AN AVIAN CHOLERA EPIZOOTIC AMONG SANDHILL CRANES IN COLORADO

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Abstract: An epizootic of avian cholera resulted in the death of about 50 greater (*Grus canadensis tabida*) and lesser (*G. c. canadensis*) sandhill cranes at Monte Vista National Wildlife Refuge, Colorado from 7 February to 15 March, 1984. Sandhill cranes ran short of food on their wintering grounds in New Mexico and migrated north 2 weeks earlier than normal. Upon arrival at Monte Vista NWR they were exposed to severe winter conditions and an avian cholera waterfowl die-off. These stressful conditions are believed to have caused the epizootic, the largest avian cholera die-off recorded in sandhill cranes.

PROCEEDINGS 1985 CRANE WORKSHOP

This paper describes the first recorded significant (>10 deaths) sandhill crane die-off from avian cholera. This epizootic occurred in the Rocky Mountain population of greater sandhill cranes (*Grus canadensis tabida*) (Drewien and Bizeau 1974, Lewis 1977) and some lesser sandhill cranes (*G. c. canadensis*) that were intermingled in the flock. The deaths occurred during the early portion of spring migration in February and March 1984 on Monte Vista National Wildlife Refuge (NWR).

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AVIAN CHOLERA

Krapu and Pearson (1981) have summarized much of the available literature on avian cholera, particularly in wild birds. Avian cholera is an infectious disease caused by the bacteria *Pastuerella multocida*. The disease has been reported primarily in domestic poultry and waterfowl. It has been recorded in all four migratory waterfowl flyways, and on breeding, migratory, and wintering grounds. Rosen (1972) reported the deaths of 10 sandhill cranes from avian cholera, the largest losses recorded to that date, in California during an outbreak in 1970-71.

Avian cholera kills birds rapidly and often the only evidence of an outbreak is dead birds. Occasionally waterfowl at Monte Vista NWR also showed signs of equilibrium imbalance before death. Chronically infected carriers may occur among birds that have survived outbreaks. These birds shed the bacteria from nasal exudate and in feces. The bacteria may then contaminate food and water that other birds ingest. Inhalation is another means of infection.

Various factors have been suggested as contributing to avian cholera outbreaks. These include shortages of food, water, and abrupt changes in diet. Various weather factors such as wind velocity, relative humidity, and cold temperatures, resulting in stressful conditions, have been associated with outbreaks. Stressed birds are thought to be more susceptible to the disease. Total mortality does not appear to be directly correlated with bird density. However, high bird densities may facilitate disease transmission.

STUDY AREA

Monte Vista NWR is located on the west side of the San Luis Valley approximately 10 km south of the city of Monte Vista in southcentral Colorado. This high mountain valley has elevations varying from 2,280 to 2,380 m on the valley floor. Climate is dry and cold with winter temperatures as low as -45° C and summer temperatures as high as 32° C. Despite low annual precipitation (18 cm), the valley has abundant groundwater and stream flow from surrounding mountains. Ponds, creeks, rivers, and associated wet meadows provide crane and waterfowl roosting and loafing habitat. Grain fields, primarily barley, provide feeding habitat.

Crane use in the valley was described by Drewien and Bizeau (1974) and Kauffeld (1981). Greater sandhill cranes use the area in spring and fall as a migratory stopover, spending as much as two months each migration season. Since 1975, foster-parent-reared whooping cranes (*G. americana*) have accompanied sandhill cranes (Drewien and Bizeau 1978). Currently, about 17,000 sandhill cranes and 32 whooping cranes use the valley.

Many cranes concentrate on Monte Vista NWR. The 5,758 ha refuge is primarily managed as a production area for waterfowl, but also provides for migratory use by cranes, waterfowl, and other migratory birds, and wintering use by waterfowl and bald eagles (Haliaeetus leucocephalus). The refuge has numerous artesian and pump wells capable of supplying roosting and loafing areas for cranes and waterfowl at locations throughout the refuge. These wells and associated water areas provide open water for waterfowl and cranes in winter and early spring. The refuge can create new open water areas by turning wells on. Water areas freeze or dry up when wells are turned off. Bird use of water areas can be controlled in this manner during cold months.

Avian cholera was first documented in Monte Vista NWR waterfowl in 1967 (unpubl. refuge data). Since then epizootics have occurred in 1968, 1971-75, 1982, and this outbreak in 1984. Generally, these epizootics have occurred during December, January, and February. The main species involved have been mallard (Anas platyrhyncos), the primary wintering duck species, and Canada goose (Branta canadensis maxima). Sandhill cranes normally mix with these species in February when they arrive during spring migration. Ducks, geese, and cranes all use the same roost areas. One crane was found dead during the cholera outbreak in 1982, however, it was not necropsied and may have succumbed to a cause other than avian cholera.

FIELD OBSERVATIONS

Sandhill cranes left wintering grounds in and around Bosque del Apache NWR, near Socorro, New Mexico earlier than usual in 1984, in late January when the refuge ran short of grain planted for waterfowl and cranes. The food shortages caused sandhill cranes to use other off-refuge areas that were also used by snow geese (Chen hyperborea). The late season snow goose hunt in New Mexico caused harassment of 5-6,000 sandhills that were feeding with snow geese and these cranes migrated north on 4-6 February (Rod Drewien, pers. comm.). About 4,500 sandhills arrived at Monte Vista NWR on the 6th of February. The first foster-parent-reared whooping crane was seen on the refuge on the 7th. By 20 February about 6-7,000 cranes were on the refuge and several thousand more were scattered in other parts of the valley.

The arrival of large numbers of cranes was about 2 weeks earlier than normal. The valley at this time was still experiencing a very severe winter. When cranes arrived about 30 cm of snow blanketed the valley floor. Minimum temperatures during February ranged from a low of -28° C (-19° F) to -12° C (10° F) with only 13 nightime minimums above -23° C (-10° F), and only 5 above -18° C (0° F). The relatively warm temperatures were on nights when snowstorms occurred. Temperatures in February were considerably below normal; 22 of 29 days had minimum temperatures more than 10 degrees below normal. The other 7 days had below normal temperatures.

During February, a fog cloud usually was present over the entire refuge each night from about 1700 hours until 1000 hours. High humidity and cold temperatures caused hoarfrost accumulations of 0.5 - 1 cm nightly on trees, poles, and the snow.

The worst crane losses occurred from 15-19 February during the most unsettled weather of the winter. Snowstorms with windspeeds of 77 km/hr occurred on the 14th and 15th, and again on the 17th with windspeeds of 61 km/hr. Both of these storms were followed by nighttime temperatures of below zero; -23° C (-10° F) on the 16th and -26° C (-14° F) on the 19th. Of the 65 dead cranes found, 26 (40%) died during this period.

Temperatures remained cold until 8 March when the last recorded night below -18° C (-0° F) occurred. Daytime temperatures began to moderate, snow and ice began to melt rapidly, and by 15 March spring breakup was in full progress.

Sandhill cranes appeared stressed from the severe conditions. Cranes that were using private land obtained feed by probing through the snow. They spent all day foraging in the fields, which is not normal for cranes in the valley. Usually, they forage for 2-3 hours in the early morning and again during late evening, and loaf at midday (Kauffeld 1981). Cranes also fed in small temporary feedlots where ranchers had removed snow from meadows so they could feed cattle more efficiently. Minimal feed for cranes was available in these locations. Cranes roosted at night on ice in many areas.

On refuge farm fields a road grader was used to remove snow so that ducks, geese, and cranes could reach the unharvested grain. These species literally followed the road grader as it removed snow from the fields. Refuge grain was exhausted by 15 March, nearly a month earlier than normal, due to extremely heavy bird use.

MORTALITY FROM AVIAN CHOLERA

The first crane mortality from avian cholera occurred on 7 February. Dead sandhill cranes were found until 15 March when the epizootic ended. A total of 65 dead cranes were found (Table 1). Five were found from 7-13 February, 26 during the severe winter period of 15-19 February, and 31 from 20 February - 7 March when the weather moderated. Only three were found from 7-15 March.

Cranes were generally found dead on roost sites, but three were found in farm fields. Two were found alive and died shortly after capture. Six additional carcasses were found during April but these had been scavenged and could not be necropsied.

Twenty two of the 65 dead cranes were laboratory analyzed. One of the first specimens found was sent to the National Wildlife Health Laboratory (NWHL), Madison, Wisconsin to verify the field diagnosis of avian cholera. Ron Windingstad from NWHL subsequently made a field inspection of the epizootic and necropsied 10 cranes. These cranes, and the heart, gizzard, and livers from 11 other cranes, were submitted to NWHL for diagnosis. Table 1 lists causes of death reported for those 22 specimens. About 20 of another 39 cranes found dead were necropsied in the field and examined by refuge personnel for liver necrosis and lesions, and hemorrhaging of the heart, the typical signs of avian cholera. Avian cholera was the major cause of death of both laboratory-diagnosed and field-necropsied cranes and a conservative estimate of the total avian cholera losses is 50 cranes.

DISCUSSION

This paper documents sandhill crane mortality from avian cholera and describes environmental conditions that contributed to the epizootic. Sandhill cranes are generally thought to have a low susceptibility to avian cholera. However, the disease reached epidemic proportions under a series of stressful conditions at Monte Vista NWR.

The first of these stressful conditions occurred when cranes ran short of food in late January on the wintering grounds. Lack of food, in combination with harassment by goose hunters, appeared to cause them to migrate north earlier than usual. When they arrived in the valley, they were exposed to severe winter conditions. These conditions included deep snow which limited access to food, subzero temperatures, and winter storms with high winds which caused additional stress. The conditions on the New Mexico wintering grounds, weather conditions upon arrival in Colorado, followed by exposure to avian cholera while mixing with ducks and geese that were dying from the disease, completed the chain of events that probably led to disease and resulting mortality.

The die-off probably would have been more severe if the refuge staff had not taken management actions to minimize losses. Refuge personnel encouraged the movement of cranes and waterfowl to clean water areas by opening and shutting wells. Usually a pond would freeze solid within 2 days after the well was closed, forcing birds to move to a new roost. This action diminished disease contamination and reduced opportunities for transmission of the disease.

Table 1. Causes of death of 65 sandhill cranes, 7 February to 15 March, 1984 Monte Vista NWR, Colorado.

Causes of death	Number of causes
Powerline strike	4
Lab Necropsy	
Avian cholera	18
Gunshot	1
Emaciation	2
Lead poisoning	1
Other cranes found dead	39
Total	65

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PASTEURELLA MULTOCIDA INFECTION IN A WHOOPING CRANE ASSOCIATED WITH AN AVIAN CHOLERA OUTBREAK

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Abstract: A debilitated whooping crane (*Grus americana*) captured on Bosque del Apache National Wildlife Refuge, New Mexico, in late November, 1984, was found to be suffering from a suppurative otitis caused by *Pasteurella multocida* infection. Signs of respiratory disease (i.e., high pitched squeaking sounds on auscultation of air sacs, and clouded air sacs seen on radiographs) were also present. The infection clinically resolved following antibiotic therapy with daily long-acting oxytetracycline injections for 2 weeks, but the rehabilitation effort failed when the crane fractured a leg and died after 7 weeks in captivity. It was force-fed the entire time. Hematologic and blood chemistry parameters were monitored throughout the rehabilitation. The initial blood count revealed leukocytosis, heterophilia, and lymphopenia (white blood cells 24,680, heterophils 19,744, lymphocytes 987). Early blood chemistry values showed elevated Creatinine Phosphokinase values (1540 [Units/Liter] and Serum Glutamic Oxalacetic Transaminase [940 U/L]). The illness in this crane was associated with a fowl cholera outbreak in which 600-800 other waterbirds died during a three month period at the refuge. The whooping crane appeared sick 9 days after cholera deaths were first noted in snow geese (*Chen caerulescens*). The strain of *P. multocida* isolated from the whooping crane was also isolated from snow geese, thus implying the infection in the whooping crane was a chronic form of avian or fowl cholera. This is the first recognition of *P. multocida* infection causing disease in a whooping crane, and it should prompt careful monitoring of cholera epornitics among avian species in whooping crane use areas.

PROCEEDINGS 1985 CRANE WORKSHOP

Efforts to save the whooping crane from extinction have been successful in increasing the population from 21 in 1944 to about 150 in North America in the winter of 1984-85. A portion of that increase is due to efforts to establish a wild population in the Rocky Mountain region. As part of this introduction, whooping crane eggs are transferred from Wood Buffalo National Park, Canada, to nests of greater sandhill cranes (*G. canadensis tabida*) at Grays Lake National Wildlife Refuge (NWR), Idaho (Drewien and Bizeau 1978, Drewien and Kuyt 1979). Eggs have been transferred annually beginning in 1975, with a resulting population of 32 birds in the winter of 1984-85.

Morbidity and mortality among the Rocky Mountain whooping crane population are closely monitored by field observation. This report describes the first *Pasteurella multocida* infection documented in a whooping crane, one from the Rocky Mountain flock. The case occurred at Bosque del Apache NWR, New Mexico, during a fowl cholera outbreak among other birds at this refuge that is a wintering site for large numbers of sandhill cranes, ducks, geese, and other waterbirds. The case history, clinical signs, diagnosis, and management of the effected whooping crane are presented.

A review of fowl cholera outbreaks at sites along the migration route of the Rocky Mountain whooping crane population is provided to show the potential for exposure to this disease agent. Avian or fowl cholera is an infectious bacterial disease caused by *Pasteurella multocida*, and has long been recognized as an important epornitic disease of North American waterfowl in numerous areas where these birds congregate (Rosen 1971, Krapu and Pearson 1981). Sandhill and whooping cranes are sympatric with affected species of waterfowl throughout their range, and are thus potentially exposed to this bacteria. There is a possible threat to the fragile whooping crane population posed by exposure to this disease agent.

ROCKY MOUNTAIN WHOOPING CRANE MIGRATION ROUTE

The Rocky Mountain whooping crane flock summers in southeastern Idaho and western Wyoming, migrating in September and October southeasterly across the northeast corner of Utah, then passing through western Colorado to the San Luis Valley near Monte Vista (Drewien and Bizeau 1978, 1981, Drewin and Kuyt 1979). The flock stops at the Monte Vista and Alamosa NWR's from early October to mid-November before continuing to their main winter habitat in the middle Rio Grande Valley, New Mexico, at Bosque del Apache NWR near San Antonio. The first cranes arrive at the Bosque del Apache NWR in October or early November and the population peaks in late December or January. In February and early March the cranes return to Monte Vista and Alamosa NWR's and remain until late March to early May when they return to their summering areas (Drewien and Bizeau 1978).

While in the San Luis Valley, whooping cranes associate with 17,000 to 20,000 sandhill cranes of the Rocky Mountain population and some lesser sandhill cranes (G. c. canadensis). There they occupy habitat also utilized by hundreds of Canada geese (Branta canadensis) and thousands of ducks, primarily mallard (Anas platyrhynchos), pintail (A. acuta), and blue-winged teal (A. discors). At winter areas in the Rio Grande Valley, sandhill and whooping cranes are joined by many other waterfowl. Included are some 40,000 snow geese (Chen caerulescens) of the Western Central Flyway flock that breeds in the western Canadian arctic, notably on Banks Island.

AVIAN CHOLERA IN WHOOPING CRANE USE AREA

Kauffeld (1986, this Proceedings) reports on the most recent cholera outbreak at Monte Vista and Alamosa NWR's when about 50 sandhill cranes died in February and March 1984. Previous cholera outbreaks occurred there in 1967, 1968, 1971-1975, and 1982, mainly from December-February (Kauffeld 1986, this Proceedings). The main species involved before the 1984 deaths were mallard and Canada goose.

Avian cholera outbreaks were also previously recorded in the Rio Grande Valley, New Mexico. Twenty-four snow geese and four other waterfowl died at the Bosque Refuge November-January, 1980-81. In 1982, 130 snow geese and 70 Ross' geese (C. rossii) died (Hawkes 1984. Migratory bird disease contingency plan: Bosque del Apache NWR, 25 pp. + Appendices. In files, FWS Regional Office, Albuquerque, New Mexico).

The most recent epornitic at Bosque del Apache NWR began 5 November 1984, when two snow geese were found dead. The disease outbreak lasted until 9 February 1985, during which time the effected whooping crane became ill. Dead geese were found in all marsh units used by whooping cranes and in farm fields; 320 birds were picked up and incinerated. Species and age composition of dead birds were 70.3% adult snow geese, 9.4% juvenile snow geese, 8.4% adult Ross' geese, 0.6 juvenile Ross' geese, 2.5% mallard, 1.9% coot (Fulica americana), and 6.9% sandhill cranes (pers. comm. Mike Hawkes, refuge biologist). Several hundred dead birds were scavenged by avian and mammalian predators and scavengers before they were retrieved. Total die-off was estimated at 600-800 birds. Six specimens were submitted to the U.S. Fish and Wildlife Service's National Wildlife Health Laboratory, Madison, Wisconsin (2 sandhill cranes, 3 snow geese, 1 mallard) and all tested positive for fowl cholera (Hawkes 1985. Final report: Fowl cholera outbreak, winter 84-85. Memo in files, FWS Regional Office, Albuquerque, New Mexico). Management measures to diminish disease losses included pumping clean water through roosting sites to dilute and wash away cholera bacteria, cutting additional corn and milo in various fields to disperse feeding flocks, and removing all carcasses.

P. MULTOCIDA INFECTED WHOOPING CRANE

Case History

The first whooping cranes arrived at Bosque Refuge on 2 November 1984, their population peaked at 16 in mid-January 1985, and all had migrated north by mid-March. At least 20 whooping cranes utilized the refuge sometime during the winter but we are aware of only 1 that became ill.

Whooping crane 83-15, a 1 1/2 year old female, spent the 1984 summer along Hams Fork River in western Wyoming. It migrated to the San Luis Valley Colorado, by 25 September and remained until 8 November. It was seen at the Bosque del Apache Refuge on the evening of 12 November and was noted acting abnormal on 14 November, 9 days after cholera deaths were noted in snow geese. This whooping crane was roosting in Marsh Unit 18, an area where cholera deaths had not yet occurred. On 18 November, 83-15 did not accompany the other cranes in their feeding flight to agricultural fields, and remained at the roost all day. Marsh Unit 18-D was a roost for several thousand sandhill cranes and snow geese, several whooping cranes, and other waterfowl.

On 20 November, 83-15 remained on the roost for the third consecutive day. It was drinking regularly, appeared alert, wings and head did not droop, and fed very little, if any, in the marsh. It could stretch its wings and there was no evidence of body injury. When an observer approached within a few hundred meters the bird walked away. There was no evidence of gaping. Facial swelling was noted on 21 November, the 7th day of illness, and the left eye was swollen shut on 22 November.

By 25 November the swelling had receded and the eye had opened, however the bird's general state of health was deteriorating. There was increasing listlessness, anorexia, and it was reluctant to fly. The bird spent long periods making stereotypic pecking movements without picking up food and frequently preened. No other signs of illness (e.g., wing drooping, labored breathing, diarrhea) were noted. The bird's feathers appeared ruffled and the breast contour showed signs of weight loss. On 28 November the ill whooping crane was captured by night-lighting (Drewien et al. 1967) at its roost site. It was immediately transported to the Rio Grande Zoo in Albuquerque, the closest location equipped for medical diagnosis and care of a wild crane.

Physical Examination

The crane was examined immediately upon arrival at the zoo. It stood quietly in the transport crate, having struggled little during capture and it made no attempt to escape. It was alert, head erect, and aware of its surroundings. The bird moved freely with no evidence of injury or neurological deficit. It weighed 5.7 kg and was moderately thin (expected weight 6.4-6.8 kg). There were greenish watery feces in the crate and green stained feathers around the vent. The musculoskeletal system was normal. Cloacal temperature was 38.3 C, respirations 20/min., and heart rate 120/min. Auscultation revealed high pitched squeaking sounds over the posterior thoracic and abdominal air sacs. The oral cavity, choana, eyes, cere, and contour of the head appeared normal. Examination of the ears revealed whitish purulent plugs filling both canals. Removal of the inspissated plugs showed mucoid exudate extending deep into the middle ear, the tympanum being obliterated bilaterally. The abdomen was normal on palpation.

Radiographs (ventral dorsal/lateral) were taken of the body. A blood sample was collected from the right jugular vein and aliquots were submitted for hematology, serum chemistry, and blood lead determination. Culture and smears of ear exudate and cloaca were made. Feces were examined by flotation, wet mount, and smears.

Laboratory Findings

Results of supportive diagnostic tests are summarized as follows:

1) Radiographs 28 November 1984, VD/Lat body: clouded air sacs, posterior thoracic and abdominal; negative for lead in gut or tissues.

2) Hematology: Sequential hematology values from eight samples collected 28 November 1984 to 2 January 1985 are given in Table l. The initial sample of 28 November revealed leukocytosis with heterophilia and lymphopenia (WBC 24,680; Hets 19,744; Lym 987).

3) Serum chemistry: Sequential values from six samples collected between 28 November 1985 to 15 January 1985 are listed in Table 2. The initial sample of 28 November revealed no clearly diagnostic values. The CPK was higher than expected (1540) indicating probable tissue necrosis. The sample of 7 December showed more evidence of tissue necrosis, possibly hepatic (SGOT 940). SGOT was not obtained on the first sample.

4) Blood lead: <0.1 PPM, 28 November (Atomic Absorption Spectroscopy, New Mexico Diagnostic Services, Albuquerque, NM).

5) Ear Exudate, 28 November: Smears: white blood cells too numerous to count in oil immersion field (OIF); gram negative rod bacteria. Culture (New Mexico Diagnostic Services, Albuquerque, NM). 1. Pasteurella multocida; 2. Staph aureus coag. pos.; 3. Enterococcus.

6) Cloaca, 28 November 1984: Smears: WBC 2-3/OIF; RBC many/OIF. Culture: 1. Echinococcu coli; 2. Klebsiella pneumonicae; 3. Campylobacter.

7) Feces, 28 November: Wet mount and flotation negative for coccidia and other parasite ova.

Table 1. Sequential hematology values for whooping crane 83-15.[a]

Date of Sample	PCV %	WBC[b] No./ul	Heterophil %	Heterophil No./ul	Band %	Band No./ul	Lymphocytes %	Lymphocytes No./ul	Monocytes %	Monocytes No./ul	Eosinophil %	Eosinophil No./ul	Basophil %	Basophil No./ul
28 Nov 1984	45	24,680	80	19,744	6	1,480	4	987	6	1,480	1	246	3	740
7 Dec 1984	44	22,602	53	11,979	0	0	26	5,876	12	2,712	4	904	5	1130
11 Dec 1984	51		53		1		29		10		2		5	
13 Dec 1984	48	16,182	71	11,489	0	0	20	3,236	7	1,132	1	162	1	162
14 Dec 1984	48	18,046	70	12,632	0	0	18	3,248	10	1,804	1	180	1	180
21 Dec 1984	51	23,654	74	17,504	0	0	14	3,311	11	2,602	1	236	0	0
28 Dec 1984	50	25,258	71	17,933	0	0	18	4,546	8	2,020	3	758	0	0
2 Jan 1985	50	21,677	56	12,139	0	0	26	5,636	8	1,734	6	1,300	4	867
Normal values sandhill crane[c]														
Mean	42.5	12,200		7,000		0		4,200		465		70		40
Std. dev.	±3.5	±4,200		±3,300		0		±2,200		±465		±124		±99

[a] Rio Grande Zoo Laboratory, Suzi Flenniken, packed cell volume (PCV), white blood cells (WBC), band (immature heterophil).
[b] Diem, 1984
[c] ISIS, 1983

Diagnosis and Treatment

The problems identified from the initial examination including x-ray, hematology, and cytology were: weakness, mild starvation, enteritis with diarrhea, respiratory rales with clouded air sacs, bilateral otitis externa and media, leukocytosis with left shift, and lymphopenia. The preliminary diagnosis was: 1. bacterial respiratory infection with ascending otitis and possible sepsis; 2. enteritis as concurrent infection or associated with sepsis. The differential diagnosis included Pasteurella and/or Haemophilus infection and special effort was made to identify these microorganisms.

Treatment was initiated with broad spectrum antibiotics: gentamycin (Gentocin, Schering Corp.), @ 5 mg/kg intramuscular twice daily (IM bid) and carbenicillin (Geopen, Pfizer), @ 100 mg/kg IM bid. Otic antibiotic/steroid ointment (Panalog, Squibb) was infused in the ear canals. An elemental diet (Vivonex High Nitrogen, Norwich-Eaton Pharmaceuticals), administered by tube gavage for hydration and to provide easily assimilated nutrients, was given at 60 cc three times daily, intramuscularly. The wings were brailed and the bird was placed in a darkened room for recovery. The next morning the bird was alert and stronger, emitting alarm calls but offering little resistance when handled. It remained calm when not being handled or approached, thus brails were removed.

The presumptive diagnosis of Pasteurella multocida infection came 1 week later when the predominant organism was identified from the ear exudate. The isolate was fastidious on artificial media making it particularly difficult to key. The organism was forwarded to the National Wildlife Health Laboratory, Madison, WI for confirmation and serotyping, thus providing the definitive diagnosis. The isolate was found to be the same strain as that recovered from snow geese dying of cholera at the refuge.

The gentamycin/carbenicillin regimen was discontinued on 1 December because of fear of renal toxicity from gentamycin when pinkish-appearing urates were noted with RBC's. Doxycycline (Vibramycin, Pfizer), 100 mg twice daily was initiated per os by tube. This was discontinued on 4 December because of profuse watery diarrhea with very few bacteria seen on wet mounts, apparently a result of its adverse affect on gut microflora.

Oxytetracycline injection, long acting (Liquamycin LA-200, Pfizer), was initiated on 4 December. A single daily dose of 100 mg subcutaneously, was given for 14 days with apparent effectiveness in controlling infection, judging from diminishing signs of respiratory infection, and hemotological parameters (decrease in immature heterophils and mature heterophils, increase in lymphocytes , Table 1). The ear infection clinically resolved uneventfully, aided by daily administration of the otic ointment for 5 days.

The birds strength, alertness, and activity improved moderately over the first 5 days. It refused all food offerings including whole corn, gamebird diet, dry dog food, frozen smelt, live goldfish, and live and dead mice ranging in age from 4 to 21 days. It was thus force-fed twice daily at the time of medication. The initial diet was 4 oz. gamebird diet (Gamebird Layena, Purina), 1/2 jar strained beef (beef baby food, Heinz), 2 egg yolks, 1/3 tube of high calorie dietary supplement (Nutri-Cal, Evsco), and water. The ingredients were mixed by blender to a mushy consistency that would pass through a catheter-tip 60 cc syringe and an 18 Fr. stomach tube; 170 g were given by the tube gavage twice daily. It was also force-fed four small mice each day.

Rehabilitation

Clinical recovery from the respiratory and otic infection seemed evident by 18 December. There were no respiratory rales and ear canals were free of exudate. Hematological parameters were somewhat equivocal. The total WBC had decreased significantly by 13 December, but later increased (Table 1). Heterophils decreased, then increased, while lymphocytes increased and remained stable. Radiographs were not repeated. All medications were discontinued and only nutritional support was given. The bird was moved to an outside pen and the diet was changed with the goal of increasing body weight. Its weight had dropped to 5.4 kg on 18 December and remained at this point until mid January. Methionine and choline (Methischol), one capsule per feeding, was given to enhance hepatic lipid metabolism. The diet was 113 g of liquid mix, 4-28 g gelatin caps filled with whole corn and grit, four mice or six smelt, or six balls of bird of prey diet (Nebraska Brand, Animal Spectrum) twice daily. Solid items were lubricated (K-Y Jelly, Johnson and Johnson) and placed in the birds mouth, whereupon it would readily swallow. It steadfastly refused self-feeding.

By mid January, the bird began gaining in weight and strength. It ran around the pen flapping its wings, actively evading capture, as well as vocalizing more frequently. It weighed 5.9 kg on 20 January, the weight gain correlating with the increase in vigor. On the morning of 21 January it was found down in the pen, unable to stand. When forced to stand, the right leg dangled freely. There was an obvious fracture near the stifle joint, with swelling, crepitous, and pain at the effected area. Presumably the crane flew or ran into the fence, incurring the injury. A transverse fracture of the right proximal tibiotarsus was found on radiographic examination. Surgery was performed to stabilize the leg but the bird died suddenly after 90 minutes of anesthesia using fluothane and nitrous oxide.

The carcass was forwarded to the National Wildlife Health Laboratory for necropsy (report by Nancy J. Thomas, DVM). Cultures of right and left ear, sinuses, air sacs, bone marrow, spleen, liver, and intestine failed to recover P. multocida, thus confirming the clinical cure of infection. Gross pathologic diagnoses were: skeletal fracture, acute, right tibia; and skeletal fractures, chronic with callus formation, multiple ribs. The histopathologic and bacteriologic diagnoses were: chronic active otitis media (mixed enterococci-type bacteria isolated); mild suppurative enteritis (mixed growth including Salmonella sp. and Enterococci sp.); mild multifocal nonsuppurative hepatitis; gastric parasitism (Tetrameres sp.); focal metatatic calcification, skeletal muscle. These lesions were mild and were not considered to be the cause of death.

DISCUSSION

Avian cholera is endemic among some waterfowl populations that frequent NWR's in the San Luis Valley, Colorado, and the middle Rio Grande Valley, New Mexico. Disease outbreaks have occurred frequently in migratory water birds in Colorado since 1967 and in New Mexico since 1980. This occurrence provides a source of infection for species such as sandhill and whooping cranes. Sandhill cranes have recently died of cholera at both locations.

Our findings show that whooping cranes are susceptible to P. multocida infection. Crane 83-15 had a chronic otitis and respiratory infection as compared to the peracute septicemic form which typifies avian cholera. Ear infections have previously been suspected in ducks (Rosen 1971), and a chronic form of infection occurs in chickens with fowl cholera (Whitman and Bickford 1983). Although fulminant septicemic infection is the usual pathogenesis of avian cholera, it is likely that other host-parasite relationships can occur, as with other infectious diseases. We interpret this case as a variant chronic form of avian pasteurellosis or avian cholera.

Infection with P. multocida in this whooping crane was clinically resolved by antibiotic therapy. A single daily dose of long-acting oxytetracycline, 100 mg. subcutaneously for 14 days, was apparently effective in eradicating infection, including the carrier state. This antibiotic has been shown to protect turkey poults experimentally infected with P. multocida (Association of Avian Veterinarians, December 1982, Newsletter 3 (4):78.) Adverse effects of other antibiotics used, gentamycin and doxycycline, were suspected.

Data from hematologic studies provided initial supportive evidence for acute infection, (i.e., leukocytosis, heterophilia, and lymphopenia). The initial lymphopenia rapidly reversed and the heterophil count decreased, then increased, and remained high (see comparative values in Table 1). The persistent leukocytosis may be a reaction to stressful confinement in captivity (Hoffman and Leighton 1985). The early decrease in band heterophils did seem to correlate well with control of infection.

During the early phase, the serum chemistry parameters were indicative of tissue necrosis, probable hepatic (i.e., elevated CPK and SGOT), and possibly indicative of prerenal azotemia (elevated blood urea nitrogen [BUN] and BUN:Creatinine ratio on 28 November, see comparative values, Table 2). Later changes in these values had little correlation with the birds clinical condition. All of the values returned to the normal range by 2 January when the bird was near

Table 2. Sequential blood chemistry values for whooping crane 83-15.[a]

Test	Units	Normal values[b] Mean	Normal values[b] Range	Date of sample 28 Nov 1984	7 Dec 1984	11 Dec 1984	14 Dec 1984	2 Jan 1985	15 Jan 1985
Glucose	mg/dl	232	210- 267	272	160	180	236	232	212
BUN	mg/dl	3	2- 7	48	12	3	12	8	12
Creatinine	mg/dl	0.6	0.4- 0.8	1.2	1.2	0.5	1.2	1.2	0.8
BUN: Creat.	-	6	3.3-11.7	40	10	6	10	6.6	15
Uric Acid[c]	mg/dl	8.1	6.5-10.2	1.8	1.6	1.8	2.4	4.2	4.0
Triglycerides	mg/dl	157	89- 252	-	48	61	640	52	32
Cholesterol	mg/dl	148	96- 200	272	204	280	180	336	268
Total bilirubin	mg/dl	0.16	0.11-0.26	0.8	0.4	0.6	0.4	0.8	0.8
Direct bilirubin	mg/dl	0.02	0.01-0.07	0.6	0.2	0.5	0.2	0.4	-
Total protein	gm/dl	3.8	3.1- 4.4	5.2	2.8	3.7	3.6	4.0	4.0
Albumin (A)	gm/dl	1.5	1.2- 1.7	1.6	0.8	1.4	1.4	1.2	1.2
Globulin (G)	gm/dl	2.3	1.8- 2.8	3.6	2.0	2.3	2.2	2.8	2.8
A : G		0.65	0.57-0.76	0.44	0.4	0.6	0.64	0.42	0.42
Alk Phos	U/L	46	28- 72	40	64	35	40	60	40
ASAT (SGOT)	U/L	261	133- 612	QNS	940	580	692	472	428
ALAT (SGPT)	U/L	53	41- 71	QNS	76	41	32	40	40
LDH	U/L	440	178- 975	664	740	625	424	692	-
CPK	U/L	-	-	1540	264	209	164	232	600
Na	mEq/L	147	140- 152	QNS	148	155	-	132	148
K	mEq/L	3.4	2.6- 4.2	5.2	2.0	1.7	-	1.2	2.0
Ca	mg/dl	9.1	8.3- 9.7	9.6	8.4	10.9	-	8.4	8.4
Inorg. phos.	mg/dl	2.8	2.0- 4.1	0.4	2.7	3.3	4.8	3.2	2.0
Lipase	u	-	-	-	1.0	1.8	-	1.3	1.4
Amylase	u/dl	507	412- 602	-	176	419	-	312	348

[a] BMD 8600 Chemistry Analyzer, Southwest Veterinary Diagnostics, Inc., Phoenlz, Arizona.
[b] Gee et al. 1981.
[c] IL Multistat Chemical Analyzer, Southwest Veterinary Diagnostics, Inc., Phoenix, Arizona.

its weakest point. Total and direct bilirubin values were consistantly elevated from published norms. Serum protein dropped markedly on 7 December then returned to normal. This might correlate with hepatic injury. The most useful criteria for prognosis seemed to be from clinical appearances (i.e., strength, alertness, activity, and weight gain).

Long-term (7 weeks) nutritional management by forced feeding was apparently successful because the crane eventually gained in weight and vigor before fracturing its leg. The most frustrating problem was that the crane steadfastly refused to eat. It continued to make stereotypic pecking movements but without picking up food. We interpreted this as a displacement reaction from anxiety. We believe the persistent anorexia was due to liver damage. A mild multifocal nonsuppurative hepatitis was found at necropsy.

Cognizance of the susceptability of whooping cranes to P. multocida infection should prompt careful monitoring of cholera epornitics among avian species in whooping crane use area. Areas for future investigation are apparent. The potential usefulness of vaccines for protecting rare wild bird populations should be further explored. New methods of disease control might be further investigated and implemented.

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GREATER SANDHILL CRANES AND COMMON RAVENS ON MALHEUR NATIONAL WILDLIFE REFUGE, OREGON: THEIR HISTORY AND RELATIONSHIP

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Abstract: Of the five populations of greater sandhill cranes (Grus canadensis tabida) presently recognized, the Central Valley Population is the only one known to be declining in portions of its range. Low annual recruitment rates have been noted in the population since 1975 when surveys were initiated. Predation rates have been high for both crane eggs and young on Malheur National Wildlife Refuge in southeast Oregon. Sandhill cranes probably declined after European settlement, but increased after the mid-1930's as predator control programs intensified and more nesting habitat became available. Common ravens (Corvus corax) probably increased after European settlement as their food sources during critical periods increased because of human activities. Populations were reduced during predator control programs but since 1972 the species has increased. Sandhill cranes share incubational duties and it is during the short period when eggs are left unattended that raven predation occurs. A raven will rarely attempt to drive an incubating crane from the nest. Raven predation on crane nests increases during drought years. Improved crane nesting habitat on the refuge has reduced predation in recent years. The highest raven predation occurred in crane nests in common cattail (Typha latifolia) and the lowest occurred in nests within grasses and forbs.

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The five greater sandhill crane populations presently recognized can be classified into three status categories: (1) The Eastern, Rocky Mountain, and the Lower Colorado River Valley Populations are stable or increasing; (2) The Interlake Population's status is undetermined; and (3) The Central Valley Population is declining in portions of its nesting range. Here we report on one of several factors involved in the decline of the Central Valley Population.

Low annual recruitment rates have been noted in the Central Valley Population since censuses were initiated (8% of 589 cranes in 1975, 5.7% of 2020 in 1976, 8.8% of 2067 in 1977, 7.6% of 1048 in 1978, 6.2% of 1939 in 1979, 5.0% of 946 in 1980, 4.4% of 1226 in 1981, 9.4% of 1282 in 1982, 8.1% of 309 in 1983, 3.5% of 1556 in 1984, giving an average of 6.7% for the decade). Predation rates have been high in some years, particularly since 1972 after Presidental Executive Order 11643 prohibited the use of chemical toxicants on federal lands. On Malheur National Wildlife Refuge (NWR), Harney Co., Oregon, coyotes (Canis latrans), raccoons (Procyon lotor), and common ravens have preyed heavily on greater sandhill crane eggs, and coyotes have been serious predators on unfledged young. For destroyed nests where the predator could be determined, the common raven has been identified as the major crane egg predator on the refuge. Although coyotes and raccoons (particularly coyotes) are serious predators, this report concerns the relationships between the common raven and greater sandhill crane, and provides a historical account for the two species in southeast Oregon.

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STUDY AREA

Malheur NWR, Oregon, encompasses over 72,000 ha, making it one of the largest federal refuges in the contiguous United States. It is located in the semi-arid Basin and Range province. Freshwater marshes, two large lakes, and shrub uplands occur within the refuge boundary. The refuge units are Malheur, Harney, and Mud lakes, the Double-O, and Blitzen Valley. Underlying these units are deep pluvial lake sediments and older alluvium of Pleistocene age. Most deposits consist of debris eroded from surrounding outcrops and mountains but peaty soils are present in many areas (Walker and Swanson 1968). Harney Lake, the lowest point in the closed Malheur-Harney Lakes Basin, normally consists of highly saline water, soils, and scant vegetation near the shoreline. Harney Lake is usually about 1 m in depth but depths of 7 m were recorded in 1984.

The Double-O unit, west of Harney Lake, receives water from Silver Creek and a series of freshwater springs. Numerous meadows and marshes provide feeding and nesting habitat for about 25 crane pairs. Soils are rather alkaline and uplands primarily support greasewood (Sarcobatus vermiculatus) shrubs. Extensive stands of hardstem bulrush (Scirpus acutus) occur in the deeper ponds and channels. Baltic rush (Juncus balticus), sedges (Carex spp.), and several grass species predominate in the meadows.

The Blitzen Valley is the most important crane nesting area on Malheur NWR. The valley is flat and narrow, with numerous ponds, sloughs, and meadows. Depressions, channels, and ponds often have dense stands of hardstem bulrush, giant burreed (Sparganium eurycarpum), and common cattail. Big sagebrush (Artemesia tridentata), rabbitbrush (Chrysothammus spp.), and greasewood covered uplands are interspersed among the meadows in some portions of the valley. A total of 162 crane pairs occupied territories in the valley in 1982. About 27 additional crane pairs nested along the southern shore of Malheur Lake and near Harney Lake. For a description of Malheur Lake see Duebbert (1969).

Surrounding this wetland complex are basaltic rimrocks and highlands. Highlands are shrub covered, usually with sagebrush. Western juniper (Juniperus occidentalis) grows in dense stands in some regions, particularly on Steens Mountain (southeast of the refuge) and the Jackass Mountains (west of the Blitzen Valley). Like Steens Mountain, the Jackass Mountains are a tilted basalt fault-block.

Much of Malheur NWR contains excellent sandhill crane nesting habitat. Excellent common raven nesting habitat is also present among the many kilometers of rimrock, especially adjacent to most of the Blitzen Valley and Double-O units.

METHODS

In most years since 1966, an average of 60 sandhill crane nests have been examined and their fates determined. Most nests have been found in the Blitzen Valley because most pairs occur there. Sample sizes varied from 30 nests examined in 1980 to 88 nests in 1969.

Whenever a nest was located, the stage of egg development was determined by the floatation method (Westerskov 1950) as modified for sandhill crane eggs (Littlefield unpubl. data). Nests were examined and fates recorded after the expected hatching date. Nests which had been depredated by ravens were characterized by either the punctured egg(s) in the nest bowl, or more commonly a few shell fragments among the nesting material. Sandhill cranes normally cover shell fragments after the chicks hatch. Therefore, to identify successful nests it was necessary to remove the upper portion of the nest before its fate could be verified.

Measurements were taken at the nest site. Vegetation surrounding the nest has been recorded in most years since 1966. Beginning in 1976, land use regime data were collected and nesting success compared between idle, grazed, and hayed lands. Common raven control, with the chemical DRC-1339 (3-chloro-p-toluidine hydrochloride) was applied in 1982 and 1983 at two refuge locations. The chemical was either sprinkled on meat cubes or injected into chicken eggs, and experimental control efforts were conducted in the southern Blitzen Valley and Double-O units. Results of the study will be presented at a later date.

Historical information was obtained from Malheur NWR files and early documentation from ornithologists who worked in the region from 1874 through 1932. From 1940 through 1983, information was primarily from Malheur NWR Narrative Reports. Beginning in 1975, 382 km of raptor and corvid counts were initiated on and surrounding the refuge. Transects were driven at 33 kmph with stops for 3 minutes every 1.6 km.

RESULTS

History of Greater Sandhill Cranes on Malheur NWR, Oregon

Greater sandhill cranes commonly nest in southeast Oregon where favorable wetland habitat is available. In this northern Great Basin region, most nesting areas are located in wetlands which were once inundated by large Pleistocene lakes. The largest nesting segment of the CVP presently occupies one of these Pleistocene remnants-Lake Malheur. Lake Malheur was the third largest of the Great Basin lakes, covering 1470 km^2 with depths to 21 m (Houghton 1976). Today, Malheur Lake (avg. 18,200 surface ha) and Harney Lake (12,500 surface ha when full) are all that remain of this once large pluvial water body. Pluvial Lake Malheur still existed about 13,000 years ago but was beginning to recede (Bedwell 1973). It was probably about that time when crane nesting habitat became available over much of Malheur NWR.

Information is not available on the number of crane pairs nesting on what was to become Malheur NWR during European settlement. The first account of the species was by Brewer (1875:164), who reported..."G. canadensis is very common and breeds here abundantly." Bendire (1877) later described its status in the Malheur-Harney Lakes Basin as a common summer resident, breeding abundantly on the lowlands and in the highest mountain valleys. However, crane pairs probably began declining in the late 1800's coincident with settlement and subsequent habitat destruction.

Early in the 20th Century, most reports referred to cranes from an area adjoining Malheur Lake, which had been established as a bird sanctuary in 1908. However, little information was available about cranes on the private land which would later become a portion of Malheur NWR. In 1912, an estimated 25 crane pairs were nesting in the vicinity of the lake, and several pairs were seen near Harney Lake on 17 April 1915. A nest containing two eggs was located on the edge of Mud Lake on 20 April 1915 and about 50 pairs were nesting predominantly on private land, probably the Blitzen Valley (refuge file records). Willett (1919) reported the subspecies as nesting generally in swampy locations throughout the region in 1919 but apparently nowhere in great numbers. Twenty-five pairs raised their young along the south shore of Malheur Lake. However, older settlers reported to Willett that the bird was declining in numbers. Between 25 May and 15 June 1921, Prill (1922) found six pairs near the west end of Malheur Lake but these were the only cranes seen. Prill further reported a few other pairs probably nested elsewhere around the late in 1921. Cranes were also scarce in 1922. Two were heard calling on 12 June and a nest containing two eggs was found in a hay meadow along the southwest margin of the lake (refuge files).

Fifteen to 20 sandhill cranes were seen in the Blitzen Valley (in Diamond Swamp) in 1932. Additional pairs were heard calling near the southern extremity of Blitzen Valley (Jewett 1936). Jewett's observation was the first for the southern portion of the valley other than a report of a crane killed by a local rancher in the late 1800's.

After their decline in the late 1800's and early 1900's, greater sandhill cranes apparently increased after the mid-1930's. Crane nesting success and brood survival increased as efficient predator control methods were developed for the livestock industry (Littlefield 1976). Poisoning, trapping, and shooting reduced predator populations either directly or secondarily. Information from Malheur NWR Annual Reports (Bureau of Biological Survey 1938-1940) and Narrative Reports (U. S. Fish and Wildlife Service 1941-1964) indicate the intensity of the control program.

1938 - The following predators were killed on the refuge: coyote and bobcat (Felis rufus) 216, common raven 77, American crow (Corvus brachyrhynchos) 14, and black-billed magpie (Pica pica) 117.

1939 - A total of 336 coyotes was killed.

1941 - At least 160 coyotes were killed. Thallium bait was used and it seems to have measurably decreased the raven population.

1946 - The usual control program on ravens was entered into with good results. Outside the refuge boundary a local sportsmen's organization sponsored a raven, crow, and magpie hunt which removed almost 300 ravens.

1947 - An avian predator hunt accounted for 292 ravens, 1026 magpies, and 225 crows. Refuge personnel removed an additional 150 ravens, 300 magpies, and 50 crows. A neighboring valley which usually supported 30 to 40 raven pairs had only 1 pair in the spring.

1953 - By summer, the coyote population had been reduced to the lowest number in refuge history. Canada goose (Branta canadensis) nesting success was 87%.

1960 - An unknown number of coyotes was killed at poison-bait stations.

1964 - A total of 184 coyotes and 32 raccoons was taken. Winter numbers of ravens appeared to be fewer.

C. Sooter (unpubl. data) reported sandhill crane nesting success was 89% for 11 nests he examined in 1940. High nesting success evidently continued for the succeeding three decades as intensive predator control occurred on the refuge and adjacent areas.

Along with predator control, several large deep marshes unsuitable for crane nesting were drained and developed for increased livestock forage. Griffiths (1903) described the Blitzen Valley at the turn of the century. In 1902, both the upper and lower courses of the Blitzen River had a well-defined channel but in the mid-section there was a large swamp. Here, water spread out and covered an area 13 to 16 km wide and 19 to 24 km long. This entire region was a huge bulrush marsh with meadows along the edges, which would provide limited habitat for sandhill cranes. In the early 1900's, the Blitzen River was channeled and lateral ditches constructed, providing several thousand hectares of new crane habitat. In 1982, this former monotypic marsh provided habitat for 57 crane pairs. In the 1930's, the Civilian Conservation Corps developed lateral ditches, dams, and other water structures to increase meadow and pond habitat. This meadow development also provided new habitat for nesting pairs (Littlefield and Thompson 1979).

Similar to Malheur NWR, the 11,000 ha Sycan Marsh, Lake Co., Oregon supported only three to four crane pairs in 1940 (C. Sooter unpubl. data). Drainage of the marsh in the 1940's eliminated extensive stands of emergents. In 1984, 128 sandhill crane pairs had nesting territories on the meadow habitat which had been created (M. Stern, pers. comm.).

Greater sandhill crane pairs on Malheur NWR apparently reached their peak abundance in the late 1960's. The long-practiced compound 1080 bait station program was terminated in February 1972. Extensive predator management has not recently occurred, consequently, crane production has decreased. Breeding pairs numbered 236 in 1971 but had decreased to 219 in 1977 and 214 in 1982.

Common Raven: A Historical Review

Common raven have inhabited the northern Great Basin for many centuries. In southeast Oregon fossil remains have been collected from Pleistocene deposits at Fossil Lake, Lake County (Littlefield, C. D. 1980. The ecological history of the Malheur-Harney Lakes Basin, Oregon. U. S. Fish and Wildl. Serv., unpubl. ms. 67 pp.), however, it is unlikely their numbers exceeded those presently found in the northern Great Basin. Although the species has recently declined in portions of its North American range, this is certainly not occurring in southeast Oregon. Ravens are abundant on Malheur NWR. In winter they concentrate on communal roosts within and surrounding the refuge. In the morning they disperse to feed on harvested grainfields, refuse dumps, and rangelands. On rangelands, feeding occurs primarily on livestock carcasses and road-killed animals such as mule deer (Dama hemionus) and black-tailed jackrabbits (Lepus californicus). A total of 836 ravens was counted at a single roost site on Malheur NWR on 4 January 1977 (Stiehl 1978). In the winter of 1983-84, over 1100 ravens were counted at roost sites within the Malheur-Harney Lakes Basin. Ravens disperse to breeding areas in February. Basaltic rimrocks are the preferred nesting sites but willows (Salix spp.), western juniper, windmills, and deserted buildings are also used. Stiehl (19780 found 74% of the raven nests he examined on rimrocks, 23% around human structures, and 3% in trees. Nesting occurs from late March through early June. Important components of their diet during the nesting season include small mammals, carrion, insects, fish, and eggs (Stiehl 1978). Heavy egg predation is more likely to occur when a raven nest is located near wetland habitat. Several flocks of 20 to 30 subadult ravens also regularly feed on portions of the refuge, preying particularly on eggs of wetland nesting species, including sandhill cranes. One flock of over 300 ravens was observed on the western portion of Malheur NWR on 16 July 1979.

Common ravens probably increased with the advent of livestock into the region. Early references noted the close association between ravens and domestic animals. Bendire (1877:123) stated..."I have seen as many as thirty [ravens] at one time, searching the manure piles, or near the slaughter house for food." Jewett (1936) saw 12 on a sheep carcass on 17 May 1934 on Steens Mountain. With this new and abundant food source, ravens have undoubtedly increased in southeast Oregon since the 1860's. There appears to be a relationship between raven abundance and livestock, consequently, it seems warranted to briefly discuss the history of livestock grazing on or near Malheur NWR.

Cattlemen moved into the region in 1868, but no intensive grazing occurred on what was to become Malheur NWR until 1872. By 1878, one rancher controlled much of the Blitzen Valley and over $100,000 worth of cattle were sold annually (Jackman and Scharff 1967). The livestock industry suffered a depression when the mining industry declined in the late 1870's. Some recovery occurred in the 1880's as the human population east of the Cascade Range increased from 39,100 to 73,162. However, severe winter weather in 1889-90 caused thousands of cattle to die and another economic depression began in the early 1890's (Shinn 1978). By 1900, the livestock industry was well established in southeast Oregon and continued to expand through the 1970's. Cattle continued to graze in Blitzen Valley even after it was purchased by the federal government in 1935 (Double-O was purchased in 1941). After these two areas were purchased, there was a short period of light grazing, but use intensity began increasing in the mid-1940's (Table 1). In 1941, Animal Unit Months (AUM - 1 cow for 1 month) totalled 21,602 and increased to 101,726 in 1951. A slower but steady increase continued through 1961 (122,404 AUM's) and 1971 (123,807 AUM's), reaching a grazing peak in 1973 of 126,597 AUM's. During the winter of 1973-74, grazing was reduced to 97,200 AUM's and by 1983 had declined to 21,119.

Domestic ungulates presumably replaced the bison (Bison bison) in the northern Great Basin, but Shinn (1978) provided evidence to attest to the scarcity of bison in the intermountain west. He reported: (1) Many native tribes west of the continental divide journeyed across the Rocky Mountains to obtain bison meat and hides; (2) In 1820, the native peoples of the Lewis River Valley, Idaho reported large herds of bison were present but noted such was unusual; (3) A Nez Perce folktale proclaimed that the coyote, cultural hero of the tribe, attempted to bring bison across the eastern mountains but succeeded only in bringing them as far as the Bitterroot Range in Montana; and (4) Apparently large grazers did not influence evolution of native vegetation in the northern Great Basin.

If bison had been abundant in southeast Oregon, common ravens would have been more evident than early records indicate. Limited food because of the scarcity of wild ungulates, apparently resulted in ravens being scarce in the northern Great Basin during pristine times. Brewer (1875) first recorded the common raven in the Malheur-Harney Lakes Basin, in the vicinity of Camp Harney (16 km N of Malheur NWR), throughout the winter. Bendire (1877) found ravens common and somewhat gregarious in winter. Generally, in the 1870's, ravens were seen in pairs, rarely alone, with Bendire noting no large flocks in the basin. However, Bendire (1895:397) later reported..."I have met with them [ravens] at every Post at which I have been

Table 1. Animal Unit Months (AUM's) on Malheur NWR, Oregon.

Year	AUM's	Year	AUM's
1941	21,602	1963	116,569
1942	38,974	1964	106,927
1943	38,663	1965	111,653
1944	49,496	1966	114,667
1945	50,736	1967	119,335
1946	64,077	1968	125,365
1947	68,485	1969	108,180
1948	74,385	1970	124,429
1949	95,145	1971	123,807
1950	95,617	1972	111,350
1951	101,726	1973	126,593
1952	84,677	1974	97,200
1953	96,256	1975	98,502
1954	112,456	1976	88,221
1955	116,660	1977	58,214
1956	97,199	1978	48,222
1957	97,818	1979	47,401
1958	94,574	1980	42,506
1959	96,760	1981	31,101
1960	95,510	1982	28,216
1961	122,404	1983	27,119
1962	112,914		

stationed in the West, but nowhere so abundantly as Camp Harney, Oregon where I had excellent opportunities to observe them." By 1912, ravens were very common and according to Dr. L. E. Hubbard (refuge files), egg shells of other birds were in such numbers that around raven nesting sites a person could get a shovelful at one scoop. The species was reported even more common in 1915. Willett (1919) reported ravens as common in hill and mountain locations, nesting abundantly on bluffs and hills around Malheur Lake, and making regular trips to the marshes to obtain eggs, upon which they subsisted largely in the summer. Ravens continued to be reported as common in 1921 and were still noted for their destruction of eggs (Prill 1922).

In 1922, the species was reported to have multiplied and increased "wonderfully" within the past few years. It was considered 25 times more abundant than formerly. According to refuge files (Bureau of Biological Survey 1922:7-8):

> "They nest on deserted windmills in the valley and among rimrocks in the surrounding hills and wage a continuous war against the nesting waterfowl thruout [sic] Harney Valley. The eggs of ducks and all other waterfowl destroyed by these birds amounts to an enormous number. Everywhere one goes, he finds the remains of eggs destroyed by these birds...A few rods from an egret colony beneath an old gatepost, one could have gathered nearly a bushel of egg shells carried by ravens."

The raven population continued to thrive through the 1920's and 1930's and control efforts on Malheur NWR were initiated in the late 1930's. According to refuge files (Bureau of Biological Survey 1937:11):

> "As a result of a poisoning program which was carried out, approximately 120 ravens were picked up dead and all indications are that this was a very small percentage of the total ill-fated birds. Approximately 35 of these birds were shot by personnel and nest robbing resulted in the killing or capture of about 50 ravens."

The experimental poisoning campaign continued through 1938 and the raven population was noticeably reduced. Only limited shooting and nest destruction was conducted in 1939, and by 1940 it became evident that ravens had increased in such numbers during the past year that extensive control measures were going to have to be initiated to prevent enormous losses to nesting waterbirds (refuge file records). The use of thallium treated baits was initiated in 1941 and raven populations again declined but not for long. Another increase in their numbers was reported in 1943 because no poisoning was done in 1942 and 1943. Few were shot because of a lack of ammunition, gasoline shortages, and reduced personnel during World War II.

In the mid-1940's, coyote control was initiated on Malheur NWR by use of compound 1080 poison bait stations. Efforts through the preceding years to control ravens had been successful but of short duration. Raven numbers began to decline with the start of coyote control by use of "1080." The 1944 Christmas Bird Count showed 6 ravens compared to 45 in 1943. Along with chemical control, the Harney County Chapter of the Izaak Walton League initiated a predacious bird shoot adjacent to the refuge in 1946. A total of 592 ravens was killed in 1946 and 1947 as a result of these hunts. In 1947, neighboring Catlow Valley, Harney County, supported only 1 nesting raven pair where formerly 30 to 40 pairs nested. The 1949 Malheur NWR Narrative Report (U. S. Fish and Wildlife Service 1949:8) included the following excerpt:

> "Each year since the inception of "1080" coyote poisoning, these two species [raven and magpie] have built up their numbers during the summer when little poisoning was done, and in late summer and fall, flock to the refuge. By the following spring, winter poisoning of coyotes has decimated the ravens to where few are seen at nesting time on the refuge."

Common raven nesting sites were largely unoccupied on the refuge in 1950, and the only active nest was found near the Double-O Unit. Most ravens seen on the refuge in late summer had drifted in from distant nesting locations. Two active nests were recorded in 1952 and raven numbers were low through the remainder of the 1950's. During the 1960's, generally there were few on the refuge. By 1970, their numbers began to show a slight increase but were still low in comparison to peak numbers of the 1920's and 1930's.

Changes in their status were noted in the early 1970's. The long standing 1080 bait station program was terminated in 1972. By 1973, ravens were classified as abundant. Predation by ravens was considered a major factor limiting bird production on Malheur NWR in 1975 and in

1977 there were 35 known raven nests on or adjacent to the refuge. Beginning in 1975, a quarterly raptor census involving 382 km of transects was initiated in the Malheur-Harney Lakes Basin. Ravens were counted on these transects beginning in fall 1976. Quarterly counts were made in 1977, 1979, 1980, 1982, 1983, and 1984 (Table 2). Surveys have shown fluctuations in raven numbers. The highest population (756) was recorded in the fall of 1982.

Raven Behavior Related to Predation on Crane Eggs

Members of a crane pair share incubation duties. Eggs are normally unattended for only short intervals, however, raven predation occurs during these periods. On Malheur NWR, cranes rarely leave their nests during inclement weather. During moderate weather, however, both pair members occasionally feed together, leaving their eggs exposed. Ravens continually hunt wetland areas from March through mid-May and eggs are eaten if an unattended nest is located.

Common ravens rarely have sufficient time to consume egg contents at the nest site, particularly if the crane pair is feeding nearby. On 18 April 1967, both members of a crane pair were feeding together when their nest was approached by a raven. The raven was flying in a direct line until it spotted the crane eggs, then it began circling the site. Before the raven could drop onto the eggs, the male crane took flight and rapidly pursued the raven. The raven performed evasive flight behavior but the crane remained in close pursuit until the raven left the territory. The male crane immediately landed near the nest, walked to the site, and settled onto the eggs. Crane eggs generally are punctured by ravens and removed intact similar to the behavior of crows (Montevecchi 1976). Punctured crane eggs are regularly found on dikes, along fences, near rimrocks, and abandoned windmills on Malheur NWR; only a few small shell fragments are found at crane nests.

Common raven predation has been highest in drought years when sandhill crane nests are concentrated in the restricted wetlands. In 1967, six crane territories converged at one point. On 4 May 1967, one of these territories was observed throughout the day. The male did not relieve the female, but remained in the area where males from the five adjoining territories had congregated. Of the six nests within these territories, only one successfully hatched. Four of the nests were destroyed by ravens. Because of territorial strife, the males frequently failed to relieve their incubating mates. If not relieved by 1200 hours, the female would usually leave the nest to feed. Ravens then found the nest when eggs were left exposed (Littlefield 1968).

Ravens will rarely attempt to drive an incubating crane from the nest. On 18 April 1967, a raven was observed on the ground near an incubating bird. The raven would run toward the nest, then fly to the other side and repeat the performance. The female crane, however, remained on the nest. The raven left the area after the male crane, which had been watching this activity from about 0.25 km away, approached the site. R. Johnstone (pers. comm.) observed a raven pair "combined-effort hunting" (Mindell and Black 1984) for nests near Burns, Harney County, Oregon in May 1981. Both ravens would "leap frog" each other, dropping instantaneously into dense

Table 2. Common raven numbers recorded on 382 km of raptor census transects in Malheur-Harney Lakes Basin, Oregon.

Year	Winter	Spring	Summer	Fall
1976	--	--	--	209
1977	--	130	135	164
1979	99	92	78	162
1980	282	119	183	437
1982	173	196	286	756
1983	110	144	152	201
1984	201	98	210	147
Average	173	130	174	297

vegetation. This behavior continued until a female mallard (Anas platyrhynchos) flew from a nest. Both ravens landed at the site and consumed the eggs. Although crane eggs are not known to have been preyed upon in this manner, it is possible that "combined-effort hunting" by ravens could result in an incubating crane leaving the nest.

Raven Predation on Crane Eggs (1966-1984)

Greater sandhill crane studies were initiated on Malheur NWR in 1966 and have continued in most years through 1984. Before 1966, the extent of raven predation on crane eggs was unknown but predation has been monitored periodically from 1966 through 1984. The percentage of crane nests destroyed by ravens had ranged from 3.3% in 1983 to 40.8% in 1973 (Table 3).

Since 1966, common raven predation on sandhill crane eggs has varied on Malheur NWR, depending on annual precipitations, habitat condition, alternative prey sources, and raven density. Factors associated with raven predation can be divided into the following periods: (1) Predator control was practiced with chemical toxicants from 1966 through 1971. However, crane nesting habitat was degrading severely because of intensive livestock grazing; (2) In 1973 and 1974, predators were not controlled and grazing intensity peaked; (3) From 1976 through 1981, nesting habitat improved as grazing pressure was reduced but predators were not controlled; (4) In 1982 and 1983, nesting habitat was excellent and raven populations were controlled with DRC-1339 on portions of the refuge; and (5) In 1984, nesting habitat was in good condition, however, predators were not controlled and Malheur Lake flooded 17 crane territories.

Common raven predation averaged 17.7% from 1966 through 1971. Compound "1080" bait stations were being used but ravens were still evident during the nesting season. Winter livestock grazing was approaching its peak and crane nesting habitat was severely degraded by spring. Crane nests could easily be seen from a vehicle at distances up to 1.6 km. Raven predation was highest for the period in 1967 when 22.0% of the crane clutches were consumed.

Highest losses to ravens occurred in 1973 and 1974 when grazing peaked, predator management was not practiced, and jackrabbit populations were almost nonexistent. When jackrabbits are abundant, ravens feed on the numerous road kills and young. Nelson (1934) reported rabbits were found in 51% of the raven stomachs examined in Harney County in the mid-1930's. Grazing pressure was the highest in Malheur NWR history in 1973 and 40.8% of the crane nests were

Table 3. Percentage of sandhill crane nests known destroyed by common ravens on Malheur NWR, Oregon.

Year	Nests examined	Nests destroyed by ravens (%)
1966	51	16.6
1967	59	22.0
1969	88	11.4
1970	86	19.8
1971	83	19.3
1973	49	40.8
1974	50	28.0
1976	52	7.7
1977	50	18.0
1978	55	12.7
1980	30	13.3
1981	31	16.1
1982	81	9.9
1983	60	3.3
1984	67	11.9
Average	60	16.7

destroyed by ravens. This high grazing pressure was also accompanied by drought. In 1974, ravens destroyed 28.0% of the crane nests. Precipitation increased in 1974 and grazing levels dropped from 126,593 to 97,200 AUM's. These two factors probably were responsible for the 31.4% decline in raven predation in 1974.

Predator numbers were not controlled on the refuge from 1974 through 1981 but nesting habitat was greatly improved. By 1981, AUM's had been reduced to 31,101, the lowest since 1941. Raven predation varied from 7.7% in 1976 to 18.0% in 1977. Drought I 1977 and 1981 again apparently contributed to the higher predation rates. Livestock grazing reductions during this period not only improved nest concealment but ungrazed habitat had increases in meadow vole (Microtis montanus) populations (Feldhamer 1979, Cornely et al. 1983). This alternative prey base probably had a major influence on reducing raven predation on sandhill crane eggs.

Specific common raven control with DRC-1339 occurred on portions of the refuge in 1982 and 1983. The chemical was successful in controlling ravens; however, it was 1983 before their numbers were sufficiently reduced in the Double-O area. In 1982, ravens destroyed 9.9% of the monitored crane nests. This was the second lowest raven predation since studies were initiated. All known raven nesting pairs in the control areas had been eliminated by 1983, and only 3.3% of the nests were preyed upon by ravens. No control occurred in 1984 and raven predation increased to 11.9%. Three pairs had established territories in areas where the species had been eliminated during the 1982 and 1983 control effort.

Raven Predation in Relation to Vegetative Type

Four major crane nesting habitats were analyzed for raven predation. A total of 397 (47.0%) crane nests occurred in burreed, 319 (37.8%) in hardstem bulrush, 59 (7.0%) in cattail, and 70 (8.3%) in grasses and/or forbs. Highest success occurred in cattail (55.9%) and hardstem bulrush (55.5%); the lowest success was in burreed (43.8%). Nests in grasses and/or forbs had 44.3% success. Both cattail and bulrush remained erect through the winter and spring, providing better nest concealment. Burreed and grasses are usually flattened by winter snowcover, thus providing little concealment.

Common raven predation was highest in crane nests in common cattail where 13 (22.0%) were destroyed. Seventy-two (18.1%) of the 397 nests in giant burreed were lost to ravens. The lowest raven predation occurred in nests in grasses and/or forbs (10.0%). Forty-two (13.2%) nests were destroyed in hardstem bulrush. Ravens destroyed 134 (15.9%) of the 845 nests in the four vegetative types. Only in grasses and/or forb habitat did other predators (coyotes, 14.3%) destroy more nests than ravens.

Raven Predation and Land Use Practices

Beginning in 1976, nesting success was compared between idle, grazed, and mowed land use regimes. Idle lands are those which had not been mowed or grazed by cattle for at least 1 year, grazed lands had been grazed by cattle in winter, and mowed lands were mowed in August or September and the forage removed for cattle feed. Within the mowed areas grasses were cut but emergent aquatic plants were usually left standing. Under these land use practices, adequate crane nest samples were available from giant burreed (N = 180) and hardstem bulrush (N = 167) (Table 4) vegetative types.

Common ravens generally concentrated their feeding activities in early spring on grazed lands. Raven surveys from 1976 through 1981 indicated about 65% of all birds were in areas being grazed or that had been grazed by cattle. Cattle use degraded nesting habitat. These two factors were probably responsible for the high raven predation in grazed lands.

CONCLUSIONS

The common raven is perhaps the most "generalized" species known, nesting from arctic mountains and coasts, and boreal forest, south through the United States and Mexico to Honduras and El Salvador (Jollie 1976). Their habitat varies from largely deciduous forested mountains to the dry, almost barren interior valleys of California and the Great Basin region. Jollie (1976) further reported that the habitat of the common raven is characterized as usually strongly contoured lands or lines of cliffs. Basaltic rimrocks adjacent to Malheur NWR provide ideal habitat for the species. Nesting sites are usually inaccessible to mammalian predators and adjacent wetlands and rangelands provide an abundance of food. Their omnivorous diet allows ravens to be reproductively successful in most years. Although productivity of most

Table 4. Crane nesting success and percentage of unsuccessful nests that were known to be destroyed by common ravens within various vegetative types and land use regimes.

Land use and nest success	Burreed	Bulrush
Idle land sample size	71	85
% nest success	60.6	58.8
% nest failure due to ravens	8.5	10.6
Mowed land sample size	19	27
% nest success	52.6	63.0
% nest failure due to ravens	5.3	0.0
Grazed land sample size	90	55
% nest success	43.3	56.4
% nest failure due to ravens	13.3	12.7

wetland nesting species has declined the past decade on Malheur NWR, common raven breeding territories had increased from 35 in 1977 to 42 in 1982. Human activities have been beneficial to ravens, providing increased food supplies throughout the year and increased nesting sites. With an abundance of food, nesting sites, and continual protection provided by several state and federal statutes, few limiting factors presently exist for ravens.

Most nesting range of the Central Valley population of greater sandhill cranes is presently occupied by common ravens. The extent of predation on the total population is unknown but probably represents a significant mortality factor in areas where ravens are abundant. On Malheur NWR, raven predation on crane nests has averaged 16.7% annually since 1966. Assuming a minimum of 210 crane pairs nesting annually on the refuge, 35 nests would be lost to ravens. In 20 years, 700 crane nests would have been destroyed. With an average clutch size of 1.92 eggs, 1344 of the 8060 sandhill crane eggs produced would have been consumed by ravens during this 20 year period. Combined with losses to coyotes and raccoons, predation by ravens is one of the major factors limiting greater sandhill cranes in the Pacific Flyway.

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ACTIVITY PATTERNS OF WHOOPING CRANES WINTERING ON THE ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS

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Abstract: Whooping crane (*Grus americana*) behavior was quantified for 71.9 hours on the Aransas National Wildlife Refuge wintering grounds between 1981 and 1983. Activity patterns were stratified by time of day, flock size, and habitat. Cranes on the uplands spent considerably more time in alert postures than cranes in wetland habitats. Decreased predator detection and avoidance abilities of whooping cranes in thickly vegetated upland habitats may account for this behavior.

PROCEEDINGS 1985 CRANE WORKSHOP

Early studies of the whooping crane at the Aransas National Wildlife Refuge (ANWR) have focused on distribution and abundance, territoriality, and habitat utilization (Allen 1952, Blankinship 1976, Labuda and Butts 1979, Bishop and Blankinship 1982). Although broad habitat use patterns of the whooping crane have been identified, determinations of functional use of specific habitats have not been made. Verner (1965) suggested that for a given habitat a species will exhibit an optimum time-activity budget. Numerous authors (e.g., Tamisier 1876, Paulus 1984) have utilized time budget analysis to determine the functional role of wetlands for wintering waterfowl in North America. After the functional use of specific habitats has been identified, habitat management decisions can be made to meet species-specific needs.

To date no time budget analyses on whooping cranes are available in the literature. We report on activity patterns of whooping cranes on the ANWR during the winters of 1981 thru 1983. We specifically investigated the relationship of activity budgets to flock size, time of day, and habitat.

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METHODS

Behavioral observations of whooping cranes were made in upland, coastal bay, and salt marsh habitat types on ANWR (Fig. 1). The upland habitat on Blackjack Peninsula consisted primarily of oak-grassland savannah. Motts of live oak (*Quercus virginiana*) and patches of low thicketized oak dotted the open grasslands. Coastal bays (primarily Sundown Bay and the waters adjacent to Ayres Island) were perennially flooded with 0.15 to 0.6 of brackish water. High turbidity and unstable substrates prevented the establishment of vegetation. Salt marshes, located between the bays and the uplands, were dominated by cordgrass (*Spartina* spp.), sea ox-eye daisy (*Borrichia frutescens*), salicornia (*Salicornia* spp.), and wolfberry (*Lycium carolinianum*). A mosaic of small ponds and tidal sloughs was found throughout the salt marsh habitat.

Cranes were observed in the salt marshes and uplands from vehicles or permanent, elevated blinds, while those in the bays were observed from the cover of a small outboard motorboat. Observations were made using a 15-60 zoom spotting scope and 7 X 35 binoculars. In wetland habitats crane behavior was observed from a distance of 100 to 200 m. On the uplands, cranes appeared to be extremely wary, and behavioral observations were often made at 100 to 800 m.

Behavioral observations of subadult cranes in the bays and marshes occurred between 1 Jan 1981 - 15 Jan 1982, and 1 Apr 1982 - 30 Apr 1982 respectively. Both subadults and family groups were observed on the uplands between 1 Nov 1982 and 1 Apr 1983. Focal animal and scan sampling techniques were used to quantify behavior at 12 and 15 second intervals respectively (Altmann 1974). Behavior was classified into nine categories: forage and drink, alert, rest, comfort or maintenance, fly, walk, agonistic, other, and unknown. Behavioral categories were

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derived from those described by Masatomi and Katagawa (1975). The percent of time cranes spent in each behavioral activity was totaled and stratified by time of day, group size, and habitat.

RESULTS AND DISCUSSION

Whooping cranes were observed for a total of 71.9 hours, 60.6 hours in bays, 5.7 hours in salt marshes, and 5.6 hours in upland habitats. Fifty-six percent of the cranes total time was spent foraging. Lesser amounts of time were spent in resting, comfort, walking, and alert behavior (Fig. 2).

Only minor differences in activity patterns were observed at different times of the day (Fig. 3). Cranes in the early morning hours appeared to spend more time foraging than at other times of the day. Alert behavior occurred more often towards evening, while more time was spent resting near mid-day than during early morning or late evening time periods.

When behavioral observations were segregated by crane group size (greater than 5, or less than or equal to 5), cranes in the larger flocks appeared to engage in more resting and less alert behavior than cranes in smaller flocks (Fig. 4). Greater predator detection and avoidance capabilities of the larger flocks may account for the differences. Similar relationships between increased group size and decreased vigilance has been reported for geese (Lazorus and Inglis 1978) and darkeyed juncos (Junco hyemalis) (Golden 1980).

When activity patterns were separated by habitat type, several behavioral differences became apparent (Fig. 5). Cranes in the bays spent over 50% of the observed time foraging, and significant amounts of time were spent in resting, comfort, and other behavior. Only 6% of the time was spent in alert postures while in the open bays. Cranes in the salt marshes spent over 70% of the total time foraging. The relative proportion of time spent in the other behavioral activities while in the salt marsh, was comparable to that observed in the bays.

Cranes in the uplands, however, displayed very different activity patterns. Fifty eight percent of the observed time was spent foraging, but alert behavior accounted for over 33% of the total time. No resting or comfort behavior was observed.

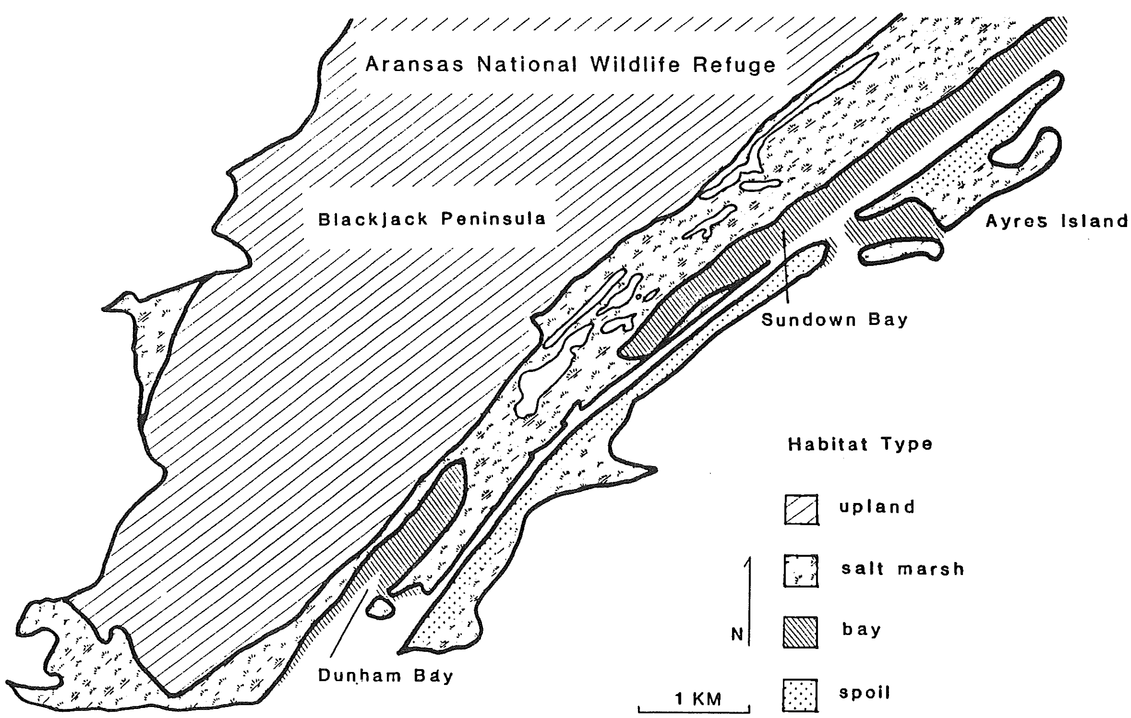

Fig. 1. The upland, salt marsh, and coastal bay habitats where whooping crane observations were made between 1981-1983.

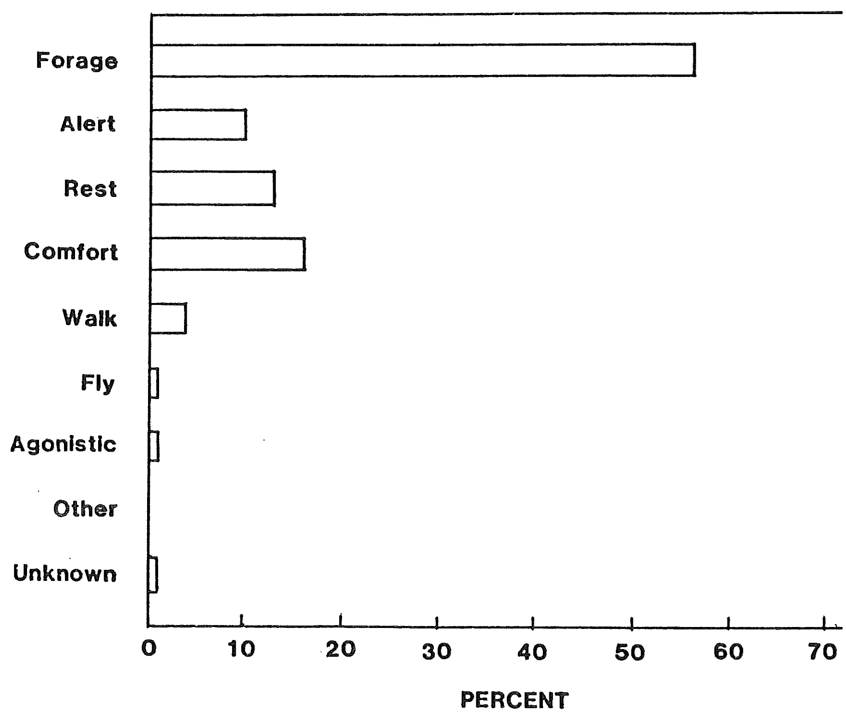

Fig. 2. The proportion of time whooping cranes spent in the various behavioral activities from 1981 to 1983 (N = 71.9 hrs).

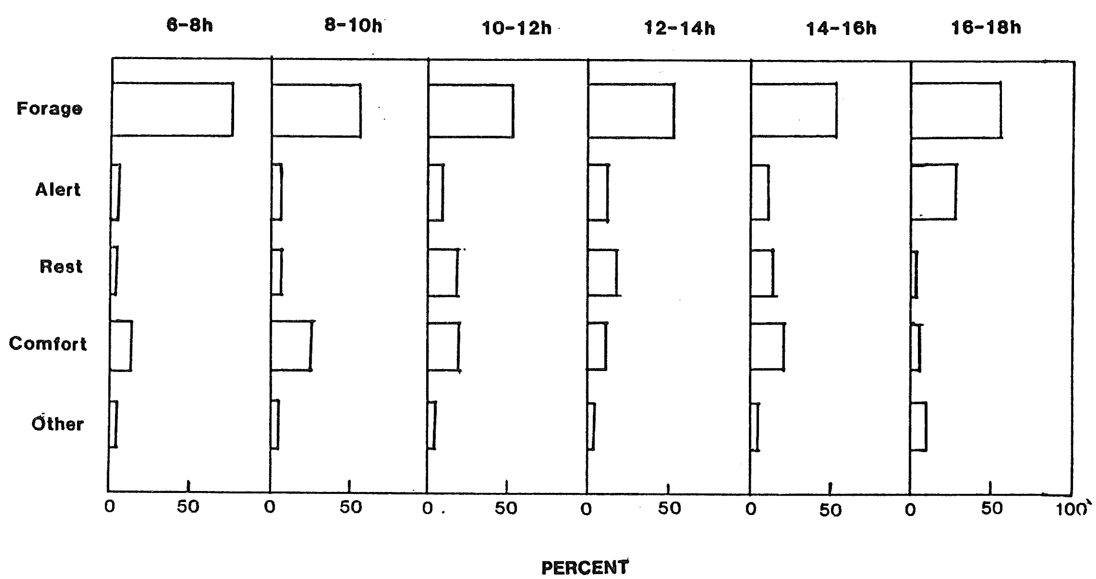

Fig. 3. The proportion of time whooping cranes spent in the various behavioral activities in relation to time of day (N= 71.9 hrs).

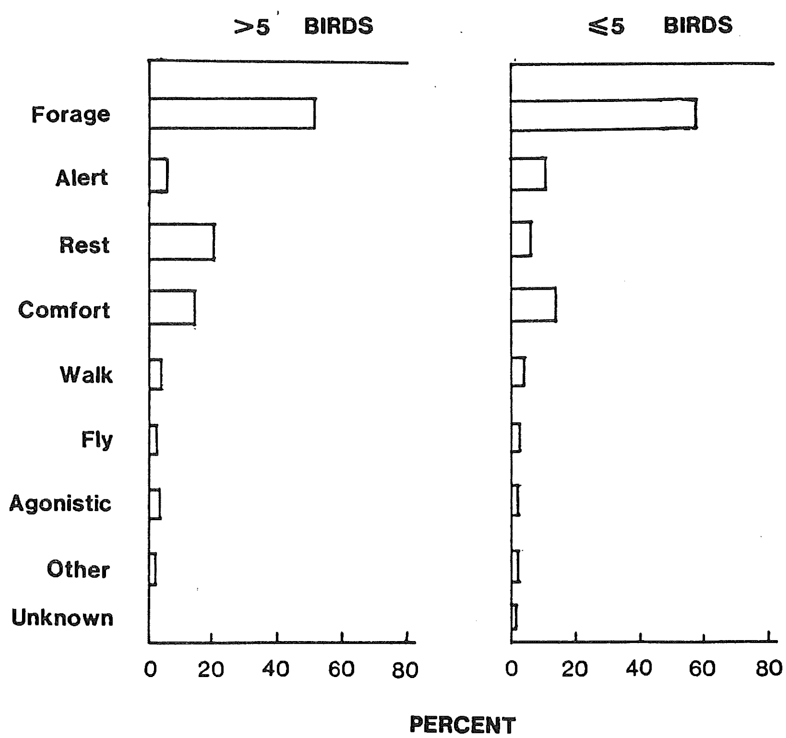

Fig. 4. The proportion of time whooping cranes spent in the various behavioral activities in relation to crane group size (N = 71.9 hrs).

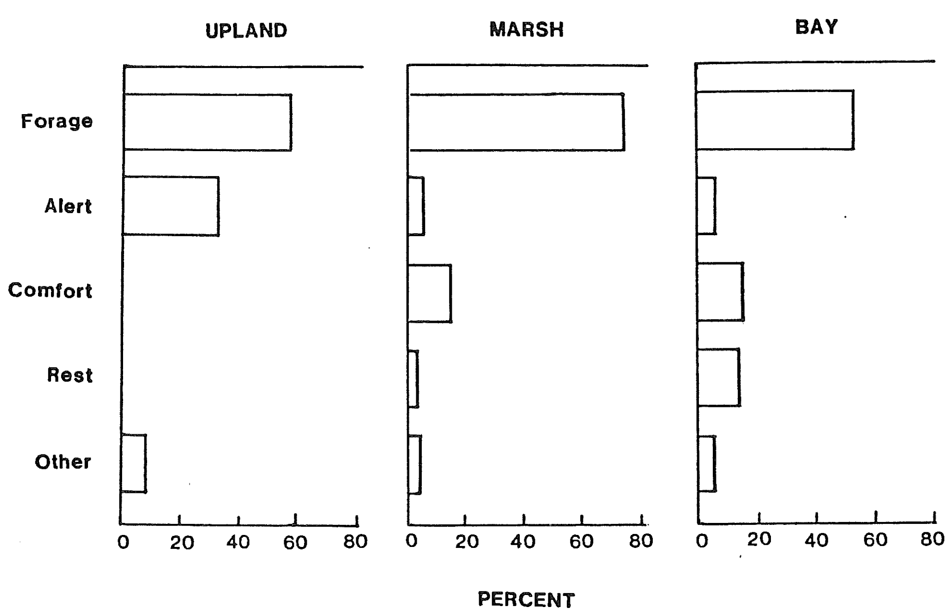

Fig. 5. The proportion of time whooping cranes spent in the various behavioral activities in relation to habitat (N = 71.9 hrs).

This large amount of alert behavior in the ANWF uplands is similar to that observed in the experimental whooping crane flock in New Mexico, where from 23% to 35% of the observed time was spent in alert behavior (Drewien, pers. comm.). The upland habitat used by whooping cranes in New Mexico has cover characteristics similar to the uplands of Blackjack Peninsula. Tacha (1981) suggests that alert behavior serves to reduce mortality from predators. The bays and salt marshes at Aransas are very open and offer good predator avoidance opportunities. In the uplands, patches of thick vegetation provide ample cover for predators. An increased risk of predation on the uplands may account for the higher incidence of alert behavior. The loss of a juvenile whooping crane to predation on the uplands in 1982 offers some support for this contention (Hunt et. al. this proceedings).

We anticipate that these data will stimulate additional quantitative evaluation of whooping crane behavior on ANWR. More extensive sampling will provide a standard for behavioral comparison between different populations/flocks. Valid behavioral comparisons may also provide a basis for the assessment of habitat and territory quality within or between populations, as well as clues to the effects of disturbance or other variables on whooping crane behavior.

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DRINKING SITES AND REQUIREMENTS OF WINTERING SANDHILL CRANES

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Abstract: The world's largest concentration of wintering sandhill cranes (*Grus canadensis*) is located in western Texas, an area of limited and dwindling freshwater sources. Cranes drank at nearly every freshwater source available; however, they preferred and were most abundant at large, permanent springs. Springs had variable salinities (0.4 to > 20.0 parts-per-thousand (o/oo)), and as a result, the mean salinity of crane drinking sites was relatively high (6.1 o/oo). Highest crane roost counts corresponded with relatively small amounts of fresh water. However, continued loss of fresh water alternatives for cranes in western Texas makes further research and development of fresh water sources imperative.

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The purpose of this study was to describe the fresh water resources available and their use by sandhill cranes wintering in western Texas and extreme eastern New Mexico. This area holds the largest concentration of wintering sandhill cranes in the world with nearly 450,000 cranes estimated (Iverson et al. 1985). The limited amount of available fresh water in the area may cause problems for these cranes in the near future. Much of the area's water is highly mineralized (Cole 1966), which could pose physiological problems for the sandhill crane, a bird possessing a small salt gland, if any at all (Hughes and Blackman 1973, Franson et al. 1981). Also, the area is underlain by the Ogallala aquifer which is shrinking and lowering water tables (Bolen and Guthery 1982) and causing some of the area's water sources to dry up or become saline (Brune 1981).

I thank Drs. Frank Schitoskey, Larry Talent, and Scott Shalaway for their advice, Randy Moore for help with field work, and Judy Gray for immeasurable logistical assistance. Dr. Thomas Tacha provided valuable suggestions during the initial stages of this study and also helped acquire funding for the study. I thank Muleshoe National Wildlife Refuge personnel for their assistance and companionship.

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STUDY AREA

The study area, located within the southern High Plains or Llano Estacado, encompassed approximately 20,000 km^2 (Fig. 1). Most of the study area was planted in a vast cotton monoculture, but some sorghum, wheat, corn, and rangelands were also present. The study area was characterized by relatively flat terrain with 20-25 saline lake basins and numerous scattered playas.

Playas are shallow natural depressions formed through wind erosion, which periodically contain fresh water (Rettman 1981), whereas saline lake basins are ancient lake beds formed along prehistoric stream systems (Reeves 1966). Most saline lakes are saltier than seawater due to years of evaporation. Lakes receive some runoff from surrounding areas, but springs also help fill many basins (Reeves 1965).

Ten study sites were established in western Texas and eastern New Mexico with a saline lake (Fig. 1) at the center of each site. Each study site was contained within a 16 km radius of the center of a lake basin and had an area of 800 km^2; this is equivalent to the daily activity range for sandhill cranes in western Texas (Oklahoma Cooperative Wildlife Research Unit, OCWRU, unpubl. data). Some study sites contained more than one basin. The 10 lakes studied included Rich and Mound lakes located near Brownfield, which are part of the Brownfield complex, and 8 lakes located near Muleshoe in the Muleshoe complex.

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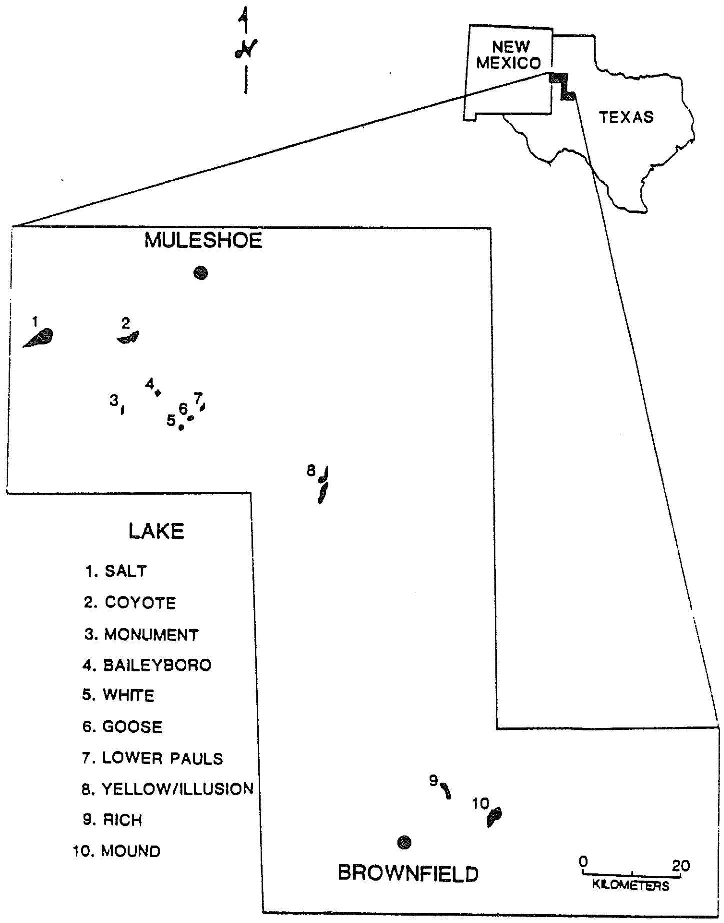

Figure 1. Study area in western Texas and eastern New Mexico illustrating the saline lake basins studied.

METHODS

The study was conducted from early October 1982 to early March 1983. Blinds or a 15 x 60 X spotting scope were used to observe sandhill crane drinking locations and behavior. Cranes were identified as drinking by posture and subsequent swallowing motions (Tacha 1981). Water temperature, salinity, and water depth were measured at drinking sites of cranes throughout November and early December 1982 to determine crane preference levels.

Early in the study it was determined that freshwater springs were the primary water source used by cranes. As a result, more intensive research was initiated on the springs. Water temperature, salinity, water depth, and surface area were compared between springs with crane tracks and springs without crane tracks as well as between springs heavily used and those lightly used. These measurements were taken at springs at least four times from December 1982 to March 1983. I assumed that springs with crane tracks were the drinking sites of cranes because there was always at least one individual observed drinking while a flock was at a spring. Heavily used springs were defined as springs that attracted cranes consistently throughout the study period.

Differences in salt content (e. g., springs flowing into saline lakes) may cause stratification of water layers of different density (Ruttner 1965). Stratification could enable a sheet of fresh water from a spring to flow out over saline lake water. This could cause sampling errors without knowledge of thickness of stratification layers and/or water sampling depth. A test to discover if water was stratified by salinity and temperature was conducted at 36 sites. A YSI model 33 salinity meter was used to measure salinity and water temperature and a large syringe was used to collect water samples from various depths.

Cranes do not drink the salty water of saline lakes. However, the springs had salt concentration gradients that gradually increased from the source out to where the level was the same as the lake's. After crane preference levels for salinity were identified, tentative boundaries were used to help determine surface area of "drinkable" spring water. Boundaries were determined at each spring on each sampling date. Surface area was measured only for water greater than or equal to 0.5 cm and less than or equal to 30 cm deep. Water deeper than 30 cm was assumed to be too deep for cranes and water 0.5 cm deep was the shallowest at which crane were observed drinking. Heavily vegetated areas of springs were assumed to be unavailable to cranes for drinking water. Surface areas of springs, playa lakes, and other measured water sources within each study site were compared with crane roost counts to determine the minimum amount of water needed to hold "X" number of cranes in an area. Crane counts and surface area measurements were taken at about 2 week intervals. Crane counts on each lake were averaged if more than one count was conducted at a basin in a 2 week period. Cranes were counted in small flocks as they left the roost in the morning or as they arrived in the evening. The Statistical Analysis System (Helwig and Council 1979) was used for statistical analysis.

RESULTS

Forty-five springs, 3 cattle watering areas, 10 playa lakes, snow, and innumerable periodic mudholes in fields and on and along section line roads were available to cranes for fresh water on the study sites. Two saline basins contained fresh water for 3 weeks in February after considerable precipitation. Cranes were observed drinking at 25 springs, 2 cattle watering areas, 4 playa lakes, and 6 mudholes, and 9 cranes were observed eating snow (cranes which ate snow exhibited the same behavior as when drinking water). Cranes were never observed drinking water from saline basins or metal cattle tanks.

Water temperature, salinity, and water depth were measured at 55 crane drinking sites (Table 1). Mean salinity at drinking sites was 6.1 o/oo. One bird drank water with a salinity of 24 o/oo which is only 11 o/oo less than seawater. I observed at least three other birds attempting to drink water of about this salinity; however, all of them responded by shaking the water from their bills and not lifting the head and neck in the typical swallowing posture. Ninety-one percent of the drinking sites had salinities less than 10 o/oo. Sandhill cranes have succumbed to salt poisoning when restricted to water with a salinity of 10 o/oo for over 1 week (Franson et al. 1981) and Wetzel (1975) stated that most freshwater animals are restricted to waters with salinities less than 10 o/oo. For these reasons, only water sources with salinity less than 10 o/oo were considered available for sandhill cranes as drinking water.

Although playa lakes generally had large surface areas of fresh water available, and all mudholes, cattle watering areas, and most playas had salinities less than 1 o/oo, springs were definitely preferred by cranes. Some of the larger springs would be used by cranes throughout the day on most days, and 5,000 or more cranes could be present. Most of the larger springs were relatively permanent. I judged springs to be permanent if water was flowing in them at the onset of the study when drought conditions were present and most springs were dry.

Table 1. Water measurements at sites where sandhill cranes were observed drinking in western Texas and eastern New Mexico, winter, 1982-83.

Measurement	Drinking sites			
	Mean	SE	N	Range
Water temperature ($^{\circ}$C)	14.0	0.65	55	3.0-21.3
Salinity (o/oo)	6.1	0.60	55	0.0-24.0
Water depth (cm)	2.5	0.27	55	0.5-11.0

Cranes entered springs in two ways. One consisted of walking from the basin into a spring. Cranes usually flew to the edge of the basin water and walked into the spring, but occasionally walked from their roost in the basin to a spring, especially in the morning during foggy or stormy weather. However, after cranes were established at springs, other cranes flying to the area would often land right in the spring.

Cranes would typically begin drinking at a spring near the basin water perimeter. They usually moved towards the spring head, apparently aware of the salt concentration gradient direction. However, when a spring began to fill up with cranes, new arrivals were forced to drink saltier water closer to the basin. At one heavily used spring at Mound Lake, a barbed wire fence cut across the spring 15-20 m from its head. Even when cranes filled the spring, none would fly to the other side of the fence, where water was fresher, and tracks were never found there.

I compared springs having crane tracks with springs without tracks to determine the differences in springs used by cranes and those which received no use (Table 2). Mean water temperature was significantly lower and surface area was significantly larger at springs with tracks compared with springs without tracks. To further elucidate differences cranes may detect between spring habitats, I compared heavily used springs with lightly used ones (Table 3). The amount of surface area of fresh water was the only major difference between the two, with heavily used springs having an average of nearly 4,000 m^2 more useable fresh water.

I correlated the number of springs per basin with the average number of cranes present at that basin's roost(s) (Fig. 2). The highest crane count was at a basin with two springs and the lowest counts at basins with no springs. Duncan's Multiple Range Test showed average counts of cranes at basins with two and three springs were significantly higher (P = <0.05) than at basins with either fewer or more springs. Although, ANOVA procedures revealed no significant correlations between crane counts and surface area of springs in study sites, or total fresh water in study sites, graphs of the data did show some general trends (Fig. 3). These graphs showed average crane counts did not reach peaks at the largest surface areas of fresh water available. This suggests that with increased fresh water surface area, greater than surface areas associated with peak counts, other habitat factors may become important in limiting crane numbers.

Five of the 10 lakes studied had freshwater springs flowing into them. Analysis of 36 sites tested for stratification revealed that salinity was significantly higher ($P < 0.07$) at 2 cm than at 1 cm, with a difference in means of 0.07 o/oo. There was no significant difference between temperatures.

Some of the springs had little vegetation in or near them. The majority of springs, however, were characterized by desert salt grass (*Distichlis stricta*), sedges (*Carex* spp.), bulrush (*Scirpus* spp.), and scattered salt cedar (*Tamarix* spp.). Cattail (*Typha latifolia*) was found at more permanent springs, generally near the mouth of the spring. The main vegetational differences between springs was less salt cedar and salt grass, and denser stands of cattail, sedges, and bulrush extending farther towards the basin at fresher springs.

DISCUSSION

Cranes drank at nearly every type of water source available in the study area. Probably the only major restrictions for crane drinking sites would be water too saline, too deep or shallow, or too close to human use areas. Observations of cranes "testing" water and large concentrations of birds at fresher and larger springs showed that cranes did not randomly choose springs.

Although water less than 1.0 o/oo was usually available, the mean salinity of crane drinking sites was 6.1 o/oo. This value would be classified moderately saline according to the breakdown of saline waters by Krieger (1963). House finches showed no preference for distilled water or NaCl solutions less than 5.9 o/oo (Bartholomew and Cade 1958); however, they drank twice as much distilled water when offered saline solutions of 11.7 o/oo or greater. Red crossbills, a species known for its salt-eating habits, also showed a strong aversion to NaCl solutions greater than 11.7 o/oo (Dawson et al. 1965). Harriman (1967) found laughing gulls had a strong aversion to NaCl solutions greater than 11.7 o/oo, although they are generally marine.

Although most sandhill cranes also drank water less than 11.7 o/oo, many were obtaining water within the "discrimination range" of some birds more likely to tolerate higher salinities in drinking water. I believe that there can be at least two reasons for this observation:

1) Cranes preferred drinking at sites with saltier water (springs) over sites with fresher water (playa lakes, etc.) because of reasons other than water salinity. Some possible reasons are less human disturbances at springs, proximity of springs to roost, and the relative reliability of springs as a water source. 2) Cranes are flexible in the salinity they tolerate in drinking water. Possession of a salt gland or other physiological adaptations could be responsible for this tolerance (Bartholomew and Cade 1963). Franson et al. (1981) claimed that if there was any salt gland in sandhill cranes it was probably very small. However, they did not try to isolate other physiological processes cranes may use for voiding excess salts.

Water temperature was significantly lower at springs visited by cranes, probably as result of spring morphology. I believe one component of springs that could cause a water temperature difference between them is the degree of spring permanence. Permanent springs probably have a more direct link with cool underground waters. Subjectively, I would say cranes preferred and were most abundant at permanent springs. An attribute of permanent springs that cranes would most likely select is larger size. Permanent springs had larger surface areas and springs with crane tracks had an average of about 3,000 m^2 more surface area than springs without tracks. Sandhill cranes prefer areas with larger expanses for roosting (Johnson and Stewart 1973, Solne 1982, Haley 1983), and the same probably holds true for drinking areas.

There was a small difference in mean salinity (0.7 o/oo) at 2 and 1 cm deep water strata; however, cranes probably could not discriminate between them. Sample sizes were too small for statistical testing on sites deeper than 2 cm. However, there were more pronounced differences in salinity and temperature at depths greater than 6 cm with a general increase in temperature and marked salinity increases. This difference probably results from persistent winds having less mixing effects on deeper waters.

Table 2. Characteristics of freshwater springs that were known and not known to be used by sandhill cranes in western Texas and eastern New Mexico, winter 1982-1983.

	Used by cranes			No known use			
Spring measurement	Mean	SE	N	Mean	SE	N	P[a]
Water temperature (°C)	8.4	0.45	107	10.6	0.63	32	0.02
Salinity (o/oo)	6.7	0.24	107	6.8	0.45	32	NS[b]
Water depth (cm)	2.4	0.36	99	4.3	0.86	28	NS
Surface area (m^2)	4125.6	838.8	150	1254.5	434.5	50	0.003

[a] Observed significance level of t-value from t-test.
[b] Not significant at 0.05 level.

Table 3. Characteristics of freshwater springs used heavily by sandhill cranes compared with springs used lightly, western Texas and eastern New Mexico, winter 1982-83.

	Heavily used			Lightly used			
	Mean	SE	N	Mean	SE	N	P[a]
Water temperature (°C)	7.5	0.77	37	8.7	0.68	51	NS[b]
Salinity (o/oo)	6.4	0.31	37	7.2	0.39	51	NS
Water depth (cm)	1.6	0.16	34	1.4	0.13	51	NS
Surface area (m^2)	6054.4	1972.3	53	2266.5	672.2	94	0.075

[a] Observed significance level of t-value from t-test.
[b] Not significant at 0.10 level.

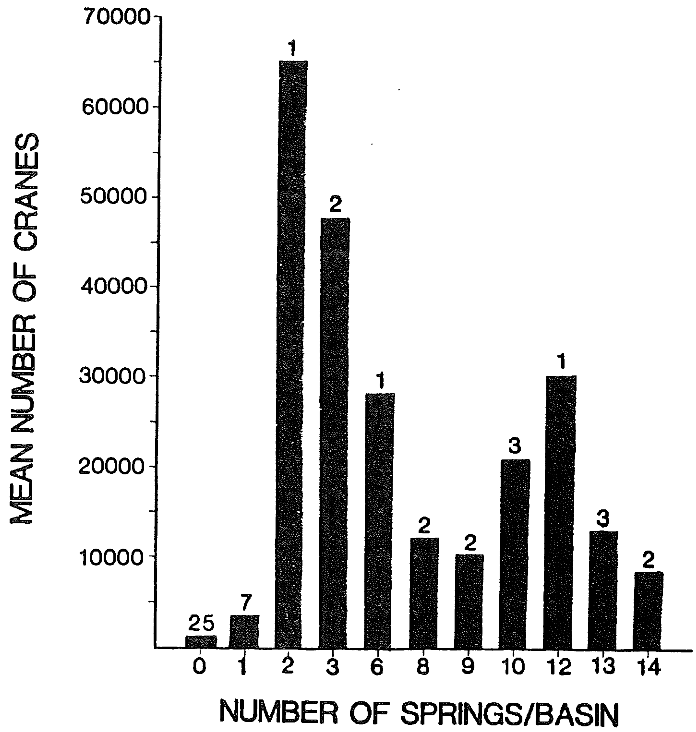

Fig. 2. Graph of basins with varying numbers of springs compared with mean number of sandhill cranes counted. Sample sizes are indicated on the top of the bars.

Springs were extremely variable in their salinities (0.4 to > 20 o/oo) although they apparently had the same groundwater source and similar depths. Factors which could be affecting spring salinities were: 1) weather, 2) strata through which water must pass, 3) different amounts of precipitated salts the water flowed over, and 4) different rates of flow.

Precipitation and wind probably affect spring salinities more than anything else. I believe these effects are due to shallow depth and the small area that springs cover. Wind not only affected springs by mixing water strata, but also through the action of wind tides. Wind tides occurred when strong winds blew consistently, pushing the shallow basin water to the leeward side of the lake. At Illusion Lake, on 22 December, winds gusting to 50 km/hr from the southwest moved the southwest water line nearly 0.8 km to the northeast in 6 hours. Most springs on the leeward side of wind tides were inundated with very saline water and became unusable by cranes. Spring water on the windward side was blown farther into the basin, with the general effect of water depth decreasing and surface area and salinity increasing. Permanent springs were less affected by wind tides, mostly because of faster flow of water associated with these springs.

Comparisons of crane roost counts with surface area of water showed that highest counts corresponded with relatively small amounts of playa, spring, and total fresh water. Minimum amounts of fresh water necessary to hold large numbers of cranes at a basin during this study was between 3 and 7 ha total fresh water, at least 1 ha playa water, and 1 ha spring water within an 800 km^2 area of the center of the basin; and 1 ha spring water consisting of 2 or 3 springs in association with the basin. At various water surface area values, there were low crane counts, probably because factors other than drinking water availability were limiting crane numbers.

This study was one of the first to examine sandhill crane drinking sites and requirements. Further research should be initiated to better understand relationships between wintering cranes and fresh water resources, especially in areas such as western Texas where fresh water is limited. Development of wells and simulation of springs should be investigated to ensure proper habitat for cranes when springs in the area dry up.

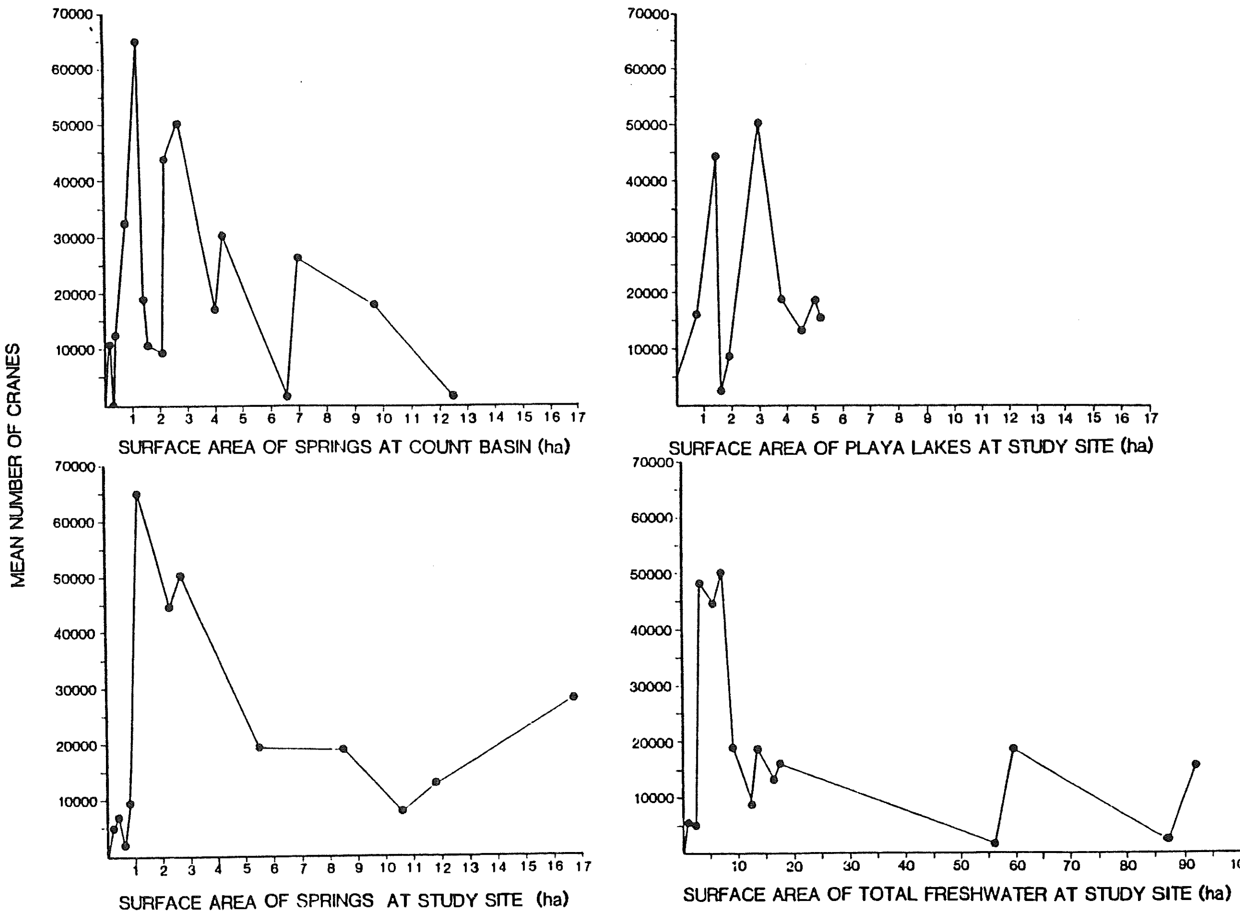

Fig. 3. Plots of mean numbers of sandhill cranes counted with surface areas of springs, playa lakes, and total freshwater available.

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DISTRIBUTION OF WINTER TERRITORIES OF WHOOPING CRANES ON THE TEXAS COAST

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Abstract: The location of winter territories for paired adult whooping cranes was derived from weekly aerial census data for the winters' of 1950-51, 1961-62, 1971-72, 1979-80, 1982-83, 1983-84, and 1984-85. The number of territories situated on the east shore of the Aransas Refuge has increased from 6 in 1950-51 to 16 in 1984-85. Average territory size in this area equalled 117 ha, significantly less than past estimates. Information from color-banded cranes shows that a crane upon pairing will tend to establish a territory adjacent to the area where it spent its first winter at Aransas. This tendency may be the dominant factor in explaining why more and more cranes are using the same traditional areas rather than expanding their range. Some limited range expansion took place on Lamar Peninsula in 1971-72 and on Welder Point in 1973-74. Only 37% (8,175 ha) of the 22,096 ha of apparently suitable marshland on Aransas, Matagorda, San Jose, Lamar Peninsula, and Welder Point is presently being used by whooping cranes. It appears that sufficient winter habitat is available to support the 40 mated pairs enumerated as a management objective in the 1980 Whooping Crane Recovery Plan. During 1984-85, the Aransas flock consisted of 58 adults (29 pairs), 13 subadults, and 15 young. Thirty-three of the total 86 cranes were color-banded.

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The whooping crane winter range is located on the central Texas coast between Corpus Christi and Houston. Aransas National Wildlife Refuge has historically been the winter home of the whooping crane. The mainland portion of Aransas is situated on the Blackjack Peninsula (Fig. 1) and contains 22,189 ha, including 2,833 ha of marsh with the remainder in brush, oak savannah, and grasslands. Approximately 17,763 ha on Matagorda Island make up another unit of Aransas. This unit is now managed by the Texas Parks and Wildlife Department. Matagorda Island's total area is 21,450 ha of which 10,927 are marsh.

The endangered whooping crane's year is about evenly divided between Texas (October-April) and Canada (April-October). While in Canada the birds nest and raise their young in Wood Buffalo National Park, Northwest Territories.

The refuge conducts weekly aerial censuses over the coastal marshes during the period that the cranes are in Texas. Precise locations of adults and young are plotted on maps and maintained in the refuge files as well as mailed to U. S. and Canadian officials. These data have been recorded in this manner since 1950-51.

A paper entitled Habitat Use By Wintering Whooping Cranes on the Aransas National Wildlife Refuge by Labuda and Butts (1978) defined areas of coastal Texas used by wintering whooping cranes. Since this discussion by Labuda and Butts, many things have taken place. The most notable is the whooping crane banding program started in 1977 and the radio tracking of the cranes which began in 1981. Marking of young flightless cranes approximately 6 to 8 weeks after hatching in Canada offers a unique opportunity to study individual birds. New knowledge has been gained on the behavior of subadult birds and the initiation of pair formation (Bishop and Blankinship 1981). The objectives of this study are to: 1. Delineate winter territories of crane pairs; 2. Describe changes in territory locations over a 34-year period; 3. Discuss factors that influence where cranes establish winter territories; 4. Discuss future expansion of the Aransas flock's winter range; and 5. Present current information on the composition of the 1984-85 Aransas whooping crane population.

We would like to express our appreciation to the following staff at Aransas National Wildlife Refuge: Kenneth Schwindt - historical research on crane locations, Carol Smith - drawing figures, and Louise Frasier - manuscript typing. Others whose research established the foundation upon which this report is built are gratefully acknowledged in the text.

METHODS

Census data as found in the refuge files are obtained by chartered light aircraft with a member of the refuge staff riding as observer. Short transects are flown over areas traditionally used by whooping cranes. These include marshlands adjacent to the Blackjack Peninsula, Matagorda Island and San Jose Island marshes, Welder Point, and a small marsh area on Lamar Peninsula. The refuge observer makes precise notes about the location of family groups, pairs, and single birds. Observations also are made by all refuge personnel on patrol and other routine work. Crane data have been recorded since the early days of the refuge (1940's) but only since 1950 has a systematic aerial survey been conducted on a regular basis. Although there may be some variance in the manner in which censuses were conducted and/or recorded, we believe that overall crane locations have been recorded rather consistently over the years.

Repeated observation and census map data give a fairly reliable indication of the use area of most cranes. Leg bands which indicate year of birth and distinct color combinations for individual birds greatly assist in determining use areas of these birds. A pattern of exclusive use of an area by a pair of cranes becomes apparent after one plots all the crane locations for a given winter. We define this exclusive use area as the winter territory of a crane pair. If weekly aerial census data did not indicate a consistent pattern, or if the number of cranes ranged from one to several, then it was assumed the cranes were subadults and were not in a defended territory. Thus, the knowledge from color banding and subadult behavior studies has enabled aerial survey data from previous years to be reanalyzed and winter territories delineated.

RESULTS

Much has been written and said about the available habitat for whooping cranes on the Texas coast. Marshlands located on Aransas, Matagorda, San Jose, Lamar, and Welder Point total approximately 22,096 ha. Crane use areas presently cover 37% (8,175 ha) of the available habitat; thus, 13,921 ha of marshes contiguous to the present crane range are not being used by the cranes.

In the past, it had been assumed that as the flock increased, new territories would be established southward on San Jose Island with nearly 6,070 ha of marsh and tidal flats and northward on Matagorda Island with 10,927 ha of marsh. Welder Point also contains 2,023 ha of marsh. Instead of spreading out, the whoopers have tended to remain faithful to the following areas: 2,833 ha on Aransas, 1,214 ha on South Matagorda, 3,076 ha on North San Jose, 809 ha on Welder Point, and a 243-ha marsh on Lamar Peninsula.

Labuda and Butts (1979) pointed out that 71% of all adult use days and 74.6% of all juvenile use days have been in Mustang Lake, Sundown Bay, and Dunham Bay on Aransas Refuge. The present study shows a similar pattern for the territories of families and paired adults.

As the number of Aransas cranes has grown from 18 in 1938-39 to 86 in 1984-85, the areas of use have not increased proportionately. Despite the scattered wanderings of a crane or two, the old traditional wintering grounds of Aransas, South Matagorda Island, and North San Jose Island have remained the primary use areas of the wintering flock. Average annual crane numbers using the major areas are shown in Table 1.

Notable but infrequent sightings of whoopers outside of their traditional winter areas have been recorded: (1) Two seen near Matamoras, Mexico in February, 1951; (2) Three (a family group) spent December, 1955 thru March 1956 on Mustang Island, Texas; (3) Two seen near Tampico, Mexico in January, 1964; and (4) scattered reports of whoopers on the King Ranch (1944-45). Unusual sightings are listed in Table 2. In some instances, whoopers have mixed with sandhills and moved away from their usual habitats. Other sightings outside traditional ranges occur during migration periods. One subadult spent one week with sandhill cranes at Lake Texana near Edna, Texas in early December, 1980. Radioed cranes tracked south during fall, 1983 reached the Texas coast 24 km southwest and 72 km northeast of Aransas respectively. Two instances are known of whooper chicks spending the winter away from the Aransas area. In 1977-78, chick nil-R was not seen at Aransas but was sighted with sandhill cranes in Kansas during the spring migration. In 1984-85, chick B-W was sighted with sandhill cranes from December thru February near El Campo, Texas, 104 km northeast of the refuge.

Only slight pioneering to new areas can be noted as paired adults established territories on Lamar Peninsula (1971-72) and Welder Point (1973-74). These latter two areas can now be

Table 1. Whooping crane winter use at Aransas National Wildlife Refuge and adjacent areas.[a]

Year	Total cranes[b]	Aransas NWR	Matagorda Island	San Jose Island	Welder Point	Lamar	Other
1938	18	No data	c	c	c		
1939	22	11	c	c	c		
1940	26	No data	c	c	c		
1941	15	No data	c	c	c		
1942	19	No data	No data	No data			
1943	21	No data	No data	No data			
1944	18	10	8	0	c		c
1945	17	9	8	0			
1946	25	20	3	2			
1947	31	No data	Some	No data			
1948	30	21	7	2			
1949	34	31	3	0			
1950	31	25	6	0			c
1951	25	20	5	0		c	c
1952	21	15	6	0			
1953	24	18	6	b			
1954	21	17	4	0			
1955	28	19	9	0			c
1956	24	20	4	0			c
1957	26	21	5	0			
1958	32	21	7	4			
1959	33	23	6	4			
1960	36	24	10	2			
1961	39	31	8	c			
1962	32	20	10	2	c		
1963	33	27	6	c			c
1964	42	36	6	c	c		
1965	44	36	8	c	c		
1966	43	35	8	c			
1967	48	36	10	2	c		
1968	50	43	5	2			
1969	56	41	12	3			c
1970	57	45	10	2			
1971	59	38	8	10		3	
1972	51	36	10	2		3	
1973	48	29	8	5	3	3	
1974	49	32	8	4	2	3	
1975	57	36	11	5	2	3	
1976	69	42	16	6	2	3	
1977	70	45	14	6	3	2	
1978	74	47	14	6	5	2	
1979	76	50	12	7	5	2	
1980	78	50	14	6	6	2	c
1981	73	40	18	9	4	2	
1982	73	47	14	6	4	2	c
1983	75	45	16	6	5	3	
1984	84	41	21	12	6	3	c

[a] All numbers are averages, based on "typical" numerical distribution of cranes for the entire winter period. Cranes, particularly subadults, are known to sometimes move between one or more of the areas listed above.

[b] Figures do not reflect peak population for those years when cranes died during the fall.

[c] See notes in Table 2.

Table 2. Notes on reported whooping crane winter use adjacent to Aransas National Wildlife Refuge (referenced from Table 1).

1938 to 1941	"A few whooping cranes were seen by the refuge staff between 1938 and 1941 on the adjacent Matagorda and St. Joseph Islands and the mainland in the vicinity of Green Lake and Welder Point, Calhoun City" (Stevenson and Griffith 1946).
1939	Half of the whooping crane population was split between Matagorda and San Jose Islands.
1944	Refuge narrative mentions cranes on Welder Point and the King Ranch. First recorded crane use of marsh east of refuge headquarters.
1950	Two cranes reported near Matamoris, Mexico in February 1951.
1951	A "few" whooping cranes were located on Lamar Peninsula. One pair of cranes was found 5 km west of Rockport, Texas on 25-27 March 1952.
1953	One crane was sighted 1 February 1954 on San Jose Island. This was the first observation on San Jose in 5 years.
1955	One family group spent part of the winter on Mustang Island, south of San Jose Island.
1956	One whooping crane stayed on the King Ranch south of Corpus Christi from mid-March to 17 April 1957.
1961	Two cranes on San Jose Island during November only.
1962	One crane on Welder Point from 22 November to 4 December 1962.
1963	Three cranes on San Jose Island on only two occasions. Two cranes reported near Tampico, Mexico on 16 January 1964.
1964	Three cranes observed only once on San Jose Island on 19 February 1965. Ranch foreman reported occasional use by whooping cranes on Welder Point during the winter.
1965	Three cranes occasionally used San Jose Island. On 21 November 1965 a family group was sighted on Welder Point. Because of the upcoming waterfowl hunting season, a helicopter was used on 23 November to "persuade" the cranes to leave the heavily hunted Welder Point marsh. The family flew to Panther Point on Matagorda Island, stayed 2 days, then moved to Mustang Lake in the refuge.
1966	Two cranes sighted on San Jose Island only once.
1967	Two cranes sighted on Welder Point on 6 and 9 November 1967.
1969	Two cranes utilized a prescribed burn on the refuge's Tatton Unit in the fall.
1980	One crane (1979 chick) sighted at Lake Texana near Edna, Texas with sandhill cranes for one week in December.
1982	Rancher reports four whoopers in a field just outside the refuge's back gate with sandhills on 21 December 1982. Two Welder Point pairs located in rice fields with sandhills near Powderhorn Lake, 16 km northeast of their territories on 14 and 23 November 1982.
1984	One chick wintered with sandhill cranes 104 km northeast of the refuge near El Campo, Texas. Mustang Lake family group utilized newly planted corn fields 4 km southeast of Austwell, Texas on 23 and 25 February 1985.

Table 3. Number and distribution of territories.

Winter	Peak pop. adult & young	Refuges east shore	Egg Point/ Lamar	Matagorda Isl.	San Jose Isl.	Welder Point	Total	# of nests Canada[a]
1950-51	26+5=31	6	1	0	0	0	7	-
1961-62	34+5=39	8	0	1	0	0	9	-
1971-72	54+5=59	10	2	4	1	0	17	16
1979-80	70+6=76	10	1	3	2	2	18	19
1982-83	67+6=73	14	1	5	3	2	25	24
1983-84	68+7=75	16[b]	1	6	2	2	27	29
1984-85	71+15=86	16[b]	1	7	3	2	29	-

[a] Data from Kuyt (1981) and Kuyt (pers. comm.).
[b] Includes one use area of a pair without a territory.

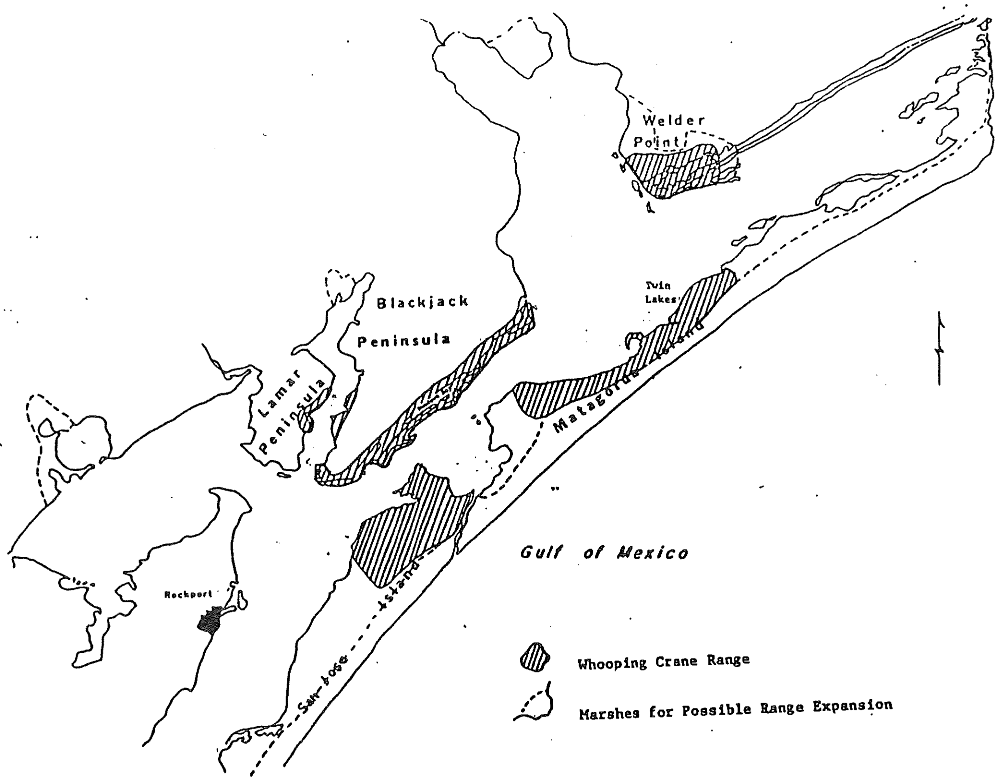

Fig. 1. Whooping crane range at Aransas National Wildlife Refuge in 1984-85.

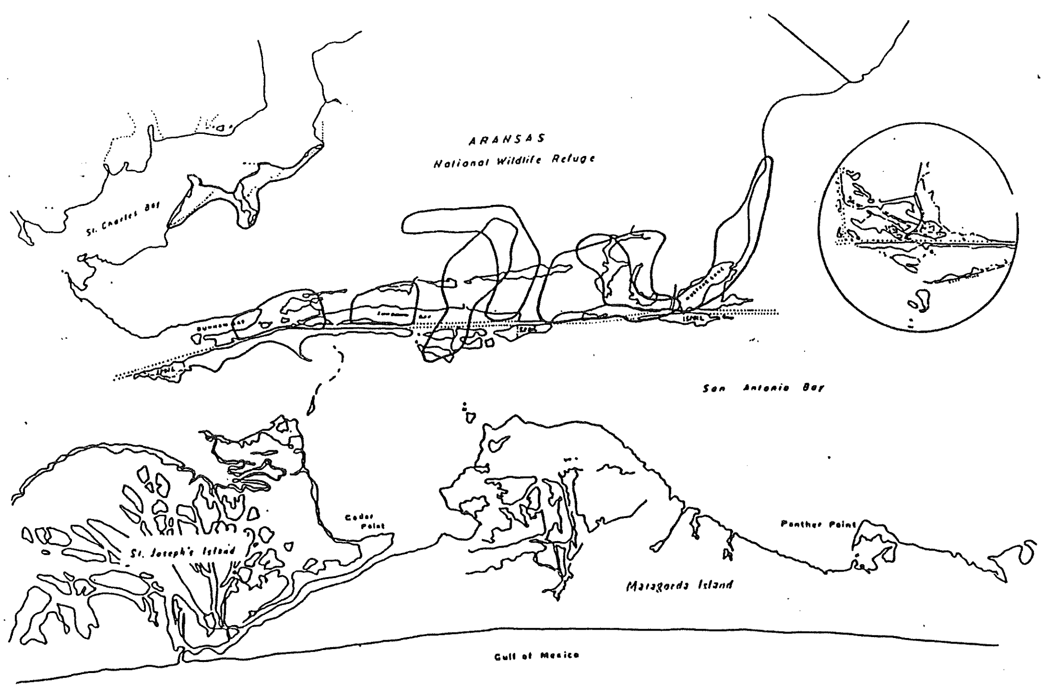

Fig. 2. Whooping crane winter territories at Aransas National Wildlife Refuge in 1950-51

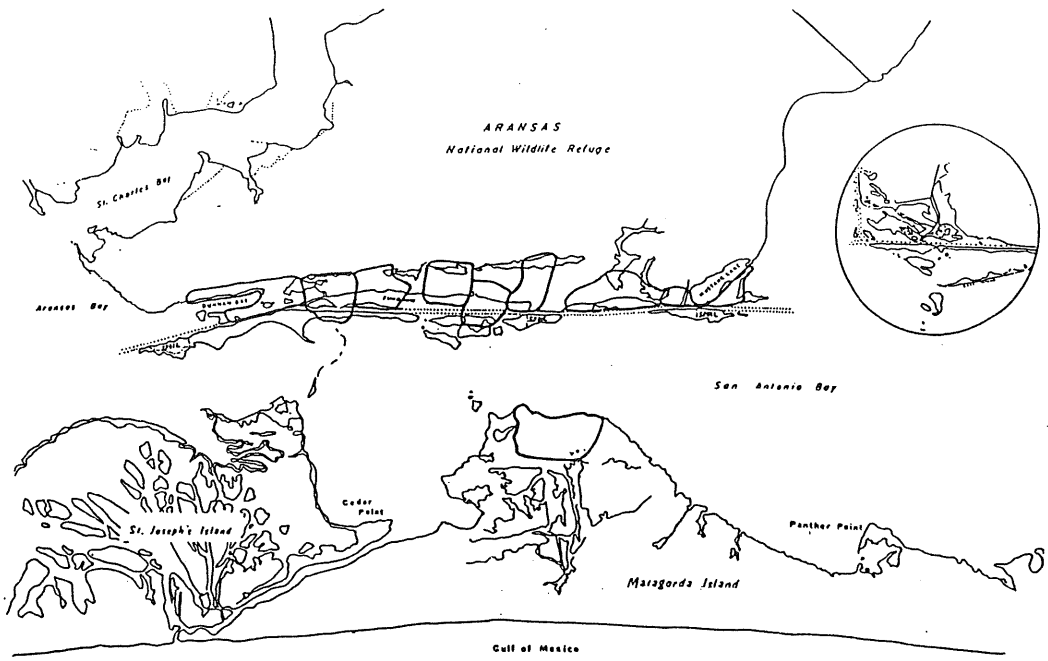

Fig. 3. Whooping crane winter territories at Aransas National Wildlife Refuge in 1961-62.

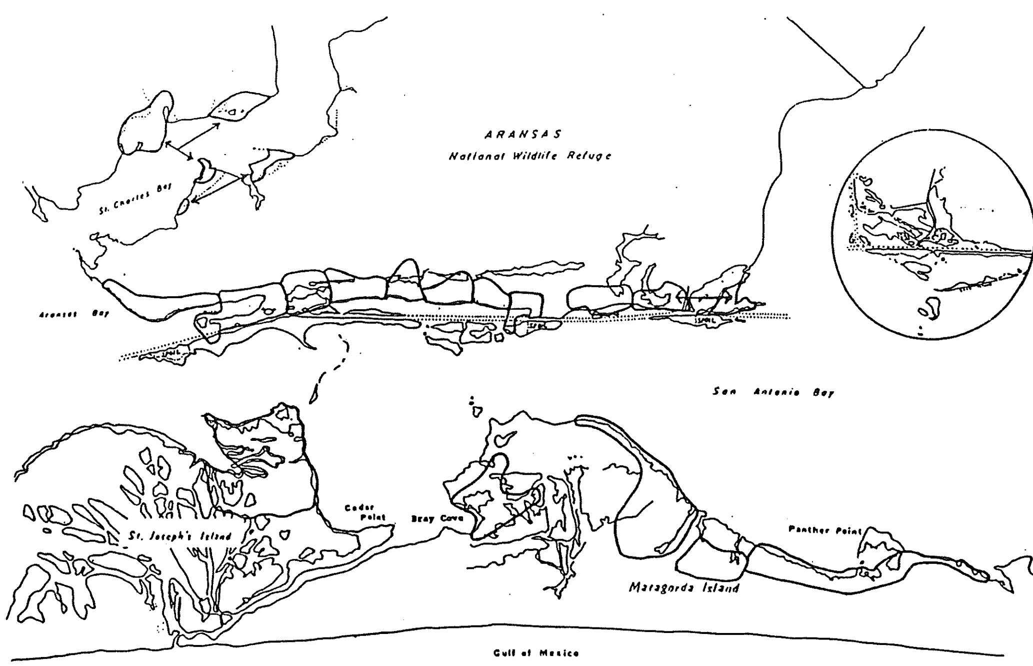

Fig. 4. Whooping crane winter territories at Aransas National Wildlife Refuge in 1971-72

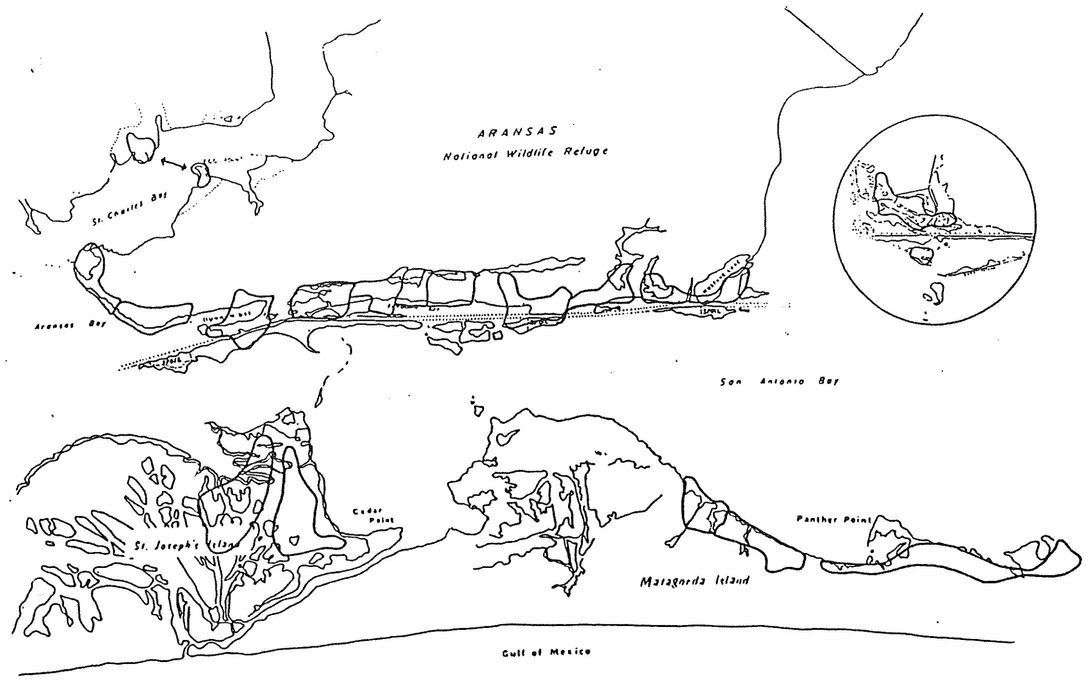

Fig. 5. Whooping crane winter territories at Aransas National Wildlife Refuge in 1979-80.

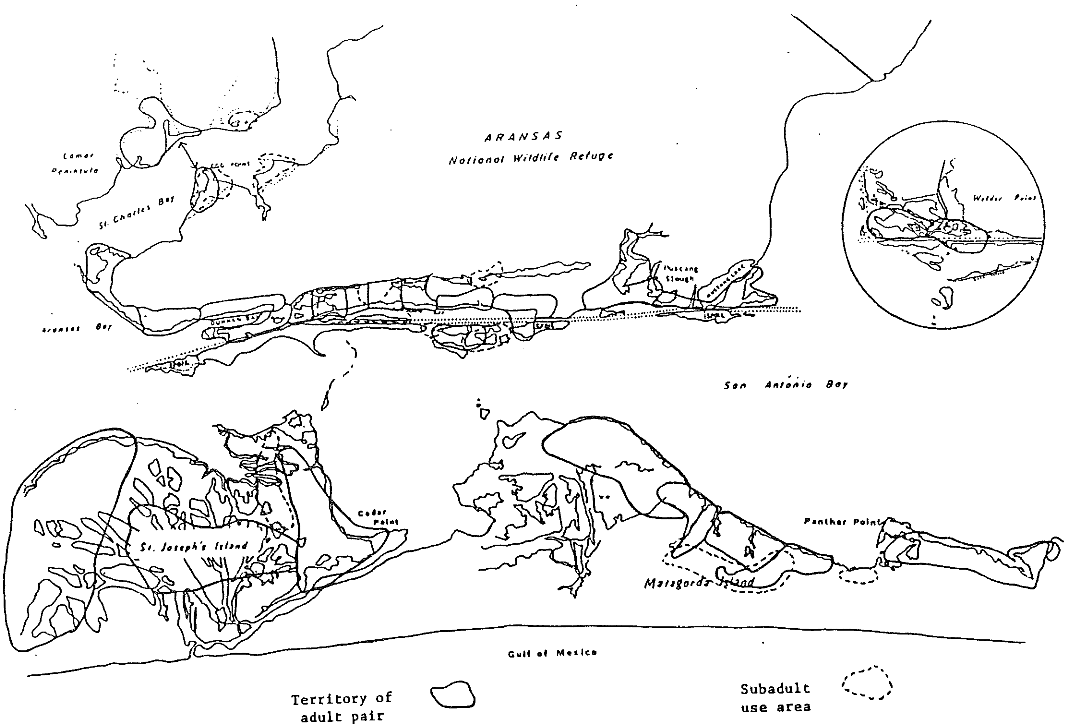

Fig. 6. Whooping crane winter territories at Aransas National Wildlife Refuge in 1982-83

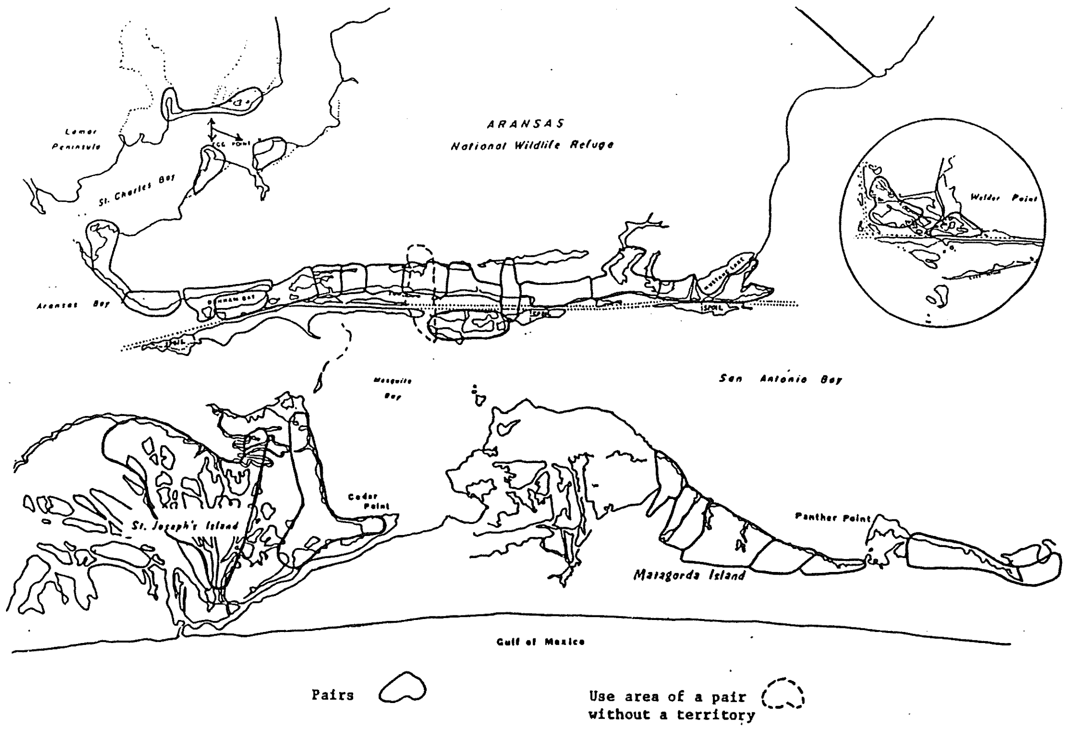

Fig. 7. Whooping crane winter territories at Aransas National Wildlife Refuge in 1983-84.

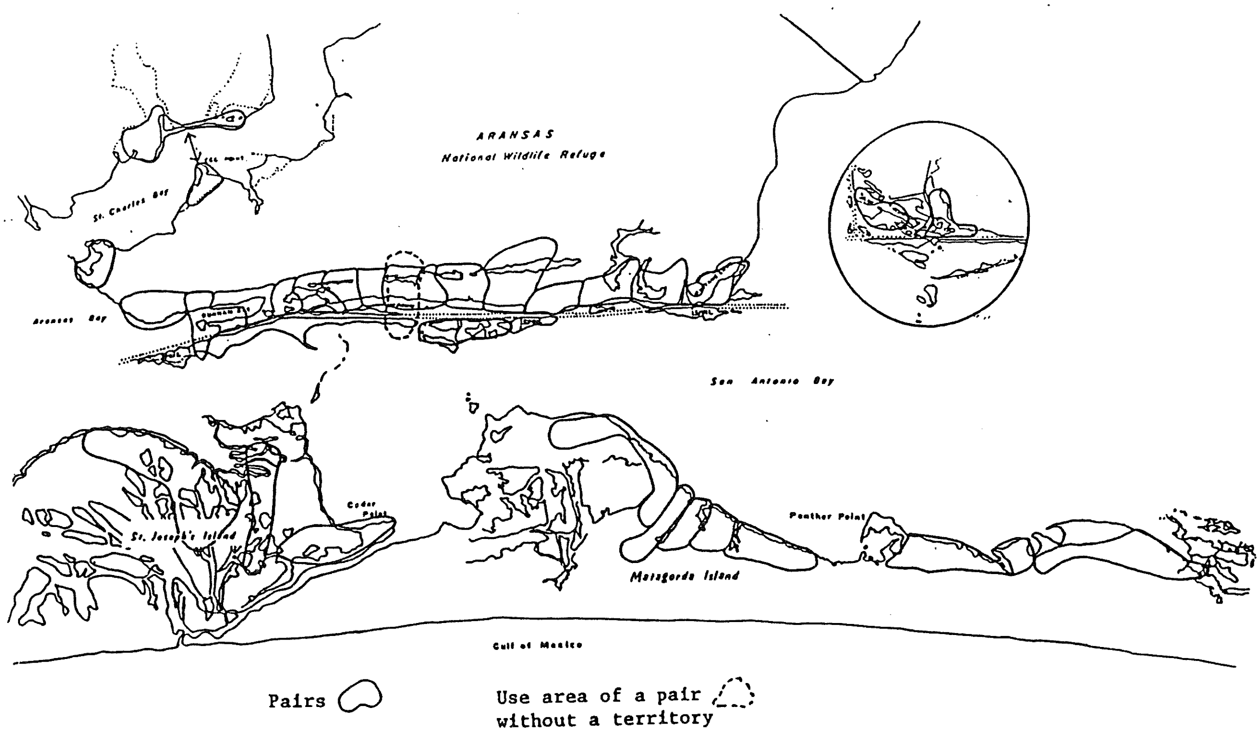

Fig. 8. Whooping crane winter territories at Aransas National Wildlife Refuge in 1984-85

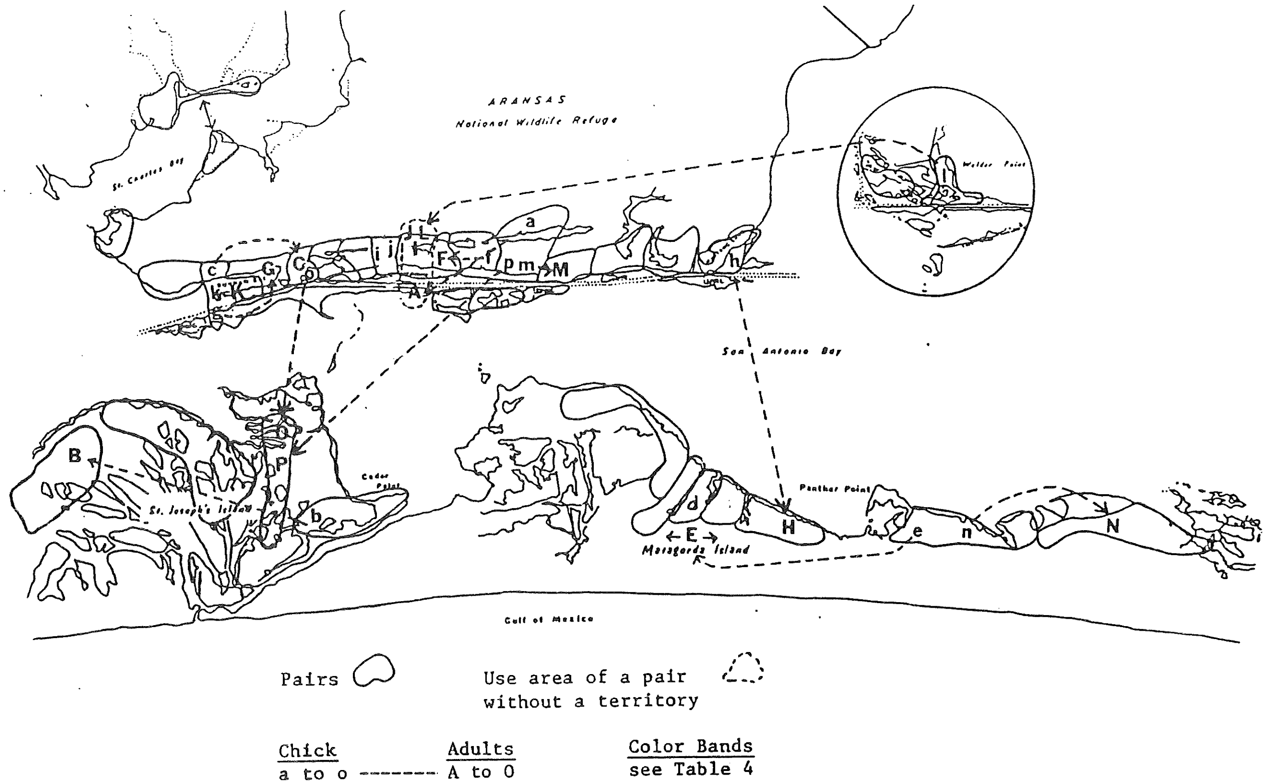

Fig. 9. Whooping crane chick to adult winter territories at Aransas National Wildlife Refuge 1980-81 through 1984-85.

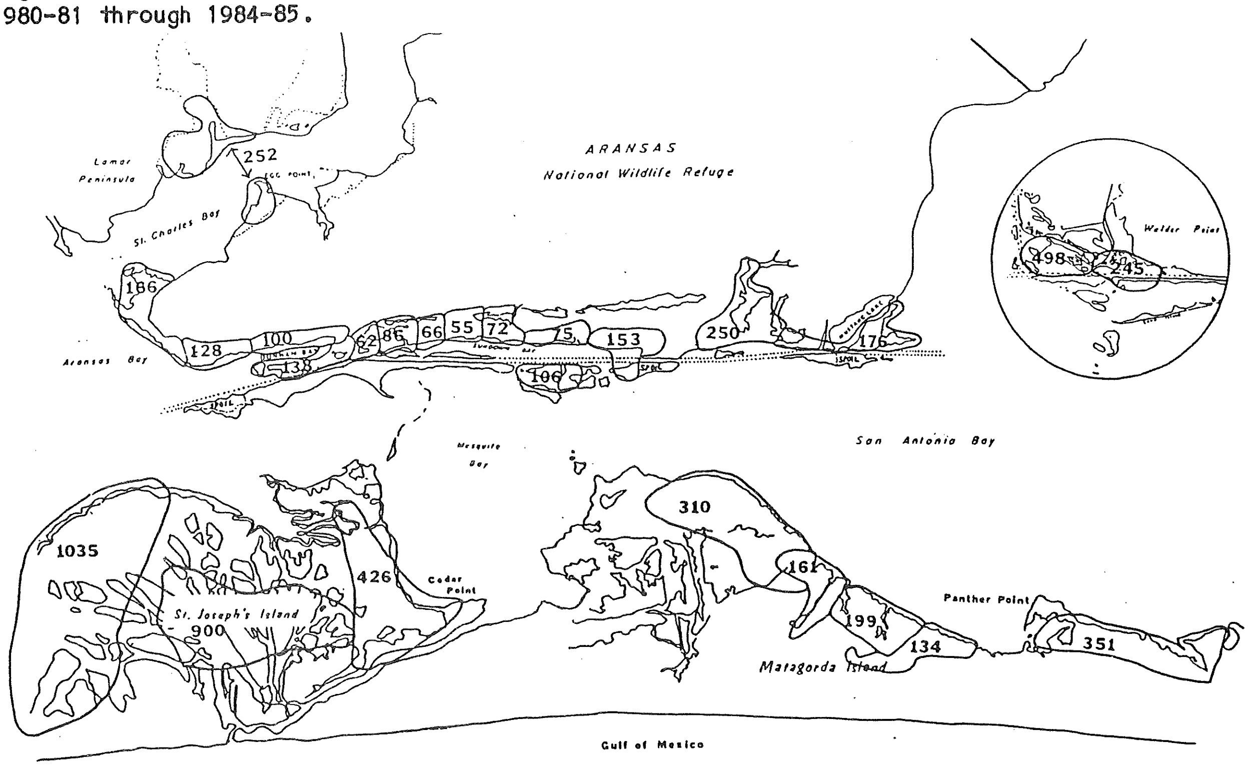

Fig. 10. Whooping crane winter territory sizes (hectares) in 1982-83.

included as traditional range of the whooper. With the many thousands of hectares on the middle Texas coast that look similar to the traditional wintering areas of the whooper, many questions arise. Do the unoccupied areas differ in food availability, water depths, bay bottom soils or other factors; or is there an inbred homing instinct for offspring to return to their parents' winter territory? These questions may one day be answered, but for the purpose of this study a factual look was taken at winter territories of paired adults over a period of 34 years.

Winter territories derived from aerial census data are shown for the winters of 1950-51, 1961-62, 1971-72, 1979-80, 1982-83, 1983-84, and 1984-85 (Figs. 2-8) with statistics summarized in Table 3.

Heavy crane use has occurred along the refuge's east shore marshes since records have been kept beginning in the late 1930's. Some of these territories have stayed remarkably consistent for at least the past 34 years. For example, there have been pairs at Mustang Lake, Mustang Slough, Sundown Bay, and Dunham Bay for all of the years listed above. The number of territories along the refuge's east shore has increased from 6 in 1950-51, to 10 in 1971-72, and 16 in 1984-85.

Early records of cranes on Matagorda, San Jose, and Welder Point indicate these areas are traditional crane use areas. The number of territories on Matagorda has increased from zero in 1950-51, one in 1961-62, to the present total of seven. San Jose territories have increased from one in 1971-72 to three in 1984-85. A territory was first established on Welder Point in 1973-74 and a second pair took up winter residence in 1978-79 (refuge files).

The banding of cranes initiated in 1977 has been a breakthrough in learning where individual birds spend their time as chicks, subadults, and as breeding adults. Sixteen banded cranes have become members of breeding pairs, although only 12 are currently surviving (Table 4). Two pairs currently have both cranes banded.

Table 4 identifies banded whooping cranes (A through P) that are now or have been paired. We are defining pairing as establishment of a winter territory and/or attempt at nesting. Eight known males have paired with unmarked females. Only one known female has paired with an unmarked male. Two cranes of unknown sex paired with unmarked birds. Three pairs have had both partners with color bands. It appears that males will generally pair at 3-4 1/2 years of age, whereas the 3 known females averaged 5 years of age at pairing.

Pairs may defend a winter territory before their first nesting attempt (Bishop 1984). Conversely, known breeding pairs have failed to establish winter territories. For example, crane pair A and J that nested for the first time in 1983 failed in the following winter to squeeze into the already crowded territories adjoining Sundown Bay. The pair was observed with subadults on eight occasions and as a separate pair five times between November, 1983 and March, 1984. The pair remained near Sundown Bay close to where the male had wintered as a chick. This pair was not seen in the winter of 1984-85 and is presumed dead. Cranes I and L that nested in 1984 (Kuyt, pers. com.) similarly failed to establish a territory in Sundown Bay and was usually observed with one banded subadult. Crane pair O and P used an area on San Jose but were also seen on several occasions on the refuge where the male had wintered as a chick before they were presumably chased off by a territorial pair. It is not known if failure to establish a winter territory is related to individual behavioral characteristics, the relatively young age of the pair, or is a result of intraspecific aggression resulting from the increased number of territories on the refuge.

Lower case letters indicate the territories in which banded chicks (a through p) spent their first winter with their parents (Fig. 9). Upper case letters show the territories defended during the winter of 1984-85 by these paired adult cranes. Almost without exception, the paired adults established a territory adjacent to the area where one or the other of the pair spent its first winter as a chick. We postulate that the adult territory of a mated pair will be established as close as possible to the area where the male spent its first winter as a chick. Observations suggest that subadults spend a high percentage of their time in the vicinity of their first winter territory. However, subadult cranes tend to wander more and move between different use areas.

The use of areas near first-year wintering grounds for adult territories is quite apparent in the refuge's Sundown Bay and Dunham Bay areas. As illustrated, cranes C, D, F, G, and M have squeezed into territories adjacent to their parents, thus shrinking the acreage formerly occupied by their parents and other paired adults. Crane K has pair bonded with an unmarked male crane in the area where she spent her first winter as a chick. One exception is crane F that was raised on the refuge and established an adult territory on Matagorda Island. Crane N

Table 4. Paired whooping cranes with bands.

Year banded	Sex[a]	Band colors	Mate	Age at pairing[b]	Chick	Adult
1977	F	R-G[c]	BWB-g/r	6	a	A
	M	R-W[c]	No bands	3	b	B
	M	B-R	No bands	4 1/2	c	C
	M	R-nil[cd]	No bands	3	e	E
1978	M	RWR-W	No bands	3 1/2	f	F
	M	RWR-B	No bands	3 1/2	g	G
	M	RWR-nil	No bands	5	h	H
	-	RWR-O	BWB-r/w	6	i	I
1979	M	BWB-g/r[c]	R-G	4	j	J
	F	BWB-R[e]	No bands	5	k	K
	-	BWB-r/w	RWR-O	5	l	L
	M	r/w-BWB	No bands	4 1/2	m	M
	-	R-BWB	No bands	4 1/2	n	N
1980	M	R-r/b	r/b-R	4 1/2	o	O
	F	r/b-R	R-r/b	4 1/2	p	P
	M	R-r/w	No bands	4	d	D

[a] Sex as determined by Bishop (1984).
[b] Data from Kuyt (pers. comm.) and refuge files. Ages 3 1/2 and 4 1/2 indicate pairing observed at Aransas before nesting.
[c] No longer surviving in 1984-85.
[d] Sightings as an adult occurred on Matagorda Island, but location of territory undetermined.
[e] Sex determined when injured mate captured in fall, 1984.

was raised on Matagorda Island adjacent to Panther Point as a chick in 1979. It paired in 1983-84 and used the marsh just south of Panther Point. In 1984-85, the pair was seen on two occasions south of Panther Point, but spent the remainder of the winter north of Panther Point. Crane B was a chick on San Jose in 1977, and in 1980 had its adult territory also on San Jose.

The map showing 1982-83 territories (Fig. 6) turned out to be a very good tool in predicting where new 1982-83 territories would be established. During 1982-83, areas of undefended marsh existed on the refuge south of Mustang Slough and on Matagorda Island south of Panther Point. The following winter, newly formed pairs (cranes M and N, both with unbanded mates) established winter territories in these exact locations (Fig. 7).

The size of territories during 1982-83 is shown in Fig. 10. Although territories overlap and some areas are shared by adjacent pairs (Blankinship 1976), the territories are shown as non-overlapping units simply for ease of depicting the different defended areas. Thus, the areas shown reflect the minimum are defended and not the overall area used by pairs. Also, territory boundaries were based primarily on weekly aerial locations. More frequent locations would presumably have increased territory sizes somewhat, although use patterns are generally very consistant.

The role of intraspecific interactions in limiting the size of crane territories has also become apparent. On the refuge, the smallest territories are found in the crowded Sundown Bay area along the refuge's eastern shore (Fig. 10). The territories at both ends of the eastern shore are larger than the average territory size on the refuge. Similarly, the two territories on the north and south ends of the crane use area on Matagorda Island are larger than the three territories in the middle. This size difference is presumably because the cranes on the "ends" can wander in one direction without encountering a neighboring pair and thus have larger territories. Territories are largest on San Jose Island where there is a huge acreage of marsh occupied by only three pairs of cranes.

Adjacent crane pairs are very aware of each others presence. A pair may utilize nearby portions of a neighboring pair's territory if their neighbors are located at the far end of their respective territory. During migration periods when some territories are vacant, cranes will wander extensively into the adjacent empty territory for days at a time. This demonstrates the role of intraspecific interactions in limiting the size of crane territories.

Allen (1952) found that the 14 territories he mapped along the refuge's east shore averaged 176 ha. However, these territories must not all have been permanent defended areas because Allen estimated the population contained only seven breeding pairs. Blanlinship (1976) during the 1971-72 winter mapped 10 territories in the same area that also averaged 176 ha. During the present study, 14 territories were mapped along the refuge's east shore for 1982-83. Areas ranged between 55 and 250 ha and averaged 117 ha. If areas shared by adjacent pairs are taken into account, the hectares used by crane pairs are larger than 117. However, it would still be significantly less than the 176 ha found by Blankinship (1976). Thus, refuge territories have become smaller over the past 11 years as more territories have been established.

During 1982-83, three territories were located on San Jose Island. These areas ranged from 426 ha to 1,035 ha in size and averaged 787 ha. Five defended areas were located on Matagorda Island in habitat that appears very similar to marshes on the refuge. Each Matagorda territory had frontage on the bay. The areas ranged from 134 ha to 351 ha and averaged 231 ha. The single territory on Egg Point/Lamar contained 252 ha.

Cranes on the refuge have demonstrated they will squeeze into areas of less than 100 ha. Assuming that crane habitat in the different use areas is of comparable quality, it is expected that additional crane territories will someday be located in the existing use areas on Matagorda, San Jose, and Welder Point. On the refuge, it seems reasonable to assume that a minimum acreage threshold is being approached. We expect that further expansion to other areas may occur rather than more and more cranes crowding onto the refuge as has been the rule in the past.

However, the refuge files contain reports that go back many years mentioning "crowding". The urge to set up a territory close to the first year winter territory may be so strong that cranes will continue to squeeze into refuge marshes with only limited expansion in the total occupied marsh.

On Matagorda Island, we anticipate that in addition to more territories being established in the present use area, expansion will occur to the north and south as chicks raised on Matagorda reach maturity. In 1971-72, a crane territory was established on the south end of Matagorda near Bray Cove. Since no other cranes were near, observations could not be made to determine if the area was defended by a pair (Blankinship, pers. com.). Instead, it is possible that two subadults consistently were found in the area. This territory was vacant the following year. Crane sightings in this area have been very infrequent up to the present time. In addition to the marsh void of cranes on South Matagorda, thousands of hectares of quality marsh exist north of the present occupied habitat. This area was used by the U. S. Air Force as a bombing range from 1941 to 1973 and these activities may have had a major impact in limiting crane use and/or expansion. In the past 20 years, little northwards expansion on Matagorda has occurred. Future expansion may occur much slower than anticipated if past trends are continued. The northernmost territory on Matagorda in 1983-84 included Panther Point. Crane use of this area dates back to 1958-59 with use recorded annually starting in 1962-63. The territory established there in 1968-69 has remained occupied to the present time. This territory extends northwards to the Twin Lakes area. However, in 1984-85, a new territory was established north of Twin Lakes.

Pioneering cranes have established territories in new areas on Lamar Peninsula in 1971-72 and on Welder Point in 1973-74. Lamar Peninsula is located across St. Charles Bay, approximately 2 km from the refuge's Egg Point. Occasional crane sightings on Lamar date back to 1950-51, but territories were not present until 1971-72. Welder Point is located across San Antonio Bay, 14 km northeast of the refuge's Mustang Lake. Records of cranes at Welder Point date back to 1938-1941. Subsequent sightings were made in 1944 and again in 1962. Occasional use was made of Welder point during 1964-65. On 21 November 1965, a family group was sighted in the area. because of the impending waterfowl hunting season, a helicopter was used on 23 November to "persuade" the family to leave the heavily hunted Welder Point marsh. The family flew to Panther Point on Matagorda Island, stayed 2 days, then moved to Mustang Lake on the refuge for the winter. Two cranes were again sighted on Welder Point in November, 1967, possibly migrant

Table 5. Banding record for whooping cranes of the Aransas-Wood Buffalo flock.[a]

		Wintering at Aransas NWR					
Year	Banded in Canada	Chicks	1-year-olds	2-year-olds	3-year-olds	4-year-olds	5-year-olds
1977	R-G	R-G					
	R-R	R-R					
	R-W	R-W					
	R-B	R-B					
	R-Nil	R-Nil					
	G-R	G-R					
	W-R	W-R					
	B-R	B-R					
	Nil-R	Nil-R[b]					
	9(+1 UnB)	9(+1 UnB)					Total: 9
1978	RWR-W	RWR-W	R-G				
	RWR-B	RWR-B	R-R				
	RWR-O	RWR-O	R-W				
	RWR-Nil	RWR-Nil	R-B				
	B-RWR	B-RWR	R-Nil				
	O-RWR	O-RWR	G-R				
	Nil-RWR	Nil-RWR	W-R				
	W-RWR	7	B-R				
	8		Nil-R				
			9				Total: 16
1979	BWB-R	BWB-R	RWR-W	R-G			
	BWB-G/R	BWB-G/R	RWR-B	R-R			
	BWB-R/G		RWR-O	R-W			
	BWR-R/W	BWB-R/W	RWR-Nil	R-B			
	R-BWB	R-BWB	Nil-RWR	R-Nil			
	R/W-BWB	R/W-BWB	5	G-R			
	6(+UnB)	5(+1UnB)		W-R			
				B-R			
				8			Total: 18
1980	R/W-R	R/W-R	BWB-R	RWR-W	R-G		
	R-R/B	R-R/B	BWB-G/R	RWR-B	R-R		
	R-R/W	R-R/W	BWB-R/W	RWR-O	R-W		
	R/B-R	R/B-R	R-BWB	RWR-Nil	R-Nil		
	R-B/R	4(+2UnB[c])	R/W-BWB	Nil-RWR	G-R		
	B/R-R		5	5	W-R		
	6(+2UnB)				B-R		
					7		Total: 21
1981	G-R/W[d]	G-R/W	R-R/B	BWB-R	RWR-W	R-G	
	W-R/W[h]	W-R/W	R-R/W	BWB-G/R	RWR-B	R-R	
	R/W-G[h]	2	R/B-R	BWB-R/W	RWR-O	R-W	
	3		3	R-BWB	RWR-Nil	R-Nil[e]	
				R/W-BWB	Nil-RWR	G-R	
				5	5	B-R	
						6	Total: 21
1982	W-R/R[h]						
	R-B/W[h]						
	G-W/R[h]	G-W/R	G-R/W	R-R/B	BWB-R	RWR-W	R-G

(continued next page)

Table 5 (cont.). Banding record for whooping cranes of the Aransas-Wood Buffalo flock.[a]

Year	Banded In Canada	Wintering at Aransas NWR						
		Chicks	1-year-olds	2-year-olds	3-year-olds	4-year-olds	5-year-olds	
1982 cont.	W-R[h] R/R-B[h] B/W-R[h] W/R-G[h] 7(+1UnB)	W-R R/R-B B/W-R[f] W/R-G[g] 5(+1UnB)	1	R-R/W R/B-R 3	BWB-G/R BWB-R/W R-BWB R/W-BWB 5	RWR-B RWR-O RWR-Nil Nil-RWR 5	R-R R-W[h] G-R B-R 5	
							Total:	24
1983	R-Y[h] Y-B/B[h] Y-Y/R[h] BWspiral-R B/W-R/B B/B-Y[h] B/R-W[h] W-G[h] W-R/Y[h] Y/R-G[h] 10(+ZUnB)	R-Y[i] Y-B/B Y-Y/R BWsprial -R B/W-R/B B/B-Y 6(+1UnB)	G-W/R W-R R/R-B 3	G-R/W 1	R-R/B R-R/W R/B-R 3	BWB-R BWB-G/R R-BWB R/W-BWB BWB-R/W 5	RWR-W RWR-B RWR-O RWR-Nil Nil-RWR 5	R-G R-R G-R B-R 4
							Total:	27
1984	W-B B-W Y-Y WBW-R WBW-Y Y-WBW Y-BWsp BWsp-Y BWsp-W BWsp-BWsp R/R-WBW B/Y-B/Y Y-W 13(+5UnB)	W-B B-W[j] Y-Y WBW-R WBW-Y Y-WBW Y-BWsp BWsp-Y BWsp-W BWsp-BWsp 10(+5UnB)	R-Y[i] Y-B/B Y-Y/R[l] BWsp-R B/W-R/B B/B-Y 6	G-W/R[k] W-R R/R-B 3	G-R/W 1	R-R/B R/B-R 2	BWB-R R-BWB R/W-BWB BWB-R/W 4	RWR-W RWR-B RWR-O RWR-Nil 4	R-r/w G-R B-R 3
							Total:	33

[a] Bands read left leg-right leg. "/" indicates 2-40 mm bands on same leg. All other bands are 80 mm. R = Red, G = Green, W = White, O = Orange, Y = Yellow, BWB = Blue, white, blue, BWsp = Blue, white spiral, nil = no color band, UnB = Unbanded

[b] Never sighted at Aransas. Sightings in N. Dakota and Kansas during migration with sandhill cranes indicated bird may have wintered elsewhere.

[c] Unbanded chick last sighted at Aransas in December 1980. Presumably dead.

[d] Indicated radioed crane.

[e] Sighted during fall, 1983 migration.

[f] Found dead at Aransas 1-4-83.

[g] Found dead at Aransas 2-2-83.

[h] Band never read due to inaccessibility. Bird presumed present based on location of pair on St. Joseph's Island.

[i] 40 mm red band.

[j] Spent the winter 65 miles NE of the refuge with sandhill cranes near El Campo, Texas.

[k] Died on the refuge 11-15-84 from avian predator.

[l] Last located on the refuge on 11-21-84. Presumed dead.

cranes that had stopped short of the refuge. A territory established on Welder Point in 1973-74 has remained occupied up to the present time. That first year, a chick wintered on Welder Point with its parents. In 1978-79, a second pair established a territory on Welder. To speculate, perhaps the 1973 Welder chick reached maturity and established the second Welder territory. It does appear that future crane expansion will be strongly influenced by which pairs successfully bring chicks to Aransas.

In addition to the areas mentioned above, other suitable marsh that someday may be used by whooping cranes includes that on Mission Bay located 22 km west of the refuge, and marshes at the mouth of the Guadalupe River, located 13 km north of the refuge headquarters (Fig. 1).

During 1984-85, 29 wintering pairs have been identified. Past data (Table 3) show close correlation between the number of winter territories and the number of nests found the following summer. Thus, we anticipate 29 nesting pairs in Wood Buffalo during 1985. Through the banding of chicks that began in 1977, and the more recent inclusion of banded cranes in mated pairs, the nesting and wintering grounds are known for approximately 22 of the current 29 pairs. Three pairs with winter territories at Redfish Slough, Dunham Point, and Blackjack Point, have not raised a chick since 1977, and their specific summer nesting sites are unknown.

The 1984-85 Aransas flock consists of 58 adults, 13 subadults, and 15 chicks. Thirty-three of the 86 cranes are banded, including 12 adults, 11 subadults, and 19 chicks. However, two radioed subadult cranes died and/or turned up missing at Aransas during the winter. Thus, the flock is estimated at a maximum of 84 in March 1985. The banding record for the Aransas flock is shown in Table 5. Radioed cranes present include one each from 1981, 1982, and 1983. The radios are still functioning although the 1981 radio has extremely limited range, probably due to a broken antenna. The average crane distribution during 1984-85 is shown in Table 6.

As the crane population has increased from a low of 15 in 1941-42 to 84 at the end of the 1984-85 winter, most pairs have established territories in traditional use areas rather than expanding their range over considerable portions of the Texas coast. The concept of crowding that has appeared in refuge correspondence for over three decades, that could result in new crane pairs having to establish territories outside of the current crane use area, is still not defined. One management implication of this study indicates that there is sufficient habitat to support a minimum of 40 mated pairs - a prime objective in the 1980 Whooping Crane Recovery Plan. If the whooping crane is to continue on the road to recovery, it is imperative that management efforts maintain the environmental quality of all habitat discussed in this paper.

Table 6. 1984-85 average crane distribution at Aransas,[a] 1984-85.

	Refuge	Egg Point /Lamar	Mata- gorda	San Jose	Welder	Totals
Adults	32	2	14	6	4	58
Subadults	4	0	2	4	1	11
Chicks	5	1	5	2	1	14
Totals	41	3	21	12	6	83

[a] Data does not include one chick that wintered at El Campo, Texas, or two radioed subadults that died.

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WINTERING OF GREATER SANDHILL CRANES IN FLORIDA

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Abstract: Use by wintering sandhill cranes (Grus canadensis tabida) has declined on state-owned areas of Florida over the past 15 years. The decreasing use is related to changes in management practices. A large part of the Eastern migratory population now winters on private land. Recommendations are presented for managing an area of historic use in a manner more compatible with crane habitat requirements. State acquisition of a marsh/cropland complex, intensively used by approximately 33% of the Eastern greater sandhill crane population during 1983-84, has been proposed.

PROCEEDINGS 1985 CRANE WORKSHOP

Crete and Toepfer (1978) and Anderson et al. (1980) expressed concern over current and future greater sandhill crane (GSC) wintering habitat loss to housing and agricultural developments. The uncertain future of private lands as secure wintering areas underscores the importance of state-owned properties utilized by cranes. Williams and Phillips (1972) identified Paynes Prairie, Alachua County, Florida, as the most important sandhill crane wintering area in the eastern United States. They applauded State acquisition of this area and recommended that sandhill cranes receive "high priority consideration in any plans for development and use of this property by the State of Florida". By 1977, however, sandhill crane use of Paynes Prairie as a wintering area had declined; many greater sandhill cranes that previously wintered there were apparently wintering elsewhere (Nesbitt 1977). This decline was attributed to the elimination of cattle grazing and ineffective fire and water management. Vegetation had become too rank, making much of the area unattractive to cranes. Nesbitt (1977) expressed the hope that this unfortunate trend would be reversed by implementing management practices more conducive to crane habitat preferences.

We have examined the recent status of Paynes Prairie as a GSC wintering area to see if habitat conditions have improved on this important area since 1977. In addition, we tried to ascertain if and where cranes that originally wintered on Paynes Prairie had moved, and whether any other sites in Florida warranted protection.

METHODS

We compared a combination of Christmas bird counts and various Florida Game and Fresh Water Fish Commission estimates of cranes on Paynes Prairie with available GSC fall population counts for the Eastern population from 1968 to 1984. Between 1983 and 1985, we attempted to locate wintering concentrations in Madison, Putnam, Alachua, Lake, and Marion counties. Time constraints prevented a more thorough statewide survey. We monitored flocks for the presence of individually marked cranes originally color-banded (Nesbitt et al. in press) on Paynes Prairie. Based on our understanding of local Florida sandhill crane (G. c. pratensis) population densities, we did not believe that the number of Florida cranes wintering in the same areas would significantly inflate our GSC estimates. Only individually marked cranes known to be of the tabida subspecies were considered in the analysis.

RESULTS

Status of Cranes Wintering On Study Areas

Since 1968, the GSC population has increased approximately fourfold, as evidenced by counts at Jasper Pulaski, Indiana (Table 1). Jasper Pulaski is a fall stopover area where 68% to 90% of the Eastern GSC population stops enroute to Florida (Table 1). The estimated peak

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Table 1. Winter population estimates of the Eastern Population of greater sandhill cranes.

Year	Jasper Pulaski[a]	Total Eastern GSC population[a]	Peak winter population Paynes Prairie, Florida	Paynes Prairie and vicinity[b]
1968	2,700		600[c]	10
1969	3,200		1,000[c]	500
1970	4,300		1,800[c]	600
1971	4,300		800[c]	570
1972	5,000			687
1973	7,500			971
1974	8,700			407
1975	8,500			392
1976	12,100			579
1977	8,746		400[d]	338
1978	12,928			331
1979	11,990	14,385		403
1980	10,700	15,125		328
1981	10,813	12,001	300(preburn) 1,500(postburn)	1,469
1982	10,306	13,879		432
1983	11,053	16,148	300	267
1984	11,694[e]	16,363[e]	750	693

[a] U.S. Fish and Wildlife Service 1983.
[b] Alachua County Audubon Society Christmas Bird Counts.
[c] Williams and Phillips 1972.
[d] Nesbitt 1977.
[e] Schumann, L. 1985. The Unison Call. Vol. 7:(1) 2 pp.

population wintering on Paynes Prairie has varied from a known high of 1800 in 1970 (42% of the total Eastern population) to a low of 300 in 1983 (0.02% of the total Eastern population).

Table 2 and Fig. 1 depict the numbers and locations of cranes concentrating on Paynes Prairie and private lands in Putnam, Madison, Alachua, Lake, and Marion counties. During the winter of 1983-84, 300 cranes were counted on Paynes Prairie. Of these, 65 regularly roosted on the prairie but flew to private lands along the eastern edge of Paynes Prairie to feed. The remainder both fed and roosted in Paynes Prairie marshes. In 1984-85, 750 wintered on Paynes Prairie (5% of the total Eastern population) and none occurred on the eastern edge. This complete shift off private lands on the east side coincided with an October 1984 controlled burn on the east side of Paynes Prairie. One hundred and fifty cranes were checked for color-bands on this burn; the other 600 were inaccessible. In 1981, a similar situation demonstrated wintering cranes' willingness to return to Paynes Prairie when habitat conditions are suitable. This same section of the prairie (traditionally the most heavily utilized by wintering cranes) was burned during November, resulting in an increase from 300 to 1500 birds. Nonetheless, 1500 cranes in 1981 represented only 12.5% of the total estimated GSC population. Clearly, there is still reason to be concerned over GSC use of Paynes Prairie.

The fall and winter 1982-83 and 1983-84 had reduced amounts of burning on Paynes Prairie with a corresponding decline in winter crane use. In 1983-84, two cattle ranches located south and west of Paynes Prairie contained 250 and 300 cranes and two other areas, Orange Lake muck farms and Archer agricultural fields in Alachua County, yielded an additional 2500 birds (Table 2, Fig. 1). In 1984, these ranches south and west of the Prairie wintered flocks of 350-400 and 300, respectively. The Orange Lake area was utilized by up to 800 birds and the Archer area contained a maximum of 500 birds. The other wintering/feeding areas surveyed, Emeralda marsh/muck farms and Oklawaha muck farms, were used by 5000 and 160 cranes, respectively, during 1983-84 (Table 2, Fig. 1) (we received unconfirmed reports of as many as 4000 additional

Table 2. Estimated wintering GSC populations and the number of color-banded cranes per area. Numbers in parentheses are total number of cranes checked for color-bands.

Wintering area	1983-1984	Color-banded cranes	1984-1985	Color-banded cranes
Private land east of Paynes Prairie and/or Paynes Prairie	300(65)	28	750(150)	25
Archer	1500(600)	34	1500(500)	2
Private lands west and south of Paynes Prairie	550(550)	48	650+(650)	16
Orange Lake Muck Farms	1000(1000)	15	800(800)	7
Oklawaha Muck Farms	160(160)	7	5000-6000(0)	?
Emerald Marsh/Muck Farms	5000(3000)	7	750-1000(1000)	5
Total	8510	139	9450-10700	55

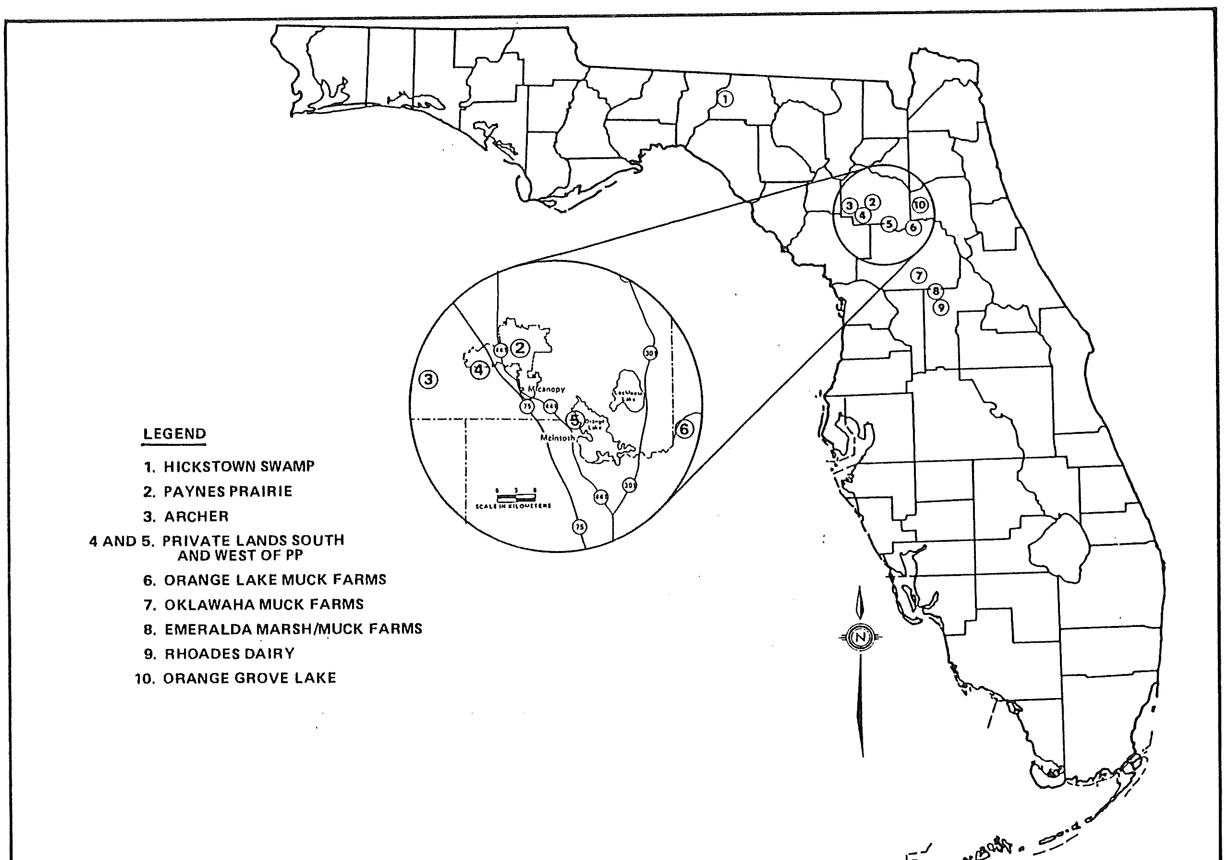

Fig. 1. Numbers and locations of cranes concentrating on Paynes Prairie and private lands in Putnam, Madison, Alachua, Lake, and Marion counties.

cranes in the vicinity of Ocala National Forest in 1983-84). A conservative estimate of 8510, combined with the approximately 1000 birds that overwintered at Okefenokee NWR (D.J. Voros, pers. comm.), accounts for 59% of the 1983 GSC population. In 1984, 750-1000 birds utilized Emeralda farms and 5000-6000 were in the Oklawaha area. In 1984, a conservative estimate of 9450 on our study areas, plus 1000 Okefenokee birds, a flock of 500 in Madison County, and another inaccessible wintering group of at least 300 birds in Putnam County totals 11,250 or 69% of the 1984 Eastern GSC population (Table 1).

Movements of Wintering Color-marked Cranes

A portion of these color-marked birds formerly wintered on Paynes Prairie, as substantiated by observations of birds (orginally trapped on Paynes Prairie) wintering on these sites (Table 2). As mentioned, some color-marked birds roosted on the Prairie and fed on private lands to the east. The Putman County and Madison County flocks, and the Oklawaha population, were inaccessible for observation during 1984-85. These other sites represent complexes of roosting and feeding sites that appeared to be discrete during a particular winter.

Of the 34 color-banded tabida seen on agricultural fields near Archer, 10 were also sighted on the ranches south and west of Paynes Prairie, and 1 was seen earlier in the winter at Oklawaha. Nine color-banded cranes were seen on private lands south, west, and east of Paynes Prairie. Thus, there was interchange between these wintering areas but very little interchange from more distant wintering locations. However, a color-marked bird seen in the Archer area was seen only once east of Paynes Prairie.

Of the 15 marked cranes observed on Orange Lake Muck Farms, 2 were also observed either south or west of Paynes Prairie, 2 were seen earlier in the season at Emeralda Marsh farms, and 2 were seen east of Paynes Prairie. There apparently was no interchange between Orange Lake muck farms and the Archer area.

There was considerably less movement of color-banded cranes between the various wintering sites in 1984-85. Of the 25 banded cranes seen on the Paynes Prairie burn, 1 had been sighted at Orange Lake Muck farms, and 2 were seen at ranches south and west of Paynes Prairie earlier this year. There were no migratory cranes on properties east of Paynes Prairie. One crane seen at Emeralda Marsh in December 1984 showed up southwest of Paynes Prairie in March 1985. This bird was probably enroute during spring migration. We checked the 1983-84 wintering site use of the 1984-85 Paynes Prairie birds to determine whether improved habitat conditions on Paynes Prairie had drawn birds back from other sites. Ten had previously wintered just east of Paynes Prairie, 3 had moved back from ranches south and west of Paynes Prairie, 2 from Orange Lake, and 2 from the Archer area. Three birds that moved between lands east, south, and west of the Prairie, the Archer area, and Orange Lake in 1984 had likewise returned to winter on Paynes Prairie in 1985. Thus, 40% of the color-banded birds seen on Paynes Prairie had wintered the previous year on lands closest to that portion of Paynes Prairie traditionally used most heavily in the past. However, the return of nine others (36%), indicates that birds will move from other sites back onto wintering areas in response to habitat improvements. We surmise that there were probably many more color-banded cranes in the flock of 650 on Paynes Prairie that we could not check. It is likely that some of the reductions in densities noted in 1984-85 on private wintering sites represented the return of cranes to Paynes Prairie.

The Emeralda Marsh and Oklawaha area sightings for both winters may be interpreted two ways. These birds may have stopped off temporarily on Paynes Prairie during fall or spring migration. We compared banding dates with months in which these cranes were seen at Emeralda Marsh and Oklawaha muck farms and, for the most part, the data support this theory. It is also possible that with more suitable habitat conditions, some or all of these cranes would have remained on Paynes Prairie instead of wintering farther south.

DISCUSSION AND RECOMMENDATIONS

The problems associated with wintering cranes' use of private lands are myriad:

1) Complaints of crop depredation are becoming commonplace and the State of Florida has no means of compensating owners for their losses.

2) The heavy concentration of cranes in one relatively self-contained marsh/cropland complex (Emeralda Marsh or Oklawaha) without management capability put a significant portion of the GSC population at risk through disease transmission, pesticide contamination, or some other catastrophic event.

3) At the present time, cranes are feeding in corn, rye, and peanut fields or in fields in which these crops were formerly planted. Any change in crop types (e.g., to watermelons) could limit feeding areas for cranes. Moreover, the conversion of wetlands to intensive agricultural use is degrading the non-agricultural winter crane habitat.

The agency responsible for managing Paynes Prairie, The Department of Natural Resources, has implemented a controlled burning program in recent years on a 3 year rotation. Our observations on color-marked cranes indicate that wintering birds will return to traditional areas when habitat conditions remain suitable. The immediate response by cranes to both the November 1981 wildfire and the fall 1984 controlled burn bodes well for the future of Paynes Prairie as a major GSC wintering area. However, the current wintering GSC population is nowhere near the capacity of Paynes Prairie. The recent improvement in management of the prairie for wildlife has resulted in increased winter crane use that is commendable. An annual goal of 607-810 ha burned, grazed, or mowed in the fall to produce suitable over-wintering acreage should produce the optimum conditions for wintering an appropriate number of migratory cranes. This amount of habitat should attract cranes from surrounding private lands and any present or potential crop depredation problems could be alleviated.

In September 1984, we submitted a proposal for State of Florida acquisition of Emeralda Marsh and most of the surrounding muck farms. State control of this area and proper management would provide an ideal opportunity for maintaining this marsh/cropland complex for cranes, waterfowl, and other wildlife. Problems associated with pesticides, changes in crop types, and depredation would be controlled. Moreover, the crane population could more easily be monitored for any disease outbreaks. As of March 1985, the proposal had survived the first cut and is currently 1 of 30 proposals being reviewed.

Continued restoration of suitable habitat on Paynes Prairie and the acquisition and management of Emeralda Marsh would enhance opportunities for the nonconsumptive use of cranes, as recommended in the Management Plan for the Eastern population of greater sandhill cranes (U.S. Fish and Wildlife Service 1983). Both areas are highly suitable for crane observation and photography by the general public.

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