ECOLOGY OF THE SANDHILL CRANE IN THE SOUTHEASTERN CENTRAL FLYWAY

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in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
December, 1974

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PREFACE

The purposes of this study are to determine the subspecies of cranes found within Kansas, Nebraska, Oklahoma and eastern Texas and to describe the ecology of these cranes. This is accomplished by a discriminant analysis of taxonomic measurements of cranes, by field studies conducted within the four states, and by laboratory studies of collected specimens.

The Oklahoma Cooperative Wildlife Research Unit, the U. S. Fish and Wildlife Service, the Oklahoma State University Department of Veterinary Parasitology and Public Health, and the Oklahoma Department of Wildlife Conservation all furnished financial and technical assistance for this study. The Nebraska Game and Parks Commission and the Texas Parks and Wildlife Department provided technical assistance.

I express my appreciation for the advice and assistance provided by John Morrison, my major adviser, and other members of my committee, John Barclay, Bryan Glass, Bertis Glenn and Dariel Howell. Thanks are also extended to Richard Corstvet, who directed surveys for Salmonella and Mycoplasma, and to Sidney Ewing, who directed surveys for protozoan parasites.

Others who deserve special recognition for their assistance are John Aldrich, Loren Bonde, Frederick Bolwahn, Milton Caroline, James Carpenter, Charles Darling, Raymond Erickson, George Gee, Richard Pillmore, Douglas Johnson, Gordon Hanson, James Hogue, LeMoyne Marlatt

and David Purinton of the U. S. Fish and Wildlife Service; Wes Webb of the Oklahoma Department of Wildlife Conservation; George Nason of the Nebraska Game and Parks Commission; Frederick Guthery of Texas A. and M. University; William Keil of the King Ranch, Texas; Charles Frith of the U. S. Bureau of Reclamation; Clarence Cottam (deceased), Welder Wildlife Foundation; E. C. Griener of the WHO Centre for Avian Malaria Parasites; Sophia C. Mery of the Oklahoma Ornithological Society; George Sutton of the University of Oklahoma; Milton Curd, William Drew, John Folks, Iris McPherson, Steve Patton, Tom Powell, William Sanford, Judith Schotland, Robert Summerfelt and Gay Williams of Oklahoma State University. Many other personnel in state and federal wildlife agencies, members of the Oklahoma Ornithological Society, and landowners within the study area were also very helpful.

Finally, the greatest credit must go to those who sacrificed the most: Kristine, Mary and Andy, who lost many hours of paternal companionship and guidance, and to my helpmate Marian, who successfully carried the extra burden of being the wife of a doctoral student.

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CHAPTER I

INTRODUCTION

Three races of sandhill cranes are found in the United States west of the Mississippi River, the greater sandhill (Grus canadensis tabida), the Canadian sandhill (G. c. rowani) and the lesser sandhill (G. c. canadensis). The greater sandhill cranes of western North America nest in portions of Colorado, Minnesota, Manitoba, Idaho, Montana, Wyoming, Utah, Nevada, Oregon, and California; they are known to winter in Arizona, New Mexico, California, and Mexico. The greater sandhill was listed as a rare and endangered subspecies when this project began (Committee on Rare and Endangered Wildlife Species 1966) but has since been removed from that category (U. S. Dept. Inter. 1973).

The Canadian sandhill nests in prairie, aspen parkland, and northern forest areas of central and northern Canada (Walkinshaw 1965a), and some are known to winter in Texas. The lesser sandhill nests in tundra and costal habitat of northern Canada, Alaska and Siberia, and winters in southern California, New Mexico, Texas and Mexico (Walkinshaw 1949). The three subspecies differ mainly in their size; the greater is the largest, the lesser the smallest, and the Canadian is intermediate in size.

When the idea for this study evolved in January, 1968, sandhill cranes were hunted in portions of Manitoba and Saskatchewan, in Alaska, eastern Colorado, western Texas, and eastern New Mexico. Farmers in a

few other states, including Oklahoma, were complaining about crop depredations caused by sandhill cranes. Game managers believed that legalized hunting would reduce crop damage and also believed that hunting would provide recreation without endangering the resource. More information was needed as a basis for decisions about managing sandhill cranes.

The research needs included information on: population trends, productivity, the extent of depredations, nest and winter areas for various populations, food habits, behavior patterns of winter flocks, the location and size of wintering populations, diseases and parasites affecting sandhill cranes, improved techniques for determining sex and age, habitat use, and the distribution of the three subspecies.

This study had the following objectives:

1. To determine the subspecies of sandhill cranes migrating through and/or wintering in Kansas, Nebraska, Oklahoma and eastern Texas.
2. To determine the nest areas and probable migration routes for sandhill cranes that winter in the study area.
3. To describe food habits, local movements, preferred roost habitat, and behavior of cranes within the study area.
4. To identify some of the parasites, diseases, and causes of mortality affecting sandhill cranes.
5. To develop techniques suitable for determining the age and sex of sandhill cranes.

These are broad objectives and obviously it would not be feasible to achieve all of them in this study. However, this study was designed to acquire some data that could be used in achieving each of the

objectives. It was not possible to judge if some of the objectives could be met until after one or two years of field work had been completed, because so little was known about sandhill cranes in this portion of the Central Flyway. For example, very few sandhill cranes had been trapped anywhere and techniques still had to be tested for the study area. Until such field testing was complete there was no way to judge whether or not enough cranes could be trapped and color-marked to learn where they nest and winter.

The Study Area

The study area includes portions of Kansas, Nebraska, Oklahoma and Texas. Field studies were limited mainly to the following areas: Quivira National Wildlife Refuge (NWR), Kansas; the Platte River and North Platte River Valleys between the towns of Lewellen and Grand Island, Nebraska; Washita NWR, Salt Plains NWR, Tillman County, and Jackson County in Oklahoma; and coastal areas of Texas between Houston and Brownsville.

The intensive study areas (Figure 1) in Kansas, Nebraska and Oklahoma are within Blair's (1942) Humid Continental (warm subtype) climatic category and the Great Plains Physiographic Province (Hunt 1967). The mean temperature during the coldest month is below 6 C and for six to nine months it is above 9.9 C. The average frost-free season varies from 160 to 200 days (Critchfield 1960). Rainfall is greatest in spring. Summers are hot and usually dry. Annual rainfall varies between 50 and 100 cm. Winter precipitation is frontal and comes with high winds. Short and mid grasses are the dominant vegetation of the

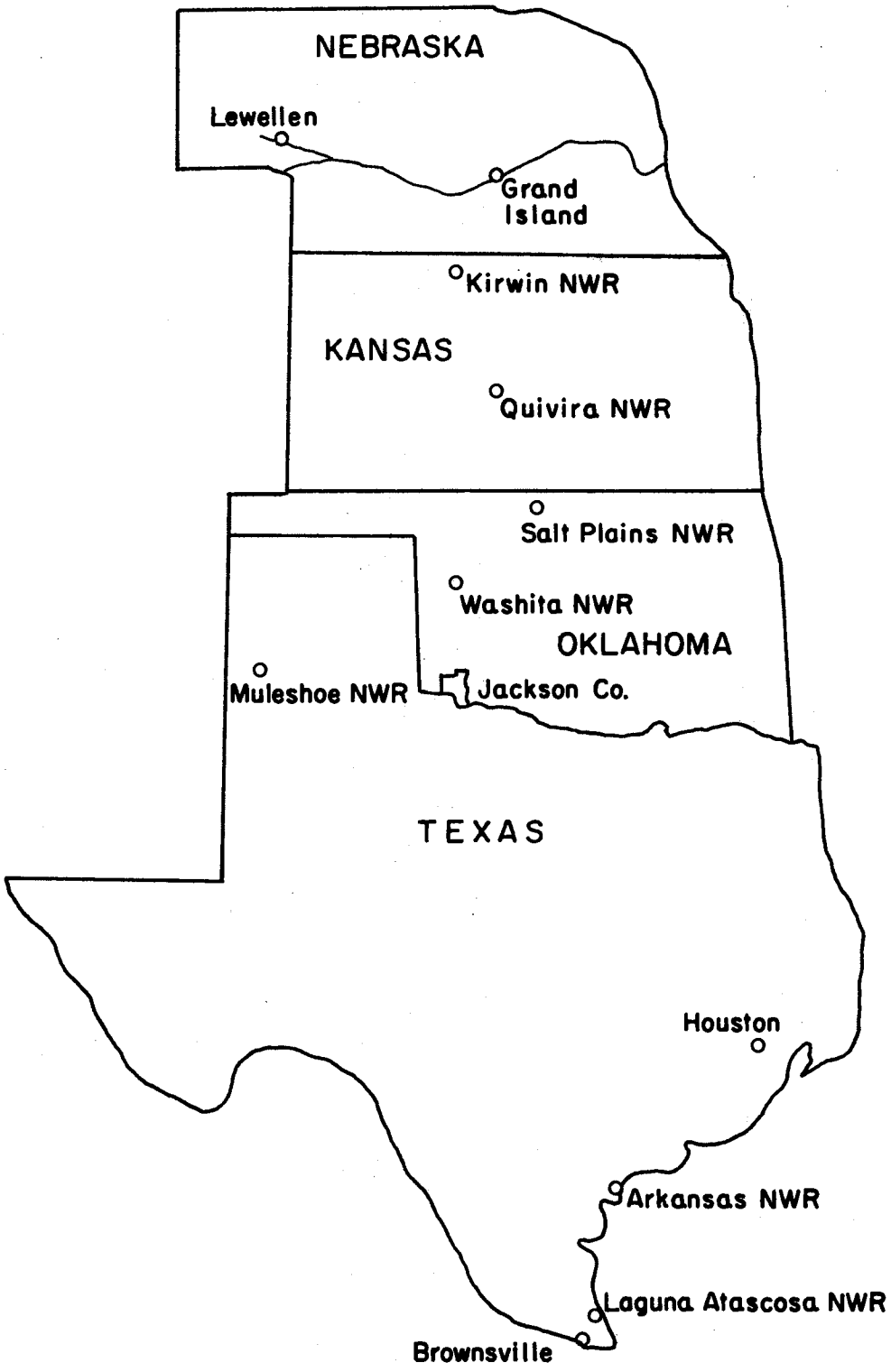

Figure 1. The Southeastern Central Flyway

upland areas used by cranes; trees are confined to the valleys.

The main staging area for sandhill cranes during spring migration is located along the Platte and the North Platte Rivers in southcentral Nebraska. Cranes arrive there in late February and their populations reach a peak in late March (Wheeler and Lewis 1972). They are found along portions of the rivers between Lewellen and Grand Island, an east-west distance of 292 km between Longitudes 102°15' and 98°25' W. They roost in the rivers and feed in adjacent wet meadows and fields of corn and milo. Late winter storms occasionally cause mortalities among these cranes (Wheeler 1966). Cranes also stop along the Platte River, Nebraska from 1 October to 15 November but in much fewer numbers than occur during spring migration (Walkinshaw 1956). Cranes have also wintered on the Platte, but this has occurred only rarely (Shickley 1965).

Quivira NWR, established in 1955, is located in central Kansas in Stafford, Reno and Rice Counties. It contains 8,834 ha and has a long history of use by migrating ducks, geese and cranes. The main wetlands there are the Big Salt Marsh and Little Salt Marsh; numerous small lakes and ponds are also present. Water depths in Big Salt Marsh rarely exceed 0.6 to 1 m. Bulrush (Scirpus americanus) and spikerush (Eleocharis rostellata) are common emergent plants along portions of Big Salt Marsh.

Salt Plains NWR is located in Alfalfa County in northcentral Oklahoma (Figure 1). The refuge borders the reservoir and the Salt Fork of the Arkansas River and includes Great Salt Plains, a basin of alluvial sand saturated with salt water and covered with a salt incrustation formed by evaporation. The refuge was established to

protect shorebirds that nest on the salt flats and to protect migratory birds that use the area in spring and fall.

Salt Plains NWR includes 4,453 ha of saline flats (Wetland Type 9) and 243 ha of saline marsh (U. S. Fish and Wildlife Service 1955), the 4,048-ha reservoir, 526 ha of cropland (wheat Triticum aestivum and rye Secale cereale), and 3,644 ha of upland woods and brush. Canada geese have wintered on the refuge since 1940 and recently the population contained 23,000 birds. Sandhill cranes stop briefly at the refuge in spring and fall. Annual precipitation is 71 cm per year. Average winter temperatures vary from -1 C to 4 C (Kincer 1928) and snowfall averages 25.4 cm to 50.8 cm. The duration of snow cover is usually limited to a few days.

Washita NWR is located at the north end of Joe Foss Reservoir in Custer County, westcentral Oklahoma. The refuge contains 3,319 ha including 405 to 607 ha of the reservoir. Approximately 1,012 ha of the bottomland and level upland areas are planted in alfalfa (Medicago sativa), wheat, milo (Sorghum bicolor) and corn (Zea mays) for waterfowl and other wildlife. Portions of the reservoir are bordered by high rolling hills cut by deep ravines; these hills overlook the main roost areas for sandhill cranes and are good observation points from which to census cranes, ducks and geese.

Trees are uncommon along the immediate border of the reservoir and the Washita River but some elm (Ulmus americana) and cottonwood (Populus deltoides) are present. The Washita River flows mainly through silt loam soils and both the river and the reservoir are turbid most of the time. Common shoreline plants are Johnson grass (Sorghum halepense), cattail (Typha latifolia), willow (Salix spp.), smartweed (Polygonum

spp.), and saltcedar (Tamarix gallica).

During fall as many as 75,000 ducks and geese are present at the peak of migration. At full pool the reservoir would cover 1,376 ha of the refuge, but the lake has never completely filled. The reservoir was built by the Bureau of Reclamation for flood control, recreation, and as a water supply for Clinton and other towns downstream. Located at Latitude 35°30' N, this is the northernmost regular wintering area for sandhill cranes within the Central Flyway. Average winter temperatures, as measured at Elk City, 27 km from the refuge are: December, 4.7 C; January, 3.3 C; and February, 5.4 C.

Southern Jackson County, located in southwestern Oklahoma, receives heavy use by migrating sandhill cranes and supports a wintering population. A few thousand ducks also winter there. The average monthly temperatures recorded at the Altus Weather Station are: December, 6.2 C; January, 4.9 C; and February, 7.1 C (U. S. Dept. Commerce 1973). The area used commonly by cranes lies between Eldorado and Tipton, within an 8-km radius of the Prairie Dog Town Fork of the Red River, and along the Salt Fork of the Red River as far north as Olustee. The Prairie Dog Town Fork of the Red River and the Salt Fork of the Red River are red, turbid, sand-laden streams. Jackson County is at Latitude 34°25' N, the same latitude as the northernmost wintering area for sandhill cranes in Texas (Muleshoe, Texas). Cranes roost along the Red River and feed in nearby milo, haygrazer (Sorghum sudanese X S. bicolor), and wheat fields. The same flocks feed in Wilbarger and Hardeman Counties, Texas, but to a lesser extent because south of the Red River there is less cropland.

Much of southern Jackson County is within the Mesquite Plains biotic district (Duck and Fletcher 1944). Blue grama (Bouteloua gracilis), hairy grama (Bouteloua hirsuta) and buffalo grass (Buchloe dactyloides) are dominant plants of the grasslands. Mesquite (Prosopis glandulosa) and prickly pear (Opuntia sp.) are abundant on some rangeland.

Sandy alluvial soils predominate on the bottomlands. Sand bluestem (Andropogon hallii), little bluestem (Andropogon scoparius), Johnson grass, switchgrass (Panicum virgatum) and Indian grass (Sorghastrum nutans) are the main tallgrass species found bordering the riverbeds. Saltcedar is common near the riverbed. Mesquite, hackberry (Celtis occidentalis), soapberry (Sapindus drummondii), sand sage (Artemisia filifolia), chittamwood (Bumelia lanuginosa), cottonwood and juniper (Juniperus sp.) are found in the rangeland that borders the floodplain. Vegetated sand dunes (Yahola soils) are found in some areas north of the river and these sandy areas are managed as rangeland.

Since the 1920's Jackson County has produced more cotton than any other county in Oklahoma (Bailey and Graft 1961), and nearly one-fourth of the cropland is irrigated. Other crops are wheat, alfalfa, and grain sorghum. The winters are mild. Average annual rainfall is 63 cm. Prevailing winds are from the south. "Northers" in winter bring a rapid drop in temperature that lasts two or three days. The average annual snowfall is 16.7 cm.

Counties included in the observations in southern Texas are (listed east to west): Waller, Ft. Bend, Brazoria, Colorado, Wharton, LaVaca, Victoria, Aransas, Refugio, Karnes, San Patricio, Live Oak, Nueces, Kleberg, Hidalgo, and Cameron. The field study sites included two NWR,

Aransas in Aransas County and Laguna Atascosa in Cameron County. The coastal area is characterized by moderate-to-heavy rainfall, 58 to 114 cm occurring through all seasons. Temperatures seldom drop below freezing. The average growing season varies from 280 to 340 days. Mean temperatures of the coldest month are between 4 C and 7 C. During the summer months the maximum reaches 32 C to 37 C with extremes above 37 C (Critchfield 1960).

The major land uses of rural areas are production of livestock, sorghum, rice and cotton (Texas Crop and Livestock Reporting Service 1969). There are three native vegetation types (Gould 1969): (1) Gulf Prairies and Marshes--level, poorly drained plains less than 50 m in elevation containing tall grasses as the climax vegetation; (2) South Texas Plains--level to rolling topography from sea level to 233 m elevation that supports a grassland or savannah climax; (3) Post Oak Savannah--rolling topography of 100 to 266 m elevation.

CHAPTER II

MATERIALS AND METHODS

Field observations were made first in areas where cooperators reported that sandhill cranes had been seen. The locations of field work changed as knowledge was gained about opportunities for collecting and observing. Finding cranes was a very time-consuming activity. Even in wintering areas like southwestern Oklahoma and southern Texas, personnel of the conservation departments often did not know the locations of roosts and knew of only some of the feeding areas. Cranes were found by asking local residents for information, by driving country roads and watching for cranes feeding in fields or flying, by listening for vocalizing cranes, and by viewing the surrounding terrain from buttes and other high points.

The following number of days, exclusive of travel time, were spent making field observations: September, 5; October, 28; November, 32; December, 40; January, 27; February, 12; March, 39; April, 13. Of this total of 196 days, 10 were spent in Kansas, 27 in Nebraska, 131 in Oklahoma, and 28 in Texas. Field work began in March 1968 and most of it was completed by April 1971. Over 49,000 miles of driving were logged during the project.

When flocks were located they were observed with binoculars or a spotting scope. Each flock was counted and its activities described. In some cases flocks were observed until they took flight and then were

followed to their roosting sites. Aerial surveys were made on 2 December 1970 in Oklahoma, and on 31 December 1969 and 29 to 30 December 1970 in southern Texas. Cranes were also censused at feeding areas, but the census method used most frequently was to begin counting before daybreak or in late afternoon as cranes left or entered a roost. The counts continued in the mornings until all cranes had left the roost, and at night counts continued until it was too dark to see. High bluffs overlooking the roosts at the Washita NWR and at roosts along the Red River provided excellent observation points.

Personnel of the Oklahoma Department of Wildlife Conservation and members of the Oklahoma Ornithological Society were requested to record sightings of sandhill cranes during fall migration in 1969 and 1970. Approximately 100 employees of the Wildlife Services Division, U. S. Fish and Wildlife Service (FWS), residing in Texas, were each sent a questionnaire about activities of migrating cranes and populations of cranes wintering in their work area. Data on populations of cranes using eight national wildlife refuges were compiled from files at the refuges.

Cranes were collected as randomly as possible by shooting, using either a .222 rifle or a shotgun. Decoys and a call were occasionally used to attract cranes to areas where they could be collected. Cooperators provided carcasses from cranes that had been shot illegally, died from disease or accidents, or died during trapping programs. Specimens were measured in museums within the study area.

Whenever possible a blood sample was taken from the cranes that were shot. The serum was extracted and stored in a freezer at 0 C for one to six months. Sera were shipped frozen to the Texas A. and M.

College of Veterinary Medicine and were tested for antibodies to the following diseases: Salmonella pullorum, S. typhimurium, Mycoplasma gallisepticum, three influenza A viruses, Newcastle disease virus, paramyxovirus, and Chlamydia psittaci. Two smears of the blood sample taken from each crane were made on glass slides using the technique described by Bennett (1970). These blood films were stained with Giemsa's stain and examined for protozoan parasites for five minutes at 430 X and for 10 minutes at 970 X.

Each specimen was weighed and standard ornithological measurements taken of the wing, tail, culmen, and tarsus (Pettingill 1970). I also measured the distances from the: (1) tip of the culmen to the posterior edge of the nares, (2) posterior edge of the ball of the foot to the tip of the anterior end of the mid toe, excluding the toe nail, and (3) the latter measurement including the toe nail.

The cranes were either processed within a few hours in the manner described below or were placed on ice and transported to Oklahoma State University for processing. The trachea of each specimen was cut open with sterile scissors. A sterile swab was rubbed along the inner tracheal wall through the length of the trachea. The swab was used to inoculate one-half of a PPLO agar plate and then placed in a test tube containing PPLO enrichment broth. Another sterile swab was rubbed along the inner walls of the abdominal and thoracic air sacs, used to inoculate the other one-half of the PPLO agar plate, and then placed in a second test tube containing PPLO enrichment broth. The PPLO tubes and plates were placed in a moist chamber and incubated at 37 C. Seven days later the inoculated solid medium was examined microscopically for the presence of Mycoplasma spp. After incubation the liquid PPLO

medium was streaked onto solid PPLO medium. The plates were examined seven days after incubation.

A sterile swab was inserted into the cloaca of each crane and then one-half of a brilliant green plate was streaked with this swab. Immediately thereafter the swab was placed into a tube of selenite cystine medium. The ceca were removed from each bird, the junction of the ceca cut open, and the cecal tonsils were used to inoculate the other one-half of the brilliant green plate. The ceca were placed in a second tube of selenite cystine medium. The plates containing the brilliant green medium and the selenite cystine medium were incubated at 37 C. The plates were examined 24 hours and 96 hours later for the presence of Salmonella spp. and Paracolobactrum arizonae. The selenite cystine medium,,24 hours after incubation, was streaked onto brilliant green medium which was incubated and examined as previously described. Other aspects of the laboratory techniques are described by Corstvet and Sadler (1966).

Fat samples were taken from the abdomen and outer surface of the gizzard of cranes, placed in glass vials and stored in a freezer. At the FWS Wildlife Research Center, Denver, Colorado, the fat samples were examined for pesticide residues.

The cloaca were examined for sexual characteristics and some were removed and preserved in formaldehyde. Gonads were removed, measured, and stored in Bouin's solution. Later, they were embedded in parafin, sectioned, mounted on slides, and stained with hematoxylin and eosin (H and E). Their histological characteristics were viewed through a microscope.

Food contents were removed from the gullet and gizzard. The vegetative materials were dried under heat lamps and stored in paper bags. Later these were separated, identified, and the volume measured by water displacement in a volumetric cylinder. Animal materials were identified and measured or they were stored in preservative.

The sources used for nomenclature of plant and animal life mentioned in this report are Burt and Grossenheider (1964) for mammals, Conant (1958) for amphibians, Borror and DeLong (1954) for insects, Robbins et al. (1966) for birds, and Fernald (1950) for plants.

The cranes' intestinal tracts were removed, cut open lengthwise, and placed in a special preservative for parasites. The analysis for intestinal parasites will not be reported as part of this dissertation. The esophagus, lungs, heart, trachea, liver and gizzard were examined macroscopically for parasites or evidence of their presence.

Each crane's skin was removed from the carcass, dried and stored as a museum specimen. Sections of the mandible, humerus, ulna, femur, tibia, and tarsus-metatarsus bones were removed for a study of age-determination techniques involving counts of annuli in the periosteal zone. These sections were decalcified, mounted in parafin, sectioned with a microtome, mounted on glass slides, and stained with H and E or iron H and E. Other sections were decalcified, cut with a razor blade, mounted on slides and stained with H and E. George Gee of the FWS Patuxent Wildlife Research Center, Laurel, Maryland, provided leg bones from three cranes of known age and these were used to test the accuracy of the technique. The sections were examined and the annuli counted through a microscope with polarized light.

Measurements from each specimen were recorded on computer cards. Each specimen was assigned to a subspecies after its measurements had been compared to records of average measurements of the three subspecies (Johnson and Stewart 1973). The computer cards were run through discriminant analysis (DA) computer program BMD05M (Dixon 1971). During the analysis, the computer listed for each specimen the probabilities that it belonged to the greater, Canadian and lesser subspecies. Discriminant analyses were run on the specimens using seven, four, and three variables (taxonomic measurements) to determine if the lesser numbers of measurements gave the same results as the seven-factor analysis. The seven variables used were the length measurements of wing, tail, culmen, culmen-post nares, tarsus, mid toe and the weight of each specimen. Measurements used as the four variables were weight, and lengths of tarsus, wing and culmen-post nares. The wing measurement was deleted when only three variables were used.

Data from adults and juveniles were subjected to the DA with the two groups combined and also analyzed separately to learn if these treatments gave different results. Measurements of sandhill cranes collected by other investigators were also subjected to the DA. A multivariate analysis of variance was used to compare the taxonomic measurements of specimens collected by Johnson and Stewart (1973) against similar measurements of specimens collected in this study.

Study skins were placed in groupings of subspecies, sex, and age. The males and females of each age and subspecies were compared to seek morphological or plumage differences suitable for determining their sex or age. Features that received particular attention were: bristles and their distribution, color pattern of pterylae, color pattern and shape

of feathers from each pteryla, characteristics of the apterium of the head, color and shape of the culmen, shape of the nare, size and shape of the wing spur, and color and shape of scales on the legs and feet. Data on the molt pattern of the remiges, and on coloration of the head, nape and body were recorded for all specimens. J. W. Aldrich (FWS) was asked to examine the progression of molt of the juvenal plumage in specimens in the U. S. National Museum (USNM). Fred S. Guthery was requested to do the same for specimens at Texas A. and M. These two men were also asked to record, for each specimen, their judgement of the likelihood that the bird could have been accurately identified as a juvenile under average field conditions.

CHAPTER III

RESULTS AND DISCUSSION

Taxonomy

For both political and scientific reasons it was not feasible to collect enough cranes to state accurately what proportion of the wintering or migrating cranes of the Southeastern Central Flyway are of a particular race. It is unfeasible politically because there is strong opposition to collecting large numbers of birds for scientific purposes and scientifically because we do not know the total population size of the migrating birds nor the populations on some winter areas.

The researcher shot 123 cranes with the assistance of wardens and biologists of state game and fish agencies. Nine cranes were shot by goose hunters in Nueces County, Texas and salvaged by U. S. Game Management Agent James H. Hogue. At Aransas NWR, Laguna Atascosa NWR, and Washita NWR, cranes shot illegally by goose hunters were salvaged. At the Quivira NWR and Salt Plains NWR cranes which died of illness or injury were recovered. Two cranes that struck powerlines were recovered along the North Platte River, Nebraska. Two cranes killed by predators were recovered at a roost on the North Platte River. Eleven specimens were examined at the University of Nebraska Museum, seven at Stovall Museum at the University of Oklahoma, two at Kearney State College, one at the North Platte office of the Nebraska Game and Parks Commission and one at Welder Wildlife Foundation, Sinton, Texas.

The Discriminant Analysis

The collections distinguish the races that use various portions of the study area. Taxonomic measurements were taken on 167 cranes within the study area and on nine specimens sent from Florida. The identification of the subspecies of specimens collected during this study, as well as others collected in other studies that are discussed in this report, are based on the DA that indicates which of the three races an individual had the highest probability of belonging to. The DA was used to identify the races because it removes the personal bias that can exist when a researcher assigns specimens to races. The DA also evaluates all taxonomic features of a specimen more accurately than an observer could.

Prior to the DA, each specimen must be assigned to the race the researcher believes it belongs to, as described in Materials and Methods. The initial choice by the researcher does not bias the computer's selection of the proper race as long as the number of specimens in the sample is adequate (John Folks pers. comm.). The sample sizes of the Canadian and lesser races were adequate. The sample of greaters was small and could have been influenced by the researcher's choice, but the results indicate that the selection was not biased. Fifteen specimens were initially assigned to the greater subspecies; using seven variables, the DA indicated 14 of the 15 were greaters and that 15 of the 111 specimens selected as Canadian sandhills were also the greater race. As an additional test, two smaller specimens from Florida were assigned to the Canadian race, where only the greater and the Florida (G. c. pratensis) races are known to occur. Lovett Williams (pers. comm.), Research Supervisor, Florida Game and

Fresh Water Fish Commission, indicates that the specimens from Florida were probably greaters. Thus, there is no evidence that the author's initial selections biased the computer's analysis.

During the DA, most adult cranes were classified in the same races regardless of whether the entire sample contained only adults or contained both adults and young. There were five adults whose probabilities of belonging to two of the races were very similar; removing all juveniles from the sample caused the computer to classify these five adults in another race. Three lessers were assigned to the Canadian race, one Canadian was assigned to the greater race, and one greater was assigned to the Canadian race. These changes were not considered significant enough to require separation of juveniles and adults during the DA.

A comparison between the author's choice of the race a juvenile belonged to and that which the computer selected showed the following. The three juveniles that the author believed were greaters, including two from Florida, were placed in the greater category by the computer. Only one of the eight juveniles assigned to the Canadian race was selected by the computer as a lesser and this was based on a difference in probabilities of 0.03; the DA indicated that the other seven were of the Canadian race. The most significant changes from the original designation to that of the DA's were among 22 juveniles the author believed were lessers; seven of these were assigned to the Canadian race during the DA, and the others were retained as lessers. Apparently the author's judgements on some of the juveniles were biased toward the lesser race.

The juvenile cranes collected during this study (October through April) were close enough to the adults in size that they could be subjected to a DA along with the adults. Most of the juveniles were collected in winter and spring when they were six to nine months old.

A DA of 219 specimens, including some specimens provided by Guthery (1972), was made using seven variables (taxonomic measurements). The analysis indicated that there were 29 greaters, 104 Canadian and 86 lesser sandhills in the sample. The analysis using four variables indicated that there were 25 greaters, 114 Canadian and 80 lesser sandhills. Results of the analysis using four variables were not significantly different from the results when seven variables were used ($x^2 = 0.98$). Another analysis, this time using only three variables, indicated that there were 33 greaters, 104 Canadian and 82 lesser sandhills in the sample. Results of the analysis using three variables were not significantly different from the results when seven variables were used ($x^2 = 0.36$). Measurements of only three features of each specimen were adequate for use in a DA when the specimens were being grouped in no more than three subspecies. Measurements of any three of the following would suffice for use in the DA: wing, culmen-post nares, tarsus, or weight.

In the study area, the average probability of a Canadian sandhill being a lesser sandhill was 0.178. The average probability of a Canadian sandhill being a greater sandhill was 0.134. Thus, measurements of the Canadian sandhills were slightly more similar to the lesser subspecies than they were to the greater subspecies. In the northern plains states, the size of Canadian sandhills was nearer the size of the greater sandhill race than it was to that of the lesser sandhill race

(Johnson and Stewart 1973). Average measurements of the races of sandhill cranes collected in this study are listed in Tables I and II. There is a range in sample sizes in these tables because some measurements were not made on all specimens.

Distribution of Races

All three races of cranes found in the western United States were present in the study area and this is the first documentation that greaters winter in Oklahoma and southern Texas. The source of these greaters is unknown but they may nest in northern Minnesota and southeastern Manitoba. The literature indicates that greaters nesting in Michigan and Wisconsin spend the winter in Florida (Walkinshaw 1960, Williams and Phillips 1972), greaters that nest in the northern Rocky Mountain States winter in New Mexico, Arizona and Mexico (Drewien and Bizeau 1973), and greaters that nest in the Pacific Flyway winter in southern California (C. D. Littlefield pers. comm.).

A greater and three Canadian sandhills were collected at Quivira NWR. The Canadian-race cranes were collected 23 March, 2 April, and 2 November and the greater on 1 April (Table III).

Two lessers were collected at Salt Plains NWR, Alfalfa County, Oklahoma; one on 30 March and the other on 27 October. Buller (1967) reported three lessers collected at this refuge in October 1964. Three greaters in the University of Oklahoma Museum collection (UOM) were collected November 1963 in Alfalfa County.

Four Canadians and one lesser were taken in October and November in Tillman County, Oklahoma. A lesser (UOM) taken there on 20 February 1923, was probably migrating through rather than wintering there.

TABLE I

MEASUREMENTS OF RACES OF ADULT SANDHILL CRANES COLLECTED DURING THIS STUDY IN KANSAS, NEBRASKA, OKLAHOMA AND TEXAS

	Greater		Canadian		Lesser	
	Male	Female	Male	Female	Male	Female
Sample Size	13	3	15-18	19-21	27-31	25-30
Weight (g)						
Mean	4,422.5	4,592.6	4,079.0	3,774.9	3,746.0	3,314.7
Standard Deviation	353.3	303.5	269.3	353.1	288.5	317.7
Extremes	3,742-5,216	4,196-4,933	3,629-4,536	3,289-4,479	3,175-4,423	2,608-3,856
Culmen-post nares (mm)						
Mean	93.8	97.0	84.5	81.3	75.3	73.0
Standard Deviation	5.0	0.8	4.2	6.2	4.1	6.0
Extremes	87-103	96-98	75-91	64-92	68-82	65-86
Culmen (mm)						
Mean	121.6	129.0	108.0	106.8	96.0	93.4
Standard Deviation	7.4	2.1	6.2	7.9	5.1	7.0
Extremes	104-135	127-132	95-119	86-121	86-104	83-108

TABLE I (Continued)

	Greater		Canadian		Lesser	
	Male	Female	Male	Female	Male	Female
Tail (mm)						
Mean	193.5	194.0	180.0	182.9	172.9	169.7
Standard Deviation	11.4	7.0	7.0	11.7	10.8	15.4
Extremes	175-220	185-202	161-196	165-210	152-197	147-227
Wing Chord (mm)						
Mean	497.5	477.0	476.1	464.6	459.9	442.8
Standard Deviation	12.8	4.5	14.2	14.1	14.7	16.8
Extremes	472-520	471-482	444-502	440-488	437-495	410-475
Tarsus (mm)						
Mean	220.6	223.6	211.6	208.5	184.6	177.4
Standard Deviation	6.0	8.4	9.5	8.5	14.6	16.9
Extremes	209-230	211-240	195-238	190-227	152-223	147-210

TABLE II

MEASUREMENTS OF JUVENILE SANDHILL CRANES
IN KANSAS, OKLAHOMA AND TEXAS

	Canadian		Lesser	
	Male	Female	Male	Female
Sample Size	10	4	11-13	1-2
Weight (g)				
Mean	3,730.8	3,387.7	3,355.5	3,401.9
Standard Deviation	367.3	490.8	262.1	0.0
Extremes	3,175-4,196	2,835-4,026	2,948-3,856	3,402-3,402
Culmen-post nares (mm)				
Mean	83.8	78.0	73.1	71.0
Standard Deviation	5.9	8.5	6.9	1.4
Extremes	72-92	70-90	63-89	70-72
Culmen (mm)				
Mean	109.1	102.8	92.6	89.5
Standard Deviation	6.8	8.3	6.0	2.1
Extremes	95-118	97-115	84-102	88-91

TABLE II (Continued)

	Canadian		Lesser	
	Male	Female	Male	Female
Tail (mm)				
Mean	176.0	162.3	164.2	147.5
Standard Deviation	10.4	10.2	10.2	10.6
Extremes	167-200	148-171	144-180	140-155
Wing Chord (mm)				
Mean	470.4	455.0	445.5	419.0
Standard Deviation	21.1	20.9	17.6	25.5
Extremes	440-505	442-486	405-472	401-437
Tarsus (mm)				
Mean	214.3	205.0	183.5	176.0
Standard Deviation	8.9	6.7	14.5	8.5
Extremes	203-230	201-215	147-200	170-182

TABLE III

RACES OF SANDHILL CRANES COLLECTED IN THE SOUTHEASTERN CENTRAL FLYWAY IN THIS AND OTHER STUDIES

Location	Races of Sandhill Crane			
	Greater	Canadian	Lesser	Total
Central Oklahoma	2	1	0	3
Quivira NWR, Kansas	1	3	0	4
Salt Plains NWR, Oklahoma	3	0	2	5
Salt Plains NWR (Buller 1967)	0	0	3	3
Tillman County, Oklahoma	0	4	2	6
Jackson County, Oklahoma	2	15	14	31
Washita NWR, Oklahoma	7	5	7	19
Washita NWR (Buller 1967)	2	2	0	4
Coastal Texas	6	18	5	29
Coastal Texas (Guthery 1972)	2	63	8	73
Coastal Texas (Aldrich and Burleigh 1958; USNM)	1	6	8	15
Nebraska	0	17	49	66
Nebraska (Wheeler and Lewis 1972)	0	0	25	25
Nebraska and bordering Iowa (DuMont 1933)	0	15	12	27
Western Texas (Aldrich and Burleigh 1958)	0	0	31	31
Totals	26	149	166	341

Three lessers and four Canadians were collected in Jackson County, Oklahoma, or just south of the Red River in adjoining Wilbarger County, Texas, during October and November. These included three lessers and a Canadian from one feeding field. Eleven lessers, two greaters and nine Canadian sandhills were collected in Jackson-Wilbarger Counties, Texas, during December, January and February and were classified as wintering birds. Canadian and lesser races were collected simultaneously from a roost on two occasions. Two of the Canadian race were taken in Jackson County during March.

Thirteen cranes were collected at the Washita NWR in October and November; three Canadians, four lessers and six greaters (Table III). On 20 October 1970, two lessers, one Canadian, and one greater were collected at the main roost. On 8 November 1970, a Canadian and a greater were collected at the main roost. On 26 October 1969, three greaters and one lesser were taken from the main roost. Obviously all races will use the same roost simultaneously. Three lessers, one greater and two Canadians were collected on the Washita NWR during December, January and February. Buller (1967) reported two Canadians and two greaters collected on the Washita NWR during fall migration.

In addition to the four UOM specimens mentioned previously, a Canadian collected 28 March 1957, in Canadian County, Oklahoma, a greater collected on 21 March 1964, in Grady County, Oklahoma, and a greater taken in McClain County, Oklahoma in November 1960 were measured at UOM.

Specimens collected in Texas are as follows (Table III): Karnes County, four Canadians, two lessers; Cameron County, two Canadians, one lesser; Aransas County, one greater; Nueces County, two greaters, three

Canadians, four lessers; Wharton County, one Canadian; Colorado County, two Canadians, four greaters; LaVaca County, three Canadians, one greater, one lesser. The Nueces County specimens were all taken during migration in fall, 30 October to 13 November 1968. A museum specimen at the Welder Wildlife Refuge is a Canadian collected 5 November 1957 in Kenedy County.

To further clarify the distribution of cranes in south Texas, Guthery (1972) provided data on the 73 specimens he collected. This author subjected Guthery's data to the DA (Table III). During fall migration, Guthery (op. cit.) collected 11 Canadians and one lesser in Kleberg County; three Canadians in Nueces County, and one greater in Calhoun County. In the period 1 December to 28 February, Guthery collected six lessers and 36 Canadians in Kleberg County; two Canadians in Nueces County; two Canadians in Brazoria County; and three Canadians and one greater in Calhoun County. In March, six Canadians and one lesser were taken in Kleberg County.

Aldrich and Burleigh (1958) collected 39 sandhill cranes wintering in Texas. The races were identified before Walkinshaw (1965a) described the Canadian race. The taxonomic measurements of the 39 cranes were subjected to a DA to determine which races were present. The analysis indicated that the 27 cranes collected in Bailey County, in western Texas, were all lessers. The 12 specimens from the costal area are listed from west to east: Cameron County, one lesser and one Canadian; Kleberg County, one Canadian and one lesser; Victoria County, two lessers and one Canadian; Jackson County, two lessers; and Fort Bend County, one Canadian, one lesser and one greater (Table III). J. W. Aldrich (letter dated 7 April, 1971, FWS) reported seven other specimens

from Texas in the USNM collection: four lessers from near Muleshoe NWR, one lesser and one Canadian from Aransas County, and a Canadian from Calhoun County. The specimens collected by Aldrich and Burleigh (1958) and those in the USNM collection indicate that the birds wintering in western Texas near Muleshoe NWR are mainly lessers.

The taxonomic data from this study, from the specimen at the Welder Foundation, from the data of Guthery (1972), Aldrich and Burleigh (1958), and from specimens at the USNM were combined to present a more complete picture of the distribution of races of cranes along the Texas coast. Specimens collected in winter (1 December through 28 February) were as follows (listed from west to east): Cameron County, three Canadians and two lessers; Kenedy-Kleberg-Nueces Counties, 40 Canadians and seven lessers; Karnes-Aransas-Victoria-Calhoun-Jackson Counties, seven lessers, 10 Canadians, and two greaters; LaVaca-Colorado-Wharton Counties, six Canadians, five greaters, and one lesser; and Brazoria-Ft. Bend Counties, three Canadians, one lesser, and one greater. Highly significant differences existed in the proportion of the different races found east and west of Corpus Christi (x^2 = 17.2, 2 DF, P = <0.005). Greaters (9.1 percent of the collection) were found from Aransas County eastward and were more prevalent in counties near Houston. The Canadian (70.4 percent of the sample) and lesser races (20.4 percent were found all along the coast.

Sixty-three specimens from along the Platte River and North Platte River, Nebraska, in spring, were grouped by the locations at which they were collected, from west to east: Lewellen, eight lessers; North Platte-Hershey, 10 lessers, one Canadian; Overton-Elm Creek, 14 lessers, seven Canadians; Kearney-Gibbon, 14 lessers, three Canadians;

and Alda, five Canadians and one lesser. Some cranes of the Canadian race occur all along the staging area except, perhaps, at Lewellen, but they are more prevalent at the eastern end of the staging area near Alda and Grand Island. Specimens of greaters have not been collected along the staging area in Nebraska.

The chi-square test was used to determine if Canadians and lessers were distributed randomly along the staging area. Among the 40 cranes collected between Lewellen and Overton-Elm Creek there were eight Canadians. In the sample collected between Kearney and Alda there were 15 lessers and eight Canadians. The test indicated that the samples were from two dissimilar populations; there were fewer birds of the Canadian race along the western end of the staging area ($x^2 = 6.14$, DF = 1, $P < 0.02$). Johnson and Stewart (1973), sampling in Montana, North Dakota, and Minnesota, found a similar size gradient among cranes, the larger races being prevalent in the eastern areas.

In addition to the specimens listed above from along the Platte, Wheeler and Lewis (1972:5) listed data for 25 lessers captured near Overton. Three other specimens were examined in museums in Nebraska; two were lessers, for which the location of the collection was not listed, and the third was a Canadian taken in September, 1912, at Kearney, Nebraska.

DuMont (1933) presented measurements for 28 sandhill cranes collected in Iowa and Nebraska between 1884 and 1891. He classified these as either lessers or greaters before Walkinshaw (1965a) described the Canadian race. The taxonomic measurements for DuMont's data (1933) were subjected to a DA (Table III). The analysis indicated that the two specimens from Nebraska, collected in April, were a lesser from

Buffalo County and a Canadian from Wolf Creek (county unknown). The specimens taken in October and November in Nebraska included two lessers, and one Canadian, Dawson County; three Canadians, Buffalo County; one Canadian, Hall County; and one lesser, Plum Creek (county unknown). Specimens from Iowa were collected in Woodbury and Monona Counties in extreme western Iowa near Souix City. These included eight Canadians and seven lessers taken from 14 March to 28 April. Another lesser and a Canadian were also taken in Monona County, Iowa but no date of collection was presented.

Johnson and Stewart (1973) collected 153 adult sandhills: 12 in Montana, 20 in northwestern Minnesota and the remainder in North Dakota. Johnson provided the taxonomic measurements from birds they collected. This author compared the measurements of tarsi, culmen-post nares and wings of cranes collected in the northern plains with cranes collected in the study area, using a multivariate analysis of variance (Barr and Goodnight 1972). The two groups were significantly different in all measurements ($P < .0001$) even when allowance was made for differences of race and sex.

It is not surprising that the two groups are different when one considers the small size of the two samples in relation to the total population being sampled. Recent estimates of the population of lesser and Canadian races that migrate through the Central Flyway are a minimum of 220,000 to 270,000 (Lewis et al. 1974). The sizes of cranes in the Central Flyway probably range from very small lessers to Canadians almost the size of greaters. It is not surprising, then, that the two samples, each representing less than 0.0008 of the total Central Flyway population, have significantly different average body measurements.

Track Measurements

Buller (1967) described the use of track measurements to distinguish greaters from lessers. The distance is measured from the posterior edge of the ball of the foot to the anterior end of the mid toe. Footprint measurements of lessers range from 76 mm to 95 mm and average 86.5 mm; those of greaters range from 100 mm to 123 mm and average 111 mm (Buller 1967). Walkinshaw (1965a) did not identify the Canadian race until Buller's (1967) study was almost complete; consequently, Buller (1967) did not attempt to differentiate the Canadian race. Subsequent studies by Guthery (1972, 1973) indicate that footprints of the Canadian race range up to 112 mm, therefore, greaters are distinguishable only when footprint measurements exceed 112 mm. Lessers are distinguishable only when footprints measure less than 89 mm. A reanalysis of Buller's data (1967) indicates that lessers are present in Phillips and Stafford Counties, Kansas, and in Custer, Jackson, and Alfalfa Counties, Oklahoma. Greaters are present in Jackson and Alfalfa Counties, Oklahoma in fall.

During this study, footprint measurements were taken at roosting areas until it became apparent from examination of collected specimens that considerable overlap in midtoe measurements of the three races would invalidate the technique as a means of indicating the proportion of various races using an area. The overlap in footprint measurements would theoretically be equivalent to the overlap in midtoe length (Table IV). The limiations of the footprint measuring technique are obvious.

TABLE IV

MIDTOE MEASUREMENTS OF RACES OF SANDHILL CRANES FROM KANSAS, NEBRASKA, OKLAHOMA, AND TEXAS

Race, Sex and Age	Midtoe (mm)				
	Mean	N	Standard Deviation	Extremes Low	Extremes High
Greater					
Adult Male	97.7	16	6.2	88.0	107.0
Adult Female	96.3	3	6.2	90.0	105.0
Canadian					
Adult Male	88.9	17	5.2	80.0	96.0
Adult Female	88.8	21	5.3	72.0	95.0
Juvenile Male	89.1	10	5.1	83.0	98.0
Juvenile Female	87.7	4	5.2	83.0	94.0
Lesser					
Adult Male	83.2	28	6.0	68.0	95.0
Adult Female	81.0	28	5.5	70.0	95.0
Juvenile Male	84.9	13	3.9	78.0	90.0
Juvenile Female	80.5	2	3.5	78.0	83.0

Sex and Age Composition

The sex ratio of sandhill cranes examined during this study, excluding the museum specimens, is 59:41 (Table V). This is not significantly different from a 50:50 ratio ($x^2 = 2.268$, 1 DF, $P > 0.05$). The male: female ratio among adult Canadian and lesser cranes in the samples is

50:50. This researcher has no explanation for the preponderance of males among juveniles.

TABLE V

SEX AND AGE COMPOSITION OF SANDHILL CRANES EXAMINED FROM THE STUDY AREA

	Number of Adults		Number of Juveniles	
	Male	Female	Male	Female
Greater	13	3	0	0
Canadian	19	21	10	4
Lesser	33	32	13	2
Totals	65	56	23	6

Stephen et al. (1966) found a male:female ratio of 56:44 among 288 cranes in Saskatchewan. Johnson and Stewart (1973) reported a ratio of 58:42 for 180 sandhills collected in Minnesota, Montana, and North Dakota. Guthery (1972) reported that females made up 48 percent of 67 cranes collected randomly in southern Texas. The ratio of 175 cranes harvested in New Mexico and western Texas was 54:46 (Boeker et al. 1962). Boeker et al. (1961) found a ratio of 50:50 in 119 cranes collected in New Mexico.

Nineteen percent of the sample (Table V) are juveniles (26 percent Canadian and 19 percent lessers). The lack of juveniles assigned to the greater race suggests that the computer might have assigned

juvenile greaters to the smaller races. However, the nine specimens examined from Florida included two juveniles, and during the DA both juveniles were assigned to the greater race. Therefore, the absence of juveniles among the greaters did not appear to be a consequence of the computer's choice during the DA, but probably was a consequence of the small sample.

Guthery (1972) reported that juveniles constituted 15 percent of his collection, which was predominantly the Canadian race. Johnson and Stewart (1973) indicated juveniles constituted 15 percent of their collection. Twenty-two percent of 137 cranes harvested in New Mexico were juveniles and this proportion was similar to that found in the prehunting season sample trapped in the same area (Boeker et al. 1961). Boeker et al. (1962) found that 24 percent of 377 cranes harvested in New Mexico and western Texas were juveniles. Stephen et al. (1966) reported that 16 to 27 percent of the harvest, in various areas of Canada, were juveniles.

The means of distinguishing adults and juveniles in field observations during fall and winter is discussed in the section entitled Field Identification of Juveniles. The technique becomes progressively less reliable during fall and winter as young-of-the-year complete their molt of juvenal feathers on the occiput and nape. The researcher notes also the many factors that make it difficult to acquire data on adult: juvenile age ratios. In addition, other aspects of the study, such as collecting specimens, often received precedence over field counts of adults and juveniles. Counting only the small flocks might have exaggerated the percentage of juveniles because these small groups were probably family groups that did not include nonbreeders. Therefore,

the researcher tried to count flocks containing between 10 and 30 cranes and portions of larger flocks (Table VI). Cranes are so gregarious that flocks larger than 30 cranes are most characteristic of refuges and winter areas, making it difficult to count them.

TABLE VI

PERCENTAGE OF JUVENILES IN OCTOBER-DECEMBER COUNTS OF FLOCKS WITHIN THE STUDY AREA

Year	Location	Flocks Counted	Birds Counted	Average Flock Size	Percentage Juveniles
1968	Oklahoma	6	310	50.1	15.1
1969	Oklahoma	6	212	35.3	8.5
1970	Oklahoma	9	326	36.2	20.5
1970	Texas	9	103	11.4	20.4
Totals		30	951	31.7	16.1

The average size of flocks in which the number of juveniles and adults were counted varied from 11.4 to 50.1 cranes. The annual percentage of juveniles ranged from 8.5 to 20.5 percent with an overall average of 16.1 percent (Table VI). Madsen (1967) found that juveniles constituted 9.4 percent of 1,306 cranes in Kidder County, North Dakota, observed mainly during August and September. Subsequent studies have indicated that Kidder County is a major staging area for Canadian sandhills (Johnson and Stewart 1973).

It is difficult to distinguish family units within large flocks, but two young per adult pair were seen frequently enough that they cannot be considered rare. Fourteen adults, presumably seven pairs, were seen with 11 juveniles in one flock. Hypothetically, four of the seven pairs had successfully reared two young. Single adult pairs were seen with two young several times each fall.

The published literature also indicates that two young per pair are not uncommon. Walkinshaw (1973:Table 8) presents data showing that 17.0 percent of 598 breeding pairs in southern Micigan had two young. Drewien (pers. comm.) observed marked family groups of greaters of the Rocky Mountain population, and found that as many as one third of the family groups are seen with two young during fall migration and on winter areas. Harvey et al. (1968) observed four of 10 sandhill pairs along the western shore of Hudson Bay, each with two young. They noted that the ability of the young to hide, and the manner in which adults separated the young, made it possible that others among the 10 pairs may have also had two young.

Use Areas and Their Populations

Flocks of cranes may stop almost anywhere in western Nebraska, western Kansas, and western Oklahoma during fall migration. Large wheat fields are used for feeding and resting. Wheat fields and wide river bottoms, containing sparsely vegetated sandy soils, are used for roosting (see section entitled Roosting Habitat).

Nebraska

Western Nebraska is not an important stopover area for sandhill

cranes during fall migration (Buller 1967). Cranes rarely winter in Nebraska. The Platte and the North Platte Rivers are the main staging areas for cranes during spring migration. An estimated 80 to 90 percent of the continental population of cranes stops along this staging area. Recent population surveys indicate 200,000 cranes stopping there during the peak of migration (Annual Spring Sandhill Crane Inventories, 1957-1970, FWS files). The use of this area for staging is described in greater detail by Wheeler and Lewis (1972).

Kansas

In Kansas the Kirwin NWR, Quivira NWR, and the Cheyenne Bottoms State Game Management Area are used by migrants, but individual flocks seldom stay longer than one or two nights. Weekly narratives at Kirwin NWR indicate that there is less use of that area by migrating cranes in fall than in the spring. Maximum fall populations have been 200 to 500 cranes, whereas populations in spring often have exceeded 500 cranes and contained 1,500 to 2,500 in four years of the report period. Arrival dates, peak concentrations and the dates cranes were last seen on the Kirwin NWR are listed in Tables VII and VIII. Blank spaces, in these and other tables presenting population data in this thesis, indicate that no data were available.

There are several reasons why the Kirwin NWR is not more intensively used by cranes. Much of the shoreline has deep water close to the bank; this is not suitable roosting habitat. Emergent plants grow in shallow areas to the edge of the shoreline and cranes will not roost in such vegetation when the stand is dense or more than 1 m high. Much of the reservoir border is hilly and covered with native prairie

TABLE VII

OBSERVATIONS ON SANDHILL CRANES, FALL 1955 TO 1968,
AS SUMMARIZED FROM FILES AT KIRWIN NWR

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
500	24/10	500	24/10	500	24/10	1,500	1955
200	6/10	200	6/10	6	29/10	4,000	1956
17	15/10	500	20/10	50	38/10	3,000	1957
120	14/10	250	8/11	250	8/11	4,200	1958
40	28/ 9	250	21/10	43	31/10	3,000	1959
6	3/10	200	18/10	6	3/11	2,500	1960
5	25/ 9	400	31/10	150	2/11	2,000	1961
75	23/10	200	10/11	200	12/11	500	1962
25	25/10	250	5/11	1	1/12	500	1963
8	1/10	328	6/10	30	8/11	2,989	1964
49	30/ 9	150	2/10	50	11/11	1,500	1965
200	3/ 9	500	13/10	2	15/11	3,000	1966

TABLE VII (Continued)

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
4	24/ 9	130	13/11	8	2/11	800	1967
75	28/ 9	525	6/10	525	6/10		1968

TABLE VIII

OBSERVATIONS ON SANDHILL CRANES, SPRING 1956 TO 1968,
AS SUMMARIZED FROM FILES AT KIRWIN NWR

Crane First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
250	24/ 2	400	21/ 3	1	16/ 4	9,000	1956
16	1/ 3	500	2/ 3	175	11/ 4	7,500	1957
25	4/ 3	500	20/ 3	25	28/ 3	3,000	1958
500	24/ 2	500	24/ 2	2	18/ 4	6,000	1959
675	6/ 3	675	6/ 3	19	30/ 4	1,100	1960
32	4/ 3	2,520	7/ 3	175	7/ 4	3,000	1961
77	13/ 2	2,000	14/ 2	4	13/ 4	5,000	1962
140	17/ 1	700	22/ 4		30/ 4	1,200	1963
65	3/ 3	160	15/ 3	26	25/ 3	1,000	1964
39	18/ 3	220	6/ 4	220	6/ 4	1,722	1965
4	2/ 3	18	16/ 4	8	19/ 4	343	1966
4	20/ 4	1,681	15/ 3	77	1/ 4	8,000	1967

TABLE VIII (Continued)

Crane First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
500	26/ 2	1,500	24/ 3	3	20/ 4	7,000	1968

vegetation in contrast to flat terrain and fields of small grains that are more attractive feeding habitat. Agricultural fields on the refuge are smaller, they have more rolling topography, and they are closer to woody vegetation than the kind of areas cranes generally utilize. Portions of the reservoir shoreline include picnic and camping sites, cottages, concession stands and a boy scout camp. The south and northeast parts of the refuge are open to public hearing. These types of activity, scattered over much of the reservoir border, discourage cranes from landing.

The importance of open shallow water areas for roosting was expressed in the 1967 refuge narrative report: "Considerably more cranes stopped here than in former years probably because of the exposed mudflats available."

Tables IX and X indicate the use of Quivira NWR by cranes. The Big and Little Salt Marshes, along with smaller impoundments, provide the main attraction for cranes, ducks and geese. During fall migration sandhill cranes are first seen in early October, peak concentrations occur between mid October and mid November (50 to 4,100) and cranes are last seen in late November. Larger numbers of cranes use this refuge during spring than during fall, in contrast to the pattern of use of the Salt Plains NWR and Washita NWR, but similar to that of the Kirwin NWR. The peak populations in spring vary from 80 to 12,000 cranes.

Most of the cranes roost on the south and west sides of the Big Salt Marsh and on ponds northeast and east of the Big Salt Marsh. Feeding areas are on private lands west of Big Salt Marsh and on refuge fields northeast of the marsh. During visits to the area, the following minimum numbers of cranes were observed: 413, 25 October 1968; 251,

TABLE IX

OBSERVATIONS ON SANDHILL CRANES, FALL 1956 TO 1973,
AS SUMMARIZED FROM FILES AT QUIVIRA NWR

Crane First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
12	7/10	50	13/10	1	10/11	100	1956
		200	11/11	5	1/12	400	1957
100	10/10	250	7/11	10	28/11	400	1958
40	7/10	400	19/10	3	18/11	450	1959
3	13/10	600	3/11	65	18/11	1,500	1960
5	2/10	9	11/10	2	1/11	100	1961
175	21/10	1,000	9/11	18	15/11	5,000	1962
15	13/10	810	6/11	6	11/11	15,000	1963
12	26/ 9	1,850	6/10	300	29/11	6,000	1964
15	20/10	700	23/10	7	29/12	6,000	1965
35	7/10	4,109	16/11	30	7/12	120,000	1966
6	1/10	281	19/10	60	25/11	6,496	1967
	24/10	1,500	28/10		19/11	10,500	1968

TABLE IX (Continued)

Crane First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
	6/10	750	22/10		10/11	4,550	1969
	29/ 9	1,500	25/10		21/11	13,500	1970
	4/10	3,100	15/11		1/12	79,000	1971
	4/10	4,155	16/10		6/12	33,800	1972
	4/10	300	23/10		28/11	9,200	1973

TABLE X

OBSERVATIONS ON SANDHILL CRANES, SPRING 1957 TO 1974,
AS SUMMARIZED FROM FILES AT QUIVIRA NWR

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
25	25/ 2	80	8/ 3	16	5/ 4	100	1957
40	1/ 3				30/ 3	50	1958
130	9/ 3	600	16/ 3	15	20/ 3	1,500	1959
75	11/ 3	500	25/ 3	20	1/ 4	5,000	1960
1	1/ 2	5,000	14/ 3	59	16/ 4	10,000	1961
17	14/ 2	12,000	14/ 3	4	25/ 3	25,000	1962
225	27/ 2	4,500	14/ 3	10	27/ 3	15,000	1963
85	4/ 3	300	18/ 3	54	1/ 4	8,000	1964
28	27/ 2	580	10/ 3	18	14/ 4	10,000	1965
40	3/ 9	4,500	19/ 3	25	30/ 3	40,000	1966
41	2/ 3	2,134	21/ 3	6	5/ 4	16,600	1967
24	5/ 3	1,800	15/ 3	35	17/ 4	30,600	1968

TABLE X (Continued)

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
	26/ 2	400	18/ 3		4/ 4	10,000	1969
	2/ 3	500	8/ 3		11/ 4	7,770	1970
	16/ 2	1,320	30/ 3		6/ 4	17,900	1971
	23/ 2	950	16/ 3		21/ 3	10,100	1972
	6/ 3	455	7/ 3		4/ 4	4,300	1973
	2/ 3	780	8/ 3		7/ 4	11,200	1974

26 October 1968; 339, 27 October 1968; 1,500, 28 October 1968; 69 21 March 1969; 185, 22 March 1969; 200, 1 April 1969; 325, 2 April 1969; zero, 18 October 1969; and zero, 20 March 1970. Large flocks seldom stay longer than a few days.

Oklahoma

The Salt Plains NWR, Oklahoma is used by cranes during both spring and fall migration, but use is usually much higher in the fall months (Tables XI and XII). Cranes arrive in early October, populations peak in mid October or November, and cranes are last seen in November or December. During the fall some flocks stay as long as a week but most apparently stay only one or two nights. The cranes roost at Sand Creek Bay, on salt flats one km south of Highway 11, and on the south end of the reservoir. They feed in wetlands and croplands of the refuge.

During spring migration, cranes are first seen in late February or early March. The peak (200 to 500) occurs in late March, and cranes are last seen in early April (Table XII). Refuge personnel report that during spring migration the cranes seldom stay for more than a day before moving on. During visits to the area the following numbers of cranes were seen: 300, 28 October 1968; 0, 2 November 1968; 67, 3 November 1968; 0, 16 October 1969; 0, 19 October 1969; and 82, 23 October 1969. The small number of feeding fields on the refuge can be censused fairly easily. Ponds and many portions of the salt flats are difficult to reach, and complete coverage of the refuge is possible only by aircraft.

The Washita NWR is used heavily during fall migration and is also a wintering area when habitat factors are suitable. In some years (i.e., 1969-70), cranes depart from the refuge before weather becomes

TABLE XI

OBSERVATIONS ON SANDHILL CRANES, FALL 1947 TO 1973,
AS SUMMARIZED FROM FILES AT SALT PLAINS NWR

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
		385	9/11			500	1947
4	15/10	300	1/11	4	27/11	300	1948
200	15/10	400	30/10	200	20/11	500	1949
2	28/ 9	500	15/11	1	17/12	700	1950
2	1/10	200	15/10	6	26/11	250	1951
2	1/10	500	15/11	200	30/11	16,500	1952
3	9/10	150	15/10	75	30/10	250	1953
		150		0	5/10	200	1954
		800	15/10	0		1,000	1955
		700	9/11	0		2,000	1956
		950	20/10	65	14/11	950	1957
4	3/10	600	25/10	1	9/11	600	1958
5	5/10	200	25/10	10	30/10		1959

TABLE XI (Continued)

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
13	7/ 10	50	21/10	6	8/11		1960
		50				67	1961
30	26/10	160	14/11	100	15/11	160	1962
60	25/ 9	2,000	6/11	500	13/11		1963
120	6/10	7,880	20/10	250	28/11	109,305	1964
2,514	5/10	5,000	14/10	40	31/12	57,500	1965
95	19/10	2,500	27/11	270	30/11	25,000	1966
8	12/10	180	22/11	45	13/12	11,550	1967
3	9/10	1,314	30/10	6	6/11	10,325	1968
4	17/10	810	22/10	810	22/10	5,698	1969
4	5/10	165	7/10	1	23/11	2,961	1970
21	6/10	900	2/11	75	15/12	12,782	1971
37	3/10	357	1/11	183	20/11	5,642	1972
22	9/10	113	23/10	21	5/12	1,519	1973

TABLE XII

OBSERVATIONS ON SANDHILL CRANES, SPRING 1947 TO 1974,
AS SUMMARIZED FROM FILES AT SALT PLAINS NWR

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
150	16/ 3	250	22/ 3	70	24/ 3	800	1947
50	15/ 3						1948
55	7/ 3	500		1	13/ 4		1949
25	16/ 3	30	31/ 3	25	10/ 4	50	1950
30	15/ 3					50	1951
5	8/ 2	500	19/ 3	35	1/ 4	500	1952
75	2/ 3	250	1/ 4	2	15/ 4		1953
90	15/ 3	100	1/ 4	12	17/ 4	125	1954
70	1/ 3	200	15/ 3	2	10/ 4	250	1955
20	10/ 3	300	30/ 3	35	7/ 4	500	1956
4	5/ 3	200	16/ 4				1957
		0					1958
50	9/ 3	300	15/ 3	14	8/ 4		1959

TABLE XII (Continued)

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
22	4/ 3	200	25/ 3	4	1/ 4		1960
		0					1961
50	19/ 2	200	18/ 3	100	27/ 4		1962
23	24/ 2	350	24/ 3	4	15/ 4		1963
100	3/ 3	200	10/ 3	11	26/ 3	1,000	1964
4	12/ 2	40	22/ 3	20	7/ 4	455	1965
1	5/ 4	6	27/ 4	6	30/ 4	112	1966
36	8/ 2	400	22/ 3	1	12/ 4		1967
433	13/ 3	433	13/ 3	30	27/ 3	4,424	1968
150	12/ 3	150	12/ 3	25	2/ 4	1,575	1969
92	24/ 3	92	24/ 3	1	15/ 4	1,120	1970
15	1/ 3	60	10/ 3	1	21/ 3	560	1971
48	23/ 2	729	22/ 3	8	15/ 4	10,073	1972
2	11/ 3	150	18/ 3	25	2/ 4	1,239	1973

TABLE XII (Continued)

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
12	22/ 2	550	8/ 3	22	2/ 4	6,818	1974

severe, and in such circumstances the suitability of roosting sites may be the influencing factor (Table XIII). In fall, the first cranes arrive about 1 October and peak populations occur in mid November (Table XIV). The spring migration occurs in late February, peaks in late March, and few cranes are seen after mid April (Table XV). The cranes generally roost on Joe Foss Reservoir within the refuge boundaries, but occasionally roost in wheat fields west of the refuge. These birds feed mainly on the refuge except during the peak of fall migration when feeding occurs on private grain fields as far as eight km from the refuge.

Censuses of cranes on the Washita NWR (Table XVI) illustrate the rapid population turnover to be expected in a few days or even in a 24-hour interval. In some years, such as 1968, few cranes are present there except in late October and early November.

Sandhill cranes regularly use an area in southern Tillman County during fall migration and are seen there briefly during spring. They roost on the Red River south of Hollister, Oklahoma and feed in grain fields within a few kilometers of the roost on the north side of the river. C. A. Babcock lives near the roost and has maintained records of cranes he saw in the vicinity during a portion of October 1970. Our observations of crane populations are recorded in Table XVII. Cranes arrive in early October and some are seen in the vicinity until late November. Mr. Babcock reports that the peak population contains 2,500 cranes in some years.

Cranes are occasionally seen flying over the Wichita Mountains NWR, Oklahoma. The rugged terrain, absence of agricultural crops, and small lakes with steep or heavily vegetated margins do not provide attractive habitat for Grus. A. F. Halloran, a retired FWS biologist, provided

TABLE XIII

OVERWINTERING STATUS OF SANDHILL CRANES AT THE WASHITA NWR IN RELATION TO WEATHER RECORDED AT ELK CITY

Year and Month	Temperature Departure From Average (C)	Snowfall (cm)	Maximum Snow Cover (cm)	Status of Cranes
1973-74				
November	+ 1.6	0.0	0.0	Depart on 26 Nov.
December	- 1.1	2.54	2.54	
January	- 1.8	4.06	5.08	Return on 28 Jan.
February	+ 2.0	T	T	
1972-73				
November	- 3.3	11.43	10.16	
December	- 3.3	15.49	15.24	Depart on 13 Dec.
January	- 2.8	38.10	20.32	
February	- 0.3	2.79	T	Return on 19 Feb.
1971-72				
November	+ 1.8	0.0	0.0	Stayed all winter
December	- 0.4	19.05	15.24	
January	- 1.1	0.0	0.0	
February	+ 0.6	0.0	0.0	
1970-71 (coldest October ever recorded in Oklahoma)				
November	- 0.5	0.0	0.0	Stayed all winter
December	+ 1.5	0.0	0.0	
January	- 0.6	0.0	0.0	
February	- 1.5	12.70	12.70	
1969-70				
November	+ 0.6	0.0	0.0	Depart on 26 Nov.
December	+ 0.1	5.08	5.08	
January	- 2.9	T	T	
February	+ 1.1	0.0	0.0	Return on 13 March

TABLE XIII (Continued)

Year and Month	Temperature Departure From Average (C)	Snowfall (cm)	Maximum Snow Cover (cm)	Status of Cranes
1968-69				
November	- 0.9	T	0.0	
December	- 2.5	2.54	2.54	Last seen 2 Dec.
January	+ 0.9	T	2.54	
February	- 0.2	2.54	0.0	Return on 5 March
1967-68				
November	- 0.2	1.27	2.54	Stayed all winter
December	- 0.8	T	0	
January	- 0.1	T	T	
February	- 2.0	35.56	20.32	
1966-67				
November	+ 2.5	0.0	0	Stayed all winter
December	- 1.5	0.76	0	
January	+ 2.2	0	0	
February	+ 0.4	T	0	
1965-66				
November	+ 3.7	0	0	Depart on 9 Nov.
December	+ 3.2	2.54	2.54	
January	- 3.0	15.24	10.16	
February	- 2.1	1.27	5.08	Return 15 April
1964-65				
November	+ 0.5	T	0.0	Over-wintered
December	- 0.2	T	0.0	
January	+ 2.0	12.70	12.70	
February	- 0.3	T	0.0	
1963-64				
November	+ 1.4	0.0	0.0	Stayed all winter
December	- 4.0	10.16	7.62	
January	+ 1.5	0.0	0.0	
February	- 2.0	0.0	0.0	

TABLE XIV

OBSERVATIONS ON SANDHILL CRANES, FALL 1961 TO 1973,
AS SUMMARIZED FROM FILES AT WASHITA NWR

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
	Date						
Number	(Day/Month)	Number	Date	Number	Date	Days	Year
30	20/10	221	22/10	2	27/10	250	1961
		45	20/11	45	21/11	300	1962
46	27/10	7,000	6/12	60	23/12	9,000	1963
170	6/10	15,000	18/11		31/12	15,000	1964
40	4/10	3,000	13/10	300	9/11	44,450	1965
1,000	19/10	7,500	13/11		31/12	230,195	1966
4	7/10	8,000	7/11		31/12	274,918	1967
21	3/10	2,150	30/10	2	2/12	28,000	1968
25	25/ 9	2,500	30/10	12	26/11	24,468	1969
450	6/10	3,000	26/10	400	31/12	121,365	1970
2	29/ 9	6,000	3/11	100	31/12	168,714	1971
29	4/10	8,000	25/10	500	13/12	99,813	1972

TABLE XIV (Continued)

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
3	1/10	800	22/10	90	26/11	15,589	1973

TABLE XV

OBSERVATIONS ON SANDHILL CRANES, SPRING 1962 TO 1974,
AS SUMMARIZED FROM FILES AT WASHITA NWR

Cranes First Seen			Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)		Number	Date	Number	Date	Days	Year
6	14/ 2		116	3/ 3	25	7/ 3	500	1962
75	28/ 1		800	20/ 3			3,500	1963
23	1/ 1		130	18/ 3	37	1/ 4	500	1964
	Present	1/ 1	4,000	19/ 3	20	1/ 4	11,500	1965
	15/ 4		2	15/ 4	2	15/ 4	14	1966
	Present	1/ 1	1,600	23/ 3	4	6/ 4	25,134	1967
1,300	3/ 1		1,300	3/ 1	2	3/ 5	18,765	1968
48	5/ 3		1,000	11/ 3	400	10/ 4	16,300	1969
140	15/ 3		2,000	27/ 3	50	4/ 4	15,500	1970
400	1/ 1		1,000	4/ 3	2	22/ 4	42,119	1971
100	6/ 1		6,000	10/ 3	5	8/ 5	60,354	1972
26	19/ 2		4,000	12/ 3	75	26/ 3	41,272	1973

TABLE XV (Continued)

Cranes First Seen		Peak Concentrations		Last Seen		Total Estimated Crane Use	
Number	Date (Day/Month)	Number	Date	Number	Date	Days	Year
3	28/ 1	385	25/ 3	11	1/ 4	6,685	1974

TABLE XVI

MINIMUM POPULATIONS OF SANDHILL CRANES CENSUSED BY THE INVESTIGATOR AT WASHITA NWR

Date (Day, Month, Year)	Population	Date (Day, Month, Year)	Population
16- 3-68	170	24-11-68	35
17- 3-68	120	26-11-68	0
18- 3-68	120	27-11-68	3
30- 3-68	44	15- 3-69	473
31- 3-68	44	12- 4-69	0
6- 4-68	16	13- 4-69	0
7- 4-68	12	5-10-69	0
27- 9-68	0	10-10-69	0
3-10-68	0	25-10-69	700
4-10-68	18	26-10-69	800
5-10-68	30	31-10-69	2,000
6-10-68	305	2-11-69	200
7-10-68	100	14-11-69	200
11-10-68	300	15-11-69	19
12-10-68	28	16-11-69	74
13-10-68	110	20-11-69	11
9-11-68	400	20-10-70	1,000
10-11-68	571	30-10-70	231
11-11-68	300	8-11-70	1,000
15-11-68	102	15-11-70	653
16-11-68	63	18-11-70	1,000
18-11-68	34	21-12-70	600

TABLE XVI (Continued)

Date (Day, Month, Year)	Population	Date (Day, Month, Year)	Population
29- 1-71	300	7- 3-71	150
30- 1-71	154	12- 3-71	135
15- 2-71	275	13-10-71	700
19- 2-71	825	10-11-71	200
1- 3-71	800	4-12-71	300

records of sandhills that he and other refuge personnel observed from 1954 to 1967. Sandhills were recorded on only eight occasions during fall and four of these groups were flying overhead. Sandhill cranes are rarely seen at the Tishomingo NWR at Lake Texoma in Johnston County, Oklahoma.

Personnel of the Oklahoma Department of Wildlife Conservation report that a major migration pathway passes between Forgan and Buffalo, Oklahoma. Nice (1931) indicated that sandhill cranes sometimes overwintered along this migration pathway near Gate, Beaver County, at the eastern end of the Oklahoma Panhandle. The investigator visited the area in November of 1968 and of 1969. None of the local people who were interviewed recalled that cranes had ever overwintered in the area. Cranes are seen migrating through the area for a two- to three-week period during fall. Some flocks stop for one or two days and then move south. Cranes roost in wheat fields and playa lakes and feed in fields of milo and wheat.

TABLE XVII

SANDHILL CRANES OBSERVED IN THE VICINITY OF THE BABCOCK ROOST IN TILLMAN COUNTY

Date (Day-Month-Year)	Number of Cranes	Location	Time	Observer
3/ 1/69	0	Roost and vicinity	1600	Lewis
23/11/69	518	On roost	1730	Lewis
24/11/69	500+	On roost	1730	Lewis
5/12/69	5	Flying		C. A. Babcock
8/10/70	236	In wheat field	0900	C. A. Babcock
8/10/70	10	In wheat field	1500	C. A. Babcock
9/10/70	24	Flying	0900	C. A. Babcock
9/10/70	6	In wheat field	1600	C. A. Babcock
9/10/70	5	On roost	1730	C. A. Babcock
10/10/70	63	On roost	1700	C. A. Babcock
11/10/70	24	Flying	0900	C. A. Babcock
12/10/70	153	Flying	1600	C. A. Babcock
13/10/70	223	Flying	0900	C. A. Babcock
13/10/70	345	On roost	1700	C. A. Babcock
14/10/70	64	Flying	1000	C. A. Babcock
14/10/70	34	On roost	1700	C. A. Babcock
15/10/70	26	Flying	0900	C. A. Babcock
16/10/70	53	On roost	1700	C. A. Babcock
17/10/70	26	Flying	1600	C. A. Babcock
24/10/70	200	On roost	1830	Lewis
24/11/70	300	On roost	1730	Lewis
4/12/70	0	Roost and vicinity	1700	Lewis

The favored crane habitat in Beaver County is located 6 km northeast of Forgan and includes an area 10 by 11 km that is used from mid October to mid November. A rancher reported 1,000 to 2,000 cranes in the area at the peak of migration in 1968, but he saw only two small flocks during fall of 1969. The rancher rarely sees more than six cranes in the spring.

Cranes arrive in Jackson County in early October and depart in early March. Peak populations generally occur in early November and the population declines until late February when some early spring migrants bolster the wintering populations. Cranes that roost along the Red River feed also in Hardeman and Wilbarger Counties, Texas. During recent winters cranes have not roosted at Santa Rosa Lake in Wilbarger County because the cranes and Canada geese were deliberately hazed and driven off by airplanes contracted by the owner of the Waggoner Ranch.

Wintering populations for the Jackson County area in the three winters 1968-69, 1969-70 and 1970-71 varied from 350 to 1,800 cranes (Tables XVIII, XIX and XX). These tables list the census for feeding areas only when the areas are utilized by cranes not previously censused at a roost that day. Weather and local habitat conditions influence the numbers of cranes that are present. During the fall of 1970, migrating cranes did not stop in normal numbers (Table XX). Cranes apparently moved quickly through Oklahoma, perhaps in response to the unusually cold weather. October of 1970 was the coldest October on record for Oklahoma, and snow fell throughout northwestern Oklahoma (U. S. Dept. Commerce 1970). Another factor probably influencing population size in Jackson and Wilbarger Counties in 1970-71 was the condition of roosting habitat along the Red River. The summer of 1970

TABLE XVIII

SANDHILL CRANE POPULATIONS IN JACKSON COUNTY, OKLAHOMA, HARDEMAN AND WILBARGER COUNTIES, TEXAS, 1968-1969

Date (Day/Month)	Total Estimated Populations	Census Areas			
		Mock and Neil Roosts	Goodwin and Young Roosts	Bush Roost	Other Roosts and Feeding Areas
20/11	3,000				2,600
30/11		100			150
1/12	1,600	903		400	90
2/12	1,600			400	
13/12	1,400				250 - Brawley Roost
14/12	1,400			400	
15/12	1,400	717	546		
26/12	1,800		400	250	
27/12	1,800		231	30	409
28/12	1,800				
29/12	1,800				559
2/ 1	1,000				476

TABLE XVIII (Continued)

Date (Day/Month)	Total Estimated Populations	Census Areas			
		Mock and Neil Roosts	Goodwin and Young Roosts	Bush Roost	Other Roosts and Feeding Areas
3/ 1	1,000				
4/ 1	1,000		200		300
18/ 1	600	250		55	225
15/ 2	350				13 - Drury Roost
16/ 2	350				10 - Drury Roost
1/ 3	350		311		
2/ 3	200		200		
8/ 3	350		350		

TABLE XIX

SANDHILL CRANE POPULATIONS IN JACKSON COUNTY, OKLAHOMA, HARDEMAN AND WILBARGER COUNTIES, TEXAS, 1969-70

Date (Day/Month)	Total Estimated Population	Census Areas				
		Mock Roost	Neil Roost	Bush Roost	Drury Roost	Other Roosts And Feeding Areas
22/11	1,200			124		240 - W. Bridge Roost
23/11	1,200					0 - Goodwin Roost
24/11	1,200					0 - Goodwin Roost
25/11	1,200	365	350			
26/11	1,200			240		
5/12	900		250			40 - Dennison Roost
6/12	900			204		
7/12	900					53 - Dennison Roost
12/12	900		337			
13/12	900	252				

TABLE XIX (Continued)

Date (Day/Month)	Total Estimated Population	Census Areas				
		Mock Roost	Neil Roost	Bush Roost	Drury Roost	Other Roosts And Feeding Areas
23/ 1	700			112		
24/ 1	700			25		
25/ 1	700	312	0			
21/ 2	1,440	711	0	550		
22/ 2	1,440				345	557
28/ 2	1,440				250	60
1/ 3	640	640	0			
14/ 3	70	53	0		0	0 - Brawley Roost

TABLE XX

SANDHILL CRANE POPULATIONS IN JACKSON COUNTY, OKLAHOMA, HARDEMAN AND WILBARGER COUNTIES, TEXAS, 1970-71

Date (Day/Month)	Total Estimated Population	Census Areas			
		Mock Roost	Neil Roost	Bush Roost	Other Roosts And Feeding Areas
10/10	150	130	0		
24/10	100			14	0 - Drury Roost
1/11	300	200	0		32
7/11	150	0	41	6	42
8/11	50	10	0		0 - Drury Roost
25/11	300			248	0 - Drury Roost
2/12	100				11
5/12	700			102	400
6/12	700	557	0		
22/12	450			12	
23/12	450	420	0		
23/ 1	500	478	0		
24/ 1	500				105
5/ 2	1,200			165	
6/ 2	1,200	897	0	0	
5/ 3	10			4	
6/ 3	10	0	0		
7/ 3	0				0 - Drury Roost

was the driest summer since the early 1930's. The Red River was almost dry west of its confluence with the Salt Fork. The Drury and Brawley Roosts, located west of the confluence with the Salt Fork, received no use that year, and populations using the Bush Roost (located just west of the junction with the Salt Fork) were lower than normal.

Texas

All field observations in Texas occurred in late December and early January of 1969-70 and 1970-71. The birds observed at that late date were presumed to represent wintering birds, although during brief periods of extremely cold weather some of these cranes may move further south into Mexico. Interviews with employees of the Texas Parks and Wildlife Department and local landowners indicated that the birds present in late December and January were representative of the wintering population. Minimum populations of cranes wintering in areas observed along the Texas coast (Figure 2) from north to south were: Waller County, 70; Brazoria-Ft. Bend Counties, 3,000; Colorado County, 1,000; Wharton County, 2,000; LaVaca County, 1,000; Victoria County, 75; Karnes County, 1,500; Refugio County, 200; Aransas County, 1,000; Atascosa County, 500; Live Oak County, 100; San Patricio County, 550; Nueces County, 65, Kleberg County, 2,050; Hidalgo County, 2,000; and Cameron County, 275. Few cranes winter east of Brazoria and Ft. Bend Counties.

Two hundred cranes were seen 2 km north of Egypt, in Wharton County, 24 December 1969. Two hundred and twenty-four were seen 5 km northeast of Egypt on 31 December 1969. Two hundred and eighty were observed in the same area on 31 December 1970. Interviews with local

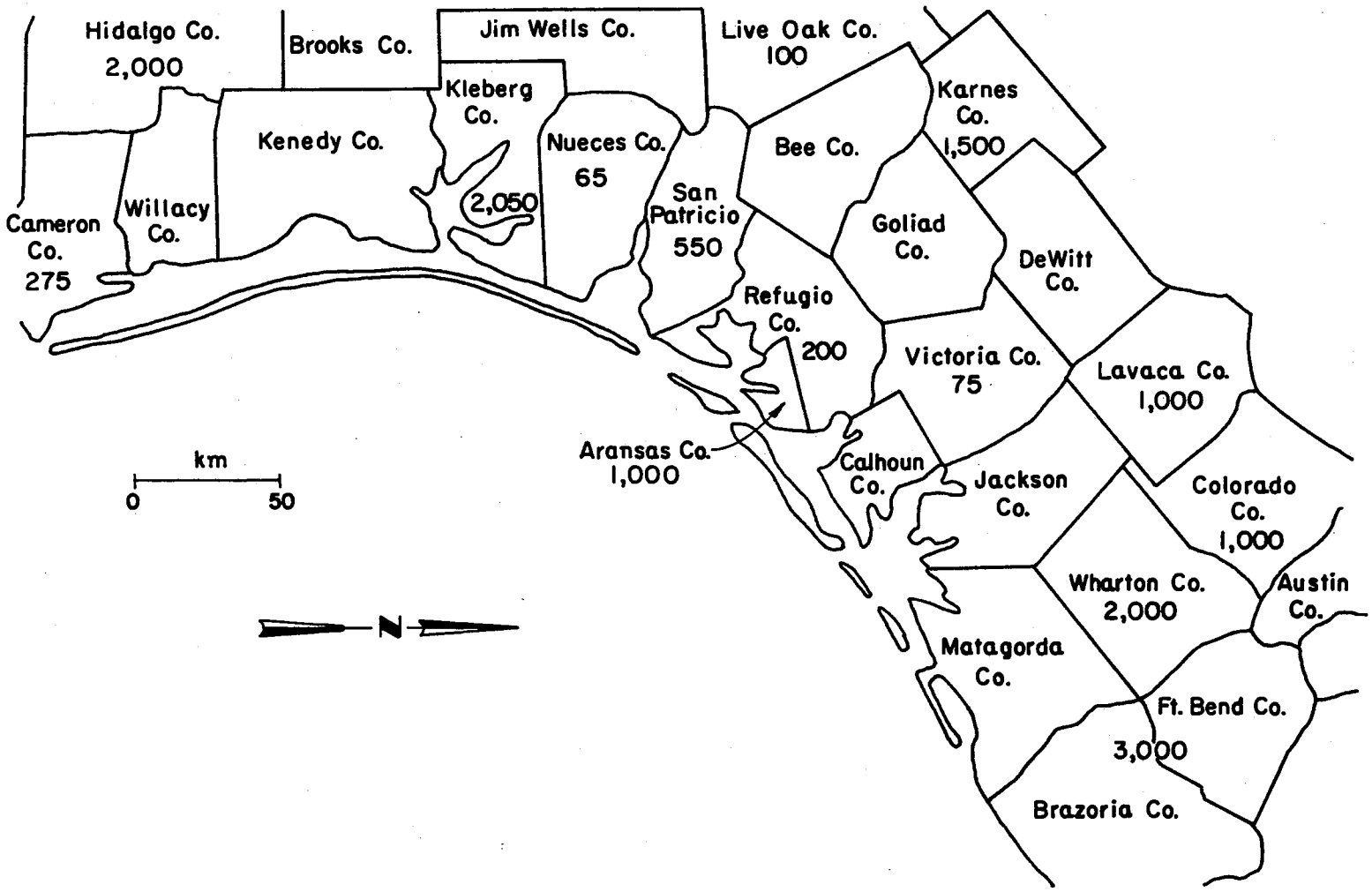

Figure 2. Wintering Populations of Sandhill Cranes Censused in Southern Texas

ranchers and personnel of the Texas Game, Fish and Parks Commission indicate that at least 1,000 cranes wintered in northern Wharton County, on and around the lower Lissie-Garwood Prairie, and that another 1,000 wintered in southern Wharton County.

Nine hundred and ninety-two cranes were seen near Speaks in LaVaca County on 26 December 1969, 717 on 28 December 1969, and 667 were seen on 31 December 1970. A minimum of 1,000 cranes, and probably more, winter 2.5 to 8 km northeast of Speaks. They feed in harvested rice fields, native grass pasture and wet glades. They were abundant on the Hancock, Neyhous and Zibara Ranches. A group of 400 roosted on 31 December 1970 in a flooded rice field in eastern Colorado County then flew 9.5 km to feed near Speaks.

About 70 cranes wintered in Waller County, feeding in harvested fields of peanuts and corn. The investigator was unable to see these birds but they use an area 6.4 km north of Pattison. A minimum of 200 cranes winter in southern Refugio County. One hundred and ninety-three were seen there on 8 January 1971.

Approximately 2,000 cranes wintered in Hidalgo County. This large group roosted at Sol del Rey Lake where the investigator saw about 2,000 on 7 January 1971. These birds flew 6 to 10 km to feed. Approximately 75 cranes wintered north of Victoria in Victoria County. They were seen within a few kilometers of the airport on 29 December 1969. Sixty-five wintered in Nueces County where they were seen in a field of harvested corn 11 km southeast of Robstown on 30 December 1970.

A minimum of 2,050 cranes wintered in Kleberg County where observations were made on 4, 5 and 8 January 1971. Five hundred and fifty-eight were observed on 4 January, 3 to 8 km east of

Ricardo. On the same date, William Kiel, a biologist for the King Ranch, and the researcher observed 305 cranes roosting at a lake 10 km west of Kingsville. Most cranes came to the roost from the direction of agricultural lands west of Kingsville. On 8 January 1971 the researcher counted 700 cranes as they left a roost on Cayo de Grulla, 15 km southeast of Kingsville. These cranes flew 4.5 to 8 km west to feed. Kiel reported that 2,000 cranes were on the Laureles Division of the King Ranch and 700 cranes were near Ricardo during the previous week. The group of 2,000 probably represents cranes that reportedly roost on Laguna Larga.

A minimum of 275 cranes were present in Cameron County on 6 January 1971 at the roost located at the old Gunnery Range on Laguna Atascosa NWR. Eleven hundred cranes were counted there 1 January 1971 by Fred Guthery. One hundred cranes wintered in Live Oak County along the upper end of Lake Corpus Christi. Twenty were seen in the area on 30 December 1970 during an aerial survey.

Twenty-six cranes were seen near Whitsett during an aerial survey on 30 December 1970. Interviews with local landowners indicate that 500 cranes wintered between Whitsett and Campbellton in Atascosa County. A minimum of 440 cranes were present on Arkansas NWR on 30 December 1969 and LeMoyne Marlatt, Assistant Refuge Manager, estimated that 1,000 cranes were there on 8 January 1971. They roosted at Thomas Slough near refuge headquarters, at Mustang Slough, and at Burgentine Lake where the investigator watched 26 roost on 8 January 1971.

At least 1,000 cranes wintered in Colorado County on the Altair Prairie northwest and west of Altair. Eight hundred and sixty cranes were seen there on 22 December 1969, 455 on 23 December 1969, and 373 on

28 December 1970. They roosted in rice fields and glades and fed in the harvested rice fields and native grass pasture. A significant portion of the crane habitat on Altair Prairie was being destroyed by gravel mining operations that left deep ponds and spoil banks alternating in long strips.

A minimum of 1,500 cranes wintered in Karnes County west of Kenedy and west of Coy City where the researcher saw 425 on 1 January and 1,500 on 2 January 1971. They were observed at roosts on Crew's Reservoir and at a reservoir on Tenne Company property 9 km southwest of Coy City.

Thirty-five cranes were seen near Fulshear, Ft. Bend County, on 28 December 1970 feeding in harvested rice on the Cardiff Brothers Ranch 5 km northeast of Fulshear. Cranes also used the Don McMillan ranch 1.6 km north and west of Cardiff's. They used these areas annually. One of the Cardiff brothers said the total population was about 150 cranes. Scattered small flocks of cranes were observed in southern Ft. Bend County and Brazoria County. After interviewing local landowners and USDA personnel, the author estimated that the area contained 3,000 wintering cranes.

The investigator observed 237 cranes along main roads in the vicinity of Sinton, San Patricio County, on 2 January 1970. Interviews with Clarence Cottam and Caleb Glazener of the Welder Wildlife Foundation, and with local ranchers, indicated that a minimum of 550 cranes wintered in the area. The main roost was located east of the Welder Refuge. Cranes sometimes roosted on the refuge on ponds and small lakes. More than 47,000 ha of sorghum was planted in the county

(Texas Crop and Livestock Reporting Service 1969); this, along with native pasture, provided the main feeding habitat.

Guthery (1972) censused cranes in some of the counties where this investigator made field observations and in some other counties the researcher did not work in. Our combined data indicate a minimum of 23,000 cranes wintering in southern Texas.

Cranes also wintered in west central and western Texas but little was known about their population size except in the vicinity of Muleshoe NWR. The responses to questionnaires mailed to Wildlife Services personnel of the FWS in Texas indicated that cranes wintered in the following counties of central and western Texas: McMullen (300 cranes), Medina, Uvalde (small flocks) Duval, Brooks, Pecos, Midland, Glasscock, Reagan, Martin, San Saba, Shackelford, Young (several hundred), Olay, Jim Hogg, Cottle (several hundred), Mitchell, Gaines (2,000), Baylor, Foard, Lubbock and Bailey (Muleshoe NWR). A resident of Damon, Texas reported that 1,000 cranes wintered in LaSalle and Frio Counties. Val Lehman, biologist at the King Ranch, reports (personal communication) that cranes wintered in Val Verde County. The subspecies wintering in Texas are unknown except for cranes in the vicinity of Muleshoe NWR, in Hardeman and Wagoner Counties, and along the Texas coast.

In some years cold weather appears to stimulate movement of large numbers of cranes from southern Texas into Mexico. On 22 and 23 December 1969, the researcher censused a minimum of 860 cranes in the vicinity of Altair, and on 26 and 28 December 1969, 992 cranes were seen in the vicinity of Speak. A cold front entered the coastal area on 29 December. During an aerial survey on 31 December, Gust Nun (FWS) and the investigator were able to see only 56 cranes around Altair and 95

near Speak. Mr. Nun was experienced in aerial surveys of waterfowl along the Texas coast and was surprised at the paucity of cranes in areas where they usually were seen.

Records summarized from files at Aransas NWR and Laguna Atascosa NWR (Tables XXI and XXII) illustrate the use of coastal areas in Texas. Cranes are usually first seen at Aransas NWR in the first two weeks of October, the population peaks in November or December, and the cranes have usually departed by mid March. Peak populations fluctuate between a few hundred and several thousand, depending on conditions of weather and habitat. Shields and Benham (1969) noted that more cranes than usual stayed on the Aransas NWR for a longer time period than usual in 1964-65, presumably due to the food plantings available that winter.

An excellent acorn and grape crop reported by refuge personnel may have added to the refuge's attractiveness in 1968 when the area had its highest population recorded. Refuge personnel reported that cranes fed extensively on acorns in the inland glades. Conversely, the mast crop was reported to be poor in 1965 when the peak population was only 800 cranes. Water conditions all along the coast also seemed to influence use of the refuge by cranes. Cranes are more widely dispersed along the Texas coast after hurricanes when low areas are flooded.

General Behavior

The following synopsis is presented to outline briefly a day's activities for a group of sandhill cranes on their wintering area. Conditions at daybreak are temperature at -1 C, wind from the east at 4 kmph, sky clear, one-eighth moon visible. At 0655 the cranes are standing in shallow water of the Red River. They are quiet. Small

TABLE XXI

OBSERVATIONS ON SANDHILL CRANES, 1949 TO 1969,
AS SUMMARIZED FROM FILES AT ARANSAS NWR

	First Noted in Fall		Peak Populations		Last Seen in Spring	
	Date					
Year	(Day/Month)	Number	Date	Number	Date	Number
1949	4/10	5	29/11	250		
1950	15/10	1	11/11	1,000	15/ 3	2
1951	14/ 9	2	24/10	400	/ 3	3
1952	14/10	12	31/12	1,500	15/ 3	3
1953	10/10	3	1/ 1	856	20/ 3	3
1954	10/10	3	7/12	500	16/ 3	19
1955	20/ 9	2	3/11	3,000	10/ 3	5
1956				2,000	/ 3	
1957	19/10	3	1/ 1	2,000	/ 4	6
1958			1/ 1	800	15/ 3	
1959	7/10		19/11	500	19/ 3	
1960				500	5/ 3	80
1961			15/ 9	635	15/ 3	35
1962	15/10	23	21/10	365	18/ 3	
1963	25/10	2	30/11	350		
1964	8/10	25	2/11	2,200	22/ 3	25
1965	3/10	2	22/12	800		
1966	12/10	15	10/12	3,000	12/ 3	50
1967	14/10	5	31/12	2,000	8/ 3	25
1968	2/10	25	7/11	6,300	15/ 3	200
1969			1/ 1	1,250	27/ 3	150

TABLE XXII

OBSERVATIONS ON SANDHILL CRANES, 1949 TO 1969, AS SUMMARIZED FROM FILES AT LAGUNA ATASCOSA NWR

	First Noted in Fall		Peak Populations		Last Seen in Spring	
	Date				Date	
Year	(Day/Month)	Number	Date	Number		Number
1949	26/10	7	8/11	60	30/12	18
1950	2/11	3	10/11	142	12/ 3	16
1951	7/10	8	11/ 1	140	22/ 4	10
1952	19/10	14	/12	151	/ 2	135
1953	10/ 9	1	/ 1	150	17/ 3	14
1954	24/10	3	/12	600	5/ 4	22
1955	14/10	11	31/12	632	23/ 2	300
1956	13/10	3	17/12	660	17/ 3	2
1957	20/10	3	29/12	776	9/ 3	3
1958	26/10	100	23/12	1,363		
1959	15/10	265	30/10	2,000	20/ 3	3
1960	22/ 9	4	22/11	676	18/ 3	27
1961	5/10	10	17/ 1	1,240	9/ 3	500
1962	18/10	8	31/10	1,150	2/ 3	637
1963	20/10	10	11/12	720	14/ 3	19
1964	9/10	70	15/11	2,400	13/ 3	7
1965	1/ 9	2	23/12	1,300	4/ 3	3
1966	13/10	68	9/11	1,800	8/ 3	13
1967	28/ 9	2	20/11	1,020	9/ 3	4
1968	21/10	10	14/11	2,000	3/ 4	17
1969	9/10	6	9/11	2,000	27/ 3	2

groups are scattered along a 0.3-km stretch of the river. Some are still sleeping with their heads resting on their backs, others have their heads upright and seem alert. At 0700 several begin stretching, flapping their wings, ruffling their feathers, and shaking. At 0720 some begin calling and they move out of the water. They walk along sandbars pecking at the ground. Gradually all awaken and leave the water. At 0725, 49 birds that roosted together fly towards a feeding field.

At 0740 they begin arriving at a haygrazer field that has been pastured by cattle. Flocks of 65, 12, 35, 43, 19, 81, and 108 glide in with wings outspread. At 0751 groups of 25, 26, 50, 9, 30 and 45 cranes arrive. At 0800 a flock of 11 lands and at 0809 flocks of 100, 11 and 17 cranes are approaching the field. The entire group moves across the field feeding rapidly. Those at the end of the feeding group fly over the others and land at the head of the flock. Groups of 1 to 12 to 20 cranes leapfrog in this manner. At 0825 six more birds come from the direction of the roost.

By 0830 the rate of feeding has slowed. Some birds begin to bow and dip in actions similar to courtship behavior. One sleeps with its head under its wing. Others are preening. One begins leaping about with a piece of haygrazer stalk in his bill, throwing and chasing it. An adult offers an item of food to a juvenile almost as large as the adult. The juvenile eats it. Some stand still except for occasionally stretching a wing or leg.

One begins feigning and sparring with his bill while facing another crane. They touch bill tips and then one steps back. Two other cranes face each other; one spreads its wings to their full

extent and the other responds with the same action. Then both go through a series of dips and bows. One does a turning pirouette with the neck folded back slightly and the bill open a few centimeters, the wings are half opened, and then the bird jumps about. The bird's partner leaps several times. Both bow briefly and the crane that initiated the dancing begins pecking at the ground. Feeding and the other activities described continue at a slow pace through the morning.

At 1137, groups of three, seven, and three fly. They form a single flock to the northwest, circle at an altitude of 50 m and return to the field at 1142. At 1155, four fly northward but return a minute later. At 1200, 3, 11, and 1 fly northward but return a minute later. Then 12 and then several hundred fly and circle at an altitude of approximately 160 m. Some return in a few minutes, while others continue to circle. At 1223 several hundred more fly. Those remaining on the ground are not feeding; they act alert and walk about rapidly. One begins leaping. One of the large flocks is now circling far to the north and another group is an estimated 200 m above the first. Small flocks return to the ground at frequent intervals. One flock circles approximately 1.5 km to north before returning to the feed field at 1238.

A flock flys to a nearby roost and lands. Seven squat near the water's edge and one stands nearby. Twenty rest 6 m away and three stand alertly near a salt-cedar thicket. Occasionally additional groups of 3 to 12 cranes join them. They are quiet except that when each new flock arrives its members call several times. Within 50 min there are 200 cranes resting there. At 1400 they fly back to the feed field.

The sky begins to cloud over; the wind is now from the north and becomes cool; rain begins lightly and then increases in volume. The cranes are feeding rapidly; mud accumulates on their feet until they appear as though they are wearing galoshes. They seem more antagonistic and more pecking occurs between cranes than occurred in the morning. Instead of their usual stately gliding walk they lift their feet high and shake them to get rid of the mud.

It continues to rain hard and the wind becomes colder. While feeding, they use their bill as a probe and also to sweep away debris. The rain turns to snow and begins to obscure visibility through the spotting scope. Snow begins to accumulate on the backs and shoulders of some birds. At 1620 the snow slackens and the entire flock stops feeding. Within a 2- or 3-min period they leave in three large flocks and fly toward the roost. Other aspects of behavior are discussed elsewhere in this dissertation, and by Lewis (1970), and Wheeler and Lewis (1972).

Interactions With Other Species

Among the interactions observed between cranes and other species were several with coyotes. The close presence of a coyote appeared to disturb cranes. At daybreak on 28 October 1968 the researcher observed a coyote walking parallel to the roost at Big Salt Marsh, Quivira NWR, Kansas. The cranes seemed to behave apprehensively and appeared to be watching every movement of the coyote. The coyote was about 33 m from the cranes and those closest to him shied away. The coyote then saw the researcher and ran into a tall stand of *Scirpus*.

On 24 November 1969 the investigator was watching cranes on the roost in Tillman County. Small flocks were scattered along the river flood plains but the researcher could only see those closest to him. These closest flocks seemed restless and moved about frequently in flights extending several hundred meters. Others flew and returned to feeding fields. A coyote was seen behind a peninsula of salt-cedar. The cranes nearby acted disturbed but did not fly, and he approached no closer to them than approximately 66 m.

On 16 February 1969 the researcher watched a coyote in a haygrazer field containing cattle and cranes. First the coyote walked in plain sight in a casual manner through the field and then ran at a calf that was lying down. The calf jumped up and ran. The coyote did not pursue it but moved slowly in the direction of the cranes. The cranes all began making their alarm call (Walkinshaw 1949:22). The coyote walked toward another calf, but when the calf stood up the coyote turned away. When the coyote was within approximately 33 m of the cranes he turned and entered a dense growth of haygrazer and weeds and disappeared from view. The cranes were all alert and in one compact group. They stopped calling when the coyote disappeared and they began moving slowly toward the spot where the coyote was last seen. After 2 min the cranes in the background commenced feeding. A few cranes continued walking toward the spot where the coyote was last seen, but before reaching that location they turned and fed in the opposite direction.

On 5 December 1970, 102 cranes at the Bush Roost, Jackson County were preening, loafing, and feeding. Dancing, bowing, and leaping occurred frequently in addition to some chasing. At 0730 the cranes appeared to be especially alert and they lined up along a sandbar.

Several were leaping and the flock moved forward while facing the wind. They appeared ready to take flight and then the investigator saw a coyote about 33 m from the cranes. It did not look directly at them. The cranes seemed to watch the coyote closely. The coyote entered a salt-cedar thicket along the river and the cranes no longer seemed ready to fly. At 0740 the flock began calling loudly and the first group left the roost.

In all of the crane-to-coyote interactions the cranes seemed much more wary than they did when interacting with other species. Coyotes probably prey on injured or sick cranes.

Cranes and crows exhibited aggressive behavior toward each other. Twenty-three cranes were feeding in a haygrazer field in Jackson County in which 20 crows were located along the field border. Individual or small groups of crows swooped low over the cranes occasionally as though harassing them. One crow was setting on a fence post above and only 1 m from a crane. The crow appeared to be scolding the crane. The crane was motionless and continued to look upward, with his neck curved back toward his back. Once the crow looked in another direction and the crane relaxed and held its head upright. When the crow looked back at him the crane again pulled his head back in what appeared to be a defensive or aggressive posture. The crane's wings were held slightly away from the body and its legs were flexed as though it was ready to jump at the crow. The crow left after 2 min.

On another occasion cranes were landing in a haygrazer field; each time cranes landed all of the crows flushed and left the vicinity. Using a spread wing posture, one crane threatened a crow that alighted about 5 m away. The crows stayed 6 m or more from the cranes and

moved when cranes came closer. On a third occasion the researcher twice saw a crane threaten and chase a crow.

A crane was observed chasing a pair of mallards (Anas platyrhynchos) on a roost at Washita NWR. All other interactions of cranes and other species seemed to be nonaggressive. Cranes were seen at roost sites with gulls, ducks, Canada geese (Branta canadensis), American avocet (Recurvirostra americana), white pelicans (Pelecanus erythrorhynchos), great blue herons (Ardea herodias), and snipe (Capella gallinago) but they did not roost together. Cranes were seen feeding near Canada geese, whitefronted geese (Anser albifrons), snow geese (Chen hyperborea), a brant (Branta bernicla), whooping cranes (Grus americana), rock doves (Columbia livia), boat-tailed grackles (Cassidix mexicanus), and pintail ducks (Anas acutus).

Migration

Behavior During Migration

Sandhill cranes vocalize frequently while migrating and this reveals their movements to observers. Although they have been known to fly at altitudes up to 2,666 m (Terres 1968) they are frequently at lower altitudes where they can be seen with the aid of binoculars and where they can be heard.

Studies of behavior of sandhill cranes during migration have not been published; however, their behavior is probably similar to that of the common crane (Grus grus). Kiel (1970) used radar and a network of visual observers to study movement of common cranes across Germany. There seemed to be a close correlation between migration of the cranes and weather factors. Their flight altitudes fluctuated between 50 m and

2,000 m, but most flocks fly at altitudes between 50 m and 300 m and at flight speeds of 46 to 65 Kmph (Kiel 1970).

Sandhill cranes frequently migrate during the daytime; however, a significant number also migrate at night. On 26 October 1968, 50 cranes were on the roost at Big Salt Marsh, Quivira NWR, at dusk, but they left sometime during the night. On the next evening 339 cranes were on the same roost by the time it was too dark to continue observing, and other cranes could still be heard calling as they arrived. Before daybreak the next morning, cranes could be heard calling as they approached the roost and landed. The census of cranes at daybreak indicated that 1,100 had arrived during the night.

Williams (1970) described the clamoring, and the subsequent circling flight to gain altitude, that precedes the departure of sandhill cranes migrating from Florida in spring. Similar behavior was observed several times in fall and spring within the study area. On 1 April 1969, 55 cranes flew at 1628 from a field on Quivira NWR. They circled for 12 minutes, gaining an altitude of an estimated 650 m, and then flew northward. They called constantly during the time they were observed. They appeared to have a strong tailwind because they flapped their wings very little as they moved northward.

On 2 April 1969, sandhill cranes were followed as they migrated over western Kansas. The flock circled awhile to gain altitude and then glided for 1 or 2 km using very few wing beats. While gliding they lost altitude but regained it during periodic circling.

East-West Distribution of Migrating Cranes

In 1969, cooperators (Rangers and Biologists of the Oklahoma

Department of Wildlife Conservation, members of the Oklahoma Ornithological Society) reported 155 observations of cranes during fall migration. In 1970, a similar group of cooperators reported 133 observations. These observations were grouped into four areas: Area one represents a north-south tier of counties between Longitudes 98° W and 98°30' W in Oklahoma, Area two is between Longitudes 98°30' and 99°30' W, Area three is between Longitudes 99°30' and 100° W, and Area four is between Longitudes 100° and 103° W. The average number of cranes sighted per observation in 1969 was highest in the western edge of the main body of the state (Area three, Table XXIII). In 1970, the average number of cranes observed migrating over Area four (the Oklahoma Panhandle) exceeded that of Area three. It would not be surprising to find that migration over Area four is generally the heaviest because it lies north of Muleshoe NWR, Texas, where concentrations of 80,000 to 100,000 cranes have occurred during fall. Data from Area four are limited because very few potential observers live there.

The number of cranes seen during individual sightings varied from 1 to 660 in 1969 and 1 to 1,500 in 1970. Sightings were distributed throughout the daylight hours (Table XXIV). Ninety percent of the reports were sightings of cranes flying overhead, the remaining reports were sightings of flocks in wheat fields.

Very few cranes migrate east of Longitude 98° W in Oklahoma and Kansas in either fall or spring. In Nebraska, few cranes are seen east of Longitude 98°30' W at the eastern end of the Platte River staging area near Grand Island. Response to a questionnaire sent to Wildlife Services personnel (FWS) indicated that cranes were seldom seen east of Longitude 97°30' W in Texas except in the southern coastal counties.

TABLE XXIII

THE EAST-WEST DISTRIBUTION OF OBSERVATIONS ON SANDHILL CRANES DURING FALL MIGRATION IN OKLAHOMA, 1969 AND 1970

Area and County	1969			1970		
	Observations	Cranes	Average Seen	Observations	Cranes	Average Seen
Area 1						
Alfalfa	17	1,944	114.0	0		
Blaine	9	392	43.5	3	152	50.6
Caddo	4	665	166.2	3	195	65.0
Comanche	10	374	37.4	8	445	55.6
Garfield	0			1	200	200.0
Area 1 Totals	40	3,375	84.4	15	992	66.1
Area 2						
Woods	2	1,050	525.0	1	70	70.0
Dewey	3	69	23.0	11	385	35.0
Custer	2	60	30.0	2	42	21.0
Washita	6	220	36.6	8	163	20.4
Kiowa	6	284	47.3	2	60	30.0
Jackson	1	30	30.0	0		
Area 2 Totals	20	1,713	85.6	24	720	30.0
Area 3						
Harper	17	2,607	153.0	18	5,589	310.5
Woodward	29	2,542	87.6	39	2,849	73.0
Ellis	3	154	51.3	11	561	51.0

TABLE XXIII (Continued)

Area and County	1969 Observations	1969 Cranes	1969 Average Seen	1970 Observations	1970 Cranes	1970 Average Seen
Area 3 (Continued)						
Roger Mills	21	3,601	171.6	1	26	26.0
Beckham	6	300	50.0	2	78	39.0
Harmon	2	68	34.0	0		
Area 3 Totals	78	9,272	118.9	71	9,103	128.2
Area 4						
Beaver	17	969	57.0	16	5,634	352.1
Texas	0			5	106	21.2
Woodward	0			2	525	262.5
Area 4 Totals	17	969	57.0	23	6,265	272.4
All Areas Total	155	15,329	98.9	133	17,080	128.4

TABLE XXIV

TIME OF SIGHTING AND STATUS OF GROUPS OF MIGRATING CRANES REPORTED BY OBSERVERS IN WESTERN OKLAHOMA, 1969 AND 1970

Hour of the Observation Beginning	Number of Sightings	
	Flying Groups	Groups on Ground
0700	7	0
0800	13	5
0900	18	4
1000	35	5
1100	29	4
1200	16	0
1300	13	1
1400	24	2
1500	30	2
1600	22	0
1700	26	4
1800	10	0
1900	8	0
2000	3	0

Phenology

Patterns of migrational movements through western Oklahoma in fall are illustrated in Figures 3 and 4. Fall migrants enter Kansas and Oklahoma in late September and migration continues until late November

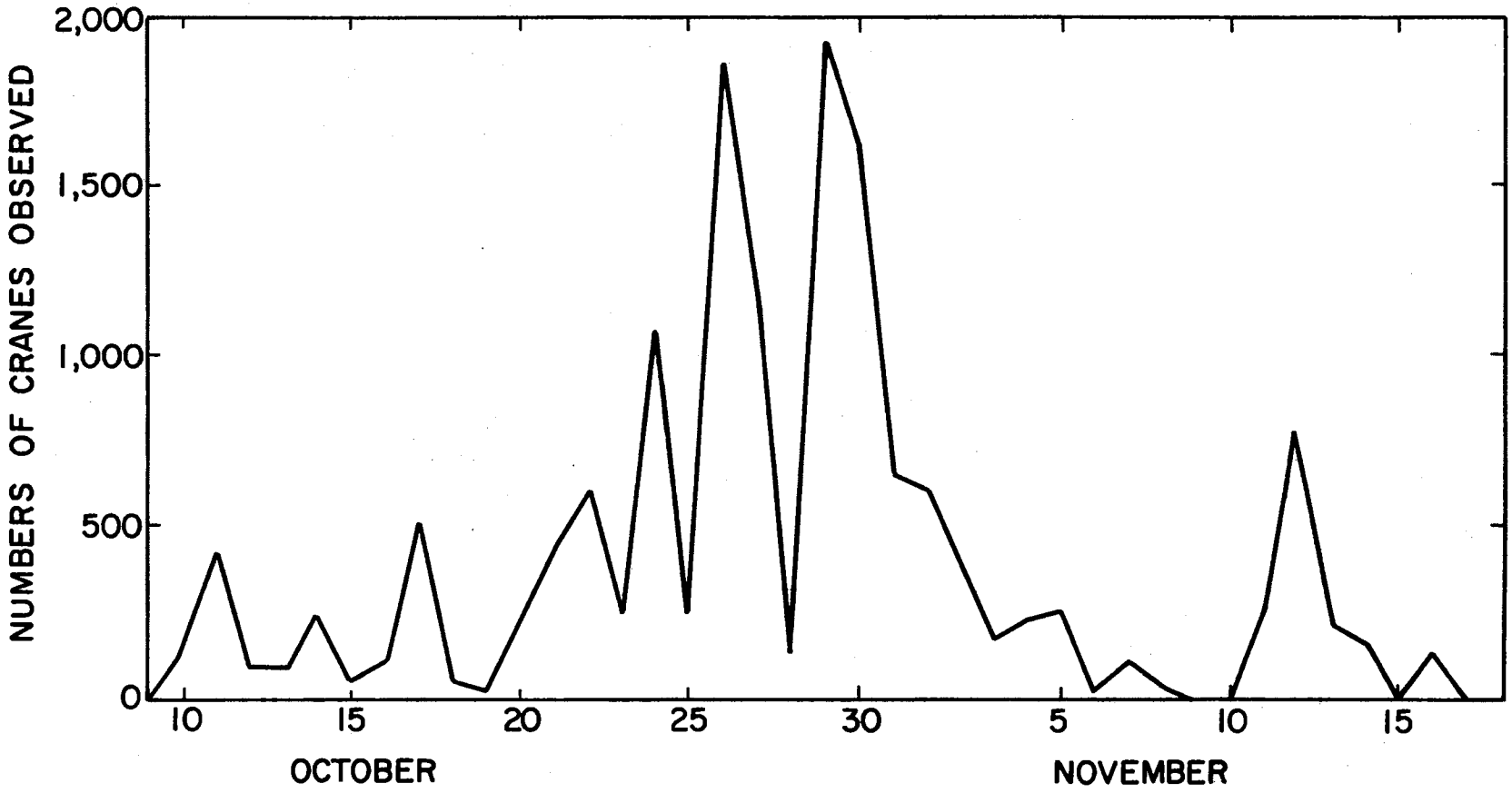

Figure 3. Timing of Migration of Sandhill Cranes Through Western Oklahoma, 1969

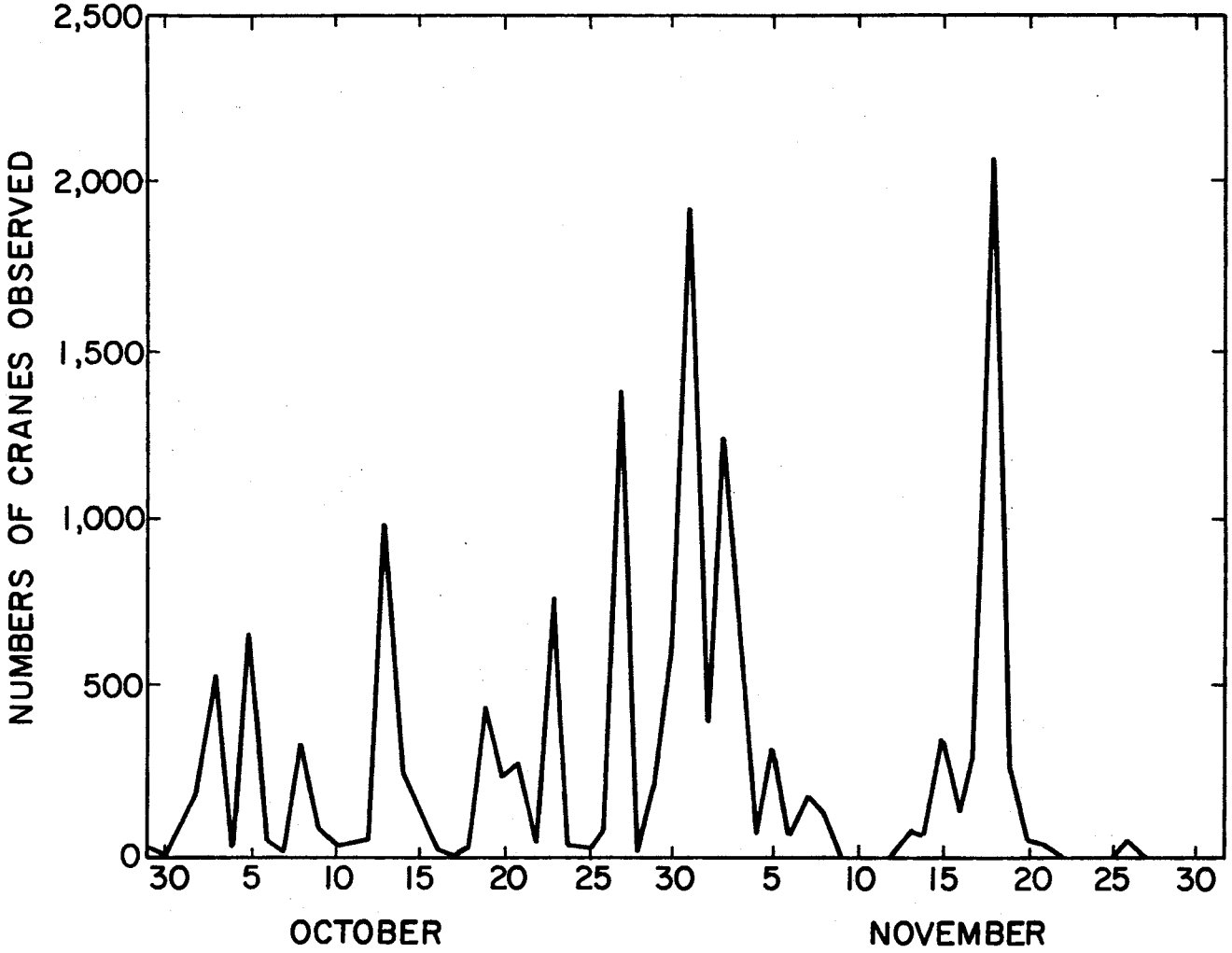

Figure 4. Timing of Migration of Sandhill Cranes Through Western Oklahoma, 1970

in most years. In both 1969 and 1970 migration peaked at the end of October; in 1970 another major peak occurred in mid November. During these peaks the number of cranes passing over was greater than indicated by Figures 3 and 4. Several observers indicated that flocks of migrating cranes were in view or could be heard almost all day on 26, 29, and 30 October 1969 and 31 October and 18 November 1970, but the observers did not have time to record the size of all flocks.

The same migration patterns in fall are reflected in the census data collected at the Quivira NWR, Salt Plains NWR, and Washita NWR. The optimum time for a crane hunting season in Oklahoma would be late October and early November if the goal were to maximize recreation and harvest. The season opening, however, is delayed so that migrating whooping cranes will not be mistakenly shot by someone hunting sandhill cranes.

The migration during spring extends from about 20 February to 25 April and peaks in March.

Greaters that winter in Texas presumably nest in western Minnesota and southeastern Manitoba. Greaters that nest in the northern Rocky Mountain States migrate through Colorado and New Mexico to winter in New Mexico and Mexico (Drewien 1973). Greaters that nest in Wisconsin and Michigan spend the winter in Florida (Williams and Phillips 1973). The only other greaters likely to migrate into Texas are those that nest in Minnesota and Manitoba.

Johnson and Stewart (1973) collected greaters on staging areas in northwestern Minnesota and North Dakota. It seems unlikely that greaters from Minnesota and Manitoba fly west to congregate on staging

areas and then fly southeast to winter in Florida; they are probably the greaters that fly south into Oklahoma and Texas.

There is no indication that greaters stop in South Dakota, Nebraska or Kansas during fall migration. Greaters were not among specimens collected in South Dakota during fall (Buller 1967). Footprint measurements taken in Campbell and Walworth Counties, South Dakota indicated that about three percent of the cranes there might be greaters (op. cit. 1967). However, the range of these measurements was 96 to 103 mm, and Guthery (1972, 1974) has since indicated that footprints are not definitely from greaters unless they exceed 112 mm in length.

In the eastern United States, greaters migrate from Jasper-Pulaski Game Management Area in northern Indiana to northern Florida without stopping (Walkinshaw 1960). The flight of 1,452 km to 1,532 km requires 25 to 30 hours to complete (op. cit.). If greaters move directly to the Salt Plains NWR and the Washita NWR from the staging areas in Kidder and Pierce Counties, North Dakota and from the Kittson County staging area in Minnesota (Johnson and Stewart 1973), they are travelling a distance of 1,177 to 1,516 km, similar to the distance greaters fly nonstop from Indiana to Florida.

There is evidence that small numbers of greaters stop along the Platte during spring. A picture taken on 5 April 1970 shows an unusually large crane among a flock near Elm Creek, Nebraska, where both lessers and Canadians are common (Tremaine 1970). Tremaine suggests that the large crane is a greater. A photograph taken on 13 March 1971 between Grand Island and Alda, Nebraska includes cranes of three distinct sizes, possibly of all three races (Frith 1974). One very large

crane is present and Frith believes this bird is a greater. Frith also reported seeing three greaters on 24 March 1973, 8 km east of Kearney.

Greaters leave the staging area in Kittson County in late September (Johnson and Stewart 1973). Kidder County in southcentral North Dakota contains some greaters until early November. If the greaters wintering in eastern Texas use the Kittson and Kidder Counties staging areas, then they would migrate through Oklahoma between late September and early November.

Greaters begin arriving in Wisconsin in early March (Gluesing 1974) and cranes probably arrive in Minnesota and Manitoba about the same time. Thus, some greaters should be migrating through Oklahoma and Kansas beginning in early March. Greaters have been collected on 21 March (UOM) in Grady County, Oklahoma and on 1 April, bordering Quivira NWR, Kansas.

Cranes are seen in Oklahoma within the time interval when observers could expect to see greaters migrating in fall and spring. S. C. Mery of the Oklahoma Ornithological Society provided records of observations she and others made of cranes migrating through eastern Oklahoma. The dates, location and observers are as follows: 24 March 1962, Washington County, R. Marquardt; 16 April 1966, Washington County, E. Messerly; 17 April 1966, Nowata County, W. Jennings; 10 May 1969, Washington County, A. M. and S. C. Mery; 20 September 1963, Price Lake, Washington County, H. H. Holland; 25 September 1965, Hudson Lake, Osage County, A. M. Mery; 11 December 1969, Richardson's Pond, 8 km south of Bartlesville, Washington County, G. Field.

Whooping Cranes

Whooping cranes nest in Woods Buffalo National Park, Northwest Territories, Canada and winter at Aransas NWR, Aransas County, Texas (Allen 1956). They have been reported seen throughout the study area. Since 1950, sightings in Oklahoma have extended almost the entire east-west distance of the state (Beaver and Jackson Counties to Wagoner and Washington Counties). Sightings have been reported from 25 September to 26 December and from 9 March to 21 May. Some of the sightings were not verified by trained observers and may not be accurate. Nevertheless, enough records have been verified to document that whooping cranes regularly migrate through central Nebraska, Kansas and Oklahoma during October-November and March-April (Allen 1952, Buller 1967, Sutton 1967). Allen (1952) reports that the main migration of whoopers ends 8 November on the wintering grounds; a few have arrived as late as the first week of December.

Albino or partial albino sandhill cranes are occasionally seen and some observers might mistake them for whooping cranes. David Purinton (FWS) and the investigator observed a partial albino sandhill near North Platte, Nebraska. It was white with light gray splotches on it and had black primaries that were visible only when the wings were extended. Both Purinton and Loren Bonde (FWS) have seen albino sandhill cranes before. Stephen Humphrey (personal communication) reported seeing a partial albino with a large flock of sandhills 2 km west of Lacey, Oklahoma in March 1971.

The main sandhill crane hunting area in Oklahoma is Jackson County. One rancher reported seeing as many as 100 whooping cranes in the early 1900's on the Brawley Roost (see section entitled Distance to Feeding

Areas) in Jackson County. Whooping cranes have been seen on one of the sandhill roosts along the bed of the Red River as recent as 1953 (Sutton 1967). To avoid jeopardizing the endangered whooping crane population, the sandhill crane hunting season in Oklahoma is delayed until early December when the whooping cranes and most sandhills have already migrated through the state.

Allen (1952) reports that in spring whoopers leave Texas between 26 March and 18 April. The Platte River is the main staging area for whooping cranes (Swenk 1933). The records of sightings in spring have been concentrated between Longitudes 98° and 100° W (between Central City and Gothenburg). The central and western portions of this area are also used by sandhills for staging.

Food Habits and Feeding Habitat

Fall

Gullet and gizzard contents have been summarized separately in the tables because soft food items are digested rapidly within the gizzard (Swanson and Bartonek 1970) and only the hard portions of insects, such as the head and legs, remain for volumetric measurement. The discussion of food habits, however, refers to the combined volumes of foods from the gullet and gizzard. "Tr." in the tables indicates an amount less than one cc.

The samples are from Nueces County, Texas (8), Stafford County, Kansas (1), Tillman County, Oklahoma (5), Alfalfa County, Oklahoma (1), Custer County, Oklahoma (12), and Jackson County, Oklahoma (5). Wheat seed had been eaten by 28 percent of the cranes and made up 40 percent of the volume of food items (Table XXV). Haygrazer and milo seeds were

TABLE XXV

FOOD CONTENTS OF 32 SANDHILL CRANES COLLECTED IN KANSAS, OKLAHOMA, AND TEXAS IN OCTOBER AND NOVEMBER

Common Name And Scientific Classification	Occurrence		Volume (cc)	
	Number	Percent	Amount	Percent
Gullet				
Wheat seed	9	28.1	131.0	23.0
Haygrazer	6	18.7	78.0	13.7
Corn	1	3.1	13.0	2.3
Milo	5	15.6	69.5	12.2
Beetle (Order Coleoptera)	1	3.1	1.5	0.3
Moth (Family Noctuidae)	1	3.1	Tr.	Tr.
Grasshopper (Family Acrididae)	2	6.2	7.0	1.2
Gizzard				
Wheat seed	9	28.1	99.0	17.4
Wheat forage	1	3.1	2.0	0.3
Haygrazer	10	31.2	80.5	14.2
Milo	5	15.6	45.0	7.9
Corn	1	3.1	5.0	0.9
Sagittaria tubers (Sagittaria latifolia)	5	15.6	11.5	2.0
Unknown forage (Family Gramineae)	5	15.6	6.0	1.0
Unidentified vegetation	6	18.7	18.0	3.2
Bone	1	3.1	Tr.	Tr.

TABLE XXV (Continued)

Common Name And Scientific Classification	Occurrence		Volume (cc)	
	Number	Percent	Amount	Percent
Beetle (Family Caribidae)	2	6.2	Tr.	Tr.
Wasp (Order Hymenoptera)	1	3.1	Tr.	Tr.
Unknown seed	1	3.1	1.5	0.3
Totals			568.5	99.9

28 and 20 percent, respectively, of the food volume. All domesticated grains (seed and forage) composed 92.9 percent of the total food volume. In addition, much of the unidentifiable vegetation in the gizzard was probably from domesticated grains. Sagittaria was the only wild plant that contributed much to the crane's diet. Haygrazer was the most important food item for the cranes in Nueces County, Texas.

Three cranes had each consumed in excess of 40 cc of wheat seed, another contained 31.5 cc of haygrazer, and a fifth bird contained 59 cc of milo. Most cranes contained 10 to 20 cc of grit and an average of 17.8 cc of food.

Insect remains constitute only 1.5 percent of the volume. On some occasions invertebrates are the major food attraction. Cranes were observed several times feeding in fields of green wheat where they spent most of their time probing for invertebrates in the soil and vegetative debris. Soil samples taken from the wheat fields contained

fall armyworm larvae (Spodoptera frugiperda) and earthworms. The same feeding behavior was observed in a harvested corn field where cranes were feeding on waste grain and probing in the soil. Soil samples indicated Carabidae adults and larvae were abundant in the field.

Feeding was not a common activity at roosts, however, some does occur. In addition to Sagittaria, soil samples at a roost on the Washita NWR showed that Noctuidae larvae were available where cranes were probing. One crane was observed picking meat from one-half of a clam shell that may have been opened by a racoon.

Observations on 3,543 cranes in fields at the Washita NWR indicated that the percentages of birds using various habitats were as follows: 33.7 percent in recently planted wheat fields, 48.5 percent in fields where the wheat plants were well established, 3.7 percent in corn fields, 0.2 percent on fallow ground, 2.5 percent in fields of milo and 11.3 percent on mowed native prairie.

Similar observations of 6,685 cranes in Jackson and Wilbarger Counties indicated the following use of habitat: 16.4 percent in recently planted wheat, 61.0 percent using fields of well-established wheat, 19.1 percent in fields of milo, 3.4 percent in native pasture, and 0.1 percent in fields of haygrazer. The haygrazer fields were not attractive feeding areas until after cattle had thinned the vegetation while feeding and walking about.

Other studies of food habits of sandhill cranes during the fall months also indicate the importance of grains. Wheat and barley were the main foods of 33 cranes collected during September and October in North Dakota (Madsen 1967). Ninety-three percent of the gullet contents of 190 sandhill cranes collected in Saskatchewan in the fall contained

wheat, barley or oats, principally wheat (Stephen 1967). Tanner (1941) examined 70 fecal droppings collected in Minnesota in October; corn was the bulk of the material (91.4 percent). Sweet clover leaves made up 4.4 percent and flax 1.3 percent.

Winter

Twenty-three samples were available from Jackson and Custer Counties, Oklahoma for the period 1 December to 28 February. Seeds of haygrazer and milo represented 94 percent of the volume (Table XXVI). Wheat seed and forage constituted another 3.7 percent. Domesticated grains continued to be the major source of food. The Sorghum spp. seeds ingested by cranes were mostly waste grain remaining in the fields after mechanical harvest or after grazing by cattle. One crane contained 100 cc of haygrazer. The cranes contained an average of 16.9 cc of food.

Observations on 6,632 cranes feeding during winter in Jackson and Wilbarger Counties indicated 23.3 percent were in wheat fields, 23.7 percent in milo, 21.3 percent in fields of haygrazer, 3.0 percent in mesquite grassland, 10.6 percent in guar (Cyamopsis tetragonoloba), 1.5 percent in alfalfa, 0.8 percent in cotton, 3.6 percent in native grassland and 12 percent in recently planted wheat. Fields of haygrazer and guar, and grasslands were used more in winter than during fall in the same counties.

At the end of February the investigator frightened several cranes from a marsh bordering the Red River (S1/2 S13, T2S, R22W). One bird had eaten all but one leg of a frog. Cranes that roosted at the Mock and Neil roosts in Jackson County frequently fed near Odell, Texas. A common item eaten was guar, a legume raised for the oils present in

TABLE XXVI

FOOD CONTENTS OF 23 SANDHILL CRANES IN OKLAHOMA,
1 DECEMBER TO 28 FEBRUARY

Common Name And Scientific Classification	Occurrence		Volume (cc)	
	Number	Percent	Amount	Percent
Gullet				
Haygrazer	11	47.8	203.0	52.1
Milo	2	8.7	41.3	10.6
Wheat forage	2	8.7	7.5	1.9
Earthworm (Order Opisthopora)	1	4.3	Tr.	Tr.
Unknown seeds	1	4.3	1.0	0.3
Gizzard				
Haygrazer	18	78.3	108.0	27.7
Milo	2	8.7	14.0	3.6
Wheat seed	1	4.3	3.0	0.8
Wheat forage	2	8.7	4.0	1.0
Snail shell	1	4.3	Tr.	Tr.
Grasshopper (Family Acrididae)	1	4.3	Tr.	Tr.
Beetle (Family Carabidae)	1	4.3	Tr.	Tr.
Beetle (Family Tenebrionidae)	1	4.3	Tr.	Tr.
Grass blades (Family Gramineae)	1	4.3	Tr.	Tr.
Vegetative debris	3	13.0	8.0	2.0
Totals			389.8	100.0

the seed, but a crane was never collected that contained this food.

Cranes are occasionally seen breaking up piles of cow manure in pastures. On 23 January 1971, scattered groups of sandhills, totaling 250 cranes, were observed breaking up cow manure in a pasture along the Salt Fork of the Red River in Jackson County. In addition to the undigested corn visible on some of these boluses, a number of insects were found within or beneath them. These include sowbugs (genus Oniscus), beetle larvae (Carabidae), adult beetles (families Scarabaeidae and Staphylinidae) and adult Hemiptera (family Reduviidae). Similar feeding behavior was noted on 1 and 2 March 1969 in Jackson County. Observations on cranes breaking up cattle boluses have been noted by others (Walkinshaw 1949, Wheeler and Lewis 1972).

Twenty food samples are from counties in southern Texas in December and January, and number as follows: Colorado, five; LaVaca, five; Karnes, five; Aransas, one; Cameron, three; and Wharton, one. Domestic grains (67.1 volume percentage) were of less importance in this area than in Oklahoma (Table XXVII). Rice, milo, haygrazer and corn seeds were 21.4, 14.5, 27.6, and 3.4 volume percentage respectively of the cranes' diet. Wild foods included duckpotato, rain lily and nutgrass. Small snail shells were present in two individuals but the shells may have been picked up as grit after the snail was dead.

Rice was important in the diet of cranes in Colorado, Wharton, and LaVaca Counties; one bird contained 21.5 cc. Nutgrass was important in Colorado and LaVaca Counties. Milo was an important food in Karnes County and haygrazer was important in Cameron and Karnes Counties. Duckpotato was important in Colorado County.

TABLE XXVII

FOOD CONTENTS OF 20 SANDHILL CRANES COLLECTED IN SOUTHERN TEXAS IN DECEMBER AND JANUARY

Common Name And Scientific Classification	Occurrence		Volume (cc)	
	Number	Percent	Amount	Percent
Gullet				
Corn	1	5.0	4.0	2.0
Haygrazer	4	20.0	24.0	11.8
Milo	2	10.0	12.0	5.9
Rice	3	15.0	13.5	6.6
Delta Duck Potato (*Sagittaria latifolia*)	3	15.0	19.0	9.4
Zephyr-lily (*Zephyranthus pulchella*)	1	5.0	2.0	1.0
Nutgrass nutlets (*Cyperus esculentus*)	4	20.0	13.5	6.6
Gizzard				
Corn	1	5.0	3.0	1.5
Haygrazer	4	20.0	32.0	15.8
Milo	4	20.0	17.5	8.6
Rice	4	20.0	30.0	14.8
Delta Duck Potato	2	10.0	7.0	3.4
Nutgrass	4	20.0	10.0	4.9
Forage (Family *Gramineae*)	3	15.0	0.5	0.2
Unknown Herbaceous Plant	1	5.0	Tr.	Tr.
Unknown Green Forage	2	10.0	5.0	2.5
Vegetative debris	2	10.0	10.0	4.9
Snail shell	2	10.0	Tr.	Tr.

TABLE XXVII (Continued)

Common Name And Scientific Classification	Occurrence		Volume (cc)	
	Number	Percent	Amount	Percent
Beetle (Family Carabidae)	1	5.0	Tr.	Tr.
Totals			203.0	99.9

One crane flushed from a harvested rice field on the Lissie Prairie, Texas had been feeding on a crayfish. Snails were an abundant potential food found under the rice straw. Cranes had been feeding on Cyperus in the same rice field. Near Sinton, Texas, cranes were observed breaking up cattle boluses and digging up Cyperus.

Sightings on 4,501 cranes in the vicinity of Altair, Texas indicated that 75.2 percent were feeding in harvested rice fields, 5.6 percent in harvested rice fields that had been plowed, 3.8 percent in fallow rice fields, 7.4 percent in native pasture, 4.5 percent in openings within wooded pastureland and 3.5 percent in wet swales (glades) or in ponds within native pastureland.

Guthery (1972) reported the food items in 70 cranes collected mainly from Kleberg County, in south Texas. These were collected from October through mid March, and as the season progressed "The importance of nutgrasses increased, consumption of animal matter decreased, the importance of cultivated crops decreased, and fewer different food items were consumed per bird." (Guthery 1972:iii). Domesticated grains composed 37.6 and 6.8 volume percentage of the gullets and gizzards

respectively. Insects and spiders made up 7.7 percent and wild plant foods constituted 53.3 percent of the volume of gullets. Other than Nueces County, Guthery's birds were collected in coastal counties that contained abundant wetlands where the cranes could feed.

Shields and Bonham (1969) managed farm crops as food supplements for whooping cranes on the Aransas NWR, Aransas County, Texas. Sandhill cranes made heavy use of the plantings of wheat forage, milo, field peas (Vigna sinensis), nutgrasses, and peanuts (Arachis hypogaea).

Spring

The foods of five sandhill cranes collected in Kansas and Oklahoma consisted of 95.1 percent haygrazer seed and 4.8 percent wheat forage (Table XXVIII).

Two hundred and fifty-two droppings collected on 16 March at a roost on the Washita NWR contained remains of corn (90 percent) and green forage (five percent). One hundred and twenty-seven droppings collected on 30 March in a wheat field on the Washita NWR were 95 percent green forage, presumably wheat.

Observations on 1,714 cranes feeding during spring in Jackson and Wilbarger Counties indicated that 39 percent of them were feeding in fields of harvested milo, 11.7 percent in guar, 7.8 percent around cattle feed troughs, 2.6 percent in fields of haygrazer, 23.6 percent in wheat and 15.3 percent in upland native pasture. Compared to the same counties in winter, there was a decline in use of fields of haygrazer and increased utilization of grassland and areas around cattle feed troughs. Eighty-five percent of the diet of 45 sandhill cranes along the Platte and the North Platte Rivers, Nebraska, were

corn (Table XXIX). Seeds of wheat and haygrazer, and earthworms were other important dietary items.

TABLE XXVIII

FOOD CONTENTS OF FIVE SANDHILL CRANES COLLECTED IN KANSAS AND OKLAHOMA DURING MARCH AND APRIL

Common Name And Scientific Classification	Occurrence		Volume (cc)	
	Number	Percent	Amount	Percent
Gullet				
Haygrazer	3	60	66.0	64.1
Moth (Family Noctuidae)	1	20	Tr.	Tr.
Beetle larvea (Order Coleoptera)	1	20	Tr.	Tr.
Gizzard				
Wheat forage	2	40	5.0	4.8
Haygrazer	4	80	32.0	31.1
Beetle adults (Family Caribidae)	1	20	Tr.	Tr.
Totals			103.0	100.0

Fish scales were present in five cranes collected near Lewellen on 22 March. All contained scales from members of the shad family (Clupeidae) (Lagler 1947) that were 3 to 5 yr old. Three birds contained scales from members of the sucker family (Catostomidae)

TABLE XXIX

FOOD CONTENTS OF 45 SANDHILL CRANES COLLECTED IN MARCH AND APRIL, PLATTE RIVER VALLEY, NEBRASKA

Common Name And Scientific Classification	Occurrence		Volume (cc)	
	Number	Percent	Amount	Percent
Gullet				
Corn	17	37.8	345.5	56.2
Haygrazer	3	6.7	16.0	2.6
Wheat seed	1	2.2	14.0	2.3
Wheat forage	3	6.7	Tr.	Tr.
Grass (Family Gramineae)	1	2.2	2.0	0.3
Earthworms (Order Opisthora)	5	11.1	11.0	1.8
Gizzard				
Corn	28	62.2	193.0	31.4
Haygrazer	3	6.7	13.0	2.1
Unidentifiable green forage	4	8.9	20.5	3.3
Pieces of bone	3	6.7	Tr.	Tr.
Grasshopper (Family Acrididae)	1	2.2	Tr.	Tr.
Fish scales	5	11.1	Tr.	Tr.
Totals			615.0	100.0

that were 3 and 4 yr old. Four contained scales from members of the minnow family (Cyprinidae) that were 3 to 5 yr old.

It seems unlikely that five cranes accidentally picked up scales of several fish species while drinking or while ingesting other foods. The presence of the scales indicates intentional feeding of cranes on fish. Cranes are not known to catch fish in the manner that herons do. The scales may be from dead or sick fish that were easily obtained. At Lewellen, cranes roost near the upper end of Lake McConaughy and fish are abundant there. Three cranes contained pieces of bone, but they did not appear to be from fish and they were not present in the cranes containing the fish scales.

Counts during census routes run along roads in Nebraska in 1969, 1970, and 1971 indicate the type of habitat utilized by feeding and loafing cranes (Table XXX). Among the 45,308 cranes observed, 47.5 percent were in corn fields and 45.5 percent in wet meadows of either native vegetation or hay. Other observations of feeding behavior of cranes in spring in Nebraska are presented by Wheeler and Lewis (1972).

Frith (1974) reported that wet meadow complexes were the most important feeding areas for sandhill cranes in late February and early March. Most of the investigator's food-habits data were collected in late March and early April and are not representative of the time period Frith mentions. Frith (1974) reported cranes feeding on young tender shoots of Veronica sp. and he suggested that when the tender vegetation and animal matter in the wet meadows had been fully utilized, then the cranes relied more on the waste grain in corn fields.

TABLE XXX

HABITAT UTILIZED BY 45,308 CRANES FEEDING AND LOAFING NEAR THE PLATTE RIVER, NEBRASKA

Location of Observations	Date (Day/Month/Year)	Cranes Observed	Corn	Meadows	Milo	Upland Pasture	Misc.
N. Platte - Sutherland	4/ 5/69	7,084	55.4	44.1	0.2	0.0	0.3
N. Platte - Sutherland	3/21/70	16,813	55.7	26.7	1.1	16.4	0.0
Kearney vicinity	3/24/70	4,900	30.6	69.4	0.0	0.0	0.0
Kearney to Lexington	3/24/71	1,705	54.3	45.7	0.0	0.0	0.0
S. of Platte River below Kearney going east 16 km	3/25/71	7,409	39.0	61.0	0.0	0.0	0.0
Kearney to Lexington N. of Platte River	3/26/71	1,086	33.9	66.1	0.0	0.0	0.0
S. of Platte River from 16 km east of Kearney to Grand Island	3/27/71	6,311	40.1	56.6	0.0	0.0	3.2
Totals		45,308	47.5	45.5	0.4	6.0	0.5

Crop Depredations

When this project was initiated, game managers in Oklahoma seemed greatly concerned about crop depredations by cranes, but in typical years little damage occurs. Occasionally, due to climatic or habitat conditions, unusually large numbers of cranes stop in Oklahoma during migration and they stay longer than normal. In years with insufficient rainfall in September, the wheat is planted late. The economic loss due to depredations may be significant when planting coincides with migration of cranes because cranes will eat the seeds and pull up young tender shoots. In years with normal rainfall, wheat is planted in September and plants are well rooted and less attractive food when cranes migrate through.

Depredations were uncommon during the study period. In the few situations where the investigator observed cranes feeding on freshly planted seed, or recently sprouted wheat, there was no opportunity to measure the actual damage that might have resulted. Cattle were pastured in these fields in late winter. Most of the wheat in western Oklahoma is pastured in this manner and damage caused by cranes could not be distinguished from that caused by cattle. The researcher returned to several fields where cranes had fed and found poor stands of wheat only in sandy areas where factors other than the feeding by cranes might have caused the sparse stand.

Fields of milo are utilized by cranes both before and after harvest. Cranes strip the seeds from the heads of milo that have not been harvested or that are shocked and left in the field. The loss is seldom extensive enough to cause concern by the owner. Farmers are more concerned about losses to blackbirds, especially in the vicinity of the

Washita NWR. There were some justified depredation complaints by the few landowners who shocked milo and left the bundles in their fields. The cranes fed on the seed heads sticking out of the bundles and occasionally climbed on top and raked the seed heads with their feet.

Two landowners complained that such behavior scattered the seed and sometimes broke the strings that held the bundles together. Mr. Bush had a milo field (NW S27, T1S, R21W) near the Bush Roost where he received depredations each year. In 1968 he had scarecrows in the field and pie pans strung from the bundle tops, but the cranes still fed there. He had tried exploders on his field. They provided only temporary relief from depredations. He also placed strings of red lights down every tenth row of milo and wired the lights to an electric fence charger. The cranes soom became accustomed to the blinking lights.

Mr. Ritchie experienced similar difficulty (SW S35, T1S, R22N). The investigator examined some of the shocks of feed in Mr. Ritchie's field in late December 1968 and estimated that 60 percent of the seeds were gone from the stalks. Some of these losses were due to birds other than cranes. Cattle eat the entire milo stalk; only part of the food volume for cattle is lost, but the nutritive value of the seeds is greater than the value of the stalks. The economic value of this depredation loss was not determined for Ritchie's 4-ha field.

The Bush field is in an isolated area. The Ritchie field is within view of, but over 400 m from, a blacktop road. Similar fields of shocked milo, that border roads having frequent traffic, are not damaged by cranes. Fields near farmhouses are also relatively safe from depredations by cranes. Judicious choice of sites where milo is to be

planted, if it is going to be bundled, would eliminate most of the damage.

Landowners in Nebraska generally had no complaint about the large numbers of cranes present in spring. Most feeding was in corn fields that had already been harvested and the cranes were picking up waste grain. One farmer complained that cranes trampled a newly planted alfalfa field.

Landowners in southern Texas also had few depredation complaints. Rice was harvested before the cranes arrived and cranes generally departed before rice was planted in spring. Ducks and geese were blamed for damage to the rice crop. One rancher reported that cranes ate seeds of his milo crop that was cut, bundled, and left in the field. Another rancher reported damage to his flax crop by cranes uprooting young plants to get grubs in the soil. Guthery (1972) reported that crop damage inflicted by sandhill cranes is infrequent and scattered in occurrence in southern Texas.

Significant crop depredations by cranes are more common in the northern United States and Canada where the presence of cranes coincides with periods when crops are more subject to damage (Buller 1967, Drewien 1973, Munro 1950, Munro 1961, Stephen 1967).

Roost Habitat and Its Use

Time of Arrival and Departure

Figure 5 shows the time of arrival in relation to sunset of 8,513 cranes at their evening roost. The data were collected to help evaluate counts of roosting cranes as a census technique. Observations were made on 29 evenings during the period from before the time that cranes

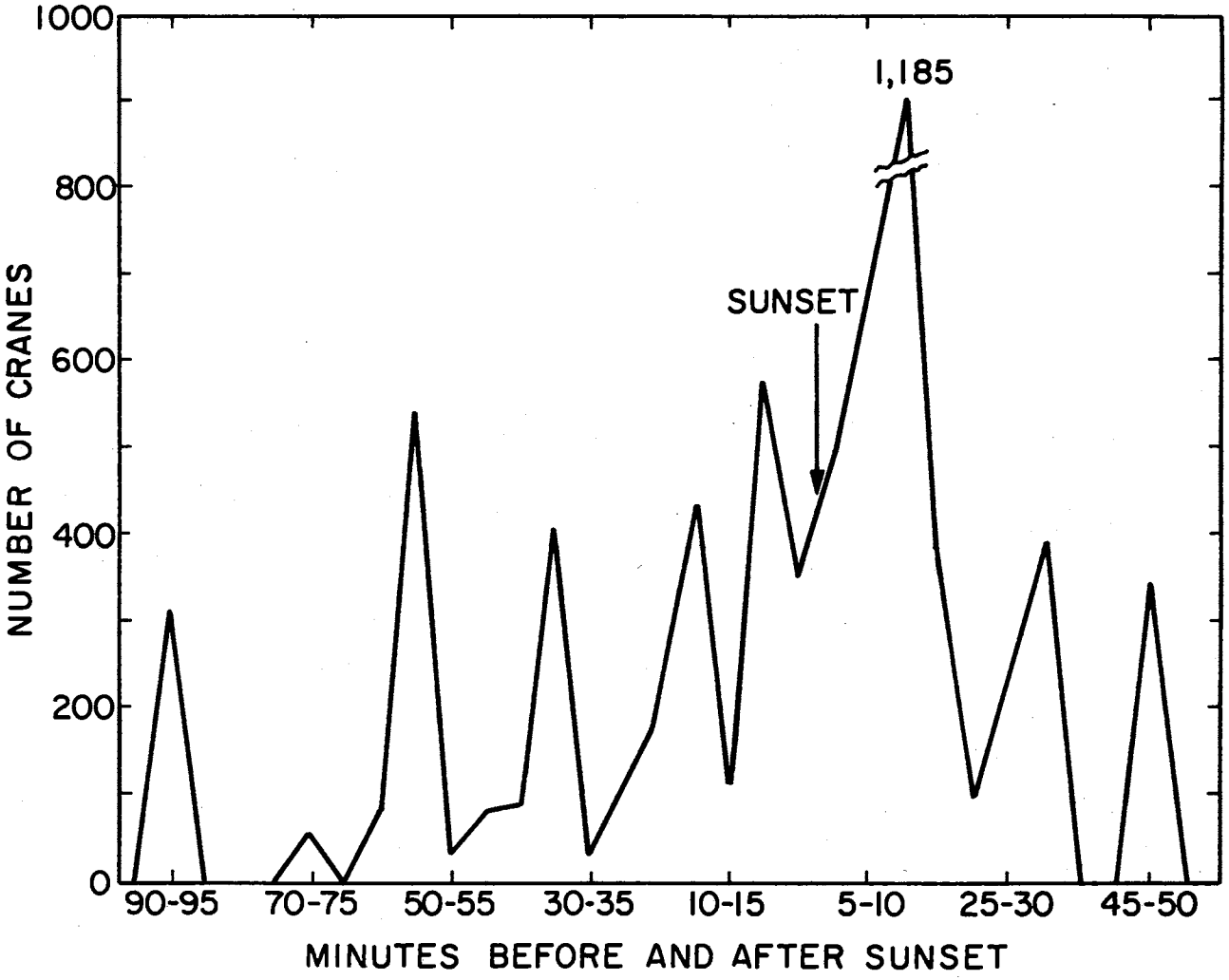

Figure 5. Time of Arrival of Sandhill Cranes at Their Roost in Relation to Sunset

arrived at the roost until it was too dark to see any other cranes that might arrive. Observations on other dates were excluded from this summary because either fog or stormy weather made visibility too poor for accurate counts or other work such as collecting specimens prevented making complete counts of arriving flocks.

Figure 5 represents the most common pattern of arrival of cranes at their roost. Except for two counts made at Quivira NWR, these counts were made at the Washita NWR and in Jackson County, Oklahoma. Eleven counts were made in fall, 11 in winter and seven in spring. The same basic pattern was evident in all seasons, so the data were combined (Table XXXI). Fifty-six percent of the cranes have arrived by sunset.

Frequent observations of cranes at fields where they fed indicate that the cranes wintering in Oklahoma almost always left these fields no later than shortly after sunset and were at the roost before dark. An exception to this occurred on 24 January 1971 when the cranes roosting at the McNeil Roost did not arrive from the feeding fields in Texas until it was too dark to count them. When it became dark on 9 November 1972 there still were 300 cranes in the fields bordering the Bush Roost and 472 were at the roost; the 300 may have been migrating birds.

Occasionally cranes arrived at the roost as much as 2 to 3 hr before sunset. This behavior was observed during all seasons: on 30 October 1970; on 24 and 25 November 1969; on a few other warm fall days; on 5 December 1969 during an afternoon when headlights were used on autos at 1500 because of fog; and on 1 March 1970. On fall days when cranes arrived at the roost in the afternoon, and stayed until dark, air temperatures were warm (19 to 25 C), the sky was clear, and there was very little wind. The birds spent their time loafing, doing a little

feeding, preening, and moving about in flights of a few hundred meters along the river bed. These birds that roosted early may have been flocks migrating through the area.

TABLE XXXI

TIME OF ARRIVAL OF SANDHILL CRANES AT ROOSTS ON 29 EVENINGS

Five-Minute Intervals Before Sunset	Cranes Arriving	Intervals Before and After Sunset	Cranes Arriving
181-185	500	16-20	436
171-175	250	11-15	103
156-160	500	6-10	580
91- 95	320	1- 5	353
71- 75	57	Sunset	
61- 65	80	1- 5	501
56- 60	557	6-10	682
51- 55	37	11-15	1,185
46- 50	78	16-20	358
41- 45	96	21-25	89
36- 40	413	26-30	231
31- 35	39	31-35	381
26- 30	125	46-50	340
21- 25	215	51-55	7
Total			8,513

An observer at the roost 100 min before sunset will normally be able to observe all cranes as they arrive. Cranes arrived at the roost more than 100 min before sunset on only four of the 29 evenings (Table XXXI). During the peak of migration some cranes may arrive after dark (as noted in the section entitled Behavior During Migration) and counts during those periods should be viewed as minimum figures.

Figure 6 illustrates the departure time of 5,850 cranes from their roosts. The observations were made on 22 mornings, beginning while it was still dark and continuing until all cranes had left the roost. Six observations were made during fall, eight during winter and eight during spring. Observations on other dates were excluded because counts were incomplete. Almost all observations were made at the Washita NWR and in Jackson County, Oklahoma.

The main flight from the roost began 5 min before sunrise and continued for 50 min (Table XXXII). Eighteen percent of the cranes left the roost by sunrise. The investigator was never aware of birds leaving the roost before daylight in Oklahoma. They called repeatedly when leaving a roost and such vocalizations were not heard before daybreak.

Dense fog or storms were the only factors noted that altered the cranes' stay at the roost. Dense fog delayed departure from the roost on 28 February 1970 when the first cranes left the roost at 41 min after sunrise and 13 were still present 50 min later. At the Washita NWR, during a light rain, all cranes left the roost 26 min before sunrise.

Either morning or evening is suitable for census of cranes as they approach or depart from a roost and either period requires as much as

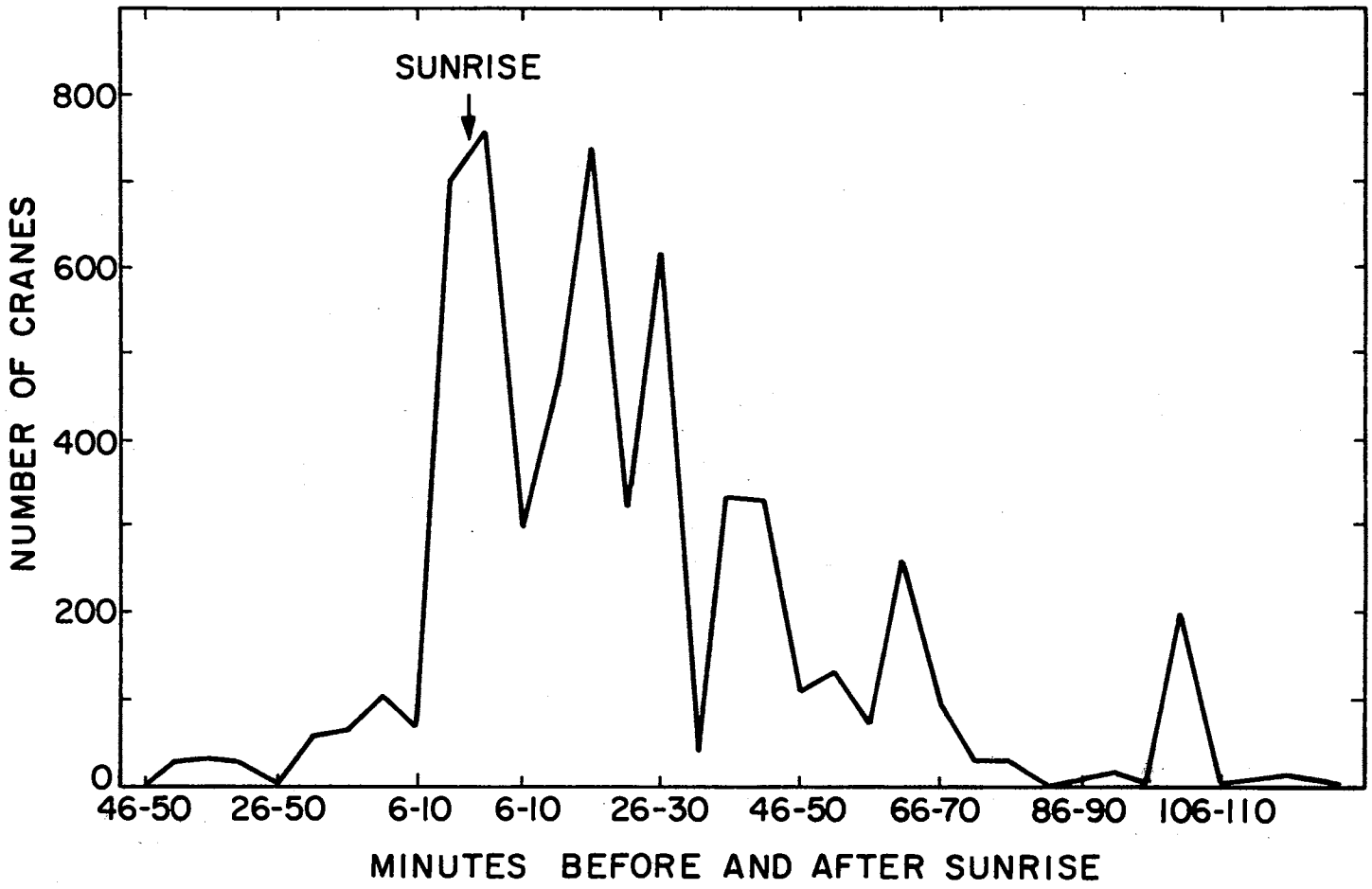

Figure 6. Time of Departure of Sandhill Cranes from Their Roost in Relation to Sunrise

3 hrs to complete the counts.

TABLE XXXII

TIME OF DEPARTURE OF CRANES FROM ROOSTS ON 22 MORNINGS

Five-Minute Intervals Before and After Sunrise	Cranes Departing	Intervals After Sunrise	Cranes Departing
41-45	28	26-30	618
36-40	30	31-35	35
31-35	24	36-40	327
21-25	60	41-45	324
16-20	68	46-50	104
10-15	103	51-55	130
6-10	72	56-60	64
1- 5	693	61-65	251
Sunrise		66-70	99
1- 5	751	71-75	25
6-10	299	76-80	25
11-15	450	91-95	13
16-20	734	101-105	200
21-25	312	116-120	11

Stephen (1967) counted large populations of cranes leaving roosts in Saskatchewan on three mornings, and the pattern of departure was

similar to that observed in Oklahoma. An estimated average of 25 percent of the cranes had left the roosts by sunrise. Walkinshaw (1949) observed a similar timing of roost activities on seven mornings and four evenings in Florida, New Mexico, and Texas.

Observations at roost sites in southern Texas indicated similar time patterns of movement to and from the roosts. Observations indicated the same general roosting behavior in Nebraska except during the peak of migration when there appeared to be a greater amount of what could be called nervousness or unrest. At these times some cranes arrived at the roost as much as several hours after dark and some left before daybreak.

Charles Frith noted similar behavior on the Platte River. Speaking of his observations at a roost on 31 March 1971 he noted:

> At 7:55 PM, we have counted 19,800 cranes. It is too dark and overcast to continue counting. We can still hear cranes coming over us at 8:10 PM calling as they come. The spring census taken on the 30th of March only showed 13,000 cranes on this 6 miles of river. Maybe they left before the plane got this far east. (Frith 1974:67).

The annual census of cranes along the Platte is timed to coincide with the peak of migration in spring. The present survey technique involves flying along the Platte and the North Platte Rivers between daybreak and sunrise and counting cranes still roosting on the river. Some cranes begin leaving the roost while it is still too dark to clearly see them flying. The numbers of birds leaving continues to increase over the next 30 min. Some birds may have already left to feed by the time the aircraft reaches the first roost of their survey route. As the survey progresses along the river, and the time passes, the number of birds remaining to be counted on the roost becomes a

smaller percentage of the total that roosted there the previous night. Detailed observations of the behavior of cranes roosting along the Platte River should be made during the peak of migration in order to increase the accuracy of the census along the Platte.

Distances Between Roosts and Areas Where Cranes Fed

Flight distances were recorded between areas used for feeding and roosting as noted at the following locations: Speaks, Texas, 9.6 km; Cayo de Grulla in Kleberg County, Texas, 4.5 to 8 km; Karnes County, Texas, 4.4 to 9.6 km; Sol del Rey in Hidalgo County, Texas, 6.4 to 9.6 km; Quivira NWR, Kansas, 0.7 km to 1.6 km; Tillman County, Oklahoma, 3.2 km; Washita NWR, Oklahoma, 0.5 to 16 km; and Jackson County, Oklahoma, 0.5 to 29 km. The observations at the Washita NWR and in Jackson County both involve in excess of 24 observations of the distance between feed fields and the roost. The other locations listed involve observations of movements from roost to feed fields on one day. Average movements between feed areas and roosts are flights of 2 to 16 km. Land management practices within a flight range of 16 km from a roost will be of the greatest significance to the well-being of cranes at that roost. Figure 7 illustrates the intensity of use of areas for feeding in relation to the locations of roosts along the Red River.

Characteristics of Roost Habitat

Observations were made at the following numbers of roost sites: along the Red River, Oklahoma and Texas (14); on or near Washita NWR (6); at Quivira NWR (2); at Salt Plains NWR (1); in Tillman County,

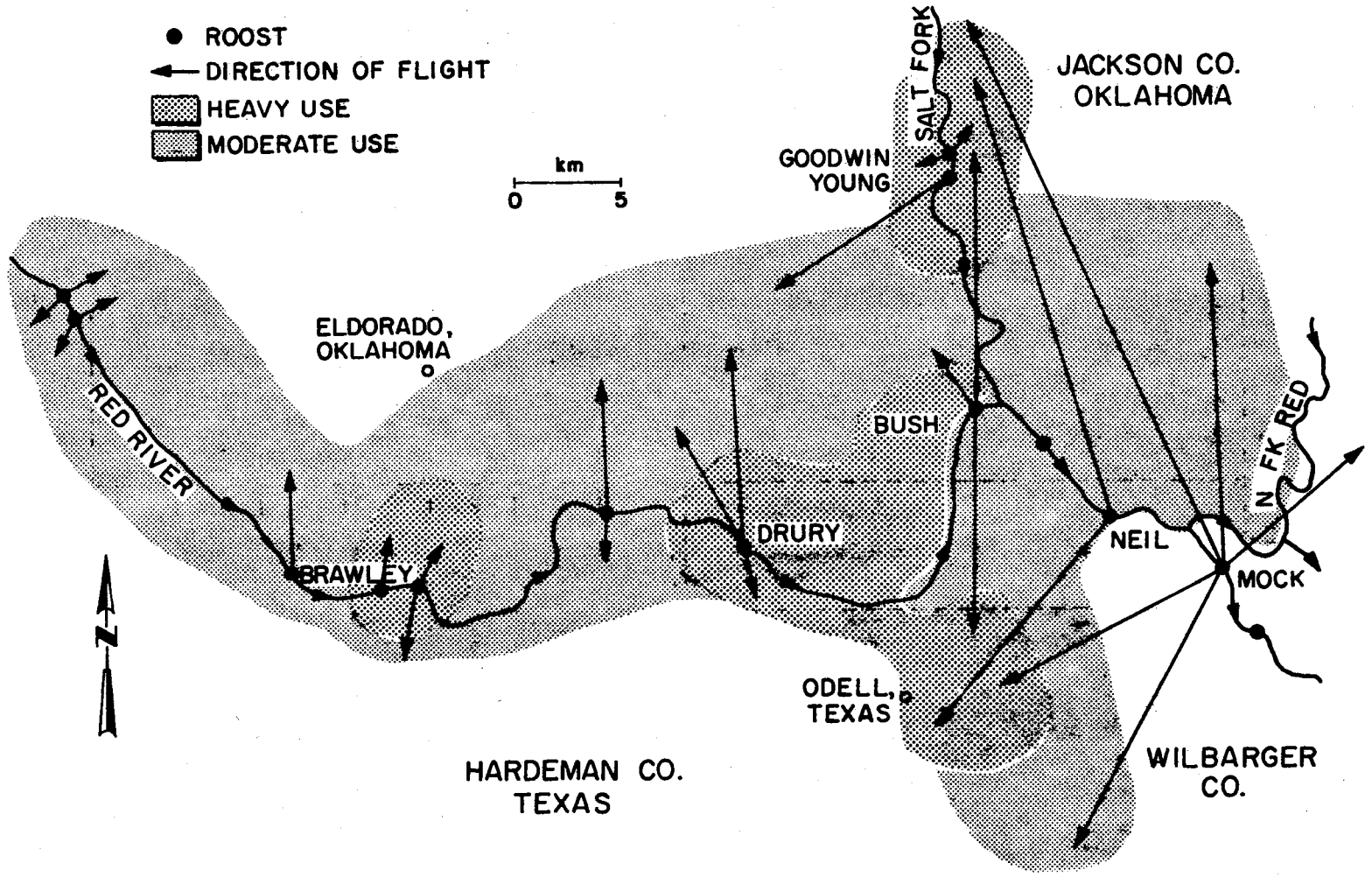

Figure 7. Roost Locations Along the Red River and the Intensities of Use of Other Habitat

Oklahoma (2); in Harmon County, Oklahoma (2); along the Platte and the North Platte Rivers, Nebraska (11); at Aransas NWR (2); at Laguna Atascosa NWR (1); in Hidalgo County, Texas (1); in Kleberg County, Texas (2); in Karnes County, Texas (2); in Colorado County, Texas (2); and in LaVaca County, Texas (2).

Observations of these 50 roosts indicate that the physical features that characterize preferred roost sites are level terrain, shallow water bordered by a shoreline either without vegetation or with only sparse vegetation, and an isolated location that lessens the chance of disturbance by humans (Figures 8 to 13).

Figure 8. Big Salt Marsh Roost Site at Quivira NWR

Figure 9. Crane Roost on the Red River, Oklahoma

Figure 10. Aerial View of Roost in Tillman County, Oklahoma

Figure 11. Roost Site on Red River, Jackson County, Oklahoma

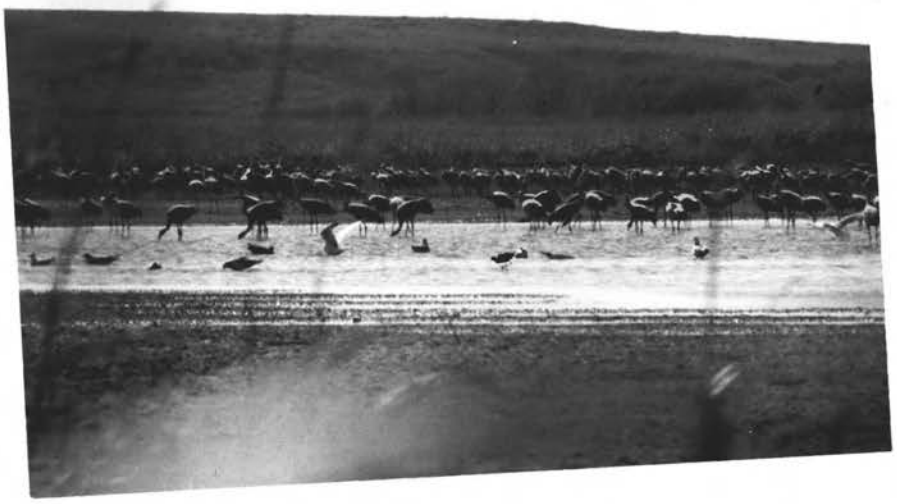

Figure 12. A Roost at Washita NWR, Oklahoma

Figure 13. The Drury Roost on the Red River.

Roost sites within the study area are found in flooded and dry rice fields that have been harvested, in wet "glades" in southern Texas, in bays along the Gulf Coast, along the edges of reservoirs, in fields where wheat is only a few cm high, in shallow portions of rivers, and in inland saline marshes. When cranes arrive at wetland roosts they either alight directly in the water or on beaches or sand bars. At dusk they wade into the water. Roosts used regularly by wintering birds generally are in shallow water several meters from shore. The shallow water between the cranes and the shore line presumably provides some protection from predators.

Cranes roost in rivers, lakes and wheat fields during their migration through Oklahoma. An estimated one-third of the roosts used during fall migration are upland sites. In contrast, only two (six percent) of the 31 roost sites used by wintering cranes were on dry land. These were located in Colorado and LaVaca Counties, Texas where suitable wetland roost habitat was not available nearby. Other cranes in the same areas of Texas were roosting in ponds, small reservoirs and flooded rice fields.

The immediate vicinities of typical roosts are characterized by fairly level terrain and vegetation that is either absent or very sparse and short; these conditions presumably provide the field of vision that cranes require to protect themselves against predators. The ground slopes gradually into the water and a large area of water 10 cm to 20 cm deep is present several meters from the shore, providing standing room for a flock containing from 10 to several thousand cranes. This water typically contains either no submergent aquatic plants or only very sparse growths.

Roosts are generally protected from possible disturbance by humans by their location on refuges or by their location in areas where access is difficult. Roosts are often bordered by extensive marshes, sand dunes, rangeland or large bluffs that make it difficult to approach them. The roost site is often 1.7 to 5 km from the nearest road and a greater distance from the nearest house.

At the Washita NWR the usual roost sites were not used on two occasions of unusually severe weather. During an unusually strong wind storm the cranes roosted in an area of open water completely surrounded by flooded Johnson grass. On 14 March 1969 a snow storm occurred with strong winds, and a temperature low of -3 C. Almost 500 cranes were present and they roosted in narrow upland draws, apparently to escape the cold wind.

Use of secondary roosts was seldom noted except in Nebraska. A secondary roost (terminology used by Robert Wheeler) consists of a pasture, hayfield, or wet meadow less than one km from the roost that is used overnight. In Nebraska (Wheeler and Lewis 1972) secondary roosts are used for resting, preening, dancing, and some feeding just after daybreak and just before dusk. A secondary roost may be used daily and annually for 15 min to 2 hr in both evening and morning. Some fields in Nebraska have a long history of use as secondary roosts.

Areas similar to secondary roosts were noted at the Washita NWR, in Jackson County, Oklahoma and in Hidalgo County, Texas. In these cases cranes flew from feeding areas in late afternoon and alighted for awhile in fields before continuing to wetland areas where they roosted. This was not the typical behavior pattern at either the Washita NWR or in Jackson County, Oklahoma. The Hidalgo County roost was observed only

two evenings, consequently the use of the secondary roost also may not have been a consistent behavior pattern of these cranes.

Factors Influencing Use of Roosts

Several factors appeared to alter the use of roosts. These include (1) changes in water levels, (2) infringement of vegetation into the roost borders, and (3) human activity in the vicinity. An example of the effect of water levels is the change that occurred in use of the Drury and Brawley Roosts during the drouth in the headwaters of the Red River. In that area the summer of 1970 was the driest since the early 1930's. The Prairie Dog Town Fork of the Red River was almost dry west of its confluence with the Salt Fork of the Red River. The Drury and Brawley Roosts received no use that year and populations using the Bush Roost were lower than in previous years.

Cranes stopped using the Goodwin Roost in the winter of 1969-70 apparently due to encroaching vegetation that left the stream channel less than 100 m wide in most places. During a prolonged period of low precipitation, and without the scouring action of floods, salt-cedar encroached on the roost sites. By 1972 suitable roost habitat no longer appeared to exist there.

C. A. Babcock reported greater numbers of cranes used to roost behind his house in Tillman County, Oklahoma, but the salt-cedar encroached and reduced the potential roost area.

Bill Ernest, Ranger, Nebraska Game, Fish and Parks Commission, and Loren Bonde, Game Management Agent, FWS, reported changes in crane roost areas. Roosts near Odessa and Elm Creek, Nebraska are not used as much as they were in the mid 1960's. A reason suggested for the birds'

apparent shift eastward from their previous roosts is the construction and subsequent human activity on I-80 on the north side of the Platte River. Another reason suggested is the reduced flow of the river in summer that permitted encroachment of willows and cottonwood onto sandbars that used to provide roost habitat.

The locations of sandbars and shallows are altered frequently in the typical dynamic river system and such changes are not detrimental to crane habitat. Permanent modifications in stream flow can have an unfavorable impact on roost habitat of cranes. Stream flow in the Red River has been reduced during flood periods by upstream reservoirs and small catchment basins. In the Platte River, summer flow has been reduced by upstream diversion of water for irrigation. These changes in river flow permit ecological change, such as encroachment of vegetation, that can eliminate suitable roost habitat of cranes.

Management of Roosts

From general observations of roost sites it appears that management of habitat for sandhill cranes should include (1) maintenance of normal water flows, including periodic floods, (2) management of vegetation, and (3) prevention of excessive distrubance by human activities. Only one of these techniques, management of vegetation, was tested during this study.

In the early fall of 1968, cranes seemed reluctant to roost on Joe Foss Reservoir. In average years the late-summer water demands for irrigation and the increased evaporation result in a drawdown in Joe Foss Reservoir that leaves substantial shore areas with little or no vegetation. Exposed shorelines, peninsulas, and mud bars devoid of

vegetation, where the cranes could land prior to roosting, were not present in the fall of 1968. Cranes loaf in such areas prior to wading into shallow water to roost. This was the one way in which roost habitat obviously differed from other years. Heavy fall rains had raised the lake level until it flooded rank growths of emergent aquatics and Johnson grass more than 1 m high. The cranes roosted infrequently in the marsh that fall. At dusk cranes left the refuge to roost elsewhere or they roosted on adjacent uplands. Prior to leaving they circled low over the marsh in what could be interpreted as an unsuccessful search for a suitable spot to land. They seemed reluctant to land in the turbid waters where they could not see the bottom.

A thicket of willows, cattail, and Johnson grass was cleared in a 30-m-wide strip extending from a wheat field to the water to see if roosting in the marsh could be encouraged. This location was subsequently used for roosting even though it was more exposed to wave and wind action than other potential roost locations on the lake.

In March of 1969 the water levels in Joe Foss Reservoir were the highest on record. An area of Johnson grass, that had been control burned as a possible trapping site, became flooded and was used regularly by roosting cranes.

Similar types of vegetation control should be considered on refuges whenever suitable roosting habitat is not present.

History of Habitat Use

Most of the roosts and feeding areas utilized for feeding by cranes appear to have a long history of use. Mr. Brawley (personal communication) reported that cranes had been roosting on the Red River behind his

ranch in Jackson County, Oklahoma since he arrived there in the 1920's. Cranes have been using the Mock Roost at least since 1941 (personal communication, Derryberry). Forest Ford (personal communication) reported that cranes wintered between Elmer and Eldorado, Oklahoma and that they roosted along the Red River as early as the late 1800's. Mr. Rape (personal communication) said cranes have used the Drury Roost at least since 1920. Mr. Fletcher (personal communication), whose land is now part of the Washita NWR, said cranes commonly fed on his property before the area became a refuge in 1961. A rancher said cranes have stopped near Forgan, Oklahoma, each fall since 1924 when he settled in the area.

One landowner (personal communication) reported that cranes have wintered near Speak, Texas, for at least 22 years. A Damon, Texas resident (personal communication) said he arrived there about 1915, and thousands of cranes wintered in the vicinity then.

Cranes have used the Tri-County Meadows near Lewellen, Nebraska each spring for as long as local residents can remember. One man said cranes were using the area near North Platte, Nebraska for staging as early as 1888.

Exceptions to the long-time use of the same roost areas were the Goodwin-Young Roosts on the Salt Fork of the Red River. Three local landowners reported that these roosts were first used about 1966. The researcher found them used frequently in 1969, but since then they have been used only for midday loafing, apparently because the vegetation encroached into the riverbed during a drouth.

Several dozen long-time residents and personnel of the Oklahoma and Texas wildlife agencies told the investigator that ducks, geese and

cranes were much more abundant in Jackson and Tillman Counties in the period from 1920 to 1940 than they are now. Geese no longer winter in these areas and only small scattered flocks of ducks are present. Much more milo was planted prior to 1940; it was bundled and removed from the fields as needed to feed cattle. Twenty-four ha fields of milo were reported common then. Now, less milo is planted and most of it is harvested mechanically. In the areas where cranes feed, less than a dozen landowners bundle their milo and leave it in fields. Ranchers rely more on winter wheat as food for cattle or they plant haygrazer and pasture cattle in it. These changes in the land use patterns are presumably one reason why fewer waterfowl and cranes might winter along the Red River.

Another factor may be the amount of water flowing in the Red River. Large numbers of small impoundments on the watershed in Texas and Oklahoma reportedly catch much of the runoff that formerly contributed to a greater flow in the Red River. The roost habitat along the Red River is probably less suitable for ducks, geese and cranes than it was 35 yr ago.

Capture Attempts

Attempts to capture sandhill cranes were the most difficult part of this study. Only two areas in Oklahoma have crane populations large encough, and present for long enough periods, to justify capture attempts; these are the Washita NWR and Jackson County. During the fall of 1968 and 1969, personnel at the Washita Refuge cooperated by baiting trap sites on weekdays, and the investigator replenished the bait on weekends. Milo, corn and wheat were tested as baits. Wheat and corn

fields were bait sites and bait was placed a few feet from rocket nets that were camouflaged as described by Wheeler and Lewis (1972).

In late October 1968, a group of cranes began using a bait site regularly. When the net was checked prior to attempting trapping, the investigator found that it had been vandalized. By the time the net was repaired, the cranes were no longer using the bait site. This was the only occasion when cranes regularly used a bait site. More recently (1970-72), ducks and geese have been attracted to bait sites bordering Joe Foss Reservoir on the Washita NWR and captured using a rocket-net trap. This trapping was done in late winter. Cranes did not use these bait sites either.

An abundant supply of milo and corn was available in fields on the refuge and this probably contributed to the difficulty experienced in attracting cranes to bait sites. Another factor that may have contributed to the difficulty was that many of these birds were migrating through and may have only been present for a few days. With a high turnover rate there was less likelihood that the cranes would feed on the bait regularly. Wheeler (Wheeler and Lewis 1972) was also unable to attract cranes to baited trap sites when other foods were abundant. Gluesing (1974) was able to attract greaters to ear corn placed on staging areas in Wisconsin. Williams and Phillips (1973) have had no difficulty baiting greaters and Florida sandhills during winter in Florida.

No attempt was made to capture sandhills at their roost site on Washita NWR because the researcher was afraid the cranes might leave the refuge and then he would be unable to achieve other objectives of the study. The invesitgator believes that cranes can be captured at the

roost site at the refuge during the peak of migration. The roosts in Jackson County were also considered for trap sites. These roosts are as much as 0.4 km long and are used with moderate consistency. On these areas cranes move about quite a bit prior to dark and perhaps after dark. These roosts are 1.6 km to 3 km from the nearest farm road, behind sand dunes and salt-cedar thickets that make access difficult. The roosts' isolation and large size do not make them suitable trap sites unless the cranes can be attracted to bait.

In November 1968, two attempts were made at Washita NWR to capture cranes using drugged (alpha-chloralose) milo and corn. The cranes would not eat the bait. Williams and Phillips (1973) have now developed, to a fine art, capture techniques using drugs. Similar techniques would probably work in Oklahoma during winter when cranes can be attracted to bait.

Baiting was attempted in Jackson County in the winter of 1969-70. Wes Webb, Ranger of the Oklahoma Department of Wildlife Conservation, baited the area whenever possible on the days the investigator was not present. A wheat field used regularly by cranes was the bait site. Mr. Webb and the researcher were unable to bait the area frequently enough because of other work responsibilities. Crows (Corvus brachyrhynchos), mourning doves (Zenaida macroura), red-winged blackbirds (Agelaius phoeniceus), and brown-headed cowbirds (Molothrus ater) were quickly attracted to the bait and ate most of it. Cranes used the bait on at least two occasions, but the bait was not replenished enough to ensure regular use. By late winter, waste grains become scarce in fields in Jackson County (Morrison and Lewis 1974), and cranes might be attracted regularly to a trap site if the bait were replenished daily.

Drewien (1973) used a spotlight attached to a portable generator to "blind" and capture sandhill cranes with long-handled nets at night on their nest grounds in Idaho. The researcher attempted to duplicate Drewien's technique to capture cranes migrating through Nebraska and Oklahoma and to capture cranes wintering in Oklahoma and Texas. A portable generator, like that used by Drewien et al. (1967), and a six-volt dry-cell battery were each used on several occasions to power the light. On only one occasion was the investigator able to approach closely enough to have any likelihood of capturing cranes. That occasion was on a night with 100 percent cloud cover and with wind gusts up to 100 kmph. The cranes involved were roosting in open water surrounded by flooded Johnson grass that extended 1 m above the water surface. The light was powered by a dry-cell battery and the strong wind hid the noise of our approach. After the light was turned on, the investigator and an assistant were able to approach within 3 m of some birds, but had a shorthandled net on that occasion and were unable to capture any. The cranes seemed reluctant to leave the roost and some juveniles (judged by their vocalizations) returned to the roost while the investigator and his assistant were present.

In all other attempts the cranes either flew or walked away from the roost site while the researcher was still 100 m away. Drewien (personal communication) also had difficulty capturing cranes that were concentrated in large roosting flocks. Failure to capture cranes using this technique was apparently due to differences in behavior of the cranes, differences in flock size, and differences between habitats of the study area and Idaho. The author accompanied Drewien on a spotlighting effort in Idaho when several cranes were banded. Drewien

captures adults and their frightless young; the adults seem reluctant to leave the young. He also captures nonbreeders by guiding them, using the light, to the edge of dense stands of bulrush (Scirpus sp.) about 1 m high and then running in and placing a net over them as they attempt to fly or run through the vegetation.

Neither adult nor young cranes remained stationary as the researcher approached them with the light at roosts on the Washita NWR, along the Red River and in a wheat field in Custer County, Oklahoma. The cranes walked away from the investigator and there were no tall, rank emergent plants to hinder them. On other occasions in Nebraska, Texas and Oklahoma, the cranes merely flew as soon as he approached. The investigator does not believe spotlighting will be a suitable method for capturing sandhill cranes in the study area except in unusual circumstances such as those described earlier on the windy night at the Washita NWR. An attempt at the Neal Roost in Jackson County on a foggy night, with misting rain and a 33-kmph wind, came close to duplicating the conditions experienced at the Washita NWR but the birds flew when they were just out of range of the light.

Banding should be an important aspect of any future studies of cranes in Oklahoma. Use of rocket-net traps and drugs at bait sites in Jackson County in winter show the greatest promise of success. If rocket-net traps are used, then several people must assist in handling the captured birds (Wheeler and Lewis 1972).

Mortality Factors

Disease

Few diseases have been reported in sandhill cranes. Francis and

Huey (1964) reported an infection of Salmonella infantis and two cases of S. belem in captive 8-wk-old greaters. The source of the cranes' infection was unknown. Many cranes died from botulism in the Texas coastal area in the winter of 1940 (Williams 1941). About 10 percent of the cranes Guthery (1972) collected in southern Texas had liver lesions similar to those of tuberculosis. Captive cranes in zoological parks have died from tuberculosis, enteritis, aspergillosis, and fowl cholera (Walkinshaw 1949).

Salmonella has previously been found in coots (Fulica americana), sparrows (Passer domesticus), partridges (Alectoris graeca), magpies (Pica pica), pheasants (Phasianus colchicus), black-headed gulls (Larus fuscus), mallards (Anas platyrhynchos), and mute swans (Cygnus olor) (Steele and Galton 1971). Salmonella spp. and Paracolobactrum arizonae were not isolated from any of 125 cranes examined in this study. One hundred and eight samples from the caecum and 119 from the cloaca were cultured (Table XXXIII). Serum samples from 28 cranes, including six from which smears from the cloaca and caecum were not made, did not have antibodies for S. typhimurium. Twelve of the same 28 specimens did not have antibodies for S. pullorum.

Air sacs and trachea or serum of 126 cranes were examined for evidence of infection with Mycoplasma spp. (Table XXXIII). Infections of the trachea and air sacs were found in one female adult Canadian subspecies wintering in Texas. One female adult Canadian wintering in Oklahoma had an infection in the air sac but not in the trachea. Evidence of M. gallisepticum infection was not found in a serologic test performed on the serum from the same bird.

TABLE XXXIII

SURVEY ON SANDHILL CRANES FROM TEXAS, OKLAHOMA, KANSAS AND NEBRASKA FOR CERTAIN DISEASE ORGANISMS, 1968 TO 1971

Organism	Sample Source	Tested Number	Results		Percent Infected
			Negative	Positive	
Salmonella spp.	Caecum	108	108	0	0
Paracolobactrum arizonae	Caecum	108	108	0	0
Salmonella spp.	Cloaca	119	119	0	0
Paracolobactrum arizonae	Cloaca	119	119	0	0
S. pullorum	Serum	12	12	0	0
S. typhimurium	Serum	28	28	0	0
Mycoplasma spp.	Air sacs	121	118	3	2.5
Mycoplasma spp.	Trachea	121	120	1	0.8
M. gallisepticum	Serum	28	28	0	0
Influenza A viruses (3 stains)	Serum	28	28	0	0
Newcastle disease virus	Serum	28	28	0	0
Paramyxovirus	Serum	28	28	0	0
Chlamydia psittaci	Serum	28	25	3	10.7

An adult female lesser collected during fall on the Washita NWR was infected in the air sac with *Mycoplasma*. The serum of this bird was negative for antibodies to *M. gallisepticum*. Serum samples taken from 28 cranes, including five from which cultural attempts for *Mycoplasma* spp. were not made from the air sacs and trachea, were also negative for antibodies to *M. gallisepticum*. *Mycoplasma* isolated from the previously mentioned three birds were not speciated. All infected birds appeared

to be in good physical condition.

Avian mycoplasmosis is a disease caused by microorganisms within the pleuro-pneumonia group. It is common among chickens (Gallus gallus), turkeys (Meleagris gallopavo), wild ring-necked pheasants (Phasianus colchicus), pigeons and chukar partridge (Alectoris graeca). Mortality is negligible in adult poultry but infections reduce egg production. Mortality among young poultry ranges from 0 to 30 percent (Yoder 1965). This is the first record of Mycoplasma among sandhill cranes.

Thirty-nine serum samples were shipped via air transport to Texas A. and M. University; 11 spoiled at a transfer point during shipment. The serum suitable for tests included members of three races and all sex and age categories. The cranes were collected in Texas, Oklahoma and Nebraska. All cranes were negative in serologic tests for three different influenza type A viruses, paramyxovirus, and Newcastle disease virus (Table XXXIII).

Three samples showed antibodies to Chlamydia psittaci, the organism causing ornithosis. A male adult lesser collected near Kearney, Nebraska in March had a titer of 1:40. A female adult Canadian wintering in Jackson County, Oklahoma had a titer of 1:40. A female adult lesser collected near Lewellen, Nebraska had a titer of 1:160. This is the first report of ornithosis in sandhill cranes. In wild birds most infections with C. psittaci do not produce clinical signs of disease (Burkhart and Page 1971).

Only a small percentage of the wild birds, with the exception of parrots, die from ornithosis and a significant percentage exhibit latent infections.

> Many wild birds have been exposed to chlamydial agents at one time or another so that the normal incidence of 1 to 10 percent positives in a group is not surprising ... determination that an individual bird has a positive titer is of little consequence, except that it indicates that the bird was, at one time exposed to a chlamydial antigen. The height of the titer is also of little significance except to indicate the strength of the antigenic stimulus. (Burkhart and Page 1971: 134).

Abnormal livers were found in several sandhill cranes. A mottled appearance of the liver was a common feature. Dr. A. L. Malle, Department of Pathology, Oklahoma State University, examined some and reported that the mottling resulted from normal postmorten tissue changes. The abnormal appearance of other livers may have been due to ornithosis (Burkhart and Page 1971). Some livers contained small necrotic areas. Samples from such areas in the livers from two cranes were cultured for bacteria. The organisms isolated were Streptococcus sp., Herellea sp. and Citrobacter sp.

Several sick cranes were observed in Nebraska. On 4 April 1969 a crane that appeared sick was observed in a corn field near North Platte. It was unable to fly and was chased into a fence and captured. The feathers were worn and frayed much more than normal and it appeared to have not molted in the previous fall. This adult female lesser was emaciated and weighed only 1,989 g, which is 40 percent below the average for an adult female lesser. One wing appeared to be injured. Some feathering was absent from the nape and one thigh. There were scaly growths on the thighs and the skin appeared very dark. Serum samples were collected but they were among the samples that spoiled during air shipment. This female was infected with Haemoproteus antigonis and Tetrameria sp. These parasitic infections probably would not entirely explain her condition.

Hunting

Sandhill crane hunting in the study area was first permitted in western Texas in 1961 (Table XXXIV). The open season dates there have evolved to coincide with the peak of the migration of sandhill cranes because whooping cranes do not migrate through that area. The western Texas hunting area is west of a boundary beginning at Del Rio, Texas and following U. S. 277 northward to San Angelo, then northwesterly following U. S. 87 to Dumas, and then northwesterly following U. S. 287 to the Oklahoma border.

Harvest estimates for Texas are from the sandhill crane committee report (Lewis et al. 1974). Western Texas is one of the most important harvest areas for the continental population of sandhill cranes. Most of the harvest occurs between San Angelo and Amarillo west of U. S. 87 (personal communication, J. K. Parsons, Texas Parks and Wildlife Department, San Angelo, Texas).

Hunting for sandhills began in western Oklahoma and the eastern Panhandle of Texas in 1968 (Table XXXIV). The season opens late to avoid jeopardizing migrating whooping cranes (see section on Migration). The eastern Texas Panhandle hunting area borders the western Texas hunting area and lies northwest of a line following U. S. 277 from San Angelo to Abilene, then along Highway 351 to Albany, then along U. S. 283 to Vernon, then along U. S. 183 to the Oklahoma boundary.
In the first year of hunting in the eastern Texas Panhandle an estimated 200 cranes were harvested; 160 of these were taken south of Lubbock in eastern Dawson and Lynn Counties (personal communication, J. K. Parsons).

In contrast to the harvest of cranes in Texas, the numbers harvested in Oklahoma are insignificant. The area initially opened to

TABLE XXXIV

SANDHILL CRANE HUNTING SEASONS AND HARVEST ESTIMATES FOR TEXAS AND OKLAHOMA, 1961-1973

Year	Season Dates (Day/Month) W. Texas	Season Dates (Day/Month) E. Texas Panhandle and Oklahoma	Estimated Harvest in Texas	Known Harvest in Oklahoma	Known Numbers of Hunters in Oklahoma
1961	4/11 - 3/12		1,200		
1962	3/11 - 2/12		1,230		
1963	2/11 - 1/12		1,230		
1964	31/10 - 29/11		1,260		
1965	30/10 - 28/11		1,350		
1966	29/10 - 27/11		890		
1967	4/11 - 2/ 1		1,070		
1968	2/11 - 28/12	14/12 - 2/ 1	1,339	10	14
1969	1/11 - 28/12	13/12 - 11/ 1	991	0	4
1970	31/10 - 10/ 1	5/12 - 10/ 1	2,000	0	4
1971	30/10 - 30/ 1	4/12 - 30/ 1	3,076	0	3
1972	28/10 - 28/ 1	2/12 - 28/ 1	No data	13	5
1973	27/10 - 27/ 1	1/12 - 17/ 1	No data	0	5

hunting was the portion of Oklahoma west of U. S. Highway 183, approximately the westernmost one fifth of the state. In 1970 the area was extended to that portion of the state west of U. S. 81, approximately the western two-fifths of the state. Harvest estimates for Oklahoma are based on the author's field observations, bag checks, and interviews with personnel on the Washita NWR and with Rangers of the Oklahoma Department of Wildlife Conservation. The only areas in Oklahoma that normally contained cranes on December 1 were Jackson County and the Washita NWR. The cranes at the refuge seldom fed on private land where they were subject to hunting.

Most hunters are not aware that cranes winter in Jackson County. Some hunters also equate cranes with fish-eating wading birds and are not interested in pursuing them. The roosts and feeding fields are on private property and in many cases these lands are not open to hunting. Most roosts are in isolated areas that are difficult to reach and few hunters know the location of these roosts.

The researcher knows of only one local person who hunted cranes. The others were military personnel from Altus Air Force Base, and residents of El Reno, Elk City, Oklahoma City, Norman, and Stillwater. With the existing season dates, crane hunting in Oklahoma has significance neither for harvest nor recreation for hunters. Likewise, the existing harvest in Oklahoma is of no significance to the stability of the wintering populations. Hunters who have hunted sandhills find them wary, as sporting as hunting ducks or geese, and excellent tasting.

Other Mortality Factors

In addition to the losses from hunting and disease, several other

mortality factors were affecting this population. A reliable source reported 15 cranes were shot at night on the Brawley Roost, Jackson County, Oklahoma, in the winter of 1968-69. Another person reported accompanying poachers 20 yrs earlier when they used a light and shot cranes roosting on the Canadian River in western Oklahoma during fall migration. The investigator does not believe poaching is a common occurrence.

Another type of loss is the illegal killing of cranes by hunters of other species, especially goose hunters. A warden in Kansas reported five cranes shot from a flock that flew over goose hunters at Cheyenne Bottoms, Kansas. A crane was mistakenly shot by a goose hunter near the Washita NWR in 1967 and another in 1972. One was killed by a goose hunter near Aransas Refuge in 1970. Nine were shot by goose hunters in Nueces County near the Chapman Ranch in 1968. One was shot near Laguna Atascosa NWR in 1970. Walter Gorham (personal communication) reported finding two cranes killed by waterfowl hunters in southern Texas.

Cranes have one call that sounds similar to the honk of a goose, and cranes and geese are sometimes seen flying together; these factors probably confuse some hunters. Some cranes are shot during early morning fog or other conditions of poor visibility. In most cases the hunter has no excuse except ignorance.

Cranes that are causing depredations (real or imagined) are occasionally shot at by farmers. Often the landowner only intends to frighten the cranes. Occasionally one is killed but the losses from this source seem insignificant.

Interactions between coyotes and cranes are discussed elsewhere. The only predation on cranes documented during this study was either by

bald eagles (Haliaeetus leucocephalus) or by great horned owls (Bubo virginianus). Robert Wheeler (in his field notes) left a styrofoam crane decoy overnight along the Platte River, Nebraska; talon and beak marks were evident on the neck and back of the decoy the next morning. On 5 April 1969, the author found two cranes that had recently been killed at a roost near North Platte. There were talon and beak marks between the wing butts on the back and also on the neck and chest of both birds. Neither crane had been fed on. Some bald eagles winter around North Platte, but the investigator had been in the vicinity several days and had seen none; apparently they had already left the vicinity. Horned owls are the only other avian predators that live in the area and are large enough to kill a crane. Horned owls were nesting along the river at the time and the presence of the cranes on the roost suggests they may have been killed at night. These owls attack larger and more powerful prey during the nesting season (Craighead and Craighead 1956) and they have been known to kill young swans (Monnie 1966).

The behavior of the cranes when eagles are around indicates that bald eagles may occasionally prey on cranes just as they do on geese. On 20 March 1971, the researcher saw an immature and an adult eagle near Ft. Kearney, Nebraska. Every time these eagles flew over a secondary roost the 1,000 cranes present there would fly. Geese react the same way in areas where eagles are preying on sick or crippled individuals.

Louis Young reported finding a dead crane that hit a power line on his farm in Jackson County, Oklahoma in fall of 1968. During strong winds on 25 March 1970, two cranes hit power lines near North Platte, Nebraska. Robert Stratton, Refuge Manager, found a juvenile crane that

hit a power line on the Washita NWR in March 1974. A farmer at Overton, Nebraska reported finding dead cranes that had struck power lines. Other observers (Brooking 1935, Walkinshaw 1956, Wheeler 1966) have reported similar accidents within the study area and this seems to be a rather common occurrence.

Parasites

One hundred and twenty-four blood smears were considered suitable for a survey of protozoan parasites. The suitable slides were from 61 cranes. The sex ratios of these cranes were almost equal and 11 were immatures. The number of cranes represented in each month are: October, 9; November, 5, December, 17; January, 8; February, 3; March, 8; and April, 11. The number of cranes collected in each state were: Kansas, 3; Nebraska, 14; Oklahoma, 27; and Texas, 17.

Haemoproteus antigonis was the only parasite found; specimens were identified by E. C. Griener of the WHO Centre for Avian Malaria Parasites. H. antigonis were present in two adults (Figure 14) or three percent of the birds. In one adult female lesser collected in Nebraska in April, approximately one in every 2,000 RBC was infected. She was severely emaciated but parasitism may not have been the main cause of weight loss. An adult male Canadian collected in Oklahoma in October had one parasite per 20,000 RBC. This crane appeared to be in excellent physical condition.

The failure to find Plasmodium in these birds is not surprising despite the proximity of their marshland nesting habitat to vectors of avian malaria. The blood smears were made at a time of year when parasitemias would be lowest. Also, wading birds are rarely found

infected with blood protozoa (Coatney and Roudabush 1937, Herman et al. 1954).

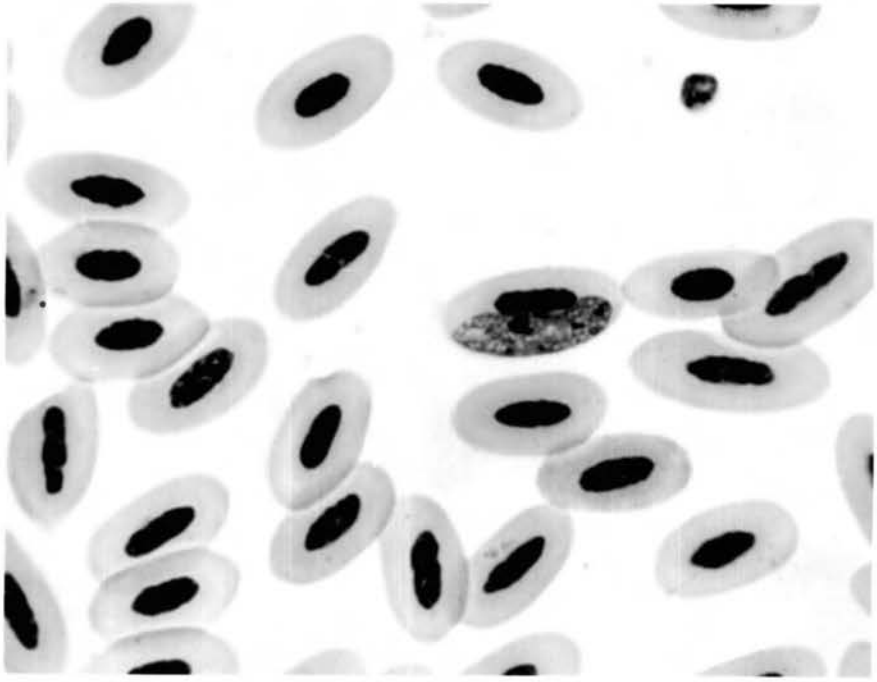

Figure 14. Haemoproteus antigonis in a Blood Film from a Sandhill Crane

Gluesing (1974) examined blood smears from 18 greaters in Wisconsin and found no protozoan parasites. Forrester et al. (1974) reported examining blood films from 51 greaters. Four contained light infections of Haemoproteus. Correspondence from E. C. Greiner indicates that the Haemoproteus that Forrester et al. (1974) found have also been

identified as H. antigonis.

The investigator examined the proventriculi and gizzards of 59 cranes. Thirty-five (59 percent) cranes contained Tetrameres in either the proventriculus or gizzard or both (range of 1 to 30 parasites per crane). Tetrameres grusi (Shumakovich, 1946 in Forrester et al. 1974) was first identified from the European crane (Grus grus) in western Siberia and Bush et al. (1973) were the first to describe the female in sandhill cranes collected in Florida. The females are found in the proventricular glands and the males are free in the lumen. Forrester et al. (1974) reported that 23 of 34 greaters from Florida contained T. grusi and had an average infection of 22 Tetrameres (range of 1 to 79). The significance of these infection rates to the cranes' health is unknown.

Pesticides

Walkinshaw (1965b) expressed concern about the possible detrimental effects pesticides might have on cranes. In this study a survey was made of pesticide residues in fat from cranes. Amounts of pesticides in fat are expected to be higher than in some other tissues because pesticides are concentrated in fat in many species of birds. Initially, four pooled samples were examined (Table XXXV). Samples from greaters collected near Gainesville, Florida include adults and juveniles of both sexes that died during a trapping program in 1968 and 1969. These greaters nest in Michigan and other Great Lakes States (Williams and Phillips 1972). The potential for exposure of greaters to pesticides appears to be high on the nest grounds of portions of the Lake States. Pesticides have been used heavily on some crops in Michigan (McMullen

1968). However, the samples from Florida contained low pesticide residues.

TABLE XXXV

RESIDUES OF DDT, DDE, DIELDRIN AND HEPTACHLOR EPOXIDE IN POOLED SAMPLES OF FAT FROM SANDHILL CRANES

Source of Pooled Sample	Residues in ppm			
	DDE	DDT	Dieldrin	Heptachlor Epoxide
Florida	0.63	<0.1	<0.1	
Nebraska	0.89	<0.1	<0.1	
Oklahoma	5.5	1.4	1.3	19.0
Texas	0.75	<0.1	<0.1	3.8

The sample from Texas included five Canadians, five greaters, and one lesser sandhill; including juveniles and adults of both sexes. They were collected in December and January 1969, in Colorado, LaVaca and Wharton Counties. As noted earlier, the Canadian subspecies nests in northern and central Canada. The greaters that winter in eastern Texas presumably nest in southeastern Manitoba and northwestern Minnesota (see section entitled Migration). The sample from southern Texas contained substantial residues of heptachlor epoxide. The author does not know where the cranes ingested this pesticide, but it may have occurred on areas in Texas that were treated for fire ant control. Some

cranes might also have been exposed on their nest grounds or along the migration route as they fed in muck soils. Trautmann et al. (1968) found that muck soils in vegetable-growing areas in Wisconsin contained high residues of heptachlor epoxide.

The 13 cranes collected in Nebraska in 1968 and 1969 include adults and juveniles of both sexes. There were two Canadians and 11 lesser subspecies collected near Hershey-North Platte (8), Lewellen (2), and Overton (3). The specific winter and nest areas for these birds are unknown, but cranes banded in the Overton area have been recovered in southern Alaska (September) and in areas in the Northwest Territories, Canada (June) (Wheeler and Lewis 1972). Cranes that use the Overton, Nebraska area in spring, winter near Littlefield, Texas, and Chihuahua, Mexico. Thus, pesticide exposure of these cranes would occur during migration and on wintering areas. The pesticide residues in these birds were low (Table XXXV).

The 11 birds from Oklahoma were collected in Jackson County in December and January (1968-69 and 1969-70) and included seven Canadians, three lessers and one greater sandhill. They included juvenile males and adults of both sexes. Seven were collected in the winter of 1968-69 and four in 1969-70. Their nest areas are not subject to much spraying of pesticides so the cranes' exposure occurs principally during migration or on the winter range.

Residues of DDT, DDE, dieldrin and heptachlor epoxide were all high in these cranes. R. E. Pillmore (FWS) reported (personal communication) that the residues of heptachlor epoxide were higher than any he had previously found in analyzing tissues at the Denver Research Center. Birds replace their fat often enough so that heptachlor epoxide residues

represent exposure less than 1 yr in advance (personal communication, R. E. Pillmore).

Jackson County probably has been the most intensively sprayed county in Oklahoma (personal communication, J. H. Young, Dept. of Entomology, Oklahoma State University). It has a large cotton acreage. During the 1960s, DDT was applied to cotton at the rate of 909 g per 0.4 ha 7 to 12 times annually. Dieldrin was also heavily used on these areas. Cleve Thompson, the owner of property east of Olustee that is used frequently by cranes, said he had placed dieldrin in the soil where cotton and wheat were planted. Mr. Bush (personal communication) has used dieldrin on fields that cranes from the Bush Roost used frequently. Neither dieldrin nor heptachlor are now recommended for use in cotton fields but both are still used to treat soil and to plant with seeds of milo and wheat. The use of DDT on cotton has been prohibited. The chlorinated hydrocarbon toxaphene is still recommended for use on cotton (Young et al. 1974).

Cranes were seldom seen feeding in cotton fields. Crops of milo are occasionally planted where cotton had been the preceding year. Some of the persistent chlorinated hydrocarbon pesticides used on cotton could be present in these milo fields in the soil (Korschgen 1970) and in the food chain for sandhill cranes.

Hollister clay soils are common in Jackson County (Bailey and Graft 1961). In such tight soils the pesticides stay within 23 cm of the soil surface for longer periods than in lighter soils (personal communication, J. H. Young). Another possible source of DDT, for cranes feeding in fields that have not been sprayed directly, was the contamination of soil and food by aerial spraying over adjacent fields.

Bowers (1969) indicated that the smallest spray droplets falling a distance of 3.3 m in a 5 kmph wind could drift as much as 8 km. Aerial spraying at altitudes of 3.3 to 16.6 m has been a common form of application of insecticides in Jackson County.

There were several possible sources of the heptachlor ingested by cranes. The most likely was heptachlor used to protect wheat seed from false wireworms (family Tenebrionidae) where these insects are prevalent in sandy loam soils along the Prairie Dog Town Fork of the Red River. The recommended rate for application of heptachlor while planting was 5.45 kg per 0.4 ha. Sandhill cranes fed on Tenebrionidae in Jackson County (see section entitled Food Habits and Feeding Habitat). Heptachlor was also worked into the soil to control white grubs (family Scarabaeidae) that feed on the roots of wheat. Cranes have been seen in wheat fields feeding on insect larvae, wheat forage and wheat seeds.

A second analysis for pesticides illustrates the variation encountered in individual cranes (Table XXXVI). The two greaters from Florida had residues suggesting low exposure to pesticides. The juvenile lesser and the adult Canadian collected during migration in October showed little evidence of exposure to pesticides. The juvenile lesser collected in Jackson County in December had been exposed to significant residues of DDT and its breakdown products.

The bird collected near the Drury Roost in 1968 contained dieldrin, but cranes collected at the Bush Roost the same year had not been exposed to dieldrin. Cranes from the Drury Roost did most of their feeding southeast of Eldorado, Oklahoma and just south of the Red River in Wilbarger County, Texas; whereas, cranes from the Bush Roost fed east of Olustee, Oklahoma, and southwest of Elmer, Oklahoma.

TABLE XXXVI

RESIDUES OF DDT, DDD, DDE, HEPTACHLOR EPOXIDE AND DIELDRIN IN FAT OF 12 SANDHILL CRANES FROM FLORIDA AND OKLAHOMA

Subspecies	Date Collected (Day/Month/Year)	Age	Sex	County and State	Residue in ppm (sample wt. basis/extractable lipid basis) DDT	DDD	DDE	Heptachlor Epoxide	Dieldrin	Location of Roost
Greater	2/68	J	M	Alachua, Fla.	0.1/.1	<0.1	0.2/2	0.0	<0.1	
Greater	2/68	A	F	Alachua, Fla.	<0.1	0.0	0.4/.4	0.0	0.0	
Canadian	6/10/68	A	M	Custer, Okla.	0.0	0.0	0.1	0.0	0.0	
Lesser	27/10/68	J	M	Alfalfa, Okla.	0.0	0.0	<0.1	0.0	0.0	
Lesser	14/12/68	J	M	Jackson, Okla.	2.4/3.0	0.2/.2	3.8/4.8	0.0	0.0	Bush
Lesser	14/12/68	A	F	Jackson, Okla.	1.3/2.0	0.3/.4	6.2/9.3	0.0	0.0	Bush
Canadian	14/12/68	A	M	Jackson, Okla.	0.3/.4	0.0	2.2/2.6	0.0	0.0	Bush
Canadian	15/12/68	A	M	Jackson, Okla.	0.4/.5	<0.1	1.6/2.1	0.0	0.7/.9	Drury
Canadian	12/12/69	A	F	Jackson, Okla.	0.0	0.0	2.1/2.6	3.7/4.6	1.0/1.2	Neal
Lesser	13/12/69	A	M	Jackson, Okla.	1.6/2.0	0.2/.2	4.3/5.3	9.1/11.3	0.4/0.5	Mock
Canadian	24/ 1/70	A	F	Jackson, Okla.	1.3/1.7	0.0	5.5/7.2	35.3/45.9	0.0	Bush
Canadian	24/ 1/70	A	F	Jackson, Okla.	0.2/.2	0.0	1.0/1.3	17.4/22.3	0.0	Bush

Specimens collected in 1969-70 at the Bush Roost had been exposed to heptachlor but not to dieldrin. This was a different pattern of exposure than that seen in birds from the same roost in the previous winter. Cranes collected in 1969-70 at the Mock and Neal Roosts had ingested both dieldrin and heptachlor. There was frequently an interchange of birds between the Mock and Neal Roosts so they represent the same basic population and they often feed in the same fields. The author noted previously the areas where the cranes from the Bush Roost fed. Cranes from the Mock Roost and Neal Roost spent most of their time feeding east of Olustee, south of Hess, north of White City, and southwest of Tipton. Thus, the different residues in individual cranes may reflect feeding patterns of various flocks within the winter area.

Pooled samples were examined again from the 1970-71 season (Table XXXVII). The sample from Jackson County contained four lessers and three Canadian sandhills taken from the Neal, Mock and Bush Roosts. Unfortunately, six of the specimens were collected in October and November before much exposure to pesticides was possible in the winter area; the other specimen was taken in late January. The birds' exposure to DDT remained high and probably will for several more years until the DDT and its breakdown products decay or leach out of the soil. The lesser pesticide levels found in these cranes in comparison to those wintering in Jackson County in 1968-69 and 1969-70 (Table XXXVI) may have resulted from the difference in the length of time that they had been exposed to pesticides on the winter area.

The sample from the Washita NWR (Table XXXVII) included a greater, two Canadians and two lesser sandhills collected in December (2), January (1) and February (2). A comparison between cranes wintering

on the Washita NWR and those wintering in Jackson County in 1968-69 and 1969-70 (Table XXXVI) indicates that those on the refuge contained fewer pesticide residues. The Washita flock usually fed on the refuge but occasionally fed in wheat and milo on private property. Apparently they were not exposed to much DDT, DDE or dieldrin, because less cotton is grown in Custer County than in Jackson County. Cranes on the Washita NWR contained residues of heptachlor epoxide and their exposure probably occurs where wheat seeds and soil on private property have been treated to control insect pests.

TABLE XXXVII

PESTICIDE RESIDUES IN FAT OF SANDHILL CRANES AND MERCURY IN THEIR BREAST MUSCLES, WASHITA NWR AND JACKSON AND TILLMAN COUNTIES, OKLAHOMA, 1970-1971

	Residues in ppm				
	DDE	DDT	Dieldrin	Heptachlor Epoxide	Mercury
Washita NWR	0.6	0.0	0.3	2.1	0.02
Jackson County	3.2	0.4	0.1	0.4	0.03
Tillman County	0.3	0.0	0.0	0.1	0.36

The Tillman County sample (Table XXXVII) included two adults and two juveniles (three Canadians and one lesser subspecies). These were migrating birds collected in October and November. Their only

significant exposure to pesticides was to mercury. The cranes in Tillman County probably ingested the mercury while feeding on freshly drilled wheat or milo. Mercury has been used in the area as a fungicide to treat seed of cotton, milo and wheat, but its use is now prohibited. Wheat seed treated with mercury was found in the gullet of a crane collected in Jackson County in 1969.

Further studies of the sources of pesticide exposure were planned. Gullet contents from cranes previously tested for pesticide levels and several soil samples were submitted for analyses. However, funds were not available for continued work and the legislation prohibiting use of mercury and DDT decreased the urgency for further studies. Dieldrin, aldrin, and heptachlor are still used in Oklahoma to treat soil or are planted with wheat and milo seed at rates of 5.7 g per 0.4 ha. The Director of the Environmental Protection Agency indicated in fall 1974 that he would soon ban further production of aldrin and dieldrin. The continued use of heptachlor and the use of toxaphene in cotton (Young et al. 1974) justifies further monitoring of pesticide residues in cranes in Oklahoma.

Without further studies the relationship between the residues in fat and breast muscle and those residues in other tissues and organs will remain unknown. Likewise, the effect of the levels that existed are unknown.

Determination of Sex

A technique is needed that will allow biologists to distinguish the sex of sandhill cranes by external examination of a bird in the hand. The two sexes are similar in external appearance and when this

project began the only method for distinguishing the sexes was post-mortem examination of the gonads or chromosome analysis (Hungerford et al. 1966). "The major disadvantages of the cytogenetic method are its expense and the fact it is extremely time consuming ...". (op. cit. 1966:711). Dieter (1973) identified the sex of eagles, owls and herons by centrifugal chromatography of plasma on silica gel columns. A similar technique could presumably be developed for sandhill cranes. The equipment for such a technique is not readily available to the average field biologist, but its purchase might be justified in some circumstances.

A means of distinguishing the sex of cranes, more rapid and simpler than either the cytogenetic or chromatographic methods, would be very useful when harvested cranes are examined.

Cloacal Examination

Male sandhill cranes lack a penis-like organ; consequently, determination of a crane's sex by cloacal examination is difficult. Blackman (1971) studied sex determination in broglas (Grus rubicundus) and eastern Sarus cranes (Grus antigone sharpii). Based on external morphological differences, four age categories (adults, sub-adults /nonbreeders/, yearlings, and young of the year) can be distinguished in these species. Blackman (1971:283) examined the cloaca of live, captive and dead specimens in all months of the year and noted:

> The cloaca of all adult male broglas possessed two vascularized erectile papillae, each approximately 2.5 mm in height and terminal to the vas deferens ducts; the papillae were lateral to the vent and medial to the ureter openings.

He correctly determined the sex of all adult broglas. Among the younger age categories he accurately sexed 37 percent of the males but

essentially none of the females. Thus, this technique allowed him to correctly identify the sex of only 22 percent of the three youngest age categories. Preliminary results suggested similar accuracy for sexing the Sarus crane.

Examination of dead cranes in the field and laboratory indicate Grus canadensis have the same features that Blackman (1971) described for Grus in Australia. The area in birds "terminal to the vas deferens ducts" (Blackman 1971:283) is generally called the seminal vesicles or seminal sac. Seminal vesicles are present in both sexes in many birds but are generally smaller in females (Marshall 1961). They are usually minute except during the breeding season when they enlarge in response to secretion of androgen. In females of some bird species the ducts also enlarge during the breeding season.

The seminal vesicles of male sandhill cranes are each as much as 10 mm long and 2 mm wide. Occasionally they appear dark, apparently due to the presence of capillaries near the surface of erectile tissue. Beneath folds of tissue, one to six small holes are visible macroscopically along each seminal vesicle.

The terminal ends of the ureters are more dorsal and deeper in the urodeum, 8 to 10 mm from the lateral end of the seminal vesicles. Like the seminal vesicle, the tissue bordering the ureter is elevated from the urodeum wall for an area 2 mm wide and up to 10 mm long, but the ureter has only a single opening. The ureters lack the dark appearance sometimes occurring in the seminal vesicles.

The author found it consistently difficult to identify accurately male sandhill cranes. The presence of seminal vesicles in females, although they are less developed, adds to the confusion. The absence

of an opening to the oviduct does not mean that the bird is a male. In Canada geese (Hanson 1962) the membrane that occludes the opening of the ovidcut is usually not resorbed until after they leave the winter area during the year they first breed. Some adult female cranes, like geese, retain the membrane of the oviduct but the author does not know if it is present until the spring in which they first breed. Female greaters generally do not nest in the wild until their third and fourth years (personal communication, R. C. Drewien and C. D. Littlefield) or in captivity greaters first produce eggs in the third year of life (personal communication R. C. Erickson). The Mississippi sandhill crane (G. c. pulla) has laid infertile eggs in captivity at 2 yr (personal communication, R. C. Erickson). Thus a membrane may occlude the oviduct of an adult female crane until she is between 2 yr and 4 yr old.

The presence of a seminal vesicle and the absence of an oviduct opening caused me to misidentify the sex of a number of female cranes. The sex of some sandhill cranes can be determined fairly accurately by noting the presence of cloacal papillae or the oviduct opening; presumably these are the breeders or sexually mature birds. After developing a technique, the investigator determined the sex of 69 percent of 78 adult cranes. Seminal vesicles are not as pronounced in juvenile males and in adult males presumably not sexually mature.

If the seminal vesicles are darkly colored or cloacal papillae are distinct it seems safe to conclude that the bird is a male. The opening to the oviduct distinguishes some adult females. Those lacking the distinct seminal vesicle, cloacal papillae, and oviduct opening may be

of either sex and their differentiation becomes a matter of judgement based on experience.

Neither coloration of the vent nor the seminal vesicle appeared to be related to age. Both juvenile and adult male cranes were either white or dark colored in these areas.

Plumage, Coloration, and Morphology

There is too much overlap in the taxonomic measurements of the two sexes of the three races to permit reliable distinction of sexes by using such measurements. Specimens of both sexes of the three races were examined simultaneously as described in Materials and Methods. The attempt to find some external feature(s) that could be used to distinguish the sexes was unsuccessful. None was found that appeared distinctive enough to provide reliable recognition of sex.

One feature was given special attention. B. W. Schranck (personal communication 1974) reported that shaft color of the primaries showed promise as a means of determining the sex of lesser sandhills. He indicated that the shafts of the primary feathers of the males are white or nearly white and that those of the female are black. The color of the primary feather shafts has previously been listed as a taxonomic feature; dark gray in lessers, whitish or yellowish in greaters (Walkinshaw 1949) and lighter in the Canadian race than in greaters (Walkinshaw 1965). Stephen et al. (1966) examined 127 specimens and found such inconsistency on individual cranes that they concluded shaft color is not a reliable taxonomic character. The investigator examined 138 specimens, including all three races, and found that color

of the primary feather shaft is not a sex-related feature (Table XXXVIII).

TABLE XXXVIII

COLOR OF THE SHAFTS OF PRIMARY FEATHERS OF MALE AND FEMALE SANDHILL CRANES OF THREE RACES

Race and Sex	Number of Cranes and Color of Primary Feather Shafts			
	White	Gray	Gray-Black	Black
Greater				
Male	9	4	0	1
Female	3	5	0	2
Canadian				
Male	18	12	1	1
Female	13	7	1	1
Lesser				
Male	9	22	7	3
Female	4	6	6	3
Totals:				
Male	36	38	8	5
Female	20	18	7	6

Testes and Ovaries

The functional morphology of the ovaries and testes has not been studied much in wild species of birds (Lofts and Murton 1973). Testes of 59 cranes and ovaries of 39 cranes were examined from specimens collected from October to early April. Ovaries were also examined from two captive females that died in mid May at the Patuxent Research Center (FWS).

Testes

In seasonally breeding birds the testis varies in size as much as 400- to 500-fold annually (Lofts and Murton 1973). Average testis size of the cranes in this study increased only slightly between fall and early April. Average maximum dimensions for an adult testis in fall was 15.5 mm by 7.6 mm and in spring it was 18.4 mm by 9.9 mm. Among juveniles the change for the same period was from 15 mm by 8.3 mm to 17.7 mm by 7.9 mm.

The annual cycle has been classified into three phases (Lofts and Murton 1973): 1. The regeneration, or preparatory phase, that follows immediately after reproduction in species having single broods annually. It is marked by rapid regression of the testes and rehabilitation of the interstitial tissue and seminiferous tubules, and is a period of sexual quiescence during which the bird displays little sexual behavior. The weakened tunica of the testis is replaced at this time. 2. The acceleration phase, which is characterized by the interstitial cells and seminiferous tubules responding to gonadotropic secretions from the adenohypophysis and increased courtship behavior and vocalization. 3. The culmination phase, a period during which spermatogenesis

becomes complete and breeding may occur.

The extreme variation in size of the testis strains the tunica albuginea and the tunica vaginalis and they are replaced annually by a proliferation of new fibroblasts rebuilding a new capsule from beneath the old sheath. The new and old layers are seen in sectioned material after the postnuptial testicular regression (Figure 15).

> This transient stage can sometimes be a useful parameter for distinguishing between a juvenile bird, in which the sexual organs have not yet undergone any expansion into a breeding condition, and an adult showing a postnuptial testicular collapse. (Lofts and Murton 1973:6).

Figure 15. The Tunica Vaginalis (1) and the Old (2) and (3) New Layers of the Tunica Albuginea of a Testis From an Adult Greater Collected 26 October 1969. 100 X

Cranes may resemble some geese and swans that continue as pre-breeders for several years after they are sexually mature (Monnie 1966, Palmer 1972). Sexually mature individuals may not complete the breeding cycle because of an inhibiting factor that occurs at a sensitive time in the annual cycle when reproduction can be inhibited. An example of an inhibiting factor would be failure to acquire a suitable nesting territory. These potential breeders may then engage in nest building in less suitable habitat and even copulate, but not produce eggs. Some greater sandhills in Idaho pair as 2-yr-olds but do not complete the full breeding cycle (Drewien 1973). Thus, the presence of two layers in the tunica albuginea may characterize all sexually mature cranes including some individuals that did not successfully complete the full breeding cycle.

A single layer of the tunica albuginea in three of the eight greater sandhills collected from October to December indicated the three were not sexually mature (Table XXXIX, Figure 16). The presence of only one layer in the tunica albuginea in two of nine Canadian sandhills indicated they were also nonbreeders. All three lesser sandhills were apparently sexually mature. Only one of the six testes removed from juvenile males in the period October through December showed evidence of a new and old layer of the tunica albuginea (Table XXXIX). The single exception was a Canadian sandhill collected in December; perhaps its tunica was being strengthened prior to spring when it might become a potential breeder in the second summer of its life. As noted in the section entitled Determination of Sex, records of captive greater (G. c. pratensis) and Mississippi (G. c. pulla) sandhills indicate that they begin breeding in their third and fourth year of life (personal

TABLE XXXIX

NUMBER OF LAYERS OF THE TUNICA ALBUGINEA IN TESTES REMOVED FROM CRANES COLLECTED FROM 1 OCTOBER TO 31 DECEMBER

Race	Age	Number of Layers	
		One	Two
Greater	Adult	3	4
	Juvenile	1	0
Canadian	Adult	2	7
	Juvenile	0	1
Lesser	Adult	0	3
	Juvenile	4	0

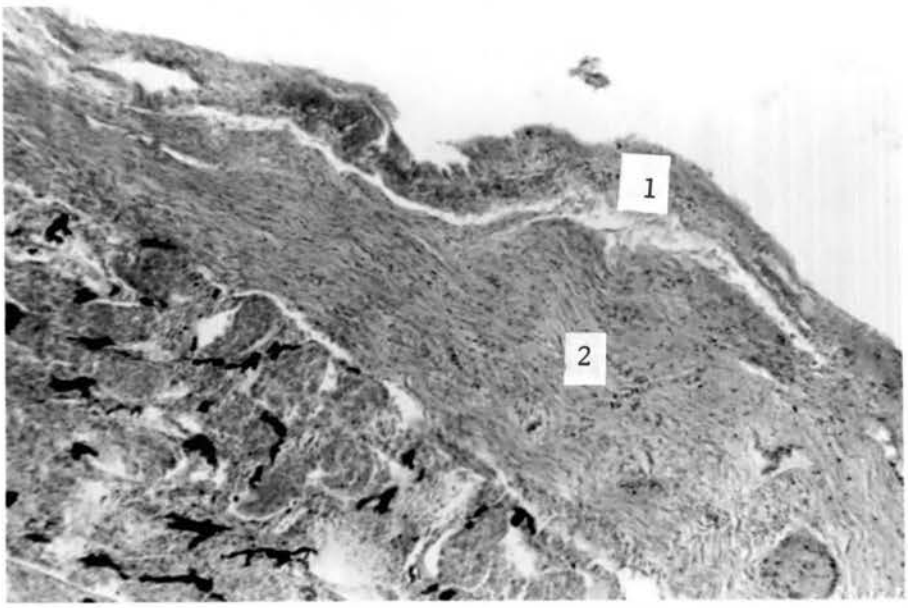

Figure 16. The Tunica Vaginalis (1) and Single Layer of the Tunica Albuginea (2) of a Testis From an Adult Greater Collected 20 October 1970. 100 X

communication, R. C. Erickson, FWS, Laurel, Md.). Data indicating the age when successful nesting occurs in the lesser and Canadian races are not available.

Regrowth of the tunica was evidenced in the thickness of the tunica as well as in the distinctive layering. Thickness of the tunica was measured at a magnification of 430 X. Adults in the October-December period had an average tunica thickness of 34 µm when two layers were present and 27 µm when only one layer was evident. The tunica of juveniles averaged 17 µm wide in the same time period.

During the period of sexual inactivity the germinal epithelium of the seminiferous tubules generally consists of a single layer of stem spermatogonia and Sertoli cells (Lofts and Murton 1973). This was the most common condition seen in sections of testes the researcher examined (Figure 17). Clermont (in Lofts and Murton 1973:8) listed three stages in the rehabilitation of the germinal epithelium to breeding condition:

> ... (1) the period of spermatogonial multiplication, during which new spermatogonia are formed continuously, and some start maturing into primary spermatocytes; (2) the period of spermatocyte division, when the cells undergo their meiotic division producing secondary spermatocytes which mature into spermatids; (3) the period during which spermatids start elongating and start their transformation into the mature spermatozoa.

Stages 1 and 2 were the only ones that could be distinguished in the testes collected from the study area. Sertoli cells and spermatogonia were the main cells present in seminiferous tubules of 32 testes, including those removed from eight juveniles from 6 October to early March. By late December, testes from some birds showed evidence of Stage 1 (Clermont in Lofts and Murton 1973:8). Several layers of spermatogonia were evident but primary spermatocytes were rare. Field

observations in the same time interval indicated an increase in courtship-related behavior (i.e. dancing) on days of mild weather.

Figure 17. "Resting" Germinal Epithelium, Wide Interstices Between Seminiferous Tubules, Sertoli Cells, and Spermatogonia in a Testis From an Adult Greater Collected February 1969. 100 X

Eighteen testes were examined that had been collected in the period 22 March to 5 April in Nebraska; six were from juveniles. One juvenile lesser was in Stage 2, having primary spermatocytes present and what appeared to be spermatids present in small numbers. This indicates that some sandhill cranes may become sexually mature in their second summer of life. However, that does not necessarily mean that they could mate that same summer. Seven of the 12 adults collected in late March

and April were also in Stage 2 (Figures 18 and 19). None of the cranes had produced spermatozoa yet; apparently this occurs on the nesting grounds or later in migration. The author observed no attempts at mating on the staging area along the Platte River although there is much dancing and general courtship behavior.

Ovaries

There is little information on seasonal changes in ovarian histology among wild species of birds (Lofts and Murton 1973). The ovary varies in size seasonally just as the testes do. The maximum diameter of follicles in ovaries removed from 18 cranes, collected during the months of October through December, averaged 2.0 mm and ranged from 0.5 mm to 3.5 mm. The average maximum diameter of follicles of 15 cranes collected in March-April was 3.4 mm and ranged from 0.5 to 6 mm. By 12 and 13 May the diameters of the larger follicles in the two Florida sandhills that died in captivity were 11 mm to 19 mm and 13 mm to 23 mm respectively. These measurements represent the size of the follicles just prior to initiation of nesting activities by other captive cranes at the same facility. Lofts and Murton noted that the final yolk deposition, that causes the enlargement of follicles, can be very rapid. In pigeons (Columba livia) the maximum follicular diameter can increase from 5.5 mm to 20 mm within eight days (Lofts and Murton 1973).

Follicle size was just beginning to increase in the cranes collected in Nebraska and the oviduct was only slightly enlarged. The oviduct of one of the Florida cranes killed in May was 13 mm in diameter while the oviducts of several lesser and Canadian sandhills examined in

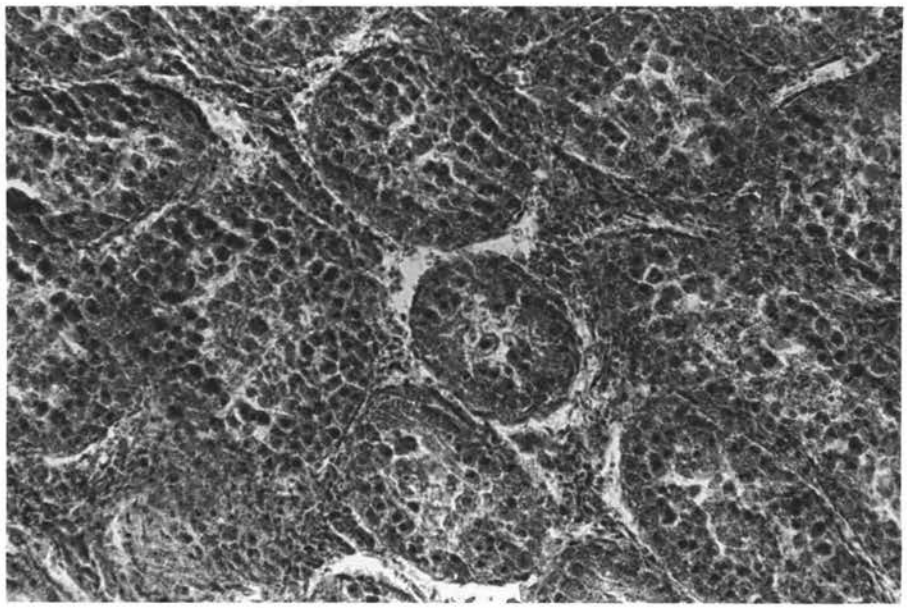

Figure 18. Stage 2, Narrow Interstices Between Seminiferous Tubules, Sertoli Cells, Spermatogonia, Primary and Secondary Spermatocytes and Spermatids of a Testis from an Adult Lesser Collected 24 March 1970. 100 X

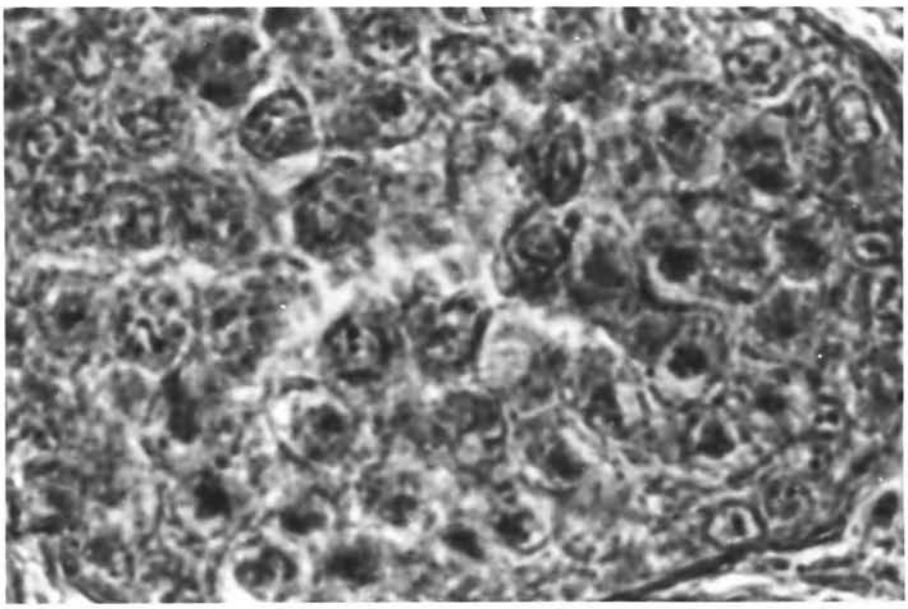

Figure 19. Primary and Secondary Spermatocytes and Spermatids in the Seminiferous Tubules of a Lesser Collected 24 March 1970. 500 X

Nebraska were 2 mm in diameter.

Small normal follicles and atretic follicles were evident in the slides examined. As Lofts and Murton (1973:43) noted "... the ovary always contains large numbers of follicles in various stages of development, as well as a spectrum of corpora atretica in various stages of atresia ...". Lofts and Murton (1973:43) state further, in most birds:

> After ovulation, the ruptured follicles rapidly regress, disintegrate, and become cleared by phagocytic action. No persistent corpora lutea of the mammalian pattern are formed, and in the Chicken and Rook the postovulatory follicle becomes resorbed within a few days, but in the Ring-necked Pheasants (Phasianus colchicus) and in the Mallard they persist for as long as 3 months.

Meyer et al. (1947:45) describe the development of the follicle scar in pheasants as follows:

> However, when ruptured follicles are approximately 6 to 8 days old a yellow pigment begins to appear in their walls; as involution continues this pigment becomes more concentrated and in the final stages the ruptured follicles consist of small brownish orange structures ... Even follicles which are not much larger than 1 mm in diameter retain an opening that can often be probed with the tip of a fine pair of forceps.

Kabat et al. (1948) found that most ovulated follicles were evident 100 days after the hen laid her eggs; as the elapsed time interval became greater, more and more ovulated follicles became complete resorbed.

The author searched for ovulated follicles on the surface of the ovaries of 37 adult sandhill cranes. Most lesser and Canadian sandhills nest in May and June (Walkinshaw 1973:Table 5) and therefore birds the researcher collected in October, November, and December would represent collections made 120 to 210 days following the date the bird laid her

last egg. Judging from the literature the author could not expect to find many ovulated follicles in the crane ovaries he examined.

Ovulated follicles appear to be present on 4 of 18 ovaries collected in fall, on 1 of 4 collected in January-February, and on 3 of 15 ovaries collected in March-April. Definite statements cannot be made about ovulated follicles in cranes until ovaries are available from sandhills with a known history of egg laying. During fall, the structures presumed to be ovulated follicles measured 1 mm across and were either dark orange of a deep golden color. By late winter they were dark red spots only 0.3 to 0.5 mm wide. Two ovulated follicles were found on each of three specimens taken in the fall.

Field Identification of Juveniles

The annual production of sandhill cranes should be measured so that biologists can more precisely manage the species. The percentage of juveniles among cranes harvested by hunters and the percentage of juveniles among cranes observed in the field provide means of measuring annual production.

A juvenile harvested in the fall hunting season can be identified by noting features of the head and nape. Adults have red papillose skin, covered with short black bristles, above the orbits and extending across the crown, forehead and lores to the upper culmen. Adults have pallid or pale mouse-gray feathers on the occiput and nape. Juveniles generally lack the reddish skin on the head. In full juvenal plumage they have tawny-colored feathers on the crown, occiput and nape and shorter pale-gray feathers on the forehead (Figure 20). The amount of feathering and the color of feathering on a juvenile's head will vary

depending on the progression of the postjuvenal molt; but some tawny feathers are present on the occiput and nape as late as April, and this plus the general absence of the reddish papillose skin makes it possible to identify all juveniles in the hand.

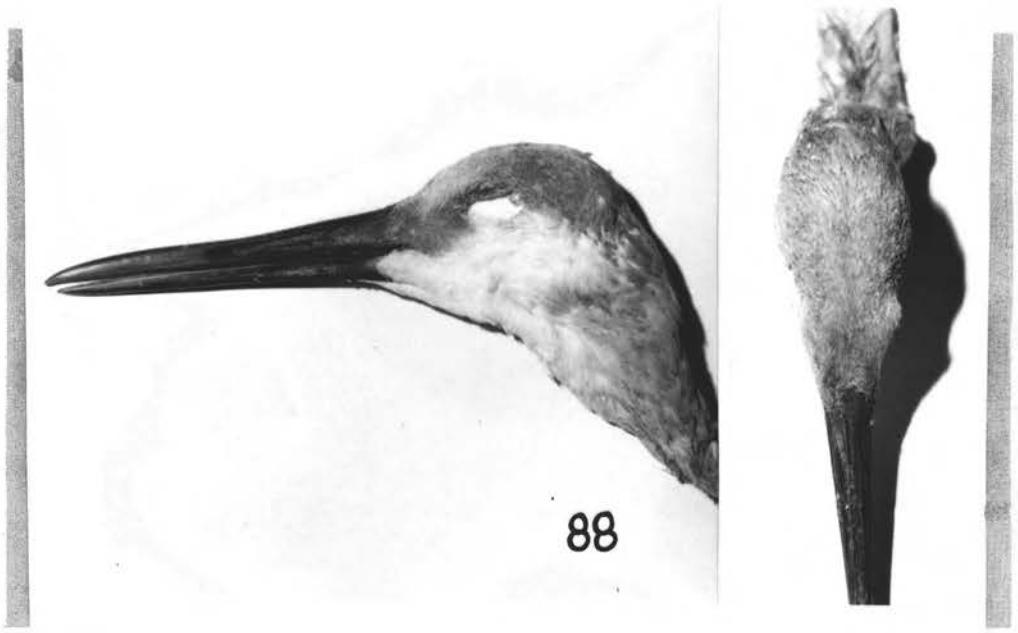

Figure 20. Profile and Top View of Juvenile Greater in October Showing Plumage on the Head and Nape

Techniques for distinguishing juveniles and adults in the field have only recently been described (Miller and Hatfield 1974) although some biologists have been making such counts for several years. The latter authors made observations in Saskatchewan in August and September and said observations of flying flocks "give the least biased estimate of

age ratios." (1974:234). They arrived at this conclusion because their counts of cranes on the ground showed lower percentages of juveniles. Unfortunately, they had no way of checking the accuracy of their aging technique. Their observations indicated an annual recruitment of only 0.035 to 0.053 to the fall population, a figure much lower than the 0.09 to 0.27 recruitment rate indicated by other researchers (Boeker et al. 1961, Boeker et al. 1962, Guthery 1972, Harvey et al. 1962, Johnson and Stewart 1973, Madsen 1967, Stephen et al. 1966). Miller and Hatfield "only recorded ages of birds which could be positively identified by a clear view of the head." (1974:238) but did not indicate how a clear view was possible when the cranes were flying overhead. The key features used to distinguish juveniles in field observations are coloration of the occiput, forehead and nape; these areas are seldom readily visible on a bird flying overhead.

Walkinshaw (1949:20) mentions the difficulty of distinguishing adult and juvenile greaters in October and the difficulty of identifying juveniles in New Mexico in early February. Aldrich and Burleigh (1958: 3), speaking of observations in Texas and New Mexico during December, January and February, say:

> An attempt was made to determine the age of the birds by the condition of the feathering. This was found to be impractical because of the difficulty of getting close enough to the birds to see whether the head was completely feathered or not.

After the postjuvenal molt is well underway it becomes difficult to distinguish juveniles from adults during field observations.

> By mid September, the forepart of the head began to lose some of its feathered appearance, and redness began to show early in the same month. ... By mid October, the young bird, now only five months old, closely resembled an adult, except that a few coverts and tertails with tawny-colored tips had been retained. (Walkinshaw 1949:20).

Walkinshaw (1949) described the juvenal and postjuvenal plumage of a captive greater. At 63 days of age the nape and the back were tawny, there was a tawny stripe from the occiput to the back and the rest of the bird was light, pale, and dark gull gray. At 83 days of age (August 1) the postjuvenal molt started and the bird began to lose the small feathers of the head, face and neck. The postjuvenal molt was a complete molt except for the primaries, secondaries, some coverts and the rectrices. In Walkinshaw's captive crane this molt was almost complete by November, but the tertials were molted through mid-January and lesser coverts were molted sporadically through winter and spring.

The same sequence of molt occurred in the lesser, Canadian and greater races examined in this study (Figure 21) but the molt is more prolonged than in Walkinshaw's (1949) captive bird. For example, Specimen 18, a Canadian sandhill collected 25 November, still had tawny feathers extending 100 mm down the occiput and nape. Specimen 156, a greater from Florida (February), still had tawny feathers on the side and top of the head, and extending 110 mm down the occiput and nape. Some juveniles have not yet completed the post juvenal molt on the head and nape when they are migrating northward in April.

The investigator knows of no previous study that evaluated the accuracy of the technique for distinguishing juveniles in field observations as the molt progresses. He examined the progression of the postjuvenal molt in 32 juveniles. Fred S. Guthery and John W. Aldrich provided similar data for 5 and 17 specimens respectively. The resulting interpretation by biologists experienced in observing cranes indicates how accurately they believe they could have identified the age of these specimens if the cranes had been observed feeding in a

field in average conditions of lighting (Tables XL and XLI).

Figure 21. Top View of Heads (L-R) of a Male Juvenile Canadian Collected in November, a Male Juvenile Greater in October, and a Male Adult Greater

Although some cranes are distinguishable as juveniles in March it is obvious that it becomes difficult to accurately classify some individuals as early as November. The sample size (Tables XL and XLI)

TABLE XL

EVALUATIONS OF THE PROBABILITY OF ACCURATELY IDENTIFYING JUVENILE SANDHILL CRANES OF THREE RACES UNDER AVERAGE FIELD CONDITIONS

Month(s) of Collection and Race	Number of Specimens and Similarity to Adults		
	Distinctly Juveniles	Intermediate	Similar to Adults
Greater			
October	1	0	0
November	1	0	0
February	0	2	1
Canadian			
September	2	0	0
October	2	0	0
November	2	0	0
December	4	1	2
January	1	0	1
February	0	0	2
March	1	0	1
Lesser			
September	1	0	0
October	2	0	0
November	1	0	1
December	6	2	2
January	3	0	1
February	0	0	0
March	2	0	5
April	0	0	1

TABLE XL (Continued)

Month(s) of Collection and Race	Number of Specimens and Similarity to Adults		
	Distinctly Juveniles	Intermediate	Similar to Adults
May	0	0	1
June	0	0	2
August	0	0	1

TABLE XLI

EVALUATIONS OF THE PROBABILITY OF ACCURATELY IDENTIFYING JUVENILE SANDHILL CRANES UNDER AVERAGE FIELD CONDITIONS

Month(s) of Collection	Number of Specimens and Similarity to Adults			Maximum Percentage Identifiable as Juveniles
	Distinctly Juvenile	Intermediate	Similar to Adult	
September	3	0	0	100
October	5	0	0	100
November	4	0	1	80
December	10	3	4	76
January	4	0	2	66
February	0	2	3	40
March	3	0	6	33
April-May	0	0	4	0

is too small to use as a correction factor for adjusting field observation data for November and December. Careful examination of harvested juveniles could provide such correction factors in the future.

Counts of juveniles appear impractical after January in the study area and counts in November, December and January should be made with extreme care. The resulting data must be recognized as a probable underestimate of the true percentage of juveniles in the population.

More information is needed on the progression of molt in the three races. D. H. Johnson and R. E. Stewart (unpubl. report) noted that adult Canadian sandhills completed the molt of brown feathers on the mantle (back and shoulders) before adult lessers did. A later molt of adult lessers is also suggested in the limited sample examined in this study. Johnson and Stewart found that the molt of the mantle of juveniles occurred later than in adults of the same race. Thus, an observer dealing primarily with lessers might accurately identify juveniles in field observations later in the year than could observers studying the Canadian or greater races.

The tawny plumage on the juvenile body and wing coverts, and the buffy tips on the wing coverts help distinguish juveniles from adults. The buffy tips on the wing coverts of juveniles present a pattern of horizontal markings on the wings of those birds that have not completed the molt (Figure 22). However, the tawny plumage of the body of juveniles can sometimes be confused with the cryptic coloration of some adults. Adult and juvenile sandhills preen themselves with marsh debris while they are on nesting grounds (Drewien 1973, Walkinshaw 1949) and the plumage becomes stained with ferric oxide (Taverner 1929) (Figure 23). Drewien (1973) postulates that the resulting rust-brown

color of the feathers provides cryptic coloration. Adults still have some of these rust-brown feathers when they migrate through the study area and when this coloration fades it can occasionally be confused with the tawny color of juvenal plumage.

Figure 22. Buffy Edges of Coverts on Juvenile Cranes That Give an Appearance of Horizontal Markings Across the Wings. Top to Bottom: Wings from Cranes Collected in March, February and December

Figure 23. Wings of Female Adult Greaters Showing Coverts Stained with Ferric Oxide

Rust-colored plumage is found on almost all adults but is prominent on only a portion of the population. The investigator examined museum specimens of 108 adults for the presence of rust-brown plumage (Table XLII) to see how many were similar in appearance to juveniles. Cryptic coloration is most prominent on the middle and greater wing coverts but in some specimens is also common on scapular feathers, rectrices and feathers of the lower back. Twenty percent of

TABLE XLII

CRYPTIC COLORATION ON THE PLUMAGE OF ADULTS IN RELATION TO THE NATURAL COLORATION OF JUVENILES

Month of Collection	Similarity of Adult and Juvenile Wing and Body Coloration								Percentage
	Greater		Canadian		Lesser		All Races		
	Similar	Not	Similar	Not	Similar	Not	Similar	Not	Similar
October	2	2	2	3	4	1	8	6	57
November		2	1	9	2	2	3	13	19
December	1	4	1	7	2	2	4	13	24
January			1	11			1	11	8
February	1	7				4	1	11	8
March			1	8	1	16	2	24	8
April	1			2	2	6	3	8	27
Totals	5	15	6	40	11	31	22	86	
Percentage	25		13		26		20		20

the adults had enough cryptic coloration on the wings and body to make their body coloration somewhat similar to that of juveniles. The red skin on the head and light gray plumage on the occiput and nape should be seen clearly to accurately classify these individuals as adults in field observations.

Several other problems are encountered in distinguishing adults and juveniles in the field. The observer should position himself so that he is looking away from the sun. Within the study area it is difficult to approach closer than 100 m to flocks of cranes. A spotting scope is necessary to view the features of the birds' heads. Counts are not attempted during the warmer part of the day because heat waves emanating from the ground distort viewing through a spotting scope. The frequent winds experienced in the plains states often make viewing difficult with a spotting scope. Insufficient light is available for using a spotting scope on overcast days and during periods late and early in the day.

On rolling terrain or in high vegetation, there is a tendency to overlook some juveniles. When feeding, juveniles spend more time with their head down than do the adults; adults often have their head upright as though they are watching for danger. Small groups of birds, therefore, must be observed for several minutes until each member is classified as an adult or juvenile. Flocks containing 30 to 60 birds can be classified fairly accurately as long as they are not rapidly intermingling or concentrating in a small group. It is difficult to classify the age of more than a proportion of the birds in flocks that contain more than 60 individuals, unless they are relatively immobile.

Determination of Age

Van Soest and Van Utrecht (1971) reported that a bird's age might be determined by counting layers in the periosteal zone of certain bones:

> Not all parts of the skeleton show the same thickness of the periosteal zone. Best areas for examination are those on which tendons are inserted: apparently secondary deposition of bone is most intense in these places. With the majority of the investigated birds the distal part of the shaft of the tibia just over the epiphysis appears to be the most suitable place (Duck, Chicken, Moorhen, Heron); only with Herring Gulls this did not work out and here the most suitable part of bone is the mandible. (op. cit. 1971:63). The results can be studied under a stereobinocular, a normal microscope or in polarized light. (op. cit. 1971:62).

Van Soest and Van Utrecht (1971) counted annuli (a light plus a dark band) in one mallard, two chickens, two jays (Garrulus glandarius), one moorhen (Gallinula chloropus), three herring gulls (Larus argentatus), a coot, and six herons (Ardea cinerea). "In those birds of which the age can be guessed from characteristics of their plumage a direct relation is found between age and number of narrow, c.q. wide zones in the periosteal zone." (op. cit. 1971:63).

Sections from various locations along the mandible, humerus, ulna, femur, tibia and tarso-metatarsus of sandhill cranes, particularly in areas where tendons are inserted, failed to clearly indicate any single area where the periosteal zone was superior for counting annuli.

When the slow staining process with H and E was used and the periosteum viewed under a microscope, as suggested by Van Soest and Van Utrecht (1971), annuli were not visible. Lines were visible in the periosteal zone when the sections were examined with a microscope in polarized light at 100 X.

As noted in Materials and Methods, leg bones from three sandhill cranes of known-age were provided by personnel of the Patuxent Wildlife Research Center (FWS). These birds were 3, 6, and 9 yr old. Sections from known-age sandhill cranes were examined using a microscope with polarized light and the "annuli" counted. Areas were found in the periosteal zone where the number of "annuli" corresponded with the age of the 6-yr-old and 9-yr-old specimens (Figure 24). Other areas in the periosteum showed fewer lines (Figure 25) but this was assumed to be a consequence of uneven deposition in the periosteal zone (Van Soest and Van Utrecht 1971). Most counts indicated that the 3-yr-old specimen was 6 or 7 yr old (Figure 26). It seemed that the ability to accurately age the 3-yr-old could be a consequence of counting false annuli (Klevezal and Kleinenberg 1967).

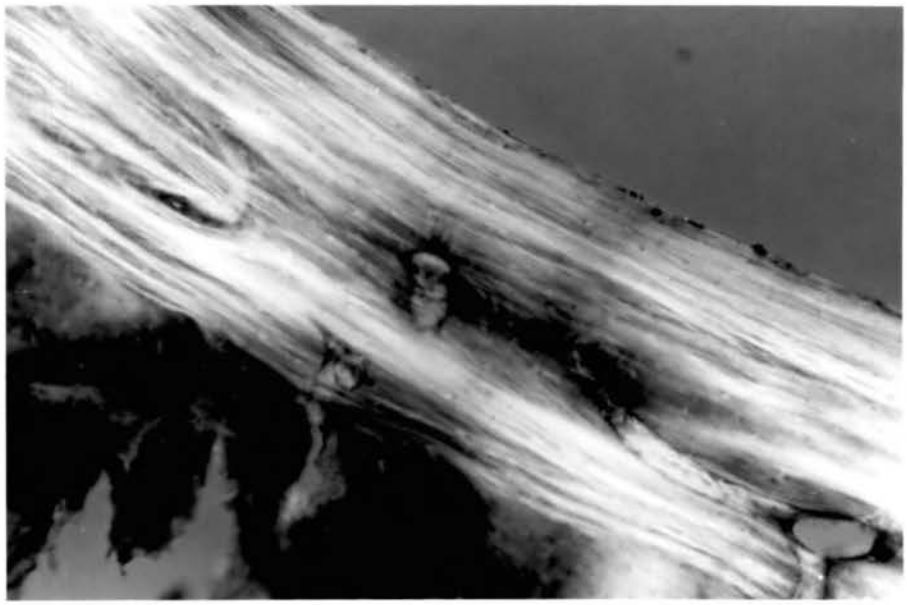

Figure 24. Layering in the Periosteal Zone of a Sandhill Crane 9 Yr Old. 100 X

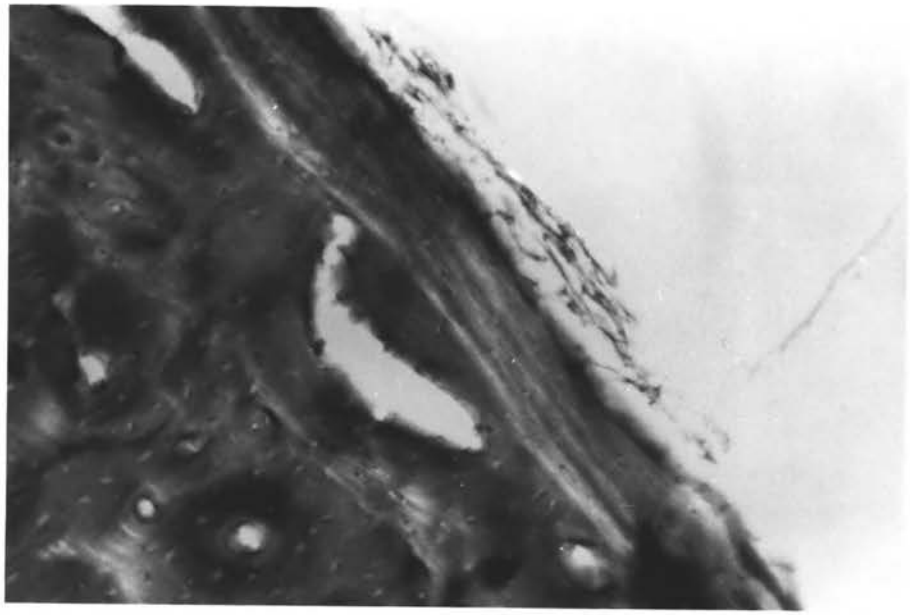

Figure 25. Layering in the Periosteal Zone of a Sandhill Crane 6 Yr Old. 100 X

Figure 26. Layering in the Periosteal Zone of a Sandhill Crane 3 Yr Old. 100 X

Three sections of known age were mailed to Van Soest. He said (letter of 22 August 1974): "I have noted the sections resemble very much the results I got with the Blue Herons I studied. Apparently some species are easier to study than others."

Lines appeared to be more distinct in sections stained with iron H and E. Therefore, sections from the distal end of the tibia of the wild sandhill cranes collected during this study were stained with iron H and E and the annuli examined.

The wild cranes were of unknown ages except for the juvenile and adult categories. Layering was common in juveniles; three to six dark layers are frequently evident in polarized light (Figure 27). Much of the layering found in the periosteal zone of sandhill cranes is deposited during the early growth of the bone and the number of layers is apparently not correlated with an individual's age.

Molt of the Remiges

Sandhill cranes have 10 primary wing feathers (the remiges attached to the manus /Pettingill 1970/) and 18 secondary wing feathers (the remiges attached to the ulna, on the antebrachium and up to the elbow). The secondaries blend into the tertiaries, which are similar in color and shape. Using standard techniques the primaries are numbered outward from the proximal-most feather and the secondaries are numbered inward from the distal-most feather.

The molt of feathers is initiated by hormonal changes (Payne 1972) and apparently the molt proceeds until it is complete or is halted by physiological changes influenced by the external environment. Stressman (1963) studied the molt of primary feathers in many bird groups and

found considerable diversity in the pattern of molt. In some orders the molt of the primaries proceeds proximally (called ascending) instead of the more common situation with the molt moving distally (descending). In several groups the juveniles may molt strictly in descending order, whereas adults of the same species molt two or three feathers simultaneously, at which time unmolted feathers border each follicle of the molted ones. Other groups of birds molt two or three consecutive primaries and replace these before continuing to molt. Other species molt first the even-numbered primaries and then the odd-numbered primaries, or vice versa.

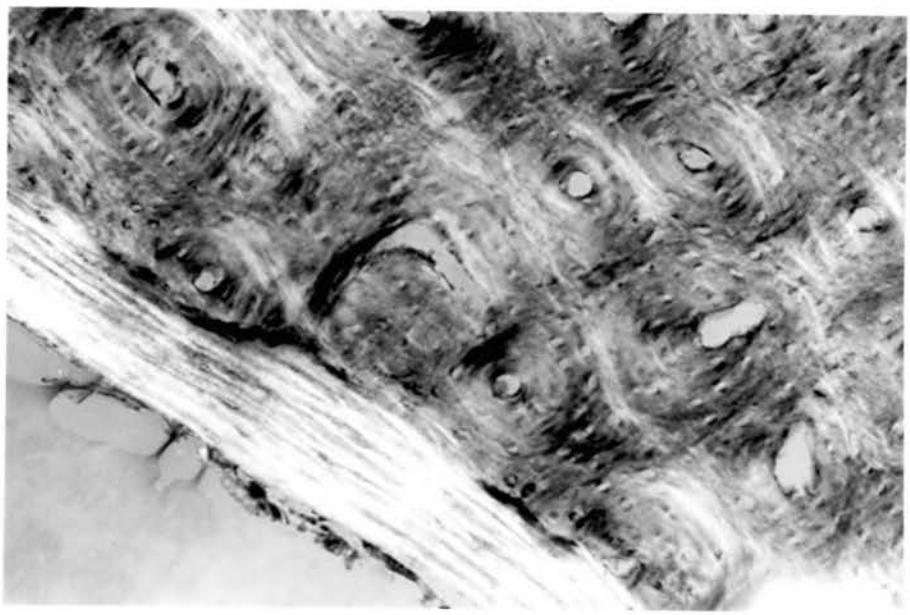

Figure 27. Layering in the Periosteal Zone of a Juvenile Sandhill Crane. 100 X

In birds that molt two or three feathers simultaneously, wherein each is bordered by unmolted feathers, two patterns of molt occur (Stressman 1963). In Pattern A the molt begins with a primary feather (the focus) somewhere between the innermost and the outermost. From this focus point the molt proceeds in both directions. In Pattern B there may be two or three foci from which the molt begins; from each the molt proceeds in the same direction. Species that exemplify Pattern B usually molt in a less regular manner because often only one focus (the proximal one) has a fixed position. The other focus or foci may be located at any of several feathers.

George W. Archibald, Director, International Crane Foundation (letter dated 20 November 1970), indicated that immatures in the second year sequentially molt the flight feathers. He said that a sequential wing molt, consisting of some old and some new remiges, characterizes nonbreeding adult Grus; they seem to molt sequentially in groups of two or three feathers and never completely lose their power of flight. Archibald also said breeders have a complete molt of all primaries and secondaries while incubating.

According to Blaauw (1897 in Walkinshaw 1949:10), most Grus in captivity, and some in the wild, simultaneously molt all primaries and some secondaries and are flightless for several days. Littlefield (1970) observed two flightless greaters in Oregon that had lost all their primaries in late May and early June. In the same time period he observed other cranes that had difficulty flying. Drewien (1973) saw flightless adult greaters during June and July in Idaho. Palmer (1972) says whooping cranes molt their wing feathers annually in captivity but the European crane (Grus grus) molts the wing feathers only every other

year.

The primaries, secondaries, and rectrices of captive sandhill cranes are lost every 2 yr or in some instances, 3 yr (Walkinshaw 1973). Walkinshaw (1949) also said that a captive juvenile greater did not molt its primaries either in the first or in the second summer. Walkinshaw's observation indicates that remiges of several ages would not characterize all adult nonbreeders and that not all immatures molt in their second year, contrary to the observations by Archibald.

It is obvious that sandhill cranes become flightless in some years and in some cases lose all their primaries simultaneously. However, there is conflicting information on both the frequency of the molt and the extent of the molt (Archibald, personal communication, Blaauw 1897 in Walkinshaw 1949, Walkinshaw 1949, 1973). If nonbreeders have remiges of two or more ages and breeders have either remiges or primaries of uniform age, it would provide a means of distinguishing the nonbreeders among harvested cranes.

The remiges of 108 adult sandhill cranes, collected from October to mid April, were examined. The molt of remiges in cranes is not sequential (Table XLIII) and is both ascending and descending. The focus does not appear to be fixed; specimens are present with only primary 1 or 2 or 3 or 4 molted. Thus, the focus can be any of these four primaries. Sometimes only a single primary feather has been molted; there is no indication that two or three feathers are molted simultaneously. Molt patterns on opposite wings often are not similar. No distinct pattern of molt is apparent in either the primaries or secondaries. Sandhill cranes have an interrupted molt cycle that lasts 2 and possibly 3 yr.

TABLE XLIII

MOLT PATTERNS OF REMIGES IN ADULT SANDHILL CRANES WITH PRIMARIES OF TWO OR MORE AGES AND/OR SECONDARIES OF TWO OR MORE AGES

Race and Sex	Primary Number(s) New On Each Wing	Secondary Number(s) New On Each Wing
Lesser Females	1-3, 5; 1-3, 6	1, 3-10; 1-10
	all one age	6-9, 11-18; 2-18
	1-2; 1	5-18; 5-18
	1-6, 8; 1, 2, 5, 7-8	1, 9-11; 2, 8, 9, 11, 13
	1-8; 1-7	all one age
	1, 3; 1, 2, 4	2, 4-18; 3, 5-18
	1-3; 1-5	all one age
	1-3; 1-4	all one age
	1-4; 1, 2, 4	all one age
	1-8; 1-8	1-6; 1-6
	1, 3, 4, 6, 8; 1, 4-8	1-18; 1-12, 14-18
	1; 2	all one age
	1-10; 1-9	all one age
Lesser Males	1-8, 10; 1-6, 8	all one age
	1; 1	3-5, 7-18; 4-18
	1-4; 1-4	1-14, 16-18; 1-14, 16-18
	all one age	12-18; 10-18
	1-4, 6-10; 1-2, 4-10	all one age
	all one age	2, 5-18; 4-6, 9-18
	1-6, 9; 1-6	1-12; 1-18
	1-6; 1-6	all one age
	1-2; 1-3	2-4; 2-4
Canadian Females	1; one age	4-18; 5-18
	4-10; 1-3	all one age
	1-4; 1-4	all one age
	2-5; one age	1, 2, 5, 7-18; 1, 2, 4-18
	3; one age	all one age
	1-4; 1-4	all one age
	1-3, 5; 1, 2, 4	all one age
	1, 4-5, 8-9; one age	2-7, 11, 14, 17; 4-7, 10-11, 13-15, 17-18
	1-9; 1-9	all one age
	1-5; 1-6	9-12; 5, 8, 11, 13
	1-6, 8, 9; 1-5, 8, 10	1, 5, 10, 13; 4, 6, 8, 10, 13
	1-7; 1-5, 7, 9	all one age
	2-5; 2-6	1, 7, 8, 10-18; 1-3, 10-18
	1, 7-9; 1, 8, 9	1-4, 12-18; 8-10, 12-18

TABLE XLIII (Continued)

Race and Sex	Primary Number(s) New On Each Wing	Secondary Number(s) New On Each Wing
Canadian Males	1-3; 1-4	2-18; 1-8, 13-18
	1-2; 1, 2, 5	2-18; 2-18
	1-4; 1, 2, 4	all one age
	1-6; 1-6	1-4, 7, 10, 12, 14, 16; 1-4, 6, 8-10, 14-18
	all one age	5, 8, 9, 12, 14-18; 4-6, 8, 10-11, 15-18
	1-4; 1-4	10-18; 7-18
	1-5; 1-5	3-7, 12, 16-18; 5-9, 17
	4; 4	1-10, 13; 2-18
	1-3; 2, 3	1, 4-15, 17; 1, 2, 4, 5, 7-18
	1-9; 1-9	1-4, 6-8, 10-18; 1-7, 12-18
	1-6, 9-10; 1-6, 9-10	all one age
	all one age	7-18; all one age
	1-9; 1-7	all one age
	1-2; all one age	1, 3, 8, 10, 12, 14-18; 1
Greater Females	1-9; 1-7, 9	all one age
	1-6, 9; 1-6, 9	3-6, 8-18; 1, 5, 8, 9, 10
	3, 6, 7, 10; 2, 3, 7, 9, 10	all one age
	3, 4, 6, 8, 9; one age	one age; 1, 2, 3, 4, 6, 10, 11
	all one age	6; 6
	1-3, 7, 8; 1-3, 7, 8	one age; 2-6, 8-18
Greater Males	2; one age	5-20; 4-18
	one age	2-18; one age
	9, 10; 9, 10	one age
	1-8; 6, 8, 10	6, 11; one age
	1-3, 6, 9, 10; 1-3, 6, 9, 10	one age
	1-4; 1-5, 7, 10	1, 3, 4, 8, 12, 13; one age
	1-6; 1-6	all one age
	1-5, 7; 1-3, 5	9-18; 3, 7, 10-18

John Aldrich (FWS) consented to examine USNM specimens of sandhill cranes to determine if the sequence of molt would be more distinct on birds collected during summer. Only one specimen was available in which the molted feathers were not completely replaced. An adult female greater collected on 22 August at Seney NWR, Michigan, has primaries 5 and 6 coming in. Secondaries 2 and 4 are molted and not regrown yet. Secondaries 1 and 5 are new and fully grown. On the opposite wing primaries 3, 6 and 8 are partially grown and secondaries 1, 2, 4 and 6 are new. New feathers were fully grown on an adult female greater collected 26 August and an adult male greater collected on 11 September, both at Seney NWR. These three museum specimens show the same type of irregular molt pattern evident in specimens from the Central Flyway.

Among specimens from the study area, 64 (59 percent) have remiges of two or more ages (Table XLIV). Sixty-one percent of 46 Canadians, 70 percent of 20 greaters, and 52 percent of 42 lessers have remiges of several ages. Fifty-five percent of the males and 63 percent of the females have remiges of several ages. Forty-seven percent of the adults had apparently molted the primaries in a short enough time span so that the feathers appeared similar in age.

In some specimens the primaries were all of one age but the secondaries included feathers of two age groups (Table XLIV). In other cases all the secondaries appeared to be new but primaries of two age groups were present. The molt had not occurred in perfect numerical sequence. In some cranes collected during fall the remiges appeared new while in other cranes they appeared old and frayed, indicating that they had not been molted in the previous summer. This observation supports

TABLE XLIV

MOLT PATTERNS OF THE REMIGES OF ADULT SANDHILL CRANES
COLLECTED OCTOBER THROUGH APRIL

Race and Sex	Cranes with Remiges of Uneven Age		Cranes with Remiges of Even Age		
	Primaries	Secondaries	Primaries Only	Secondaries Only	Remiges
Lesser					
Male	7	6	2	3	10
Female	12	7	1	6	10
Subtotal	19	13	3	9	20
Canadian					
Male	12	11	2	3	12
Female	14	7	0	7	6
Subtotal	26	18	2	10	18
Greater					
Male	7	5	1	3	3
Female	5	4	1	2	3
Subtotal	12	9	2	5	6
All Races	57	41	7	23	44

Walkinshaw's (1973) statement that sandhill cranes do not molt primaries and secondaries every year.

There was no apparent relationship between the date on which the specimens were collected and the stage of molt. The author found no evidence of molted remiges around roosts or areas used for feeding and none of the specimens collected during this study were molting remiges. Thus, the molt is complete before October and does not resume again until the following summer.

Using Archibald's criterion that nonbreeders molt sequentially means that 53 percent of the adult cranes collected in the study area were nonbreeders. Such a high percentage seems unlikely. Twenty-five percent of the adult greaters at Malheur were nonbreeders (Littlefield and Ryder 1968). Thirty-one to 39 percent of the greaters at Grays Lake, Idaho were nonbreeders (Drewien 1973). Forty-one percent of the greaters in southern Michigan were nonbreeders (Walkinshaw 1973:Table 8).

The status of the molt was compared with information on breeding status that was based on examination of ovaries and testes. Testes were available from 15 adults collected from October through December that had remiges of two ages. Nine of these had two layers in the tunica albuginea indicating they had been potential breeders in the previous summer (see section entitled Testes and Ovaries). Ovaries from four adults showed macroscopic evidence of possible ovulated follicles that indicated they had produced eggs in the previous summer. Two of these females had remiges of two ages indicating that remiges of two ages are characteristic of both breeders and nonbreeders.

George Gee and James Carpenter, of the Patuxent Wildlife Research Center (FWS), examined the remiges of captive sandhill cranes for the investigator. In February 1973, all of the primary feathers had been pulled from one wing of each of five Florida sandhills. These nonbreeders were examined in August 1974 when they were 3 yr olds. The primaries on the wings where the feathers had not been disturbed were all of uniform age and probably had been present since the summer of 1972 (since their postjuvenal molt). On the opposite wing one bird had regrown only primary 1, one bird had regrown only primary 3, one bird had regrown primary 4 and 2 was just coming in, one bird had not replaced its primaries, and one bird had regrown primary 7 and 1 was just coming in. One of these nonbreeders had a new secondary 1 feather; another bird had new secondaries 6, 7, 9, 10 and 11; the other three birds had secondaries of uniform age.

Gee and Carpenter also examined one wing of an adult breeder (Florida sandhill); the primaries appeared to be of uniform age but secondaries 1-9 were new. On another adult Florida sandhill crane they found primaries of three ages: 4 was new, 10 appeared to be 2 yr old, and the other primaries were 1 yr old. Secondary feathers 1, 2, 3, 4, 6, 9 and 10 were new on the latter bird. Gee and Carpenter examined two greaters that were breeders; both had primaries of uniform age that had been present more than 1 yr. In both birds the secondaries were of two ages; a male had secondaries 1, 2, and 3 new and a female had secondaries 6, 8 and 9 new. A Mississippi sandhill adult male had primaries that were all older than 1 yr and only number 8 secondary was new.

The observations of breeding and nonbreeding captive sandhill cranes confirm the nature of the irregular molt pattern of wild sandhill cranes. Nonbreeding sandhills do not molt feathers every year, primaries of uniform age are present in some cranes, and secondaries may be of uniform age or of two ages. The primaries of breeders are of uniform age in some cranes and of two or three ages in others. The secondaries of breeders are of two age groups. There is no pattern of molt of remiges that distinguishes breeders from nonbreeders.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The principal objectives of this study were to determine the subspecies of cranes found within Kansas, Nebraska, Oklahoma and coastal areas of Texas and to describe the ecology of these cranes. This is accomplished by a discriminant analysis of taxonomic measurements of cranes, by field studies conducted within the four states, and by laboratory studies of collected specimens.

The greater, Canadian and lesser races winter in Jackson County, Oklahoma and neighboring Hardeman and Wilbarger Counties, Texas and at the Washita NWR, Oklahoma. The greater and Canadian races use Quivira NWR, Kansas during migration. The greater and lesser races use Salt Plains NWR during migration. The Canadian and lesser races stop in Tillman County, Oklahoma, during fall migration. All three races are present along the Gulf Coast of Texas. Greaters (9.1 percent of the collection) are found from Aransas County eastward and are more prevalent in counties near Houston, Texas. The Canadian race (70.4 percent of the sample) and the lesser races are found all along the Texas coast.

The cranes using the area along the Platte and the North Platte Rivers, Nebraska, for staging are predominantly the Canadian and lesser races. Greaters apparently seldom stop there during spring migration. The Canadian race occurs all along the staging area, except perhaps at

Lewellen, but they are more prevalent at the eastern end near Alda and Grand Island, Nebraska.

The sex ratio of cranes examined during this study is not significantly different from 50:50. Nineteen percent of the collected specimens are juveniles. Field observations (1968-70) indicated that an average of 16 percent of the population were juveniles. Two young per adult pair were seen occasionally, but one young per adult pair was more common.

Long term census data are presented for populations of cranes using Kirwin, Quivira, Salt Plains, Washita, Aransas and Laguna Atascosa NWR during fall, winter and spring. Cranes winter at the Washita NWR, Oklahoma, in milder winters when habitat factors are satisfactory. The Tillman County, Oklahoma, area is used during October and November and the population apparently peaks at 2,500 cranes in some years.

Cranes arrive in Jackson County, Oklahoma, in early October and depart in early March. Wintering populations in the winters of 1968-69, 1969-70 and 1970-71 varied from 350 to 1,800 cranes. Weather and local habitat conditions influence the numbers of cranes that are present.

Observations in coastal areas of Texas indicate a minimum of 15,385 cranes wintering in the counties censused. When these data are combined with those of Guthery (1972) for other counties, a minimum of 23,000 cranes can be identified wintering south and east of San Antonio between Houston and Brownsville.

The typical pattern of cranes' daily behavior is described and interactions with coyotes, crows and other species are discussed.

Cooperators (rangers and biologists of the Oklahoma Department of Wildlife Conservation and members of the Oklahoma Ornithological Society)

reported their sightings of migrating cranes during the autumns of 1969 and 1970. The average number of cranes sighted per observation was highest along the western edge of Oklahoma and in the Oklahoma Panhandle. Very few cranes migrate east of Longitude 98°30' W in Nebraska, east of Longitude 98° W in Oklahoma and Kansas, and east of Longitude 97°30' W in Texas. Migration peaked at the end of October in both 1969 and 1970; in 1970 another major peak occurred in mid November.

Milo, haygrazer and wheat were the main foods utilized by cranes in Oklahoma. In southern Texas, rice, milo, haygrazer and corn composed 67 percent of the diet. Wild foods such as duckpotato, rain lily and nutgrass were also important foods in Texas. In Nebraska, corn was 87 percent of the diet of cranes during spring. Seeds of wheat and haygrazer, and earthworms were other important dietary items. Habitat used by feeding cranes was identified. Crop depredations were rare in Nebraska and coastal areas of Texas. In Oklahoma, crop depredations by cranes were insignificant except in the infrequent years when weather delays the planting of wheat or germination of wheat to the extent that it coincided with the fall migration of cranes.

Cranes generally began arriving at their roost 90 to 185 min before sunset and the entire flock was usually present at the roost by 50 min after sunset. Fifty-six percent of the cranes had arrived by sunset. The main departure of cranes from their roost usually began 5 min before sunrise and continued for 50 min. Dense fogs and storms altered the pattern of roosting behavior. Either morning or evening was suitable for censusing of cranes and in either period as much as 3 hr are required to complete the counts.

Cranes roosted in flooded and dry rice fields that had been harvested, in wet "glades" in southern Texas, in bays along the Gulf Coast, along the edges of reservoirs, in fields where wheat was only a few centimeters high, in shallow portions of rivers, and in inland saline marshes. Observations at 50 roosts indicated that the physical features characterizing preferred roost sites were level terrain, shallow water bordered by a shoreline either lacking vegetation or having only sparse vegetation, and an isolated location that lessened the chance of disturbance by humans. Only six percent of the 31 roost sites used by wintering cranes were on dry land and these were in areas where suitable wetland roost habitat was not available.

Factors that can alter the use of roosts are (1) changes in water levels, (2) infringement of vegetation into the roost borders, and (3) human activity in the vicinity. Management of roost habitat should include (1) maintenance of normal water flows including periodic floods, (2) control of vegetation, and (3) prevention of excessive disturbance by human activities. Most of the roosts and areas utilized for feeding by cranes within the study area have had a long history of use, some since the late 1800's.

The only capture techniques that have potential utility for programs to band cranes in Oklahoma are the rocket-net trap at roosts on the Washita NWR, and bait with the rocket-net trap or drugged bait in Jackson County during winter. The spotlight technique is not suitable for capturing cranes in the study area.

Approximately 11 percent of the cranes had been exposed to ornithosis and 2.5 percent had Mycoplasma sp. in the air sacs. Salmonella spp. and Paracolobactrum arizonae were not isolated from any

of the 125 cranes examined in this study. Twenty-eight cranes were negative in serologic tests for three different influenza type A viruses, paramyxovirus and Newcastle disease virus.

Within the southeastern Central Flyway, crane hunting is significant, in terms of numbers of birds harvested and recreation provided, only in western Texas. Poaching and the shooting of cranes causing crop depredations are insignificant mortality factors. Accidents, severe weather, illegal shooting by hunters who mistake cranes for other species, and predation are other known causes of mortality.

Haemoproteus antigonis was the only protozoan parasite found in blood films from 61 cranes. Tetrameres grusi was present in the gizzards and/or proventriculi of 59 percent of 59 cranes. Cranes that wintered in Oklahoma contained significant residues of the insecticides DDE and heptachlor epoxide in their abdominal fat. Pesticide residues were low in cranes from portions of Florida, Nebraska and southern Texas.

The technique of examining the cloaca to determine the sex of brogla and sarus cranes (Blackman 1971) works with similar accuracy on sandhill cranes. Sexually mature sandhill cranes can be sexed fairly accurately using this technique but adult nonbreeders and young cranes apparently cannot be sexed in this manner. No other external features of morphology, color or plumage were found to be characteristic of a crane's sex.

Seasonal changes (fall to spring) in testes and ovaries are described. Adult males collected in March and April in Nebraska had not yet produced spermatozoa.

Techniques for identifying juveniles in field observations during the fall months are described. Problems associated with their identification are discussed in relation to the progression of the postjuvenal molt and in relation to the plumage of adults that has been stained with ferric oxide.

The technique suggested by Van Soest and Van Utrecht (1971) for determining the age of birds by counting layers in the periosteal zone of bones was tested on sandhill cranes of known age. The technique does not work for aging cranes.

The molt of remiges is discussed. Cranes have an irregular molt pattern that is both ascending and descending and is not sequential. The focus of the molt is not in a fixed position. Molt patterns on opposite wings are often not similar. Cranes have an interrupted molt cycle that lasts as long as 3 yr. There is no pattern of molt of remiges that can be used to distinguish breeders from nonbreeders.

Additional research is needed on sandhill cranes within the study area to permit management of distinct populations in the manner that geese (Grieb 1968) are managed. The most important needs are (1) programs to band cranes to identify the nest and winter areas of cranes which stage along various portions of the Platte and North Platte Rivers and also to provide more data on the mortality rates experienced by cranes, (2) programs to identify the nest grounds of cranes wintering in various areas of Oklahoma and Texas, (3) studies to reveal whether the spring census of cranes along the staging area in Nebraska can be improved, (4) census and determination of the subspecies of cranes wintering in central Texas, and (5) additional information about cranes wintering in southern Texas.

Cranes should be censused annually on their principal winter areas to detect declines in populations or to detect habitat changes unfavorable to cranes. More information is needed about the prevalence of botulism, avian tuberculosis and other diseases among cranes. Pesticide residue levels in cranes should be monitored in winter areas wherever the potential for the cranes' exposure is high. A larger data sample is needed on the progression of the postjuvenal molt during the early fall months; such data will provide a correction factor for use when juveniles are being identified during field observations.

Judging from the available data, the population of sandhill cranes within the southeastern Central Flyway does not appear to be threatened by the existing mortality factors. The principal winter habitat seems secure at the present time. Habitat at the area used for staging in Nebraska has been seriously jeopardized by plans, proposed by the U. S. Bureau of Reclamation, to divert much of the river's flow to reservoirs. The water would be used for irrigation during the summer months. The National Audubon Society and the U. S. Fish and Wildlife Service have opposed these water management changes and they have purchased and leased some land along the Platte River to ensure preservation of habitat.

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