these collections, the diagnostic characters (sex, weight, age, and measurements--wing chord, tarsus, midtoe, and culmen) of 93 birds were made available for racial determination purposes (table 3). Eighty-eight birds were collected during the study, and five were illegally killed. They were distributed as follows: North Dakota, 61 in Kidder, Stutsman, McLean, and Ramsey Counties; South Dakota, 22 from the Pollock-Mobridge area; Oklahoma, 4 from Washita National Wildlife Refuge and 3 confiscated from goose hunters in the vicinity of Salt Plains National Wildlife Refuge; Colorado, 3 from Prewitt Reservoir. Thirty-three of the birds from Kidder and Stutsman Counties, North Dakota, were collected in 1965 for a food habits study (Madsen, 1966).

Racial determinations made by Dr. John W. Aldrich, Staff Specialist of the Bureau, indicate that of birds from Kidder and Stutsman Counties

Table 3.--Racial composition of large sandhill cranes, selectively collected, 1962-65

State and area	Date	Racial composition			
		Lesser	Canadian	Greater	Unclassified
North Dakota:					
Kidder-Stutsman Cos.	10/16-19/63	4	1	2	-
Do.	9/8-12/64	-	4	-	[1] 1
Do.	10/19-23/64	-	4	-	-
McLean County	9/23-24/64	4	1	-	-
Do.	10/21/64	4	1	-	-
Devils Lake, Benson Co.	10/2-3/64	-	1	1	-
Kidder County	9/22/65	1	7	-	-
Do.	10/3-29/65	3	20	-	-
Do.	11/2/65	-	2	-	-
Subtotal	-	16	41	3	1
South Dakota:					
Mobridge	9/26-10/5/62	3	-	-	[2] 2
Pollock	10/14-18/63	6	1	-	-
Do.	9/11/64	2	3	-	-
Do.	10/22/64	4	1	-	-
Subtotal	-	15	5	0	2
Colorado:					
Prewitt Reservoir	10/10/65	3	-	-	-
Oklahoma:					
Salt Plains NWR	10/10/64	3	-	-	-
Washita NWR	10/28-11/18/65	-	2	2	-
Total	-	37	48	5	3

[1] Typical greater if female; questionable greater if male.
[2] Body condition did not permit distinction between Canadian and greater races.

8 were typical lessers, 38 were Canadian sandhills, 2 were greaters, and 1 was a questionable greater. Of 10 birds collected in McLean County, 8 were judged to be lessers and the other 2 were Canadian sandhills. The Ramsey County birds were identified as a Canadian and a greater. Of the cranes taken in South Dakota, 15 were lessers, five were Canadian sandhills, and 2 could not be classified, because of body condition. Oklahoma birds were identified as follows: Salt Plains Refuge, 3 lessers; Washita Refuge, 2 Canadians and 2 greaters. The Colorado birds were judged to be lessers.

Of 13 sandhills collected between October 27 and November 3, 1959, by T. D. Burleigh in Kidder and Stutsman Counties, North Dakota, 9 were identified as lessers, 3 were judged to be Canadians, and 1 was a greater. Of 12 taken by T. D. Burleigh in this area September 9-12, 1960, 10 were identified as Canadians, and 2 were greaters.

Footprint measurements obtained in September indicate that the flocks found in North Dakota at this time may contain fewer lessers. This is supported by the collection program during the study and the collections by T. D. Burleigh in 1959 and 1960, which suggest that the lesser race is more numerous in October than in September, whereas the greater race is more numerous earlier in the season.

Of the sandhills that were selectively collected during the study, 5 were identified as greaters, 48 were judged to represent the Canadian race, and 37 were lesser sandhills. The condition of 2 birds did not permit clear distinction between the greater and Canadian races, and another was placed in a questionable greater category because its sex organs were destroyed when it was collected.

Correlation of the fall migration of sandhill and whooping cranes in the Central Flyway

The most important consideration in extending the lesser sandhill crane season to States other than New Mexico and Texas is the possibility of jeopardizing the endangered whooping crane. To resolve this problem, all reported sightings of fall-migrating whooping cranes (table 4) were checked for authenticity and correlated with the sandhill migration.

Five verified, three probable, and four unconfirmed sightings of whooping cranes were recorded between August 23 and November 30, 1962 (Boeker, 1963). One verified report was received during the fall of 1963. Seven verified and three probable sightings were received between the dates of September 11 and November 3, 1964. Four verified and five unconfirmed sightings were received between September 26 and November 18, 1965. The location of these sightings and the verified and probable sightings of migrating whooping cranes during the fall of 1959, 1960, and 1961 (Boeker, 1960, 1961, and 1962) are shown in figure 2. The principal congregation areas used by migrating sandhill cranes are included.

Figure 2 shows that several congregation sites or way stations are used by both whooping cranes and sandhill cranes, and these species occurred simultaneously at several of the way stations. Following are the way stations used by all species and the dates of the earliest and latest observations of whooping cranes from 1959 through 1965:

Last Mountain Lake-Quill Lakes, Saskatchewan--September 15 and October 20.

Medicine Lake Refuge, Montana--September 26 and October 18.

Missouri River near Williston, North Dakota--October 18-26.

McLean County, North Dakota--September 21 and November 1.

Kidder and Stutsman Counties, North Dakota--September 22 and October 4.

Mobridge-Pollock area, South Dakota--September 11 and October 7.

Kirwin and Quivira Refuges, Kansas--October 19 and November 1.

Salt Plains Refuge, Oklahoma--September 26 and November 8.

Table 4.--Dates and locations of reported sightings of whooping cranes during the fall of 1962, 1963, 1964, and 1965

Date	Location	Cranes	Nature of report
1962			
Aug. 23	Meath Park, Saskatchewan	4	Probable.
Sept. 21	Snake Creek NWR, N. Dak.	1	Verified.
30	Hampden, Ramsey Co., N. Dak.	1	Unconfirmed.
Oct. 4	Eldridge, Stutsman Co., N. Dak.	2	Probable.
10	Lenore Lake, Saskatchewan	7	Probable.
17	Chappell, Deuel Co., Nebr.	6	Unconfirmed.
18	Williston, McKenzie Co., N. Dak.	8	Verified.
19	Garden City, Finney Co., Kansas	9	Unconfirmed.
20	Hill City, Graham Co., Kans.	1	Verified.
20	Concordia, Cloud Co., Kans.	2	Verified.
26	Williston, McKenzie Co., N. Dak.	4	Verified.
Nov. 26	Bevaria, Saline Co., Kans.	3	Unconfirmed.
30	Dover, Shawnee Co., Kans.	3	Unconfirmed.
1963			
Oct. 19	10 mi. SE of Williston, N. Dak.	3	Verified.
1964			
April 18	4 mi. N. of Huron, S. Dak.	5	Verified.
Sept. 11-12	Pollock, Campbell Co., S. Dak.	2	Verified.
Oct. 2-17	Des Lacs NWR, N. Dak.	3	Probable.
6	Salt Plains NWR, Okla.	1	Verified.
23-27	Lake McConaughy, Nebr.	4	Verified.
25	10 mi. N. of Mandan, N. Dak.	3	Probable.
31	Kirwin NWR, Kans.	3	Verified.
Nov. 1	Vicinity Snake Creek NWR, N. Dak.	6	Probable.
3-8	Quivira NWR, Kans.	3	Verified.
3-8	Salt Plains NWR, Okla.	3	Verified.
1965			
Sept. 26	Medicine Lake NWR, Mont.	3	Verified.
26	Vicinity Long Lake NWR, N. Dak.	1	Unconfirmed.
26-30	Vicinity Salt Plains NWR, Okla.	?	Unconfirmed.
Oct. 15-18	20 mi. SE Medicine Lake NWR, Mont.	3	Verified.
18	13 mi. N, 3 mi. W Alliance, Nebr.	1	Unconfirmed.
19-20	12 mi. N, 5 mi. E, Bassett, Nebr.	3	Unconfirmed.
30	Kirwin NWR, Kans.	2	Unconfirmed.
31	Quivira NWR, Kans.	3	Verified.
Nov. 16-18	Vicinity Panhandle, Carson Co., Tex.	3	Verified.

Fall-migrating whooping cranes have been observed at several sandhill crane way stations since 1833. Allen (1952) reported the earliest and latest observations at sandhill crane congregation sites in Saskatchewan, North Dakota, and Kansas thus:

Last Mountain Lake-Quill Lakes, Saskatchewan--Fall and November 3.

Missouri River near Williston, North Dakota--September 22.

McLean County, North Dakota--September.

Kidder and Stutsman Counties, North Dakota--September 1 and October 25.

Stafford County (Quivira Refuge), Kansas--Fall and October 26.

Allen's tabulation includes three historical records of whooping cranes in the vicinity of the Mobridge-Pollock, South Dakota, sandhill crane way station. He cited two from Edmunds County immediately east of Walworth County. One is a museum specimen taken October 19, 1883, and one was a bird which was killed in September 1885. The third bird, from near

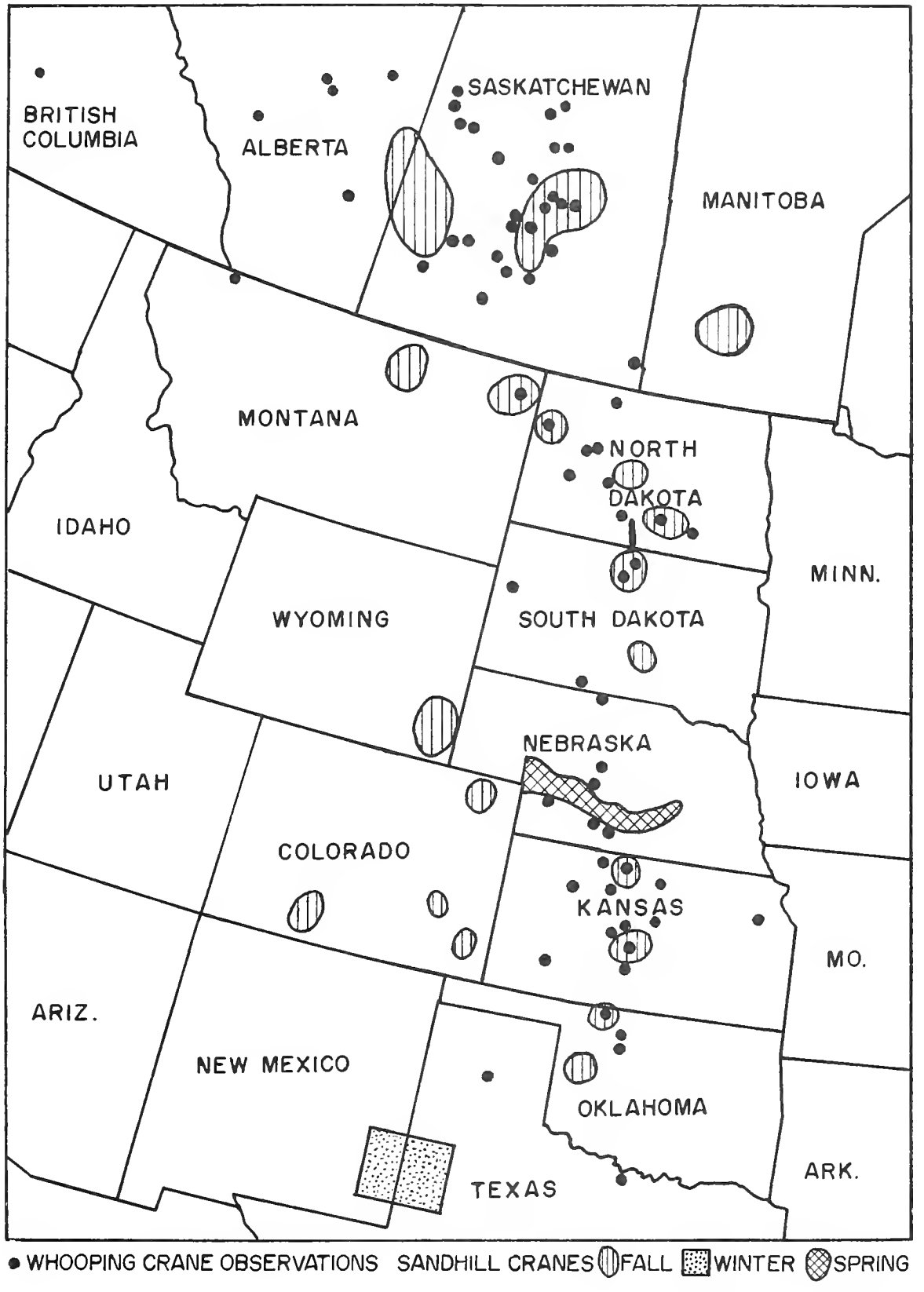

Figure 2.--Location of verified and probable sightings of fall migrating whooping cranes, 1959-65, and sandhill crane congregation areas, 1962-65.

Mobridge, is also a museum specimen, but the date it was taken is lacking. Other historical fall records of whooping cranes in South Dakota occurred in September and October 1889 and 1890, and September and November 1891; however, these were in Douglas County which is about 200 miles southeast of the Mobridge-Pollock way station.

Allen's historical records do not show fall-migrating whooping cranes from or near the present day Medicine Lake Refuge, Montana, or Salt Plains Refuge, Oklahoma.

Sandhill crane congregation areas lying entirely outside the historical and the 1959-65 fall migration route of whooping cranes include those on or in the vicinity of Bowdoin Refuge, Montana; Albany, Goshen, and Platte Counties, Wyoming; and the San Luis Valley, Colorado.

Two of the Colorado sandhill crane way stations--Prewitt and Bonny Reservoirs--are 50-100 miles north, and another, the Arkansas Valley, is 40-50 miles south of a historical fall whooping crane sighting. This observation occurred October 13-17, 1941, on the Kit Carson Refuge, Cheyenne County, which was abandoned in 1952.

Crop depredations by sandhill cranes

Recording crop depredations by cranes was an objective of the coordinated study. Sandhill crane depredations on grain crops have previously been documented by Smith and Boeker (1958), Timmerman (1958), Munro (1950), Linduska (1949), Sperry (1939), Sooter (1943), Nelson (1961), and Mackay (1962). In 1959, Saskatchewan farmers were permitted to shoot sandhill cranes in the vicinity of Last Mountain Lake under general crop depredation orders. The 1961 experimental crane season in New Mexico and Texas was authorized to alleviate crop depredations in Saskatchewan and the northern States of the flyway by reducing the size of the crane population. The New Mexico and Texas seasons were followed by limited seasons in Saskatchewan and Manitoba beginning in 1964.

In 1962, a mail questionnaire survey, which was conducted throughout the Prairie Provinces of Alberta, Saskatchewan, and Manitoba, showed that sandhill cranes fed on standing and harvested cereal crops in the Kindersley, Last Mountain-Quill Lakes, and Big Grass Marsh areas (Stephen, 1967). Sandhill cranes fed on grain crops in the Kidder-Stutsman County area of North Dakota, but the nature and extent of the depredations were not learned. It was also reported that no depredation control was practiced by farmers during the goose season in this area, since these control activities have a dispersing effect upon the geese. Approximately 30 farmers reported moderate to heavy crane depredations on corn, sorghum, and winter wheat and rye in the Mobridge-Pollock area, South Dakota.

Crop depredations by cranes in Canada during the 1963 fall migration were again localized in the Last Mountain Lake-Quill Lakes area. The lack of depredation complaints in the U.S. was attributed to mild, clear weather which permitted farmers to harvest their crops before the peak of the fall migration. One complaint of crop depredations by cranes was registered in the San Luis Valley, Colorado.

In 1964, no complaints of crop depredations by cranes were registered in the flyway. Cranes were reported to have fed on swathed grain in Kidder and Stutsman Counties, North Dakota. A killing frost in early September caused farmers to "chop" their corn for silage. A late August frost and a dry fall accelerated the grain harvest in South Dakota. Cranes stopping off in the Mobridge-Pollock area fed in cornfields containing livestock. In Kansas, sandhill cranes were observed to feed occasionally in winter wheatfields, but no depredation complaints were registered. In Oklahoma, several complaints of damage to winter wheatfields were registered in the vicinity of Washita National Wildlife Refuge. Scarecrows were effective in controlling depredations.

Several complaints of depredations on swathed wheat were registered in the Horsehead Lake area of Kidder County, North Dakota, in 1965. A permit was issued to combat crane depredations on cereal grains in the San Luis Valley of Colorado. In Oklahoma, one complaint of damage to sprouting winter wheat in the vicinity of Washita Refuge was registered, but a storm caused the birds to migrate before depredations became serious.

Sandhill cranes sometimes feed in standing or harvested cereal grains and sprouting winter wheat. Because of harvest practices, crop depredations by sandhills are more extensive in Canada than in the States of the Central Flyway. In the States, depredations are related to weather conditions before and during the harvest period. Depredations are negligible during years of mild, clear weather which permits farmers to harvest their crops before the peak of sandhill crane migration. Stephen (1967) reported that a measure of control over crane damage at Last Mountain Lake, Saskatchewan, was achieved by the use of acetylene exploders and lure crops. Too, the number and frequency of complaints arising from crane damage in eastern New Mexico and west Texas have decreased since crane hunting was permitted in 1961. Scarecrows effectively controlled depredations on winter wheat in Oklahoma. Complaints received during this study indicate that crop depredations were common throughout the Central Flyway, but were not a major problem anywhere.

MANAGEMENT IMPLICATIONS OF STUDY

This study resulted from a proposal that the Central Flyway Waterfowl Council and the Bureau study the feasibility of extending the hunting of sandhill cranes to States of the flyway other than where the hunting of these birds is now permitted. It was recognized that a decision to extend the sandhill crane season should be governed primarily by (1) its effect on whooping cranes during the fall migration, and (2) the racial or species composition of sandhill cranes using the principal fall congregation sites.

One of the most important considerations in extending the hunting of lesser sandhills concerns the endangered whooping crane, and its population status need not be reviewed here. Any extension of the hunting season should include provisions to insure that not one whooper is lost because of a crane season in the United States.

The second consideration concerns the relatively rare greater sandhill crane. As recently as 10 years ago, it was believed that the western segment of the greater sandhill crane population numbered about 1,700 birds. Sandhill cranes wintering on Bosque del Apache National Wildlife Refuge, New Mexico, numbered 5,500 birds on December 11, 1964, and these are believed to represent the greater race predominately. Although the western population of greater sandhills is larger than earlier information indicated, the incidence of the greater race at the principal congregation sites used by fall-migrating sandhill cranes was an important facet of the study.

Whooping cranes

The fall migration of the whooping crane is sometimes coincident with that of the early migrating sandhills, and during the past 7 years (1959-65) whooping cranes have been observed at sandhill congregation sites in Saskatchewan, northeastern Montana, North Dakota, South Dakota, Kansas, and northern Oklahoma. No whooping cranes have been observed during the past 7 years at sandhill crane congregation areas in north-central Montana, southeastern Wyoming, eastern Colorado, or western Oklahoma.

During the 1959-65 period, whooping cranes were observed coincidently with sandhill cranes in Kidder and Stutsman Counties, North Dakota, between September 22 and October 4, and McLean County between September 21 and November 1. Similar sightings were made in the Mobridge-Pollock area, South Dakota, between September 11 and October 7. Sightings were made at Salt Plains National Wildlife Refuge, Oklahoma, between September 26 and November 8. If it can be assumed that the latest sighting dates represent the final appearance of fall-migrating whooping cranes, it is also reasonable to assume that sandhill crane hunting seasons in these areas of concurrent use held after these dates would not jeopardize the whooping crane. A delay of 1 to 2 weeks would serve to safeguard any whooping cranes that do not follow the migration pattern exhibited during the 1959-65 period.

Historical records as well as recent records of fall-migrating whooping cranes are frequently cited when sandhill crane hunting seasons are being considered. Such records may

be used to deny hunting seasons, while the lack of historical whooping crane observations are often cited as justification for sandhill hunting seasons. Historical whooping crane records are of limited value since the birds these observations represent disappeared from the population 25-50 years ago, and changes in habitat have reduced the attractiveness of many of the areas formerly used as rest stops. Recent records of fall-migrating whooping cranes can be misleading, for it is obvious that (1) all the whooping cranes are not observed during the annual fall migration, and (2) all the rest stops made by fall-migrating whooping cranes are not recorded.

From 1959 through 1965, the first fall-migrating whooping cranes to reach their wintering grounds (Aransas National Wildlife Refuge) arrived between October 9 and 30. During the 1940-58 period, the earliest "first" arrivals reached the refuge October 4 (1949). The latest date whooping cranes were first recorded during this period was November 11 (1946); however, this cannot be considered an arrival date because road conditions prevented earlier observations.[3]

The fall migration of the whooping crane is reasonably predictable. The big cranes and their young usually begin their trip from the breeding grounds in late September. Adults with young make frequent rest stops of one or more days, whereas adults without young make longer flights with shorter rest stops. Allen (1952) described the flight from the breeding grounds to winter quarters thus: "The fall migration . . . appears to develop in successive 'waves,' single birds and pairs without young migrating in the first two or three waves, followed by the family groups at a later date. Family groups containing young-of-the-year apparently leave their nesting region by late September and the Provinces between October 1 and 10."

[3] As this report was being readied for publication, reports on the 1967 fall migration of whooping cranes showed the following: Three whooping cranes (2 adults and 1 young) were on Medicine Lake National Wildlife Refuge, Montana, on October 17, 1967. An identical group was on the Kirwin National Wildlife Refuge, Kansas, on October 24, 1967. Seven whooping cranes reached the Aransas National Wildlife Refuge on that date. By November 1, 1967, 38 adult and 9 young whooping cranes were on Aransas; another adult bird arrived between November 1 and November 11.

Greater sandhill cranes

Track measurements indicate that 27% of the sandhills using Bowdoin National Wildlife Refuge, Montana, as a way station during the 1962-65 fall migration may represent the greater race. No track measurements were obtained at Medicine Lake National Wildlife Refuge, nor were any sandhills collected at either refuge.

Track measurements from Kidder and Stutsman Counties, North Dakota, indicate that about 14% of the fall-migrating sandhills that use this way station may represent the greater race. At this congregation site 74 sandhills were collected from 1959 to 1965; 5 were identified as greater sandhills and another as a typical greater, if a female. The greater was not represented in the 10 birds collected in McLean County. Footprint measurements indicated that only 8% of the birds using this congregation area apparently represented the greater race.

Representatives of the greater race were rare in the Mobridge-Pollock, South Dakota, congregation area also. Footprint measurements indicated that 3% probably represented the greater race. Only 2 of 22 birds collected at this site were classed as "possible greaters;" body condition did not permit a clear distinction between the Canadian and greater races.

Although no cranes were collected in the Wyoming fall congregation sites, a limited number of footprint measurements imply that the greater uses these sites during the fall.

Footprint measurements and crane collections indicated that the greater race did not use Prewitt Reservoir, Colorado, as a way station during the study.

A limited number of footprint measurements from Salt Plains National Wildlife Refuge (Alfalfa County) and the Red River Bottoms (Jackson County), Oklahoma, suggests that the

greater race may occur at these way stations. Three cranes confiscated from goose hunters in the vicinity of the refuge were identified as lessers. Track measurements indicate that about one-third of the sandhills that use Washita National Wildlife Refuge may also represent the greater race. Two of four birds collected at this site were identified as greaters; the remaining birds were placed in the Canadian race.

Analyses of the footprint measurements obtained during the study and the racial composition of sandhills selectively collected from 1959 to 1965 indicate that the lesser race is much more numerous at North Dakota and South Dakota congregation sites in October than is the greater race. Moreover, the selective collecting program undoubtedly emphasized the incidence of the greater race. Thus, late October or early November hunting seasons in these States would not seriously jeopardize the rare greater sandhill.

The incidence of the greater sandhill at congregation sites in Wyoming and Oklahoma was not adequately determined during the study--additional measurements are needed in these States.

Lesser sandhill cranes

Recreational hunting of sandhill cranes in the United States was prohibited between 1916 and 1961 by the Migratory Bird Treaty and the prevailing idea that the species could not stand a harvest. This idea was based on the knowledge that some races of the sandhills were relatively scarce, although the lesser sandhill crane population was known to exceed 200,000 birds. Recurring depredations on cereal crops in Canada and the United States by sandhills and the growing conviction among game managers that this migratory game bird could withstand harvest under proper management led to the first lesser sandhill crane seasons in the United States in 1961. This was followed by limited seasons in Manitoba and Saskatchewan in 1964. These hunting seasons now result in an annual harvest of less than 5,000 birds and provide about 10,000 man-days of recreation.

The breeding range of the lesser sandhill extends from northeastern Siberia across Alaska and Arctic Canada to the region of Baffin Island, and south into the Northwest Territories (Walkinshaw, 1949). Although annual recruitment in the population may be as low as 11% (Stephen, Miller, and Hatfield, 1966) this race can withstand additional harvest under proper management.

SUMMARY

The 1961 lesser sandhill crane hunting seasons in New Mexico and Texas prompted the Central Flyway Waterfowl Council to propose that the Council and the Bureau explore the feasibility of extending the season to other States of the flyway. This resulted in a coordinated study to obtain information on the chronology of the fall sandhill and whooping crane migrations, peak populations and areas of greater use, racial composition of fall-migrating sandhills, and crop depredations by sandhills in the Central Flyway.

1. With slight variations in time and geography, the vanguard of the fall migration of sandhill cranes reaches congregation areas in Canada and North Dakota between mid-July and mid-August; in Montana, Wyoming, and South Dakota between the first week of September and the first week of October; in Colorado and Nebraska between mid-September and mid-October; and in Kansas and Oklahoma between the first and last weeks of October.

2. Fall-migrating sandhills reach peak numbers at Canadian way stations between the first week of September and the second week of October. Populations peak at way stations in Montana, North Dakota, South Dakota, Wyoming, Colorado, Kansas, and Oklahoma between the first week of October and the first week of November.

3. Crane numbers reached 100,000 in the principal Saskatchewan congregation sites during the fall of 1962. A minimum of 100,000 birds was present at way stations in the United States during the fall of 1964. During the study, 185,000 to 214,000 sandhills reached the principal wintering grounds in eastern New Mexico and west Texas by late October.

4. Sandhill cranes usually depart from Canadian way stations in mid-October. Departures from principal fall congregation sites within the States occur throughout October, November, and early December. Generally, the fall migration proceeds at a leisurely pace except when mass movements are triggered by cold fronts.

5. The fall migration of the whooping crane is occasionally coincident with the sandhill crane migration. Historically and during the past 7 years (1959-65), whooping cranes were observed at sandhill crane congregation sites in Saskatchewan, northeastern Montana, North Dakota, South Dakota, Kansas, and northern Oklahoma. No whooping cranes have been observed at sandhill crane way stations in north-central Montana, southeastern Wyoming, eastern Colorado, or western Oklahoma; nor were the two species observed together after November 8 anywhere in the flyway north of Texas.

6. Cranes using the Prewitt Reservoir, Colorado, way station were found to be the lesser sandhill. This race also dominated in the Montana (Bowdoin Refuge), North Dakota, South Dakota, and the remaining Colorado way stations--Bonny Reservoir and the Arkansas Valley. Footprint measurements imply that fall-migrating sandhills using way stations in Wyoming, Kansas, Oklahoma, and the San Luis Valley, Colorado, contain relatively higher proportions (32% to 100%) of the greater race.

7. Of 74 sandhills selectively collected in Kidder and Stutsman Counties, North Dakota, from 1959 through 1965, 5 were identified as greaters. No greaters were included in 10 birds preferentially collected in McLean County, North Dakota. Only 2 of 22 birds discriminately collected in the Mobridge-Pollock area, South Dakota, could be classed as possible greaters; body condition did not permit distinction between the greater and Canadian races. The greater race was not represented in birds collected at Prewitt Reservoir, Colorado, or in the cranes confiscated from goose hunters in the vicinity of Salt Plains Refuge, Oklahoma.

8. Footprint measurements and the collection of specimens in September indicate that the first migrating flocks to reach the principal way stations in North Dakota contain unknown numbers of the greater race, and that these are gradually replaced or diluted by the more numerous lesser race.

9. Sandhills were observed to feed on standing and harvested grain crops in Canada and throughout the States of the flyway. Control measures were not practiced in the principal North Dakota congregation area during the goose season, since farmers believed that these measures had a dispersing effect upon geese. Scarecrows effectively alleviated crane depredations on winter wheat in the vicinity of Washita Refuge, Oklahoma.

REFERENCES

Aldrich, J. W., and T. D. Burleigh.
1958. Geographical variation in sandhill cranes. U.S. Bureau of Sport Fisheries and Wildlife, Typewritten report.

Allen, R. P.
1952. The whooping crane. National Audubon Society, Research Report 3. 246 p.

Boeker, E. L.
1960. Whooping cranes in 1959. U.S. Bureau of Sport Fisheries and Wildlife, Mimeographed report. 9 p.

1961. Whooping cranes in 1960. U.S. Bureau of Sport Fisheries and Wildlife, Mimeographed report. 19 p.

1962. Whooping cranes in 1961. U.S. Bureau of Sport Fisheries and Wildlife, Mimeographed report. 12 p.

1963. Compilation of whooping crane data during calendar year (1962-63). U.S. Bureau of Sport Fisheries and Wildlife, Mimeographed report. 8 p.

Boeker, E. L., J. W. Aldrich, and W. S. Huey.
1961. Study of the experimental sandhill crane hunting season in New Mexico during January 1961. U.S. Fish and Wildlife Service, Special Scientific Report--Wildlife No. 63, 24 p.

Boeker, E. L., W. S. Huey, and P. B. Uzzell.
1962. Study of Texas-New Mexico lesser sandhill crane hunting season--November 4-December 3, 1961. U.S. Bureau of Sports Fisheries and Wildlife, Mimeographed report. 11 p.

Buller, R. J., and E. L. Boeker.
1965. Coordinated sandhill crane study in the Central Flyway. Transactions of the Thirtieth North American Wildlife and Natural Resources Conference, p. 100-113.

Gilliam, C.
1966. Little brown crane study. Oklahoma Wildlife Conservation Department, Completion Report, Project W-32-R-15, Job 12. 7 p.

Huey, W. S.
1960. Sandhill crane investigations. New Mexico Department of Game and Fish, Completion Report, Project W-91-R-3, Job 14. 5 p.

Knoder, E.
1964. Personal communication, August 18, 1964.

Linduska, J. P.
1949. Sandhill crane observations--1949, Texas and New Mexico. U.S. Bureau of Sport Fisheries and Wildlife, Unpublished report. 8 p.

Mackay, R. H.
1962. The current status of crop depredation control in Western Canada. Proceedings 25th Federal-Provincial Wildlife Conference (Ottawa, Canada), 1961, p. 48-53.

Madsen, C.
1966. Personal communication, April 6, 1966.

Munro, D. A.
1950. The economic status of sandhill cranes in Saskatchewan. Journal of Wildlife Management, vol. 14, p. 276-284.

Nelson, J. L.
1961. Waterfowl depredations control in Saskatchewan. Wildlife Branch, Saskatchewan Department of Natural Resources, Mimeographed report. 6 p.

Oberholser, H. C.
1921. Notes on North American Birds, X. Auk, vol. 38, No. 1, p. 79-82.

Smith, J. D., and E. L. Boeker
1958. Sandhill crane depredation survey, Kidder County, North Dakota. U.S. Bureau of Sport Fisheries and Wildlife, Typewritten report.

Sooter, C. A.
1943. Texas and New Mexico investigations--winter 1942-43, including crane investigations in eastern New Mexico and western Texas. U.S. Bureau of Sport Fisheries and Wildlife, Typewritten report.

Sperry, C. C.
1939. Sandhill cranes vs. grain crops in New Mexico. U.S. Bureau of Sport Fisheries and Wildlife, Typewritten report.

Stephen, W. J. D.
1967. Bionomics of the sandhill crane. Canadian Wildlife Service, Report Series, No. 2. 48 p.

Stephen, W. J. D., R. S. Miller and J. P. Hatfield
1966. Demographic factors affecting management of sandhill cranes. Journal of Wildlife Management, vol. 30, p. 581-589.

Timmerman, R. J.
1958. Report of sandhill crane depredations during the fall of 1958 (North Dakota). U.S. Bureau of Sport Fisheries and Wildlife, Typewritten report.

U.S. Bureau of Sport Fisheries and Wildlife.
1961. Sandhill crane footprint measurements. Unpublished data.

Walkinshaw, L. J.
1949. The sandhill cranes. Cranbrook Institute of Science, Bulletin 29. 202 p.

1965. A new sandhill crane from central Canada. Canadian Field-Naturalist, vol. 79, No. 3. (July-August) p. 181-184.

☆ U.S. GOVERNMENT PRINTING OFFICE · 1968 O—290-445

The Department of the Interior, created in 1849, is a Department of Conservation, concerned with management, conservation, and development of the Nation's water, wildlife, fish, mineral, forest, and park and recreational resources. It has major responsibilities also for Indian and Territorial affairs.

As America's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States, now and in the future.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
WASHINGTON, D. C. 20240