REPRODUCTIVE PHYSIOLOGY OF SANDHILL CRANES DURING WINTER AND SPRING

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Our purpose is to describe winter and spring changes in gonad size and blood hormone levels of adult sandhill cranes (Grus canadensis) from mid-continental North America. Little has been published about cyclic changes in reproductive physiology of sandhill cranes or other Gruiformes. Knowledge of the relationships between seasonal reproductive development and external stimuli aid in understanding the reproductive strategies of this K-selected, migrant species that does not breed until at least 3-4 years of age (Drewien 1973).

A number of ultimate and proximate factors (both external and internal) have been linked to control of periodic reproduction (Lehrman 1959, Marshall 1959, Immelman 1971). Immelman (1979) suggested daylength as a major proximate factor influencing annual reproductive development in migratory birds breeding at middle and high latitudes. Immelman further suggested that annual reproductive development of the male of pairs breeding at high latitudes may be more susceptible to environmental stimuli than the female, and that the male may stimulate female reproductive development by courtship. Our study integrates daylength, gonadal development, changes in blood hormone levels, age of sexual maturity, and courtship behavior of adult males and females during winter and spring to better understand reproductive strategies of sandhill cranes.

METHODS

A total of 184 adult sandhill cranes was collected in western Oklahoma (10) and western Texas (85); the Platte River Valley near Hershey Nebraska (58); near Last Mountain Lake, Saskatchewan (13); and near Delta Junction (9) and Old Chevak, Alaska (9) between 17 October 1979 and 15 May 1980 and frozen for later analysis (Fig. 1). The sample was later divided (based on cheek patch color after Tacha 1985) into categories considered to represent breeding age and nonbreeding age adults. Of 59 cranes considered to be nonbreeding age adults, 34 were males collected on 20 separate days during the study period, and 25 were females collected on 15 days. Of 125 adult cranes considered to be of breeding age, 62 were males collected on 25 different days, and 63 were females collected on 27 different days. Length and weight of the left testis were recorded for males, and diameter of the largest follicle and ovarian weight were recorded for females.

A 10 ml blood sample was drawn from 84 of the cranes collected on 15 different days between February and 15 May 1980 and frozen for later determination of steroid hormone levels. Daylength was determined for all days that cranes were collected.

Blood levels of estrogen and testosterone were measured by a radioimmunoassay procedure using New England Nuclear Radioimmunoassay Paks (Testosterone, Cat. No. NEA-042S; Estrogen, Cat. No. NEA-044). This procedure involved a competition reaction between steroid hormone of the crane and an appropriate [^{3}H] labeled steroid hormone for a known number of antibody binding sites. The assay kits showed a sensitivity of approximately 10 picograms steroid hormone per ml of blood plasma.

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Plasma was separated by centrifugation and used for the analysis of steroid hormone content. For the analysis of testosterone in males, standard protocol supplied with the assay kit was followed except that dihydrotestosterone was not separated from the sample by LH-20 Sephadex chromatography. For the analysis of estrogens in females, [^{3}H]estradiol-17B was used to compete for antibody binding sites with plasma estradiol. The level of estrone was not measured.

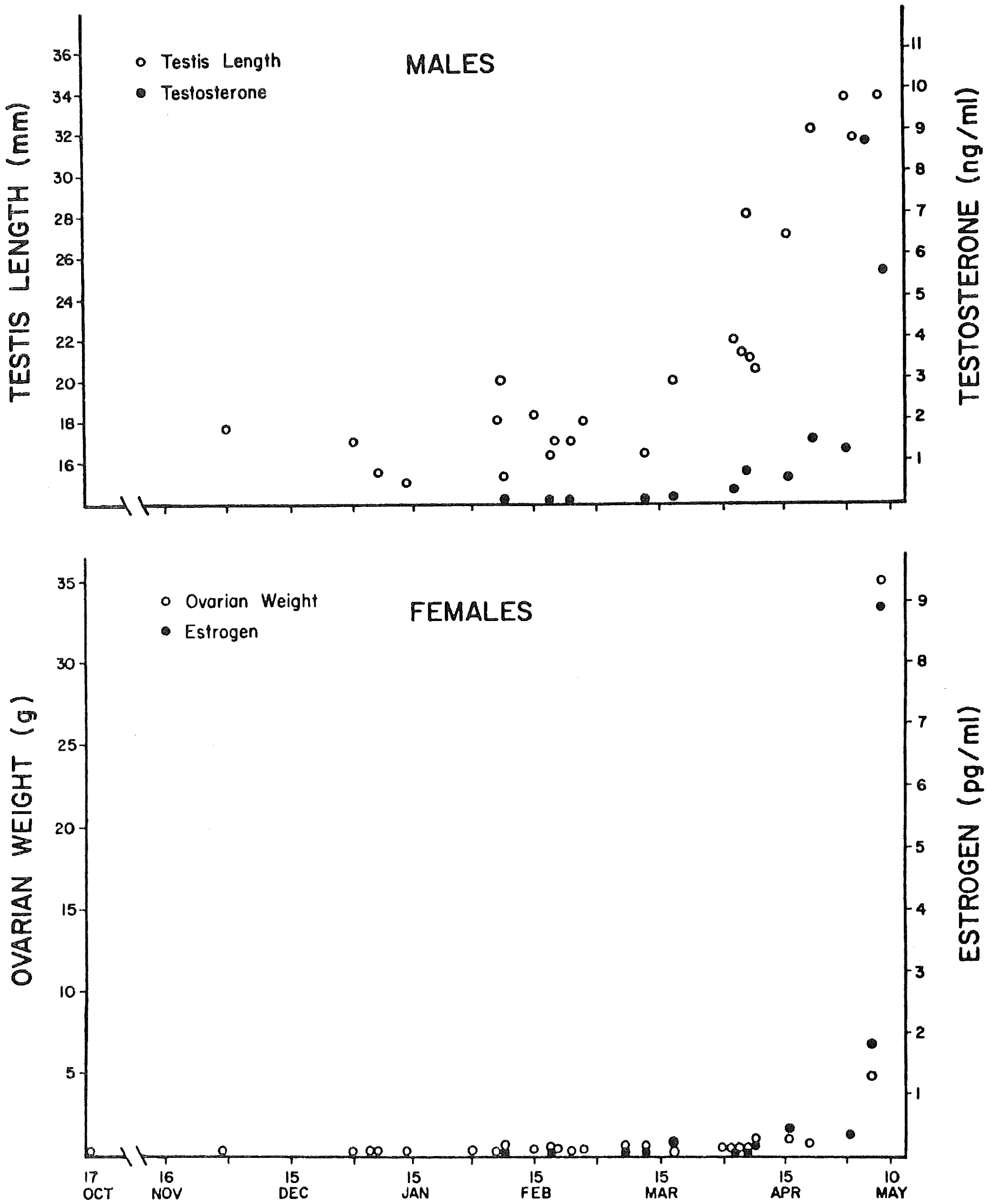

Fig. 1. Testis length and blood testosterone levels of male, and ovarian weight and blood estrogen levels of female sandhill cranes considered to be of breeding age. Plots are of daily means for all variables.

The Statistical Analysis System (Barr et al. 1979) was used to perform statistical tests. All analyses were based on daily means of gonad sizes and hormone levels to reduce effects of individual variation. Correlation and analyses were used to delineate relationships over time with pairs matched by date. Paired *t*-tests (matched by date) were used to test for differences in gonad size and blood hormone levels between breeding and nonbreeding age cranes.

RESULTS

Among male sandhill cranes considered to be of breeding age, testis length, testis weight, and blood testosterone levels increased (*P* <0.05) between January and mid-May (Fig. 1). Testis lengths and weights, blood testosterone levels, and daylength were highly intercorrelated (Table 1).

Table 1. Relationships between gonadal development, blood hormone levels, date, and daylength for adult sandhill cranes collected in Texas, Nebraska, Saskatchewan, and Alaska during the winter and spring, 1979-80. The upper right-hand half of the correlation matrix is for breeding age adults and the lower left-hand is for nonbreeding age adults as determined by cheek patch color (after Tacha 1985).

Reproductive parameter	Testis Weight	Testis Length	Male testosterone	Ovarian weight	Diameter of largest follicle	Female estrogen	Date	Daylength
Testis weight		0.86[a] 0.001 25	0.61 0.034 12	0.48 0.025 21	0.59 0.005 21	0.55 0.101 10	0.71 0.001 25	0.81 0.001 20
Testis length	0.81 0.001 20		0.69 0.012 12	0.60 0.005 21	0.70 0.00 21	0.59 0.075 10	0.70 0.001 25	0.88 0.001 20
Testos-terone	0.77 0.076 6	0.91 0.013 6		0.97 0.001 11	0.97 0.001 11	0.99 0.001 9	0.63 0.022 13	0.91 0.001 11
Ovarian weight	0.54 0.067 12	0.34 0.281 12	-0.07 0.090 5		0.90 0.001 27	0.99 0.001 11	0.35 0.067 27	0.68 0.001 23
Diameter of largest follicle	0.87 0.001 12	0.74 0.006 12	0.37 0.546 5	0.72 0.002 15		0.94 0.001 11	0.56 0.003 27	0.89 0.001 23
Estrogen	0.72 0.067 7	0.72 0.067 7	0.90 0.036 5	-0.13 0.767 8	0.40 0.325 8		0.52 0.084 12	0.78 0.008 10
Date	0.73 0.001 21	0.65 0.002 20	0.82 0.048 6	0.69 0.004 15	0.76 0.001 15	0.60 0.113 8		0.90 0.001 119
Daylength	0.84 0.001 16	0.61 0.013 16	0.92 0.009 6	0.49 0.127 11	0.71 0.014 11	0.65 0.115 7	0.80 0.001 119	

[a] The top, middle, and bottom entries in each grouping are the correlation coefficient, the *P* for the correlation coefficient, and the sample size *N* of means matched by date.

Testis lengths and weights, blood testosterone levels, and daylength were also highly intercorrelated for nonbreeding age adult males (Table 1). However, testis lengths were significantly shorter and testis weights and blood testosterone levels were significantly lower among nonbreeding age adult males when compared to breeding age adult males (paired *t*-tests, *P* <0.05).

Ovary weights, follicle sizes, and blood estrogen levels of breeding age females increased (*P* <0.05) between March and mid-May (Fig. 1). Ovary size, follicular development, blood estrogen levels, and daylength were highly intercorrelated (Table 1).

Estrogen levels of nonbreeding age females were not significantly (*P* >0.32) correlated with gonadal development. Also, gonadal development and estrogen levels of non-breeding age females were not significantly (*P* >0.11) correlated with daylength. When nonbreeding age females were compared to breeding age females, ovarian weights and estrogen levels were lower and diameters of the largest follicle were smaller among nonbreeding age females (paired *t*-tests, *P* <0.05).

DISCUSSION AND CONCLUSIONS

The difference in functional reproductive development between non-breeding and breeding age females could have been in part related to lack of stimulation via courtship by males. Generally, nonbreeding age females were not paired, and breeding age females were paired (Tacha 1985). Nonbreeding age females did not exhibit the gonadal development and concurrent increases in blood estrogen levels observed in females of breeding age. Furthermore, gonadal development and increases in estrogen were not associated clearly with increasing daylength among nonbreeding age females. Tacha (1985) found significant correlation (*P* <0.01) between exhibition of the unison call by paired (breeding age) adult cranes and female gonadal development, but nonsignificant correlations (*P* >0.05) between rates of unison calling and paired (breeding age) male gonadal development. We found gonadal development of breeding age (paired) males highly correlated with daylength. Thus, stimulation of adult females by their mates via unison calling appears important to gonadal development and concurrent increases in estrogen levels necessary for ovulation and, ultimately, successful fertilization.

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NESTING ECOLOGY AND PRODUCTIVITY OF GREATER SANDHILL CRANES AT SYCAN MARSH, OREGON.

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Abstract: Population size, nesting habitat, and productivity of greater sandhill cranes (Grus canadensis tabida) were studied during 1981-1984. Population size was estimated to be 126 crane pairs, the second largest breeding segment of the Central Valley Population. Breeding density (1 crane pair/74 ha) is one of the highest reported in North America. Overall nest success was 29.8% (n = 339), and annual recruitment was 0.0%, 3.1%, 6.7%, and 8.0% for this 4 year period. Predation of eggs by coyotes (Canis latrans) was the main factor depressing nest success. Nest sites in deep water, hard-stemmed bulrush (Scirpus acutus) habitat were most secure from predation pressure, and had significantly higher success. Trend status for this breeding population is unknown. If, however, present predation pressures persist, annual recruitment will probably remain below levels necessary to maintain a stable population.

PROCEEDINGS 1985 CRANE WORKSHOP

The Central Valley Population (CVP) of greater sandhill cranes breed in southcentral to southeast Oregon, and northeast California. The largest breeding subpopulation occurs in the Malheur-Harney Lakes Basin, Harney Co., Oregon, and totals approximately 288 crane pairs (Littlefield and Thompson 1979). The subpopulation at Malheur NWR has been studied extensively (Littlefield and Ryder 1968, Littlefield 1976, 1981, Schlorff et al. 1983). Little is known, however, about the nesting ecology and productivity of cranes at other breeding locales within the CVP. Sycan Marsh, Lake County, Oregon provides breeding locales within the CVP. Sycan Marsh, Lake County, Oregon provides breeding habitat for the second largest subpopulation in the CVP. This paper summarizes investigations of greater sandhill cranes at Sycan Marsh. Our objectives were (1) to determine the size of the crane population, (2) to describe nest site characteristics, (3) to determine nest success and annual recruitment, (4) to compare productivity between habitat types, and (5) to determine the impact of researcher disturbance on nest success. Field work took place from 1982-1984. Discussion of nest success and annual recruitment includes data collected by C. D. Littlefield in 1981 (unpublished rept., The Nature Conservancy, Portland, Oregon).

We thank C. D. Littlefield for initiating crane investigations at Sycan Marsh, and for his continued support over the past 3 years; E. Horvath, K. Kristensen, M. Smith, J. Vranizan, K. Theodore, J. Goodnight, and C. Carroll for their excellent assistance in the field; and J. Hoffnagle, E. Prior, C. Macdonald, R. Jarvis, D. Vollum, R. Fields, and J. Hainline for essential logistical support. Funding for this investigation was provided by the Oregon Field Office of The Nature Conservancy.

STUDY AREA

Sycan Marsh encompasses 9306 ha and lies at 1540 m in a basin along the east slope of the Oregon Cascades. Yamsi Mtn (2525 m) to the west, and the west slope of Winter Rim (2156 m) to the east, define the watershed. Winter snowpack levels within the watershed, and subsequent spring/summer runoff, determine annual water levels on the marsh. The marsh reaches its highest water levels in March, April, and May, when over 50% of the annual runoff occurs. In general, inter- and intra-year fluctuations in water availibility to the marsh are extreme.

The forested lands surrounding the marsh are predominantly ponderosa pine (Pinus ponderosa) and lodgepole pine (Pinus contorta); scab flats of low sage (Artmesia arbuscula) and Sandberg's bluegrass (Poa sandbergii) occur along the east edge of the marsh. The wetland vegetation on the marsh was, for the purposes of describing crane habitat utilization patterns, classified into six broadly defined habitat types.

(1) Bulrush. In the northeast portion of the marsh lies a sump, encompassing approximately 15% of the marsh. The vegetation is characterized by a dense, homogenous stand of hardstemmed bulrush on the interior, with increasing coverage of sedges (Carex atherodes, C. rostrata, C.

vescicaria) toward the outer margins. Water depth in April averages 55.0-70.0 cm. Small patches of hard-stemmed bulrush also occur along the Sycan River floodplain, and are included within this habitat type.

(2) Hydric sedge/rush. This vegetative type covers 30.0% of the marsh, occurring throughout the interior, generally along a northeast-southwest orientation. The dominant plant associations are characterized by *Carex vesicaria*, *Juncus nevadensis*, and *Eleocharis palustris*. Water depth in April averages 30.0 to 50.0 cm.

(3) Mesic sedge/rush. This type occurs throughout the marsh and is slightly more mesic than the hydric sedge/rush habitat type. Water depth in April ranges from 15.0 to 30.0 cm. This habitat type covers approximately 20.0% of the marsh.

(4) Hairgrass/rush. This habitat occurs principally on the west side of the marsh, comprising roughly 20.0% of the marsh. *Deschampsia caespitosa* and *Juncus balticus* are the dominant species of this association. Water depth is 10.0 to 20.0 cm in April.

(5) Bluegrass flat. This is the most xeric of the major vegetative types of the marsh, encompassing approximately 15.0% of the marsh. *Poa pratensis*, *P. nevadensis*, and *P. cusickii* and a high diversity of herbs characterize this type. The ground is soggy in April with water depth ranging from 0 to 3 cm.

(6) Dikes. Man-made earthen water control structures occur in some areas on the marsh. Vegetative cover includes Great Basin wildrye (*Elymus cinereus*), reedcanary grass (*Phalaris arundinacea*), Kentucky bluegrass (*P. pratensis*), and forbs.

The bulrush and bluegrass habitats are generally limited in distribution, whereas the other habitats are highly interspersed, forming a complex mosaic.

Livestock utilize the marsh in summer and fall, grazing the bluegrass flats in early summer, and gradually moving into other habitats as water levels drop throughout summer. A system of channels, head gates, culverts, and weirs facilitate water manipulations for stock water and irrigation of meadows.

METHODS

Active crane nests were located by observation through a 20X spotting scope from natural vantage points around the marsh, and by fortuitous encounters. Nests were mapped and monitored from vantage points. Data on nest site vegetation, water depth, clutch size, stage of incubation, and egg measurements were collected. Nest sites were classified into one of six habitat types. Nest fate was determined by inspection of the nest bowl after termination of incubation (Rearden 1951). A nest was considered successful if one or more eggs hatched. An estimate of annual recruitment (number of young produced/total number of individuals) was made by monitoring crane chick movements and survivorship, and also by examining premigratory flock composition throughout September. Chi-square analysis was used to assess potential differences in values for nest success.

RESULTS

Sandhill cranes were observed at Sycan Marsh in early March each year, presumably arriving in late February. Earliest clutch completion dates were 22 April 1982, 13 April 1983, and 5 April 1984. Median clutch completion dates occurred approximately 2 to 3 weeks after the earliest clutch completion: 15 May 1982, 5 May 1983, and 29 April 1984. The first fledged young were observed on 28 August 1982, 26 July 1983, and 13 July 1984. Cranes migrated asynchronously from the marsh, beginning in mid-September and on through early November.

Previous aerial surveys of Sycan Marsh in 1978 and 1981 estimated 57 and 76 crane pairs, respectively (E. J. O'Neill, unpublished rept., Tule National Wildlife Refuge, California, 1978; C. D. Littlefield, unpublished rept. The Nature Conservancy, Portland, Oregon 1981). In 1983, intensive ground mapping of territorial crane pairs on the marsh provided the most comprehensive census to date, indicating that 126 pairs occurred on the marsh (Fig. 1).

A total of 334 active nests were located; 78 in 1982, 136 in 1983, and 120 in 1984. In each of 3 years, the majority of the nests were concentrated in two areas: (1) 65.0% in the mesic and hydric sedge/rush habitats associated with Long Creek and the Sycan River in the southcentral portion of the marsh, and (2), 26.0% in the hydric sedge/rush and bulrush habitats associated with the bulrush sump in the northeast section of the marsh. The remaining 9.0% of the nests were widely scattered around the marsh, but were generally proximal to drainage channels and wet sumps.

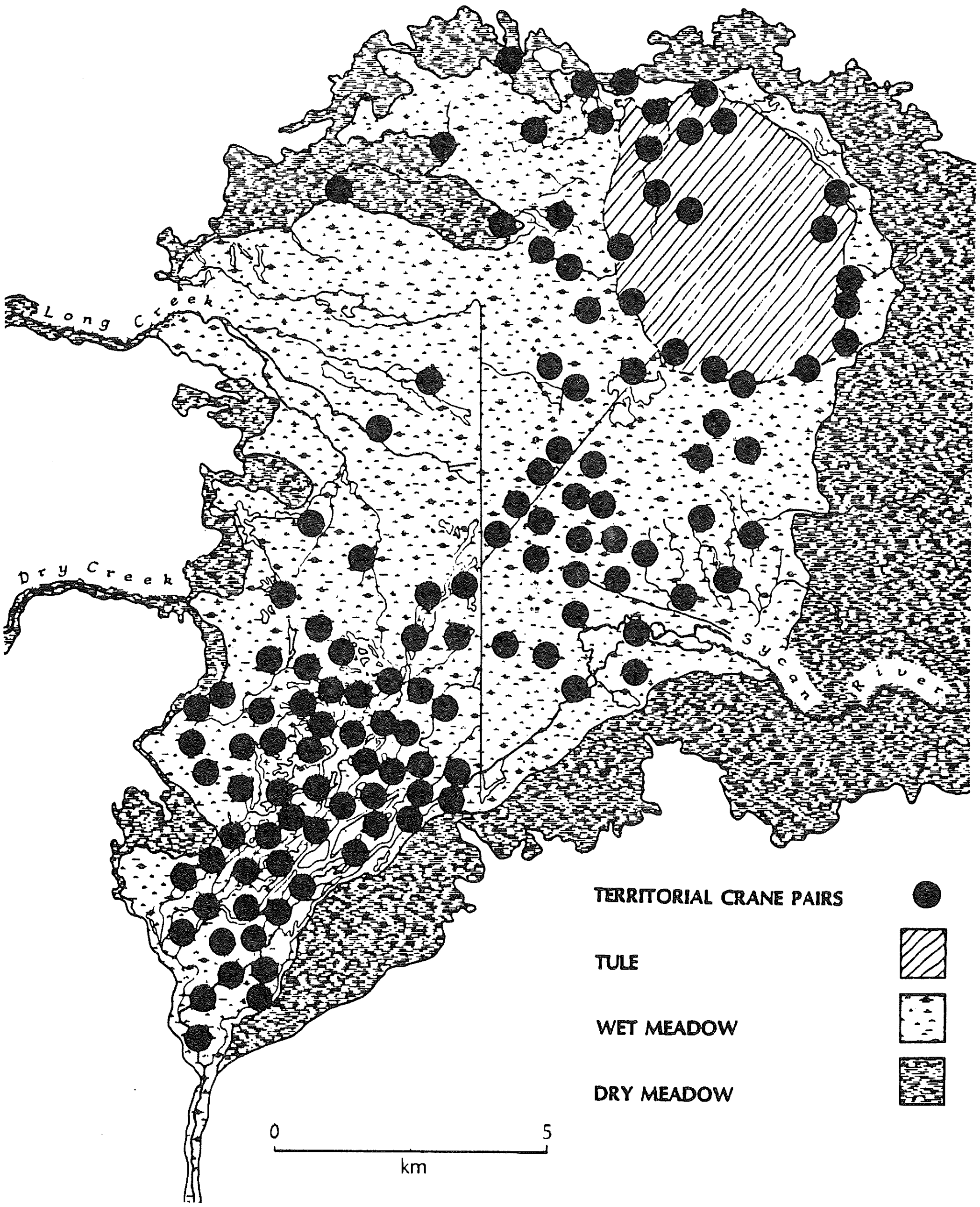

Fig. 1. Distribution of territorial crane pairs at Sycan Marsh, Oregon.

Nest sites were classified into the six habitat types described previously (Table 1). Approximately 85.0% of the nests occurred in mesic sedge/rush, hydric sedge/rush, and bulrush habitats. Mean water depths for nest sites in the three frequently utilized habitats were greater than for the other three habitat types (Table 2). Nests in the bulrush habitat were typically large floating platforms, approximately 1.0-1.5 m diameter, in 40.0 to 60.0 cm of water. Nests in other habitats were either scrapes on dry ground or mounded platforms of basal tufts and organic material in water depths up to 30.0 cm.

Nest Success

Nest success was calculated for 311 nests; 74 in 1982, 127 in 1983, and 110 in 1984; annual success was 28.4%, 22.8%, and 42.7%, respectively. Nest success was not significantly different in 1982 and 1983 but was significantly higher ($p<0.005$) in 1984. In 1981, Littlefield noted success for 28 nests at Sycan was 14.3%. The 4 year composite nest success at Sycan Marsh was 29.8% (n = 339) (Table 3).

Table 1. Distribution of greater sandhill crane nest sites by habitat type at Sycan Marsh, Oregon, 1982-1984.

Habitat type	1982 (%)	1983 (%)	1984 (%)	Totals (%)	N
Bulrush	6.0	16.0	12.0	12.0	40
Hydric sedge/rush	23.0	37.0	20.0	28.0	92
Mesic sedge/rush	40.0	39.0	56.0	45.0	151
Hairgrass/rush	6.0	1.0	3.0	3.0	9
Bluegrass/flat	14.0	5.0	9.0	6.0	22
Dikes	6.0	0.0	2.0	3.0	9
Unclassified	4.0	3.0	3.0	3.0	11

Table 2. Hydrological characteristics of nest sites by habitat type.

Habitat type	N	Water depth (cm)
Bulrush	34	50.32 ± 10.07
Hydric sedge/rush	72	22.50 ± 11.59
Mesic sedge/rush	137	12.13 ± 8.29
Hairgrass/rush	10	3.10 ± 4.70
Bluegrass	21	1.71 ± 4.80
Dikes	9	0.00 ± 0.00

Table 3. Productivity of greater sandhill cranes at Sycan Marsh, 1981-1984.

Year	Nest success (%)	N	Annual recruitment (%)	No young fledged
1981	14.3	28	0.0	0
1982	28.4	74	3.1	8
1983	22.8	127	6.7	18
1984	42.7	110	8.0	22
Mean ± S. D.	27.05 ± 11.94		4.5 ± 3.6	
Composite	29.76	(339)		

Between 1982-1984, nest success in the bulrush habitat was significantly higher ($p<0.005$) than in all other habitats combined (66.7% vs. 26.6%) and, although the bulrush habitat accounted for only 11.6% of all nest sites, nests in this habitat contributed 24.7% of all successful nests. Among other habitats there were no significant differences in nest success, nor differences in nest success within habitat types between years, except for a significant difference in nest success between years within the hydric sedge/rush habitat (Table 4).

The major cause of nest failure at Sycan was predation of unhatched eggs. In 1982-1984, egg predators accounted for 82.2% of the explicable nest failures (Table 5). Analysis of egg shell remains in the nest bowl indicated that the principal egg predator was the coyote (61.0%) and, secondarily, common ravens (<u>Corvus corax</u>) and California gulls (<u>Larus californicus</u>) (21.2%). Other causes of nest failure included abandonment (9.3%), infertile eggs (5.1%), and flooding (3.4%). Patterns of nest failure and egg predation were similar in all 3 years.

At the beginning of this investigation we were concerned that researcher disturbance (visitation) at an active nest site might affect the likelihood of nest success. In 1982, most nests were initially observed and marked from a distant vantage point. Subsequently, we visited about one-half of the nests during active incubation, collecting data on clutch size, egg size, and stage of incubation. The other nests were not visited until incubation had been terminated. This delay allowed us to compare nests that were disturbed and those not disturbed. Nest success varied between visited nest (22.0%) and nests not visited (38.0%), but the difference was not statistically significant ($p=0.43$). Table 5 summarizes the impact of research disturbance on nest success for 1982-1984. In 1983 and 1984, disturbed nests had significantly higher ($p<0.05$) nest success than nests not disturbed. We do not intend to infer, however, that our disturbance increased the chances of success. Rather, we initially observed and marked all nests from a distance; the longer a nest remained active, the greater the chance that we would have the opportunity to return and visit the nest site. Many nests, which we would have visited, failed before we could visit the site, thus explaining why in both 1983 and 1984 the undisturbed nest sites had lower nest success than the disturbed nest sites. Though prolonged and frequent visitation to an active nest, and/or physical disarrangement of the nest site may lead to abandonment, we believe that a brief visit to the nest site for the purpose of data collection does not adversely affect the chances of successful hatching.

Table 4. Nest success (%) of greater sandhill cranes by habitat type at Sycan Marsh, 1982-1984.

	Bulrush	Hydric	Mesic	Hairgrass	Bluegrass	Dikes
1982	60.0	35.3	17.2	60.0	20.0	0.0
1983	55.6	14.6	18.6	0.0	42.9	0.0
1984	84.6	52.6	30.2	33.3	50.0	75.0
N	36	84	141	9	21	9
Totals	66.7	27.4	23.4	44.4	33.3	55.6

Table 5. Causes of nest failure of greater sandhill cranes at Sycan Marsh, 1982-1984.

Causes of nest failure	N	%
Coyotes	72	61.0
Ravens/gulls	25	21.2
Abandonment	11	9.3
Infertile eggs	6	5.1
Flooded	4	3.4
Subtotal	118	100.0%
Unknown	103	
Total	221	

Annual Recruitment

Annual recruitment for sandhill cranes is generally determined by age ratio counts of large flocks in fall or early winter (Miller and Hatfield 1974). At Sycan, however, cranes migrated asynchronously, and age ratios of premigratory flocks, in and of themselves, did not provide reliable estimates of recruitment. Instead, we monitored all crane brood activity on the marsh, and determined the absolute number of fledged juvenile chicks for each breeding season. This process was aided by the relatively poor survivorship of crane chicks (fewer to monitor), and by banding and color-marking as many of the flightless chicks as possible. Annual recruitment in 1982-1984 was 3.1%, 6.7%, and 8.0%, respectively. In 1981, Littlefield noted 0.0% annual recruitment. High annual nest success generally led to high annual recruitment but the correlation was not statistically significant.

DISCUSSION

This investigation indicated that the crane population (126 pairs) was substantially larger than originally noted. The total of 126 crane pairs at Sycan is the highest density of nesting cranes in the CVP, and one of the highest in North America (1 crane pair/74 ha). Portions of the marsh are largely unused by cranes and actual nesting densities are much higher. The only report of breeding density greater than that observed at Sycan was by Drewien (1973) at Grays Lake NWR, Idaho (1 crane pair/50 ha). The high density of cranes concentrated in this basin indicates that Sycan Marsh provides excellent habitat for breeding cranes.

Despite the high density and relatively large size of this breeding subpopulation, the productivity of sandhill cranes at Sycan Marsh was notably low. Nest success between 1981-1984 averaged only 29.8%, when annual recruitment was 4.5%. In contrast to productivity values from other breeding areas in the CVP, as well as from other breeding locales in other populations (Table 6), the values for nest success and annual recruitment at Sycan are the lowest ever reported for a sizeable population of cranes.

The major cause of low nest success at Sycan has been identified as the predation of unhatched eggs, principally by coyotes, and secondarily, common ravens and California gulls. A comparison of nest success values for nests visited (disturbed) during incubation and nests not visited (undisturbed) indicated that research visitation to the nest site was not a contributing factor to the observed rates of predation. Predation rates were high in all habitat types, except in the bulrush habitat, where nest success was significantly higher (66.7% vs. 26.6%). The water depth of nest sites in the bulrush habitat was more than twice that of nest sites in other habitats. This deep water barrier apparently afforded greater protection from coyotes, thus explaining the higher rate of nest success in the bulrush habitat.

Egg predation, however, does not fully account for the depressed values of annual recruitment at Sycan. For example, if all hatched nests in 1981-1984 had raised a minimum of one chick to flight stage, then the mean rate of annual recruitment would have been 11.7%. The observed mean annual recruitment rate of 4.5%, (Table 7) however, indicates that over 60.0% of the hatched chicks failed to survive to flight stage. Specific causes of low chick survivorship are unknown. Preliminary results, however, from a current research investigation of the causes of chick mortality at Sycan (Stern et al., unpubl. data) tenatively indicated that predation, principally by coyotes, is the major source of chick mortality.

Table 6. Effect of researcher disturbance on nest success of greater sandhill cranes at Sycan Marsh, 1982-1984.

	N	Nests disturbed (% success)	Nests not disturbed (% success)	Probability of difference
1982	74	21	32	P=0.43
1983	127	28	17	P<0.05
1984	109	49	21	P<0.01
Totals	311	40	22	P<0.005

Table 7. Nest success and annual recruitment rates of sandhill cranes in North America.

Population, subspecies or locale	Young in population %	Nest success %	Nest success N	Reference
Eastern population (G. c. tabida)				
Michigan		77.0	133	Hoffman 1979
Michigan		78.9	204	Walkinshaw 1981
Wisc/Indiana	12.6			Crete and Grewe 1982
Indiana	12.0			Lovvorn and Kirkpatrick 1982
Florida sandhill crane				
Florida		77.3	119	Walkinshaw 1982
Florida	15.6			Walkinshaw 1976
Mississippi sandhill crane				
Mississippi		72.0	81	Valentine 1982
Rocky Mtn population (G. c. tabida)				
Idaho	13.0-14.0	78.0	326	Drewien 1973
New Mexico	11.5			Drewien 1973
Central Valley population (G. c. tabida)				
Oregon-Malheur	6.6	44.0	636	Schlorff et al 1983
Oregon-Sycan	4.5	29.8	339	This study

Trend data are not yet available for the crane population at Sycan. Long-lived species such as cranes are usually characterized by natural fluctuations in population levels (Binkley and Miller 1983), and status of a population is difficult to assess. The low rate of recruitment of cranes observed over the past 4 years at Sycan may reflect a low ebb in a natural cycle or it may represent the beginning of a significant downward trend in the crane population. In comparison, however, long term studies at Malheur NWR have shown that an 11-year mean annual recruitment of 6.6% has resulted in a 9.0 to 10.0% decrease in population size (Schlorff et al. 1983). Other researchers (Miller et al. 1972, Drewien 1973, Lovvorn and Kirkpatrick 1982) have suggested that annual recruitment rates of 10.0 to 12.0% are necessary to maintain a stable breeding population of sandhill cranes. Clearly, the level of annual productivity at Sycan Marsh has been below the level observed at Malheur NWR, and substantially below levels necessary to maintain a stable breeding population. If the present predation pressures persist, then annual recruitment will probably remain below equilibria levels, and one can anticipate a decline in the population of cranes at Sycan equal to, or perhaps greater, than the 9.0-10.0% decrease observed at Malheur NWR.

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PRODUCTIVITY OF FLORIDA SANDHILL CRANES ON THREE SITES IN CENTRAL FLORIDA

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Abstract: Three areas in central Florida, identified as potential release sites for a third flock of whooping cranes (Grus americana), were aerially surveyed during the 1984 breeding season for Florida sandhill crane (G. canadensis pratensis) nests. Fifteen aerial surveys were conducted between late February and mid-May. Peak nest counts in all three study areas occurred during the 9-10 March survey. On Kissimmee Prairie, 58 nests were located from the air and 11 were found during subsequent ground surveys. Forty nests were located on Webb Wildlife Management Area, and 24 nests were located on Myakka River State Park study area, all from the aerial surveys. Production from these nests (mean brood size) was estimated from fall roadside counts, and averaged 1.16 on Myakka River State Park and the Kissimmee Prairie study areas, and 1.24 on Webb Wildlife Management Area. The influence of rainfall on timing of crane nesting efforts is discussed.

PROCEEDINGS 1985 CRANE WORKSHOP

In 1979, the State of Florida proposed to the Endangered Species Office of the U. S. Fish and Wildlife Service that Florida sandhill cranes (Grus canadensis) be evaluated as potential foster parents for a third whooping crane (G. americana) population. After preliminary surveys, the Florida Game and Fresh Water Fish Commission (FGFWFC) identified possible release sites for whooping crane introduction in central Florida (Nesbitt 1982).

Although central Florida contains the greatest concentration of Florida sandhill cranes (Walkinshaw 1976), there are no estimates of size of the breeding population. Most of the available information on sandhill cranes in central Florida is derived from three studies of reproductive success. In two studies, Walkinshaw (1976, 1982) reported productivity data from over 100 Florida sandhill crane nests on Kissimmee Prairie during 1967-81. Layne (1983) monitored 1973-79 recruitment of Florida sandhill cranes observed during summer and fall road surveys in south-central Florida.

The revised edition of the Whooping Crane Recovery Plan (Whooping Crane Recovery Team 1986) has identified several biological criteria that all third whooping crane population studies need to address. One of these criteria includes determining what aspects of the biology of resident sandhill crane populations would be effected by reintroduction of whooping cranes. As part of the State of Florida's evaluation of possible whooping crane reintroduction, we initiated a study to estimate the size of the Florida sandhill crane breeding population and to determine what factors are influencing productivity on the three most promising release sites. In this paper, we present the preliminary results of our breeding and recruitment surveys during 1984.

We especially thank FGFWFC pilot Lance Ham for flying the nest surveys. We gratefully acknowledge the Babcock, L. Hudson, Rohde, Adams, Hayman's 711, El Maximo, M. Carlton, and Hi-Hat Ranches for access during our fall surveys. Special thanks to L. Walkinshaw for assistance during our aerial surveys as well as providing invaluable nesting information. We thank R. McCracken, R. Etters, and L. Campbell of the FGFWFC; R. Dye of Florida Department of Natural Resources; and R. Chandler of National Audubon Society for information and logistical assistance on the proposed release sites. S. Nesbitt and A. Wenner of FGFWFC provided advice and support throughout the study. This study was supported by the University of Florida's School of Forest Resources and Conservation, FGFWFC, National Audubon Society, and the Florida Chapter of the Sierra Club.

STUDY AREAS

Three study areas were established in central Florida (Fig. 1): Kissimmee Prairie in Osceola and Okeechobee counties (including Three Lakes Wildlife Management Area and the National Audubon Society Ordway-Whittell Kissimmee Prairie Sanctuary), Myakka River State Park (SP) in

Sarasota and Manatee counties, and the C. M. Webb Wildlife Management Area (WMA) in Charlotte County. Study areas included not only the potential release sites but also their surrounding areas. Thus, the Webb WMA study area included 450 km^2, Myakka River SP study area 500 km^2, and the Kissimmee Prairie study area an approximate 1,050 km^2.

The landscape in all three areas generally is level and consists of broad saw palmetto (*Serenoa repens*) prairies and pine flatwoods, wooded swamp drainageways, and small freshwater ponds, marshes, and sloughs. Cattle ranching, usually on improved or semi-improved pasture, is the major industry on large private tracts that adjoin all the potential release sites. Grazing is permitted on Three Lakes WMA and Webb WMA.

Annual rainfall averages approximately 132 cm on the Webb WMA (FGFWFC, unpubl. rept. 1982) and Kissimmee Prairie areas (R. McCracken, FGFWFC, unpubl. rept. 1979; South Fla. Water Mgmt. Dist. Files), and 144 cm on the Myakka River SP (U. S. Dept. Commerce 1984). Rainfall is unevenly distributed throughout the year with a dry season from November to April and a wet season from May to October. On all three areas 70-80% of the rainfall occurs during the wet season.

METHODS

Aerial sampling for Florida sandhill crane nests was considered the most accurate and efficient means of estimating the size of local breeding populations because of the large size of the proposed release sites and the great distances between them. Florida sandhill cranes in central Florida generally build their nests with emergent vegetation in shallow ponds 1 m deep (Walkinshaw 1981). Nests on dry land are rare and have been reported on only four to five occasions during this century. Thus, although sandhill cranes are difficult to observe from fixed-wig aircraft because of their cryptic coloration, their nests usually are large and conspicuous.

Aerial surveys of Florida sandhill crane nests were conducted in all study areas every 2 to 3 weeks. Due to logistical problems, surveys did not begin until the end of February. The first flight on 29 February over the Webb WMA served principally to refine census techniques. The last survey was completed on 14 May 1984. In all, 11 flight days resulted in 6 surveys of Webb WMA, 4 surveys of Myakka River SP, and 5 surveys of the Kissimmee Prairie. Linear transects, aligned in an east-west direction approximately 1.6 km apart, were flown across each study area because most latitudinal starting and ending points were landmarks such as powerlines, roads, and lakes. Transect lengths were 22.0-22.5 km long on the Webb WMA, 24.5 km on Myakka River SP, and 4.8-28.7 km on the Kissimmee Prairie.

A Cessna 172 Skyhawk was flown at a speed and height of 145 km/h and 75 m, respectively. A strip width was not defined for each transect, however most observations occurred within 0.3 km on each side of the plane. Typically the pilot observed out the left side of the plane, while the senior author observed out the right side. On five occasions an additional passenger observed out the right side of the plane.

A nest was counted if: (1) a crane was sitting on it, (2) an egg was visible but no crane was present or (3) if cranes with a chick were present. Approximate nest locations were later plotted on maps.

Florida sandhill cranes are similar to the greater (*G. c. tabida*) and lesser sandhill cranes (*G. c. canadensis*), and tend to aggregate in the late summer and early fall. Families often are visible in flocks during this time. In order to obtain an estimate of average brood size and recruitment for the three areas, surveys for juvenile-plumaged cranes were made during August, September, and October before the migratory greater sandhill cranes arrived.

Recruitment surveys consisted of counting all cranes observed over a 2 to 3 day period while driving public and private roads, and observing known off-road traditional use areas and roost sites on and around the study area. Concentrations located as far as 18 km from the study areas' boundaries were included in the overall counts. On the Webb WMA, two surveys in late August and September covered 80 km and 215 km, respectively. On the Kissimmee Prairie, surveys were conducted the first weekend in September and mid-October, and covered 136 km and 251 km, respectively. The Myakka River SP study area was surveyed one weekend in early September and covered 152 km.

RESULTS AND DISCUSSION

Nesting Chronology and Densities

Local biologists reported that cranes began nesting as early as 10 January on Kissimmee Prairie (L. Walkinshaw, pers. commun.) and 19 February on Webb WMA (L. Campbell, pers. commun.). Precipitation varied on the three study areas during the 4 months before the initial surveys and was thought to greatly influence nesting conditions. The Kissimmee Prairie and Webb WMA study areas both had precipitation slightly above normal for November and December (14.1 cm and 15.7 cm respectively). January and February rainfall was nearly average with both areas receiving approximately 8.2 cm (Webb WMA Files; South Fla. Water Mgmt. Dist. Files). Myakka River SP, however, had unusually wet conditions due to heavy rainfall during November and December. A total of 31 cm of precipitation fell during this period, approximately 21 cm above the normal rainfall for these months. January and February precipitation was slightly below average on Myakka River SP with 8.7 cm recorded (U. S. Dept. Commerce 1984, 1985).

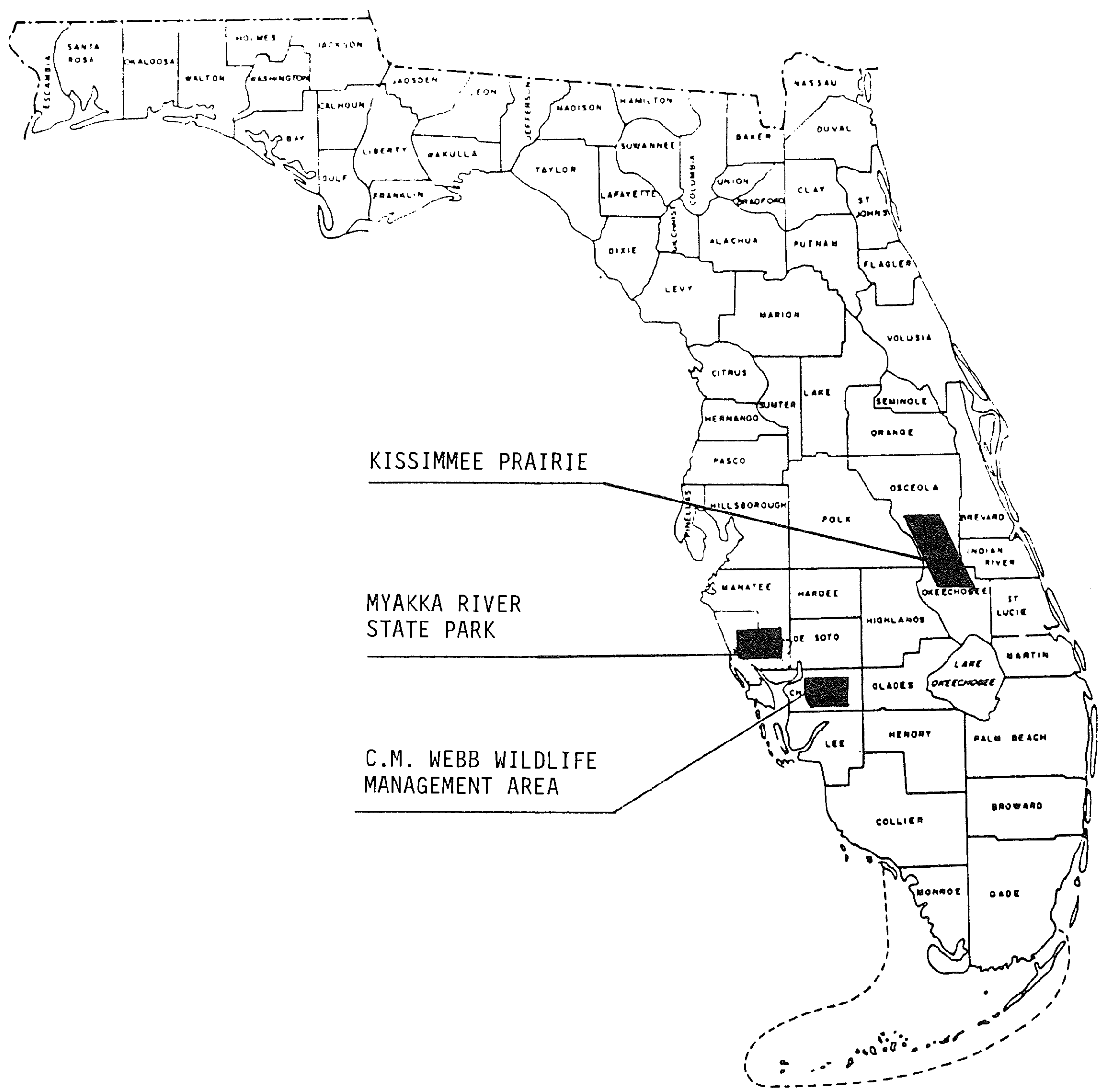

Fig. 1. The three crane study areas in central Florida.

Peak nesting was observed on all three areas during the 9-10 March aerial surveys (Fig. 2). On the following surveys, nest counts dropped by 40-60%. The number of nests sighted continued to decline throughout the remaining surveys on the Myakka River SP and Kissimmee Prairie areas. Nest counts on the Webb WMA area, however, did not drop sharply until the final mid-May flight.

Because of the lack of nesting surveys during January and February, it was not possible to document the beginning of the 1984 breeding season or to compare the nesting chronology with previously compiled Florida nesting records (Walkinshaw 1973). The peak counts from the 9-10 March flights on the three areas, however, are very close to the overall mean nesting peak (13 March) calculated from Walkinshaw's data.

On Kissimmee Prairie, 58 nests were located along the transects during 5 aerial surveys and 11 nests were located through ground searches (L. Walkinshaw, pers. commun.). The highest nesting density for all three study areas, 1.36 nests/20 km (31 nests) was recorded on this study area during the 10 March aerial survey (Fig. 3). On the 2 April flight, nesting densities had dropped by 61%. Of the 14 nests counted on 2 April, 1 egg and no cranes were present at each of 4 nests, suggesting that the first egg successfully hatched and the parents left with the chick. Most nesting had ended by mid-April, although one nest was found on the final survey 7 May. Of the 58 nests detected during the 5 surveys, 38% (22) were within 3 km of Lakes Jackson, Kissimmee, and Marion.

On Webb WMA, peak nesting occurred on 9 March (Fig. 3). Compared to the other two areas, however, Webb WMA maintained a relatively high (0.50, 0.63, and 0.57 nests/20 km) density until the end of April. It is quite likely that the 14 cm downpour on 13 March may have flooded nests and caused subsequent renesting and/or stimulated new nesters. This speculation is supported by Walkinshaw's findings (1976) that, for 75 Florida sandhill crane nests, the average height of a nest above the water was 10.9 cm. Evidence of possible renesting following the March downpour was obtained on the 17 April flight when three of the seven nests were located in the same county sections as the 9 March flight.

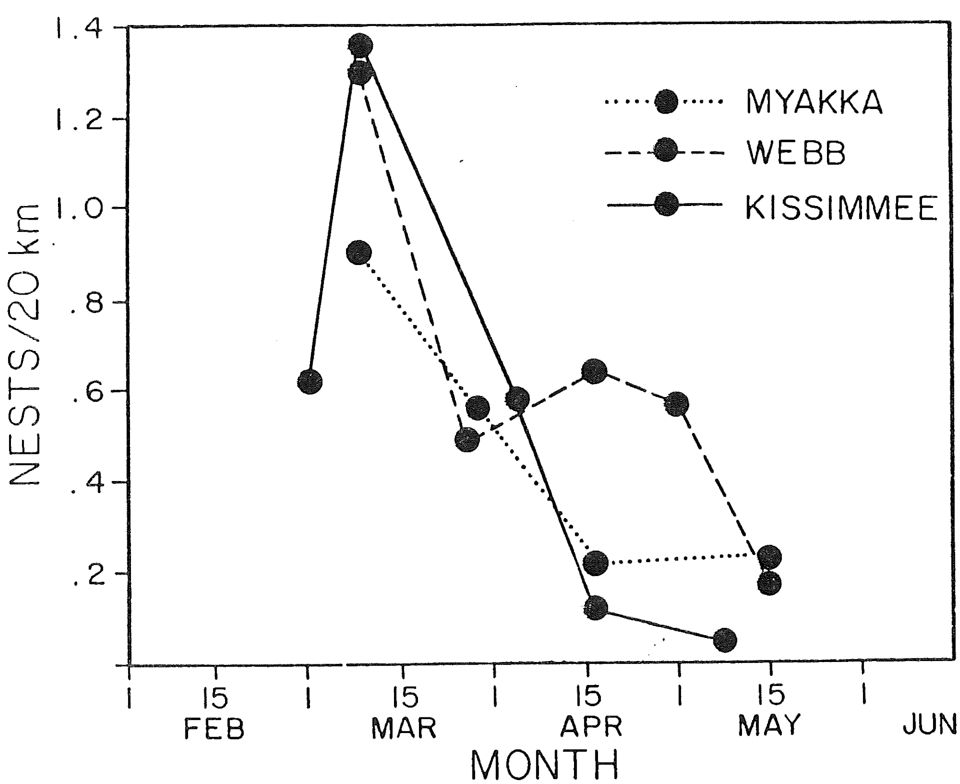

Fig. 2. Florida sandhill crane nests sighted per 20 km of aerial transect on each of the three central Florida study areas during 1984.

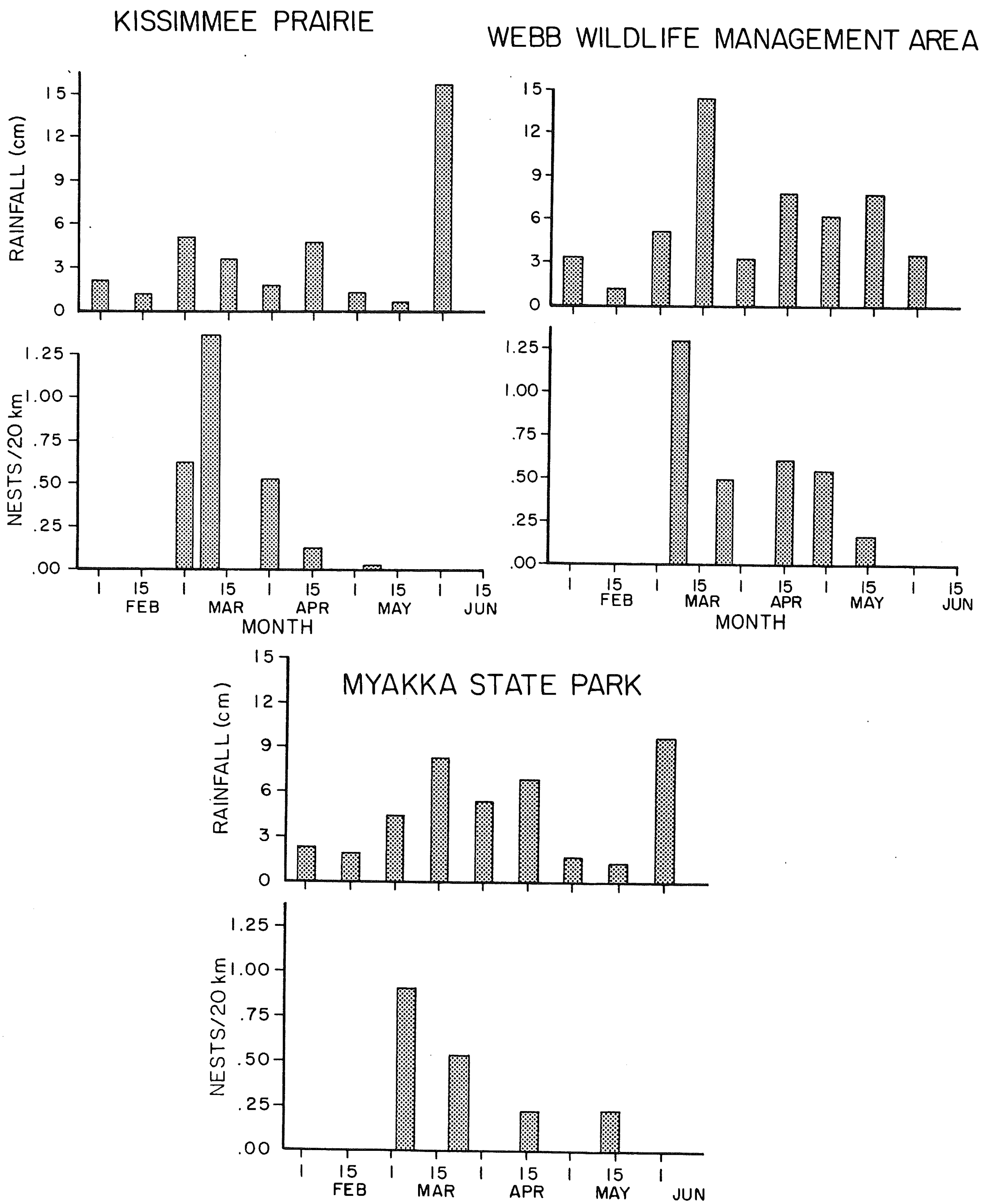

Fig. 3. Rainfall patterns and number of sandhill crane nests sighted per 20 km of aerial transect on the Kissimmee Prairie, Webb Wildlife Management Area, and Myakka River State Park study areas in 1984.

A total of 35 nests was located on Webb WMA transects, and an additional 5 nests were located incidentally during aerial surveys. Approximately 90% (36) of the nests found were on the Webb WMA. Twenty-one of the nests were located on the western third of the management area, primarily in the Alligator Slough watershed.

Peak nesting occurred at the Myakka River SP study area on 9 March when 11 nests were counted (Fig. 3). Despite 8 cm of rain on 13 March, Myakka River SP did not maintain high nesting densities throughout April. Nesting densities declined from 0.54 nests/20 km on 26 March to 0.23 nests/20 km during the final May survey. Twenty-four nests were located during the four surveys on Myakka River SP study area. In all, 54% of the nests were in the eastern third of the study area. This area is primarily private ranches with large tracts of improved pasture.

Brood Size and Recruitment

Mean brood sizes observed during the 1984 fall road counts (Table 1) were 1.16 on both the Myakka River SP and the Kissimmee Prairie study areas, and 1.24 on the Webb WMA. During the same fall, Nesbitt (pers. commun.) observed a slightly higher brood size on Kanapaha Prairie in north-central Florida ($\overline{X}$ = 1.25), but a lower brood size ($\overline{X}$ = 1.00) for cranes nesting in Martin County in southeast Florida. Mean brood size per unit area in this study and in Nesbitt's was lower than that reported previously both by Layne (1983) in southcentral Florida (X = 1.42) and by Walkinshaw (1982) on the Kissimmee Prairie for 1966-1981 (X = 1.89).

Frequency of juveniles/100 plumaged cranes ranged from a low of 6.0 on Webb WMA to a high of 11.2 on Kissimmee Prairie (Table 1). These figures are slightly lower than those recorded by Nesbitt on Kanapaha Prairie (15.2) and Martin County (9.67). The exceptionally high number seen on Kanapaha Prairie may reflect unusually good nesting conditions in a relatively small area.

Our fall surveys probably underestimate recruitment because families that stay on territories, especially territories in remote areas, are not as detectable as families found in the fall aggregations. Some family groups also may not roost communally during this time.

In particular, the frequency of juveniles/100 adults on the Webb WMA study area probably was low due to limited access to the area. Flooded roads and terrain conditions were such that no cranes were seen on the management area, despite 36 nests recorded during the breeding season. The only cranes located during the fall surveys were on private lands. Familiarization with study areas, more intensive surveys, and future color-banding will help resolve some of these problems.

Crane productivity in our three study areas was much lower than that reported previously by Layne (1983) in south-central Florida (range of 18.6-56.5 juveniles/100 adults over 7 years). Layne, however, only counted isolated pairs in determining this ratio. His results, therefore, probably are inflated because he did not count large flocks that included unsuccessful breeders, breeders that did not initiate breeding that year, family groups, and subadults.

Table 1. Mean brood size and number of juveniles in the population during mid August - mid October 1984 road surveys.

Study area	Total km driven	Total cranes counted	Total juveniles	$\overline{X}$ Brood size	Recruitment: Juveniles/ 100 adults	Recruitment: Juveniles/ total
Webb WMA	295	89	5	1.24	6.0	5.6
Myakka River SP	152	169	14	1.16[a]	9.0	8.3
Kissimmee Prairie	387	398	40	1.16[a]	11.2	10.05

[a] Two sets of chicks not included because sibling status could not be determined.

CONCLUSIONS

We believe that our methodology has tremendous potential. The aerial nesting surveys allow us to cover large areas, with limited human resources. Although our transects were not replicated precisely from survey to survey, they did provide data on nest distributions over time and space.

For the 1985 aerial nesting surveys we are using a fixed strip-width (Norton-Griffiths 1975) combined with a Loran-C navigation system. The Loran-C allows us to accurately repeat each of the transects from survey to survey. An additional aerial methodology will include an intensive nest search over 3 km^2 quadrats located along transect routes. These quadrats will allow us to develop a detectability index for nests along the transects.

Statistical analyses of the data from the transects, combined with the quadrat results, will enable us to generate area-wide estimates of the breeding population for each of the potential release sites. After the 1985 and 1986 breeding seasons, our study will be able to recommend to the State of Florida and the USFWS the site in Florida which has the most potential as a release site for whooping cranes.

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MANAGEMENT OF LESSER SANDHILL CRANES STAGING IN ALASKA

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Abstract: This paper reviews the population and habitat status of lesser sandhill cranes (Grus canadensis canadensis) on major Alaskan staging areas and suggests solutions to management problems. Major spring (late April-early May) and fall (August-mid-October) staging areas include: (1) Pt. MacKenzie-Palmer-Wasilla area of upper Cook Inlet, (2) eastern Copper River Delta, and (3) Gustavus flats used by 20-25,000 cranes in the Pacific Flyway; and (4) Tanana Valley used by nearly 200,000 cranes in the Central Flyway. Control of shrubs will be required on wet meadow and low shrub roosting and feeding areas on state-owned lands at Gustavus and federal lands on the eastern Copper River Delta where shrub invasion is threatening habitat. Alteration of farming practices and more use of hunters to harass cranes out of unharvested barley (Hordeum vulgare) is necessary in the Tanana Valley and soon will be needed in the Pt. MacKenzie-Palmer-Wasilla area. Crane use and hunter harvests need to be determined for staging areas.

PROCEEDINGS 1985 CRANE WORKSHOP

Nearly 200,000 Central Flyway and 20-25,000 Pacific Flyway lesser sandhill cranes (Grus canadensis canadensis) stage in Alaska during the August-October fall migration. Slightly fewer stage during the April-May spring migration. Pacific Flyway lesser sandhill cranes breed primarily on the lowlands of the Alaska Peninsula and Bristol Bay, on western Cook Inlet marshes, and on the Kenai River lowlands (Fig. 1). These cranes stage on and near their breeding grounds, on the Matanuska flats, Chickaloon and Portage flats in Cook Inlet, the Copper-Bering River deltas, Icy Bay lowlands, Yakutat Forelands, Gustavus flats, and the Stikine River Delta (Fig. 1). They are hunted only in Alaska and estimated harvests have ranged from 150 to 550 with an average of 230 for 1971-1980 (Kramer et al. 1983). The majority winter in the Central Valley of California, primarily in San Joaquin, Merced, Kern, and Stanislaus counties where T. Pogson and K. Kincheloe (1982. Winter survey of the Pacific Flyway population of lesser sandhill cranes in California, December 1981. Unpubl. rept., Univ. Alaska, Fairbanks. 26 pp.) counted 12,846 in December 1981.

The Central Flyway population of lesser sandhill cranes using Alaskan staging areas breeds in northeastern Siberia, and in Alaska, mainly on the Yukon-Kuskokwim Delta, but also on the Seward Peninsula, Tanana Valley, Koyukuk Valley, Kanuti flats, and upper Yukon-Porcupine flats (Fig. 1). These Central Flyway cranes stage on and near the breeding grounds and in the upper Tanana Valley where 198,000 were counted during fall 1977 (Kessel 1984). They winter mainly in eastern New Mexico and the Texas Panhandle. They are hunted throughout much of the fall migration route and the Alaska sport harvest has averaged 535 for 1971 to 1980 (Kramer et al. 1983). Spring subsistence hunters on the Yukon-Kuskokwim Delta harvested 1,033 in 1965 (Klein 1966), and 1,477 in 1981 (Copp and Smith 1981). Subsistence hunters probably take less than 500 cranes annually on and near the Seward Peninsula. Because of changes in Alaskan staging habitats, primarily due to farming and to plant succession as a result of the 1964 Great Alaskan Earthquake and glacial recession, this paper reviews the status of major Alaskan staging areas on migration routes, and discusses management concerns. Specific objectives are to:

1. Describe land ownership, land use, and vegetation of staging areas;
2. Review the distribution, timing, numbers, and harvest of cranes staging in Alaska;
3. Describe and discuss current and future problems for cranes on Alaskan staging areas; and
4. Recommend solutions to management problems.

I thank the following people for providing observations of cranes: Sharon Patchett, Barbara Jensen, Dena Matkin, Greg Streveler, and Dan Gibson. Thanks go to Dan Timm, Jack Didrickson, Don Quarberg, and Don Bunselmeier for their observations of crane habitat use and harvests. Appreciation is expressed to Tom Pogson, Dale Herter, and James Hawkins for sharing with me their understanding of the Pacific Flyway crane population and habitat changes. Special thanks goes to Phil Gipson of the Alaska Cooperative Wildlife Research Unit, the Alaska Division of Agriculture staff, University of Alaska Cooperative Extension agents, and Agriculture Experiment Station staff for assistance with crop damage questionnaires and farmer interviews. I thank Rod King and Dale Herter for their critical review of this manuscript.

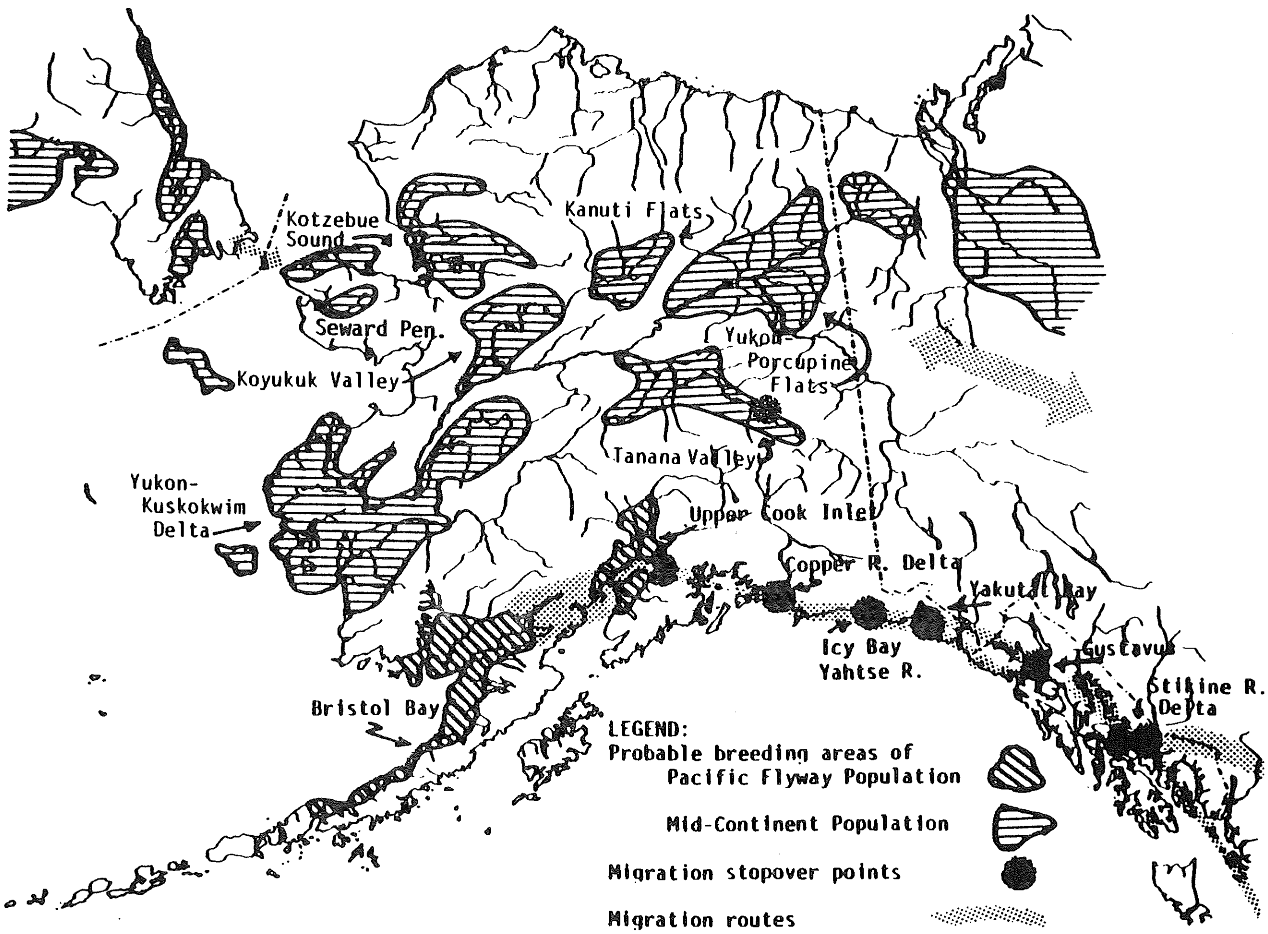

Fig. 1. Major breeding and staging areas of lesser sandhill cranes in Alaska.

METHODS

Much of this paper is based on a review of published and unpublished literature, on interviews of hunters and farmers in the Tanana and Matanuska valleys, and my observations made on the Copper River Delta, at Gustavus, and at Delta Junction. Ten farmers were interviewed and questionnaires were mailed to 194 farmers in the Tanana and Matanuska-Susitna valleys to assess crop damage caused by cranes. Alaska Department of Fish and Game area managers, Alaska Fish and Wildlife Protection officers, and University of Alaska Cooperative Extension agents were interviewed for observations of crane harvests and habitat use. Estimates of migrant crane numbers and crane use of staging areas were made by many volunteers at Cordova, Gustavus, and the Stikine River Delta.

RESULTS

Description of Staging Areas

Besides their breeding areas, which also are used for staging, major migration staging areas for the Pacific Flyway lesser sandhill cranes include western Cook Inlet and adjacent Susitna-Matanuska meadows and agricultural lands, the eastern Copper River Delta, and Gustavus flats (Fig. 1). The breeding areas for the population have not been clearly defined although

Pogson (pers. commun.) attempted to do so. Of the minor staging areas, little is known about crane-days of use at Chickaloon and Portage flats in Turnagain Arm of Cook Inlet, at the Bering River-Controller Bay flats, and at Icy Bay. In 1980 cranes made little use of the Yakutat Forelands (Patten 1981, Petersen et al. 1981) because most birds overflew the area. Finally, the Stikine River Flats received only minor use by cranes in the fall of 1984 (D. Gibson, pers. commun.).

For major staging area descriptions I will follow the avian habitat classification of Kessel (1979). Western Cook Inlet lowlands are under management authority of the Alaska Department of Natural Resources (ADNR), and of the Alaska Department of Fish and Game (ADFG) which has refuge lands at Redoubt Bay and Palmer Hay Flats. Timm (1982) and Vince and Snow (1984) have described the western Cook Inlet lowlands where cranes breed and stage in sedge-grass wet meadows and sedge-bog freshwater marsh (ranging from medium shrub to flooded wet meadow). Although portions of Cook Inlet subsided as much as 1.5 m during the 1964 Great Alaskan Earthquake (Foster and Karlstrom 1967), wet meadows have stabilized and plant succession is proceeding very slowly. Besides the wet meadows, cranes feed and rest in privately-owned agricultural fields in the Pt. MacKenzie, Wasilla, and Palmer areas (Fig. 2). Of these three areas, the Pt. MacKenzie agricultural project lands (6,800 ha) of spruce (Picea alba, P. mariana) and birch (Betula papyrifera) forest with sedge-bog lowlands (with approximately one third cleared for planting grain and hay crops) are the largest farm lands. The Pt. MacKenzie project is closest to crane breeding and roosting areas, and more lands are being cleared for farms. The older farms of the Palmer-Wasilla area are being subdivided for housing but do include fields of hay, small grains, cabbage, and lettuce where cranes can feed and rest. The area has intensive human use associated with dwellings and farms. In contrast, the western Cook Inlet flats receive little human use except by migratory bird hunters beginning in late August.

The eastern Copper River Delta (Fig. 1) is administered by the Chugach National Forest and is cooperatively managed by the U. S. Forest Service, ADNR, and ADFG. The area was designated by the Alaska Legislature as a Critical Habitat Area in 1978. Human use is minimal, with hunters only in the area during the fall crane migration. Herter (1982) has described the crane staging habitats of the eastern Copper River Delta, a 650 km^2 lowland in the eastern Gulf of Alaska, approximately 350 km from Cook Inlet staging areas. Cranes use four habitat types. (1) Medium shrub is dominated by sweet gale (Myrica gale) and sedges, and has small streams lined by alder (Alnus sinuata), and shallow ponds and lakes. (2) Wet meadows comprise most of the area, and are composed of sedges, grasses, and mosses interspersed with alder and willows (Salix spp.). (3) Salt grass meadow is dominated by sedges, salt grasses (Puccinella spp.), Plantago maritima, and Potentilla egedii. (4) Intertidal mudflats are devoid of vegetation and are inundated by saltwater. The entire area is undergoing rapid plant succession following the 2.7 m uplift caused by the 1964 Great Alaskan Earthquake (Crow 1971, Hawkings 1982). Shrub invasion is reducing the availability of feeding habitat in the wet meadow and medium shrub zones where cranes feed on bulbs of small arrowgrass (Triglochin palustris).

The Gustavus flats (Fig. 1) lie adjacent to Glacier Bay National Park in northern southeastern Alaska, approximately 570 km southeast of the eastern Copper River Delta. The 1,900 ha Dude Creek uplands are state owned except for 50 ha in private ownership. Much of the area is wet meadow dominated by sedges, mosses, and horsetails (Equisetum spp.). Willow thickets and Sitka spruce (Picea sitchensis) surround the meadows (Streveler, G. and Matkin, C. 1983. A preliminary evaluation of wildlife populations and habitats on Gustavus beaches and Dude Creek uplands. Unpubl. rept., Gustavus, Alaska. 19 pp.). Willows are invading the uplands due to glacial recession and consequent isostatic rebound, to creek entrenchment, and to construction of a drainage ditch and road. A 10 ha farm has been created at the southern edge of the uplands and 40 ha along the eastern edge may be subdivided. Although very little human use of the uplands occurs except at the farm, some skiers are present after snow falls (G. Streveler, pers. commun.). Hence, human activity is minimal and does not disrupt staging cranes.

The Central Flyway population of lesser sandhill cranes staging in Alaska uses habitats on and adjacent to their breeding areas. These staging habitats are on the Yukon-Kuskokwim Delta, Seward Peninsula, and lowlands adjacent to Kotzebue Sound, Koyukuk Valley, Kanuti flats, upper Yukon-Porcupine flats, and the Tanana Valley (Fig. 1). A majority of these cranes also pass through the upper Tanana Valley (Kessel 1984) to and from their wintering areas, primarily in Texas and New Mexico. This paper will deal mainly with the Tanana Valley staging habitats, particularly the Delta River to Gerstle River section (Fig. 3). The Tanana Valley from the

Delta River to the Alaskan-Canadian border includes 1,200 km^2 of primarily spruce (Picea alba, P. mariana); and spruce, paper birch, aspen (Populus tremuloides) mixed forest adjacent to riverine shrub thickets, wet meadows, ponds, and lakes (Kessel 1984).

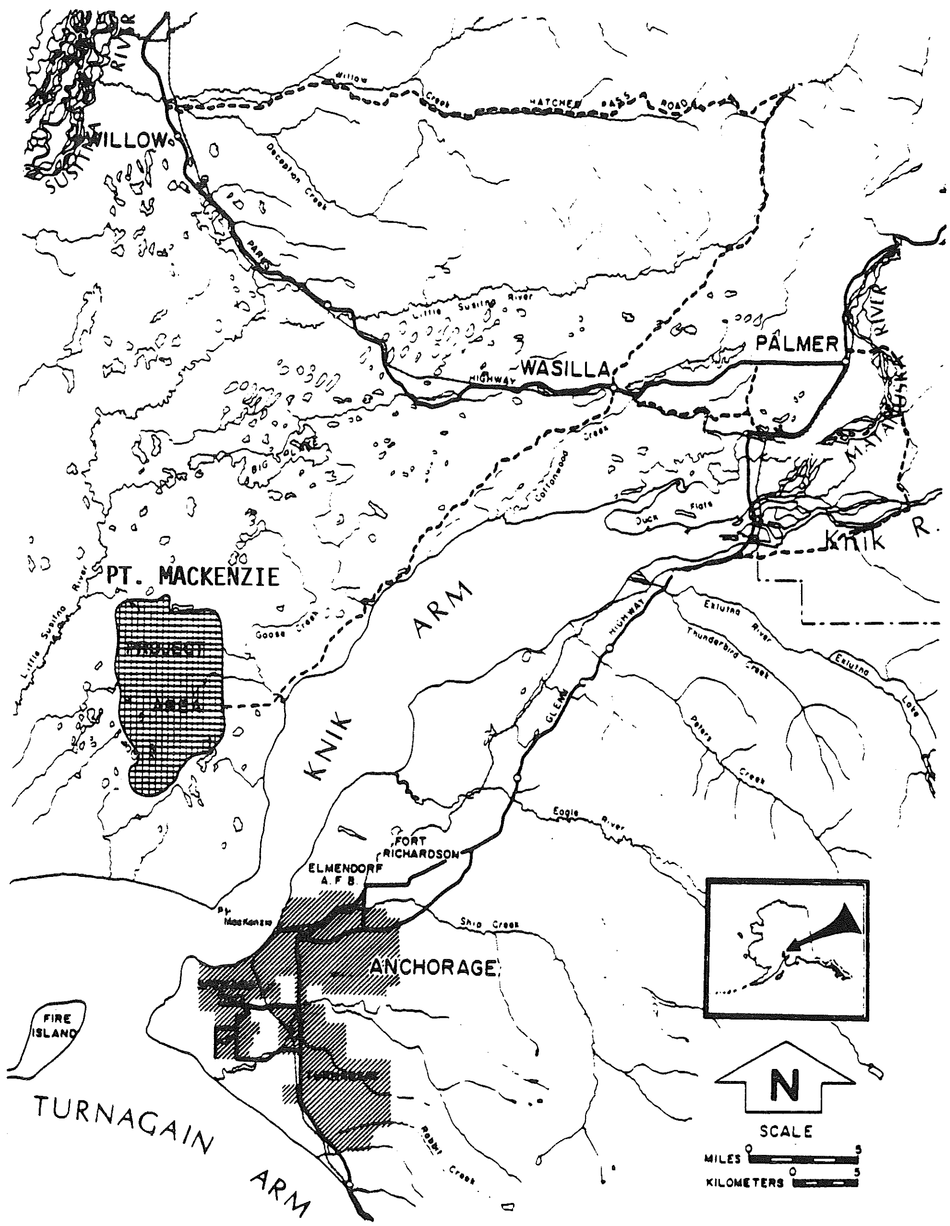

Fig. 2. Upper Cook Inlet crane staging areas.

The lower Delta River and the Tanana River from its junction with the Delta River eastward to the Gerstle River are heavily braided with numerous sand/gravel alluvial islands important for roosting cranes. These are the most important roost sites but wet meadows or edges of ponds and lakes, bogs, and open low shrub meadows and agricultural fields also are used for roosting (Kessel 1984). Kessel (1984) reported approximately 150 km^2 of agricultural lands in the area in 1976-79. There now are about 400 km^2 of farms of which an estimated 260 km^2 are cleared as fields. In 1983 over 60 km^2 was planted to barley (<u>Hordeum vulgare</u>). ADFG administers a Bison Range (Fig. 3) of which 240 ha have been cleared and 144 ha planted to grasses (Johnson 1984). Much of the Tanana River is managed by ADNR as the Tanana Valley State Forest. The Delta River and most of the land to the east (and south of the Alaska Highway) is in the Fort Greely Military Reservation.

Land use in the region is intensive on farms, although most large fields of harvested barley and unplanted fields are undisturbed while cranes are staging. Human use is periodically heavy on the Fort Greely Military Reservation lands. Roost sites on the Delta and Tanana rivers are seldom disturbed except by a few goose and crane hunters in September (D. Bunselmeier, pers. commun.).

Distribution, Timing, Numbers, and Harvest

The Pacific Flyway population of lesser sandhill cranes has been monitored most intensively on the Copper River Delta (Isleib and Kessel 1973, Herter 1982). Data on migrant cranes at Gustavus are available for 1981 through 1984. There are few records of distribution, timing, and numbers of cranes in the upper Cook Inlet area.

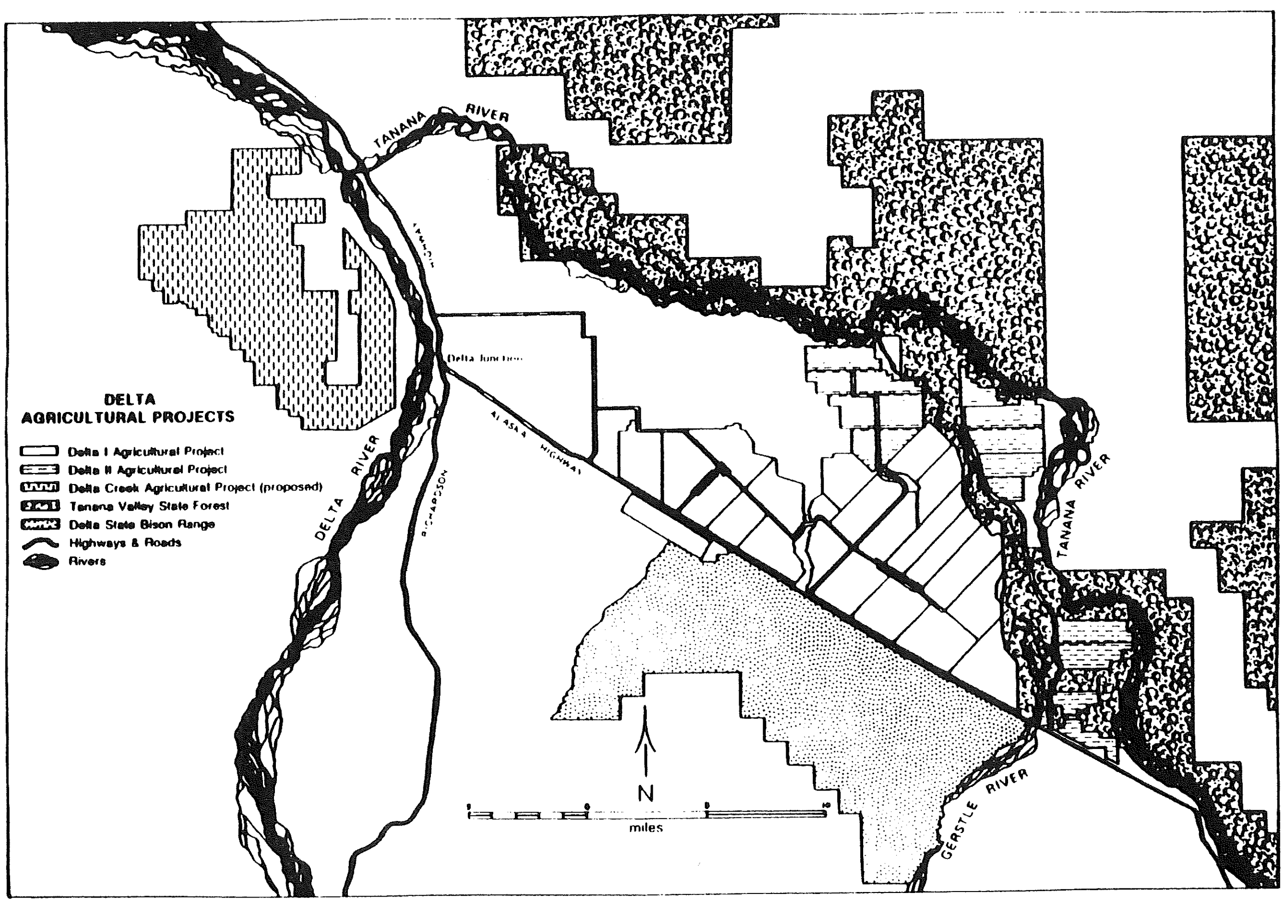

Fig. 3. Upper Tanana River Valley in the vicinity of Delta Junction, Alaska.

Cranes were observed at Gustavus from 21 April to 21 May in 1982, although a group of three stayed into July (Streveler and Matkin, unpubl. rep. 1983). Spring use of the Gustavus flats is light. Unless winds are unfavorable, most cranes continue their migration after spending a night (G. Streveler, pers. commun.). Only 1,295 were counted during the most intensive (but not complete) survey of spring 1982 (Streveler and Matkin, unpubl. rept. 1983).

Spring migrants arrive on the Copper River Delta in the last half of April, although the earliest record was 27 on 17 April 1969 (Isleib and Kessel 1973). Most pass through the area in flocks of 2 to 600 during the first few days of May (Herter 1981). Flocks were recorded daily on the wet meadows of the eastern Copper River Delta, and occasionally up to 500 birds roosted overnight. Virtually all cranes departed by mid-May (Herter 1982). The latest spring migrant was collected on 12 June 1908 (Grinnell 1910).

During fall most cranes first arrive on the Copper River Delta during late August and early September. I recorded the earliest flock (5) on 1 July 1984 although both Isleib and Kessel (1973) and Herter (1982) recorded first arrivals on 19 August in 1970 and 1980, respectively. Fall migration peaks during mid to late September. Flock sizes range from 2 to 7,000 and average 90 (Herter 1982). Cranes mostly use the eastern Copper River Delta for feeding, and roosting overnight before departing the next morning. Herter (1982) recorded some flocks staying there for 7-10 days. He observed 8,000 fly over on 16 September 1980 and the same number was recorded at Yakutat (Fig. 1) on 18 September by M. Peterson (Herter 1982). Herter (1982) suggests that some cranes overfly the delta during clear weather and stage on the Bering River--Controller Bay flats, and/or stage at Icy Bay (Fig. 1). Herter (1982) recorded the latest flock on 14 October 1979 and S. Patchett (pers. commun.) reported the last fall migrants on 24 October 1984 on the Copper River Delta.

At Gustavus, Streveler and Matkin (unpubl. rept. 1983) first saw cranes in 1981 on 2 September and most cranes passed through by 26 September. Of the 12,899 counted, at least 6,870 landed, with nearly all (5,926) using the Dude Creek uplands. Cranes appeared in numbers similar to those counted a week earlier on the eastern Copper River Delta (Herter 1982). In 1984, cranes first arrived at Gustavus on 31 August and the last flock (40) was observed on 31 October. The peak of daily arrivals was mid-September. At least 600 were at Dude Creek on 16 September (D. Matkin, pers. commun.). About 2,000 stayed a few days in mid-September at Rink and Dude creeks while awaiting favorable winds (G. Streveler, pers. commun.).

In the fall of 1980 Herter (1982) counted 18,038 cranes passing through the eastern Copper River Delta. He estimated that at least 20,000 were in the fall flight because some movement occurred at night and some cranes flew over the barrier islands and seaward beyond his sight.

In recent years the harvest of the Pacific Flyway population of lesser sandhill cranes in the Palmer-Susitna area of upper Cook Inlet ranged from under 50 in 1984 to a maximum of about 200 (J. Didrickson, pers. commun.). The range of estimated harvests has been: 25-50 for Redoubt Bay, 10-50 for Trading Bay, 10-50 for Susitna Flats, 5-25 for Palmer Hay Flats, 25-75 for Portage Flats, and 25-75 for Chickaloon Flats (D. Timm, pers. commun.). On the eastern Copper River Delta, 30 were killed by hunters in 1978 and 85-95 in 1979 (Mickelson, P., J. Hawkins, D. Herter, and S. Murphy. 1980. Habitat use of birds and other wildlife on the eastern Copper River Delta, Alaska. Unpubl. rept., Alaska Coop. Wildl. Res. Unit, Univ. Alaska, Fairbanks. 189 pp.). In recent years cranes have not been hunted or killed at Gustavus (G. Streveler, pers. commun.). Timm (1974) estimated that 290 were killed in 1973 with a harvest of 46 on the Alaska Peninsula, 200 in Cook Inlet, 22 on the North Gulf Coast, and 22 in southeastern Alaska. For 1975, Timm (1976) estimated the harvest for the same areas as: 548 total, and 100, 100, 248, and 100, respectively. Kramer et al. (1983) estimated an average harvest of 230 for 1971 through 1980. For the 1983 harvest Campbell and Rothe (1985) estimated 265.

The Central Flyway population of lesser sandhill cranes staging in the Tanana Valley arrive as early as 15 April with most first arrivals occurring during 20-22 April. The spring migration at Delta Junction was during 25 April to 16 May in 1978 when 172,000 were counted and during 27 April to 19 May 1979 when 148,000 were tallied. Peak movement was 35,000 on 7 May 1978 and 52,000 on 12 May 1979 (Kessel 1984).

During fall migration near Delta Junction 186,000 migrant cranes were recorded from 4 to 27 September 1977 and 198,00 during 1-28 September 1978. Peak movement was 51,000 on 19 September 1977 and 47,000 on 21 September 1978. In 1984 the latest migrant cranes in the Tanana Valley were observed on 9 October by R. Hadley (pers. commun.). In 1977 and 1978 Kessel (1984) did not consider the Tanana Valley to be a staging area because most birds overflew the area or only fed during the evening, roosted overnight, and departed the next morning. Since then, little effort has been made to watch cranes in spring, but a shift in crane use has been documented for fall migrants. In 1984 more cranes staged for several days on Delta I barley fields and tended not to use traditional field feeding and roosting sites north of Delta Junction (D. Bunselmeier, pers. commun.).

The estimated crane harvest in the upper Tanana Valley in 1984 was 250-300 (D. Quarberg, pers. commun.) compared with about 200 in 1973 (Timm 1974) and 729 in 1975 (Timm 1976). In 1984 more farm lands were available and open to hunters.

Management Problems

Unlike spring staging cranes on the Platte River in Nebraska (Krapu et al. 1984), cranes spend little time in spring on Alaskan staging areas. Cranes are in excellent condition upon arrival in the upper Tanana Valley in spring (Iverson 1977) and do not need to linger on staging areas before reaching their breeding grounds. Most management problems relate to fall staging cranes and center around plant succession. Staging habitats on the eastern Copper River Delta and the Gustavus flats are declining in quality due to shrub and tree invasion. New farm fields, especially in the Tanana Valley, have resulted in some barley and truck garden crop losses due to crane depredations, and in greater hunter opportunities.

The 1964 Great Alaskan Earthquake resulted in an uplift of 2.4 m on the western Copper River Delta and a 3.05 m uplift on the Bering River-Controller Bay flats (Plafker 1969). Former saltmarsh on the eastern Copper River Delta now is wet meadow with moss predominating in the mesic sites and alder, willow, and sweet gale (Myrica gale) invading well-drained sites. Shrubs already were impairing crane visibility in wet meadows by 1980 (Hawkins 1982), thereby reducing their value for roosting and feeding cranes. Observations by Hawkins (pers. commun.) in mid-September 1984 indicate that shrub stands have doubled in width and height since 1980.

On the eastern Copper River Delta during 1978-1980, Herter (1982) found cranes feeding almost exclusively in wet meadows, often adjacent to medium shrub habitat. His observations indicated that cranes were feeding farther eastward where poor drainage had slowed the shrub invasion. Cranes rarely fed in salt grass meadows but did use these areas occasionally for secondary roosts (for preening, dancing, and resting immediately preceding or following nighttime roosting) or as a refuge from hunter and aircraft harassment (Herter 1982).

Herter (1982) estimated that only 10 km^2 of wet meadows west of Spruce Islands were favorable crane feeding habitat in 1980. He points out the threat of shrub encroachment reducing crane feeding habitat in wet meadows. Thus, cranes must use small openings in shrubs where wet meadows are located, or move to salt grass meadows. He found Triglochin palustris the favored food of cranes, growing in salt grass meadows, but in dense, muddy substrates where extraction by cranes might be difficult.

Cranes roosted in all four habitat types on the eastern Copper River Delta but favored wet meadow sites. They often were forced to use these sites during stormy weather. As shrubs invade, more crane use of intertidal mudflats can be expected (Herter 1982).

At Gustavus, glacial recession in Glacier Bay has resulted in glacial rebounding of the land at a rate of 4 cm/year (Hicks and Shofnos 1965). This uplift plus improved drainage due to creek entrenchment and artificial ditching will promote plant succession (Streveler and Matkin, unpubl. rept. 1983). Drainage is a critical determinant of vegetational type (Streveler and Paige 1971). The former poorly drained Dude Creek uplands are drained by Dude Creek and Good River, and by an artificial ditch at the southern edge of the uplands. Encroachment by willow, spruce, and pine (Pinus contorta) is occurring (G. Streveler, pers. commun.). A closed canopy spruce forest developed on well-drained sites 75-100 years after deglaciation at Glacier Bay (Decker 1966) consequently, cranes may soon be forced out of the Dude Creek uplands unless shrub invasion is slowed.

Responses to questionnaires sent to 65 farmers in the Pt. MacKenzie-Wasilla-Palmer area indicate that crop damage caused by cranes has been minor. The farmer suffering the most damage estimated $3,000 worth of lettuce heads were destroyed by cranes in August 1982. Damage to crops in 1984 was fairly light (Table 1) but more can be expected as new fields are planted to barley at the Pt. MacKenzie project farm lands. Barley is usually harvested in mid-September or later, 1 week after the majority of cranes arrive in this staging area.

Only one of 110 farmers sent questionnaires in the Tanana Drainage near Fairbanks reported damage in 1984 (Table 1). In the past some farmers lost newly seeded grains and others lost cabbage heads due to crane depredations. Most truck garden crops are harvested before migrant cranes arrive in the Fairbanks area, and the number of cranes breeding and over-summering is probably less than 300. However, some serious damage has occurred at the University of Alaska

Table 1. Responses to a questionnaire/interview about lesser sandhill crane damage to crops on Alaskan farms in 1984.

	Wasilla-Palmer-Pt. MacKenzie	Tanana Valley Central	Tanana Valley Upper	Total
Number of interviews	1	0	7	8
Number of questionnaires mailed	65	110	19	194
Number of responses to both surveys	19	11	15	45
Number of farms with crops	15	8	14	37
Number of farms with crop damage by cranes	5	1	6	12
Number of farms with crop loss estimates	3	1	5	9
Estimated total crop damage by cranes	$1,120	$200	$8,145-10,438	$9,465-11,758

Experimental Farm plots where grain varieties were being evaluated (F. Wooding, pers. commun.)

Nineteen questionnaires were sent to farmers and another seven farmers personally interviewed about crop damage in the Tanana Valley near Delta Junction. A few Delta I barley project farms near crane roosting sites on the Tanana River suffered up to 10% losses of swathed barley in 1984 (Table 1). Cranes and geese (Branta canadensis, Anser albifrons) trampled, ate, and defecated on swathed grain mainly on three farms. Two of these farms were within 1 km of ponds used by resting geese and cranes. Damage to swathed grain occurred in 1984 despite increasing and even heavy hunting at these ponds and along barley fields.

DISCUSSION

Both the Copper River Delta and Gustavus flats are undergoing rapid succession. Cranes are losing important wet meadow feeding habitat. The U. S. Forest Service has expressed concern about shrub invasion on the Copper River Delta. They are developing a long range plan of action (F. Arbogast, pers. commun.) which will include shrub control on the western Copper River Delta, primarily to benefit Canada geese. G. Lingle and P. Currier (pers. commun.) have developed a successful technique for removal of shrubs and trees from crane roosting sites on sandbars of the Platte River in Nebraska. After mechanical removal of shrubs and trees with a Bush Hog or Kershaw Klearway rotary mower, Roundup or Graslan herbicide is applied to resprouts. This treatment appears feasible for control of shrubs on the eastern Copper River Delta to benefit cranes. Otherwise, cranes will be forced into salt grass meadows which are poor feeding areas and lack shelter for cranes in stormy weather.

The Dude Creek uplands at Gustavus are primarily under state ownership. Efforts were made in the past to create a state game refuge, primarily to benefit cranes. A refuge was not established due to lack of local support (G. Streveler, pers. commun.). Currently there is an effort to ask the state legislature to designate the area as Critical Habitat. This will draw more attention to wildlife and possibly result in better planning to help reduce the adverse impacts of subdivisions and farms on and near crane staging habitat. Further, G. Streveler (pers. commun.) will ask The Nature Conservancy to participate in management of the area. Through cooperation of ADFG and The Nature Conservancy, perhaps a plan can be devised to control shrubs and maintain staging habitat. If the staging habitat is not maintained, cranes will be forced to use wet meadows at Rink Creek and along the Salmon River. Both areas have more human activity than Dude Creek uplands, and they also are undergoing succession. Some fields have been cleared east of the Dude Creek uplands. They range from about 2 to 10 ha in size and some have been planted to barley. Once harvested, these fields could provide new feeding and daytime secondary roosting sites. Serious crop damage by cranes is unlikely if harvests occur before 10 September. Overnight roosting could occur in the Dude Creek uplands, at Rink Creek, and possibly near the upper intertidal flats to the south.

Cranes must begin using alternative staging areas unless plant succession is slowed or reversed. Little is known about the Bering River-Controller Bay flats. During crane migration some crane use occurs in fall (Isleib and Kessel 1973, G. Covel, pers. commun.). However, the area was uplifted 3.05 m (Plafker 1969) during the 1964 Great Alaskan Earthquake, and also is undergoing shrub invasion (Hagen and Meyer 1978). It is 350 km from Cook Inlet staging areas. This is an easy 1 day flight based on an average speed of 55 km/hr (clocked on the Copper River Delta on a windless day), and on a morning departure time of 0900 hours by the cranes.

Icy Bay may provide some staging habitat, although habitats and crane use of the area have not been described. The Yakutat forelands do contain habitat suitable for staging cranes (Patten 1981, Petersen et al. 1981). They are 640 km from Cook Inlet, or at the maximum distance of daytime crane flight capabilities. Cranes made little use of the area in the fall of 1980, possibly because clear weather and northwesterly winds permitted cranes to bypass the area in favor of staging at Gustavus.

The Stikine River Delta (Fig. 1) is 290 km from Gustavus and 550 km from the Yakutat Forelands. D. Gibson (pers. commun.) recorded light use by cranes in September 1984. During unfavorable winds, perhaps 1,000 cranes staged on Sergief Island. There is approximately 1,500 ha of wet meadow habitat on Farm and Sergief Islands (ABR 1980). The area probably could support more staging cranes.

Only a few farmers in the Tanana Valley and in the Matanuska-Susitna Valley have had significant crop damage due to cranes (Table 1). More crop damage can be expected as cranes learn to use newly created barley fields. Barley is harvested in most years in mid to late September and some fields are combined even in mid-October. Farmers often swath barley in late August then begin combining in the second week of September. Most cranes migrate through the area in mid-September when at least half of the barley is unharvested, and, therefore, more susceptible to damage by cranes. Most falls at Delta Junction have been wet--delaying the harvest. Snow and winds knock down standing barley, permitting cranes to more easily land and cause damage.

Short range methods for depredation control have included use of zon guns and patrols of fields. Stephen (1967) suggested use of a zon gun for each 65 ha of field. Hochbaum et al. (1954) estimated that one person could patrol 80 km^2 of fields, thus a minimum of four people might be able to patrol the Delta barley project lands. Some farmers and ADFG managers believe that more hunters along unharvested, swathed fields could be helpful for chasing cranes to harvested fields or to nonagricultural sites. This action would involve few hunters except at Pt. MacKenzie and Delta large agricultural tracts.

Refuges or lure crops may be needed to keep cranes out of large tracts of farm fields until barley is harvested. The two farms most susceptible to crane damage are located within 1 km of ponds that are used by roosting cranes and waterfowl. Crop damage would be reduced if these ponds (on state land) and adjacent crops (either purchased from farmers, or fields on state lands planted to barley and swathed) were closed to hunting until after most Delta I barley was harvested. Use of hunters proved to be cheaper and more effective for reducing crane and goose damage to barley in western Wyoming (Serdiuk 1981, Lockman et al. 1984). Also, the Delta Bison Range could have more land cleared and barley planted for bison, waterfowl, and cranes. However, such plantings might cause damage on more farms which lie under the cranes flight path between roosting sites on the Tanana River and the Bison Range (Fig. 3).

There are several long-range solutions to crop damage prevention and reduction. Most damage has occurred on farms where barley was swathed to reduce damage from wind, and to let immature seed heads harden (to reduce moisture content and drying costs). A high yield, early-maturing barley variety with shatter-resistant heads would be ideal for Delta barley farms. Farmers would have less need to swath barley which is easily consumed by cranes and waterfowl, and more easily contaminated by their feces. An early maturing variety could be harvested in late August and early September before the major influx of fall migrant cranes.

More planning is necessary for field design of new farms. Access trails should be bulldozed along section lines. Most clearing is by two bulldozers dragging a 60 m chain between them and knocking down a 50 m wide swath. Field width could be reduced to 40 m when trees and stumps are bulldozed into berm piles. Length of fields should be oriented perpendicular to prevailing winds. A narrow zone of standing timber separating fields, combined with a narrow field width, will reduce ability of cranes to land, and also wind erosion of soil.

Finally, zoning of lands against agricultural development should be considered for potential farms adjacent to important crane roosting sites. Also, proposed agricultural lands (e. g., the Nenana area, Fig. 1) that are located in areas where barley, due to climatic conditions, will have to be harvested after early September, probably should not be developed because of crop damage problems.

Harvested barley fields at Delta are increasingly more important to fall migrant cranes. I estimate that the waste grain after combining 6,000 ha of barley could easily support 200,000 cranes for 2 weeks during fall.

CONCLUSIONS

An effective shrub control technique needs to be applied to control shrubs in wet meadows used by staging cranes on the eastern Copper River Delta and the Gustavus flats. Alternative staging areas including the Bering River-Controller Bay area, Icy Bay, and the Stikine River Delta need to be described (in terms of vegetation, crane days of use, and hunter harvest) to assess their value for staging cranes.

Crop damage control techniques need to be more widely applied at farms, especially in the upper Tanana Valley near Delta. More intensive hunting pressure is necessary to disperse cranes from small tracts or farms until crops are harvested. Management of this hunt would require close cooperation among farmers, extension agents, and hunters, and would require use of radio and newspaper advertisements. Harvest and crane days of use should be monitored.

New farms near crane roosting areas need to be only partially cleared of trees so that narrow field width and periodic wind breaks make it difficult for cranes to land and cause crop damage. Planners for, and reviewers of farm development proposals should consider not establishing farms where: (1) crop damage will be severe due to close proximity to staging areas, and (2) there is a great likelihood of crop harvests occurring after most migrant cranes arrive in the area.

Continued documentation of crane use at staging areas is desirable to monitor changes in crane distribution and habitat use. The layover time for cranes is not known for the upper Tanana Valley staging sites. I predict that crane use during fall will increase substantially as agriculture expands. Both hunters and farmers can benefit if this expansion occurs after the barley is harvested. Some farmers have considered leasing lands for hunting and some also hunt on their own lands. Migratory bird managers should consider increasing daily bag and possession limits initially, to permit more harvest of cranes in the brief period that they migrate through Alaska. This may help attract hunters to farm areas to help reduce crane depredations. Ten of 14 farmers surveyed near Delta Junction allowed hunting. A larger bag limit may reduce wastage of cranes due to accidental or intentional shooting of more than two cranes per day (G. Brehmer and R. Armstrong, pers. commun.). The Alaska sport harvest of the Central Flyway lesser sandhill cranes averaged 535 from 1971 through 1980 (Kramer et al. 1983), and was 1,540 in 1983, in addition to 12,959 harvested from the mid-continent population in other states (Miller this Proceedings). If the bag and possession limits were raised to three and six, respectively, I would expect the harvest in Alaska to increase as much as one third. Since an estimated 250-300 cranes were harvested in 1984 in the Delta area alone (D. Quarberg, pers. commun.), 1,700 to 2,200 might be a reasonable estimate for the Alaskan sport harvest of Central Flyway lesser sandhill cranes, and 300 to 600 for the Pacific Flyway population.

Closer monitoring of crane populations is desirable if hunting pressure continues to increase. Cranes are counted on the waterfowl breeding transect surveys in spring (Conant and Hodges 1984). Perhaps a statewide spring crane watch could be coordinated to estimate number of spring migrants in both populations, as suggested by C. Lensink and T. Pogson (pers. commun.). This spring count combined with monitoring crane production in major breeding areas (including National Wildlife Refuges) could provide better data for setting new bag and possession limits. Only through cooperative efforts can we more effectively manage sandhill cranes in Alaska.

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COMPUTERIZED MANAGEMENT AND DISPLAY OF WHOOPING CRANE OBSERVATION DATA

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Abstract: This paper discusses and demonstrates a prototype information management system for whooping crane (*Grus americana*) observation data that integrates traditional data base management system (DBMS) capabilities with recently developed geographic information system (GIS) techniques. A sample dataset from the Grays Lake-Bosque del Apache National Wildlife Refuges' foster parent population is used to illustrate typical information searches and demonstrate computerized mapping of sighting locations. The data base design contains 26 items of information, including bird identification and age; sighting duration; state, county, and national/state wildlife refuge locations; latitude and longitude coordinates of observations; and observation type, seasonal status, confidence, and source. This information management approach provides an automated alternative to traditional manual methods for storing, retrieving, analyzing, and displaying biological information for environmental assessment and wildlife species management.

PROCEEDINGS 1985 CRANE WORKSHOP

Traditional natural resource information management relies heavily on manually-produced hardcopy documentation. In some situations, this textual and tabular information has been automated in a computer using some type of DBMS. Manual searches of hardcopy documentation for information retrieval are labor intensive, inefficient, and costly. Many early DBMS's were not easy to use or "friendly" to potential users while others were nonrelational and, therefore, had limited data search and retrieval capabilities. Some had poor or no statistical analysis potential. Another problem was the lack of data management techniques to geographically display certain types of resource information for planning and management purposes. Recent developments in computerized GIS technologies have solved this display problem.

The objective of this project is to demonstrate a prototype information management system for whooping crane observation data that integrates DBMS capabilities with recent GIS techniques. This system provides researchers, biologists, planners, and managers with an automated tool for rapid environmental assessment and wildlife species management. This objective attempts to address the need for better management and utilization of important wildlife and wildlife habitat observation data and knowledge. This need is documented by the seemingly continuous requests for this information for use in assessing potential environmental impacts by private industry, state agencies, and, primarily, Federal natural resource agencies.

This project was funded by the U.S. Fish and Wildlife Service. We are grateful for the technical assistance of P. W. Dempsey, D. N. Gladwin, D. M. Weyer, and D. A. Gal. Our sincere thanks go to C. I. Short, and W. M. Brown, for manuscript review and to D. E. Ibarra for manuscript typing.

METHODS

WHOOPER Data Base

The WHOOPER prototype data base is from observations of four whooping cranes hatched and reared by sandhill crane (*G. canadensis tabida*) foster parents in 1975 at Grays Lake National Wildlife Refuge, Idaho (Drewien and Bizeau 1978). Sightings were obtained by biologists and other field personnel from 1975-1982 in Montana, Idaho, Utah, Colorado, and New Mexico. Whooping cranes from the foster parent population can also occur in Wyoming, Arizona, and Mexico, but data from these areas are not included in this sample data base. The data base consists of 160 observation records, each containing 26 items of information (Table 1), and can be easily expanded to accommodate additional information items as needed. For example, additional fields of coded observation items can be added, e.g., the habitat type where observed or the associated wildlife/bird species. The number of records is expandable as the crane population grows and the number of observations increases.

Table 1. Observation items and selected codes and explanations for the prototype whooping crane data base. Two item numbers on the same line indicate that both integer and textual fields are created in the data base.

Item no.	Observation item	No. characters
1	Observation No.	4
2	Bird identification (e.g., Canadian 75-01).	4
3 & 4	Bird age: 1 = Adult, 2 = Yearling, 3 = Juv., 4 = ?	1 & 10
5	Observation or sighting: 1 = Observation (one time), 2 = Sighting (duration: from-to)	1
6	Observation date or sighting date from (e.g., 790124 = 24 January 1979)	8
7	Sighting date to	8
8	No. of observation days	3
9 & 10	State code	1 & 15
11 & 12	County code	3 & 15
13 & 14	Federal or State refuge code	2 & 25
15	Lat. coordinate of observation (e.g., 3348 = 33° and 48 min N latitude)	4
16	Long. coordinate of observation (e.g., 10653 = 106° and 53 min W long	5
17	Accuracy of lat./long. coordinates: 1 = Nearest 1 min, 2 = Nearest 5 min, 3 = Nearest 10 min.	1
18	Type of observation: 1 = Actual sighting, 2 = Radio, 3 = Ground, 4 = Aerial (e.g., 2-3 = Codes a radio location made on the ground).	2
19 & 20	Season of observation: 1 = Summer, 2 = Winter, 3 = Spring migration, 4 = Fall migration, 5 = Spring staging area, 6 = Fall staging area.	1 & 20
21	Confidence of observation: 1 = Positive, 2 = Confirmed, 3 = Probable, 4 = Uncertain.	1
22 & 23	Observer and verifier of observation (e.g., 0801 = observation made by Montana Fish and Game Department and verified by University of Idaho).	4
24	Name of observer	20
25	Status of bird: 1 = Alive, 2 = Dead	1
26	Comments	5 lines of 80

To build the prototype data base, whooping crane field observations were manually entered onto a data collection form designed around the observation items contained in Table 1. Data entry personnel key punched data from completed forms into the DBMS data base. A data base field form also was designed that allows biologists to perform interactive data entry directly at a computer terminal.

Computer Software Employed

Two software systems were required for the storage, retrieval, analysis, and display of whooping crane observation information in this prototype project. The primary system required was a DBMS to conduct relational and simple searches of information items in the data base. Relational capabilities allow the use of complex Boolean logic to relate records in one dataset to records in another dataset. For example, the user might wish to query the data base for records that simultaneously meet several selected item criteria from Table 1 such as all juvenile bird identifications and locations during the 1980 spring staging period in Colorado. Additional requirements of the DBMS included the capability to perform basic statistical calculations, to handle data in both alpha and numeric formats, and to export data subsets to an external ASCII file so that, if necessary, the data are available for other software systems to access and reformat.

The DBMS used was a system called InFoCen, developed and maintained by Creative Consulting Corporation International (3CI) in Fort Collins, Colorado. InFoCen is a proprietary DBMS that is copyrighted by 3CI (mention of trade names of commercial products does not constitute endorsement or recommendation for use by the Division of Biological Services, Research and Development, Fish and Wildlife Service, U.S. Department of the Interior).

A secondary system required for the analysis and display of crane observation locations and associated map-based information (e.g., state and county boundaries, rivers, towns, and refuge boundaries) was a GIS. The GIS used in this project, developed by the U.S. Fish and Wildlife Service's Western Energy and Land Use Team in Fort Collins, Colorado, was the Map Overlay and Statistical System (MOSS) (Lee et al. 1985). MOSS was designed by users to provide a user-friendly natural resource planning tool for geo-based information. It allows the user to retrieve, analyze, and display map themes and associated spatial data stored in a computerized system. MOSS has been used in hundreds of successful applications, including wildlife habitat evaluation, forest and range management planning, energy development planning, wetland habitat evaluation, land use planning, and coastal/off-shore ecological assessment. MOSS subsystems allow the user to work in either polygon (lines and points) or cellular (grid) formats.

Data searches for whooping crane observations that meet selected criteria are accomplished in the DBMS. Records that satisfy the criteria are accomplished in the DBMS. Records that satisfy the criteria are exported to an external ASCII file. An interfacing program reads this exported file, which contains a complete set of the InFoCen data, and creates another file. MOSS uses this new file to plot the latitude/longitude coordinates of the selected records and to overlay resource themes, such as state, county, and refuge boundaries; towns; rivers; reservoirs; and lakes. New data searches must be conducted and the resultant file run through the interfacing program whenever new records are added to the data base or when existing records are changed.

Other software systems were used in the overall project. A digitizing system, the Analytical Mapping System (Sandlin 1985), was used to manually digitize the background themes of the map data mentioned above. A Cartographic Output System (Frosh and Walsh 1983) was used to produce hardcopy maps from the MOSS files that contained the combined background information and crane observation locations. The Analytical Mapping and the Cartographic Output Systems were developed by the U.S. Fish and Wildlife Service.

RESULTS

Data Management Implications

The DBMS has a multitude of practical uses for biological research and management purposes, as well as for resource planning by government agencies and the private sector. For example, the DBMS provides a tool that researchers can use to analyze and summarize data rapidly, land managers can use to obtain needed information for management decisions, and resource planners and developers can use to help assess potential environmental impacts at specific locations.

The DBMS can be queried for general summary data or partitioned for a specific inquiry. It also can be used to perform basic statistical analyses. Answers to queries of the whooping crane observation data in the DBMS are provided in two formats: (1) tabular ouputs and (2) graphical displays, such as bar graphs, line graphs, and pie charts. To supplement the DBMS, the GIS can be used to generate maps that contain a geographical representation of the data.

Examples of the integrated use of the DBMS and the GIS, through queries of whooping crane observation data, are presented here to provide insight into the types of applications available to potential users. For example, the response to a query about the number of whooping crane records by state in the data base can be provided by (1) tabular output, such as that presented in Table 2 (question 1); (2) graphically by a bar graph, such as that in Fig. 1; and (3) geographically displayed by a map produced by the GIS (Fig. 2). These summary data can be partitioned by asking for the distribution by counties of the 40 whooping crane records for Colorado (Table 2 - question 2; Fig. 2). Figure 1 also includes a pie chart summary, in response to a query about the age class distribution of crane observations in the data base.

An example of how these data can be used in resource planning is presented in Table 2, questions 3 to 6. In this example, a utility company plans to construct a new transmission line in western Colorado, passing through Delta County. The planners are aware that whooping cranes, which are prone to powerline collisions, occasionally stop in this area. The utility company requests information on the locations of whooping crane sightings in western Colorado from the U.S. Fish and Wildlife Service. They request specific information on a sighting in Delta County, including location and date. Information contained in the DBMS documents that the observation was a confirmed sighting of an adult whooper identified as 7501. The bird stopped overnight at Fruitgrowers Reservoir during the 1982 spring migration. Name of the observer and his comments also can be provided.

Table 2. Example query questions and answers from the computerized whooping crane observation data base.

Question 1. How many whooping crane records by state are in the data base?

NO.	LOCATION/VALUE
40	COLORADO
19	IDAHO
2	MONTANA
94	NEW MEXICO
6	UTAH

Question 2. What is the distribution by county of the 40 whooping crane records for Colorado?

NO.	LOCATION/VALUE
6	ALAMOSA
2	CONEJOS
1	DELTA
1	MONTROSE
1	QURAY
1	RIO BLANCO
28	RIO GRANDE

Question 3. What dates and locations were the whooping cranes observed in Delta County, Colorado?

DATE FROM	DATE TO	LOCATION/VALUE	LATITUDE-LONGITUDE
5 APRIL 1982	6 APRIL 1982	FRUITGROWERS RESERVOIR	38°49' - 107°56'

Question 4. What was the identification and age of the whooping crane observed in Delta County, Colorado?

BIRD ID	BIRD AGE
7501	ADULT

Question 5. What is the confidence value of the Delta County, Colorado, observation and the name of the observer?

CONFIDENCE VALUE	OBSERVER NAME-VERIFIER
2 = CONFIRMED	M. PETERSON-FOREST SERVICE

Question 6. What coments were provided with the Delta County, Colorado, observation?

COMMENTS

ARRIVED 3 PM ON 5 APRIL AND DEPARTED IN AM ON 6 APRIL

Question 7. At what locations and dates did whooping crane 7501 spend the summer?

BIRD ID	BIRD AGE	DATE FROM	DATE TO	NO. OBS. DAYS	LOCATION/VALUE
7501	JUVENILE	75/06/03	75/10/14	134	GRAYS LAKE NWR
7501	YEARLING	76/06/11	76/10/03	115	BLACKFOOT RIVER, IDAHO
7501	ADULT	77/05/02	77/10/10	181	GRAYS LAKE NWR
7501	ADULT	78/04/09	78/10/13	188	GRAYS LAKE NWR
7501	ADULT	79/04/12	79/10/12	184	GRAYS LAKE NWR
7501	ADULT	80/04/15	80/10/14	183	GRAYS LAKE NWR
7501	ADULT	81/04/10	81/10/17	191	GRAYS LAKE NWR
7501	ADULT	82/04/13	82/05/13	31	GRAYS LAKE NWR

Question 8. What comments were provided for the last observation of whooping crane 7501?

COMMENTS

FOUND DEAD IN BARBED WIRE FENCE ON 15 MAY 1982

(continued next page)

Table 2 (cont.).

Question 9. When do juvenile whooping cranes migrate from Grays Lake NWR, Idaho? When do they arrive on their winter grounds? What is the duration of their fall migration?

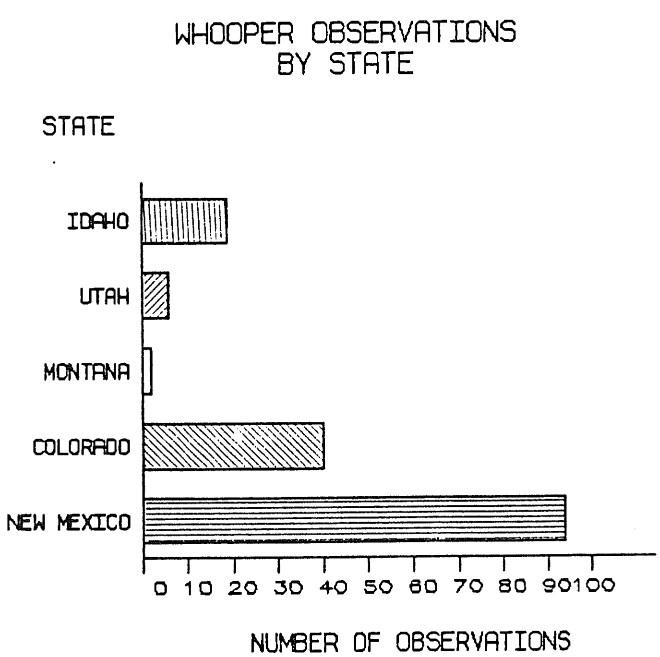
BIRD ID	DEPART GRAYS LAKE NWR	ARRIVE NEW MEXICO	NO. OBS DAYS
7501	75/10/14	75/11/11	29
7504	75/10/16	75/11/11	27
7505	75/10/08	75/10/25	18
7512	75/10/15	75/12/01	48

ITEM NAME	NO.	MINIMUM	MAXIMUM	AVG	STD. DEV
DEPARTURE	4	10/08	10/16	10/13	±3.6

ITEM NAME	NO.	MINIMUM	MAXIMUM	AVG	STD. DEV
ARRIVAL	4	10/25	12/01	11/14	±9.9

Question 10. What are the last observation dates and locations of whooping cranes hatched in 1975?

BIRD ID	OBS NO.	DATE FROM	STATE	COUNTY	REFUGE
7501	0092	82/05/13	IDAHO	CARIBOU	GRAYS LAKE NWR
7504	0147	80/11/29	NEW MEXICO	SOCORRO	BOSQUE DEL APACHE NWR
7507	0154	81/03/02	COLORADO	ALAMOSA	
7512	0018	76/02/20	COLORADO	CONEJOS	LAS SAUCES



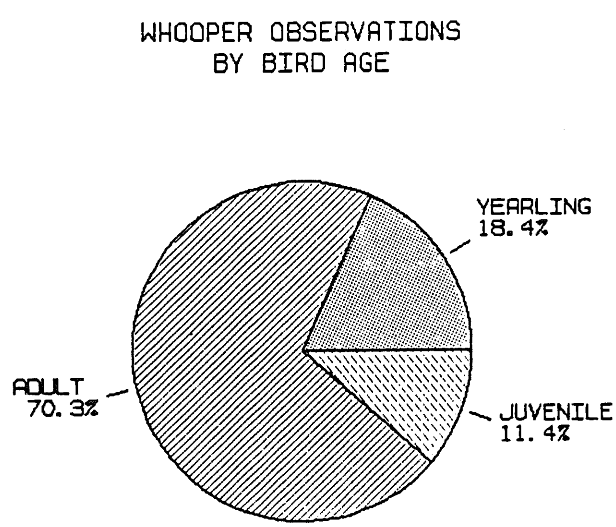


Fig. 1. Typical graphical outputs available from the WHOOPER data base using the DBMS.

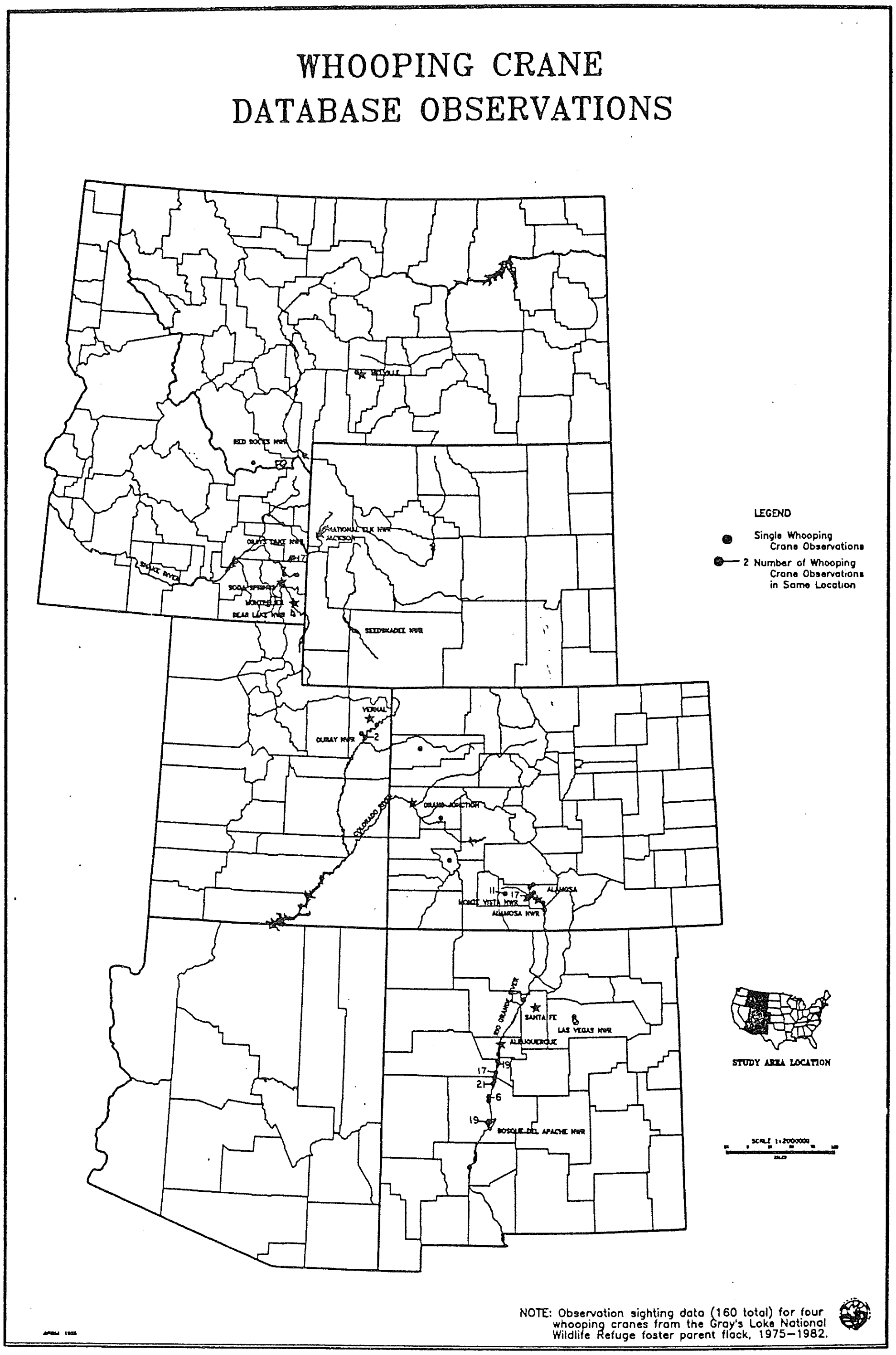


Fig. 2. Computer-generated map using the GIS that displays the locations of whooping crane observations and pertinent background information.

Another example is a researcher interested in the history of an individual, color-marked whooper on summer areas. The DBMS is queried for the locations and dates where crane 7501 spent the summers. The answer includes the age of the bird, inclusive summer dates by year, locations, days the bird inhabited specific sites, and current status (Table 2 - questions 7 to 8).

The DBMS also can be used to monitor biological characteristics, such as the migratory movements of cranes (Table 2 - question 9). This basic information is useful to researchers studying migration ecology. Refuge managers also may need this information to assess management alternatives. For example, a management plan may include opening a portion of the refuge to muskrat trapping after the whoopers depart in the fall. By querying the DBMS, it is determined that juvenile cranes leave the refuge in mid-October, with the last observation on the 16th. These data can be used to establish regulations opening the trapping season after the cranes have departed. From the same data base, researchers can establish that juvenile whooping cranes normally depart summer areas in mid-October and arrive on winter areas approximately 30 days later. Appropriate statistics for this information, including means and standard deviations, are shown in Table 2 - question 9.

The current status of individual birds, the total population, and causes of mortality, where known, also can be determined from the DBMS. For example, the DBMS can be queried for the last observation dates and locations of all whooping cranes hatched in 1975. Results, including the individual bird identification number, date, location, and observation number in the data base, are presented in Table 2 - question 10.

CONCLUSIONS

The integration of DBMS and GIS technologies, demonstrated in this prototype project, shows that computerized management and display of whooping crane observation data is feasible and practical. This information management system provides an automated alternative to traditional manual methods for storing, retrieving, analyzing, and displaying biological information for wildlife species management and environmental assessment. Automated data management is a more efficient, flexible, timely, and less costly method to provide biologists, researchers, and managers with responses to information queries. Increased efficiency in managing previously collected data allows biologists more time to conduct research and collect new biological observation data. Implementation of this computerized data management system for whooping cranes would enhance continuity and coordination among federal, state, and private sector users in querying the data base. This automated approach also has international application potential for the United States, Canada, and Mexico if implemented for observations of the Wood Buffalo National Park-Aransas National Wildlife Refuge whooping crane population and additional foster parent flocks. This technology is applicable to any migratory bird or mammal population dataset. Lastly, the methodology provides a permanent, updated record of important wildlife species observation information.

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ROOST SITE USE VERSUS PREFERENCE BY TWO MIGRATING WHOOPING CRANES

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Abstract: Five roosts used by two subadult whooping cranes migrating from Wood Buffalo National Park to Aransas National Wildlife Refuge were measured for physiographic characteristics, specifically water depth, to determine roost use versus preference by these birds. The average water depth where whooping cranes were observed roosting was 9.2 ± 2.22 cm compared to an overall water depth for the five roost sites sampled of 10.93 ± 0.98 cm. In all but one of these situations the whooping cranes may not have been selecting specific water depths to roost but instead were using what was available at that roost site. The cranes roosted in 18 cm of water at the site where they had a continuum of water depths from which to choose. The distance cranes will roost from shore may be an important component that influences water depths in which cranes roosted. In the four situations where the cranes roosted in areas with relatively uniform gradient bottoms, they were an average of 16.7 m from shore. At the site with a continuum of water depths the cranes roosted 15-20 m from shore. These data indicate (1) there may be an optimal range of water depths and distance from shore where whooping cranes prefer to roost, and (2) the presence of a whooping crane at a particular roost cannot be interpreted to mean the site is preferred roost habitat. Availability of physiographic characteristics from other sites must be measured, then compared with the same parameters at the roost, before the term "preferred" can be applied.

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Published literature concerning roosting requirements of migrating whooping cranes (*Grus americana*) is rare. Such literature usually includes data on the wetland type, upland vegetation, human activity, and water depths where the cranes roosted (Aronson and Ellis 1979, Shoemaker et al. 1981). These latter studies provide much needed data for biologists concerned with habitat types utilized by whooping cranes during migration. However, these studies fail to determine if the habitat types or physiographic characteristics of the wetlands are preferred by the cranes or if the cranes are using such areas simply because they are available. To determine if habitat types or physiographic factors are "preferred" by a species, the researcher must first determine if the individual component (i.e., habitat type) is being used more than, in proportion to, or less than its availability in the area (Johnson 1980).

Suitable roosting habitats serve primarily as resting areas for whooping cranes. A key requirement (component) of roosting habitat is that it provides protection from predators. Suitable roosts usually consist of open water (e.g., riverine, lacustrine, and palustrine wetlands) which enables whooping cranes to detect, either visually or audibly (splashing water), the approach of a predator. If migrating whooping cranes are forced to use suboptimal roost sites (i.e., areas choked with tall vegetation which limits visual distance) the risk of predation could possibly increase.

Many of these potential suitable roost sites are in jeopardy along the migration corridor. Currently 13,335 ha of prairie wetlands are destroyed each year for agricultural practices and other human activities. For example, in North Dakota, where many whooping cranes stop during migration, approximately 8,094 ha of wetlands were destroyed for agricultural purposes in 1983 (Madson 1984). Therefore, crane biologists must know what types of roosting habitats migrating whooping cranes prefer and, after obtaining this information, determine why cranes prefer such types over available sites. With this knowledge, preferred wetlands can be protected for use by migrating cranes. Managers may also be able to artificially create similar stopover sites where whooping cranes used to stop but no longer do because of lack of suitable roost sites.

This paper examines a water depth physiographic characteristic of roost sites utilized by a pair of subadult whooping cranes during their migration from Wood Buffalo National Park, Canada, to Aransas National Wildlife Refuge, Texas, in the fall of 1983. Other roost site data, including both habitat characteristics and physiographic characteristics, are presented in Table 1.

Data were collected as part of a 3 year project (1981-1984) by the U. S. Fish and Wildlife Service, National Audubon Society, and Canadian Wildlife Service. Project personnel studied behavior and ecology of whooping cranes migrating from their breeding grounds in Wood Buffalo National Park to their wintering grounds at Aransas National Wildlife Refuge. Conclusions should be viewed as preliminary because of the small sample size of the data, and only as possible indicators of whooping cranes' roost and habitat preference during migration.

Our thanks are extended to Carol Dickinson who helped in the data collection for this report; Lenny Young and Doug Benning who kept the cranes in sight during migration; Marshall Howe for asking me to participate in this unique project; and to Ernie Kuyt, Paul Goossen, Dave Blankenship, Maury Anderson, Wally Jobman, Steve Labuda, Jay Crenshaw, Larry Smith, Al Novara, Clyde Bolin, and Don Van Aspern who helped make this project a success.

METHODS

The specific roost sites used by whooping cranes were triangulated and plotted on a United States Geological Survey topographic map (scale 1:24,000). Field data were gathered after the cranes had departed to continue their migration. Habitats were characterized by use of the terminology and definitions found in the Wetland Classification System of Cowardin et al. (1979). Physiographic parameters were measured by locating five evenly spaced transects around the area where the whooping cranes were roosting (Fig. 1). Transect 3 was nearest to the approximate location where the cranes were seen roosting. Each transect was 40 m long and perpendicular to the shoreline. Water depth measurements were taken every 10 m. If present, width of emergent vegetation was recorded. Each transect extended onto land where the widths of exposed shoreline, sparse vegetation, and dense vegetation were measured.

Table 1. Habitat and some physiographic characteristics of the roost sites.

Wetland classification	Roost number[a]				
	R4	R8	R9	R10	R14
System	Palustrine	Lacustrine	Lacustrine	Lacustrine	Palustrine
Subsystem		Littoral	Littoral	Littoral	
Class	Emergent wetland	UB	UB	UB	UB
Subclass	Persistant	Mud	Mud		Mud
Dominance type	*Potamogeton coccinium*	Freshwater mollusk			Small mussels
Modifiers	IE	Pf	Pf	Pf	If
Dominant emergent species	*P. coccinium*		*Juncus* spp.	*Juncus* spp.	
Dominant submergent					
Density of emergent vegetation	Scattered		Scattered	Scattered	
Distance from roost to emergent vegetation	10 m				
Turbidity	Clear	MT	MT	MT	MT
Substrate	Mud	Mud	Mud	Mud	Mud
Slope $(\bar{x})$	15°	1°	1°	0°	0°
Visibility $(\bar{x})$	270 m	700 m	925 m	1000 m	100 m
Distance to active road (km)	0.5 out[b]	0.8 out	2.8 out	1.5 out	0.25 out
Distance to active house (km)	0.7 out	>2.0 out	2.8 out	1.5 out	0.25 in[c]

[a] UB = unconsolidated bottom, IE = intermittently exposed, Pf = permanently flooded, If = intermittently flooded, MT = moderately turbid.
[b] Out of view of the roost site.
[c] In view of the roost site.

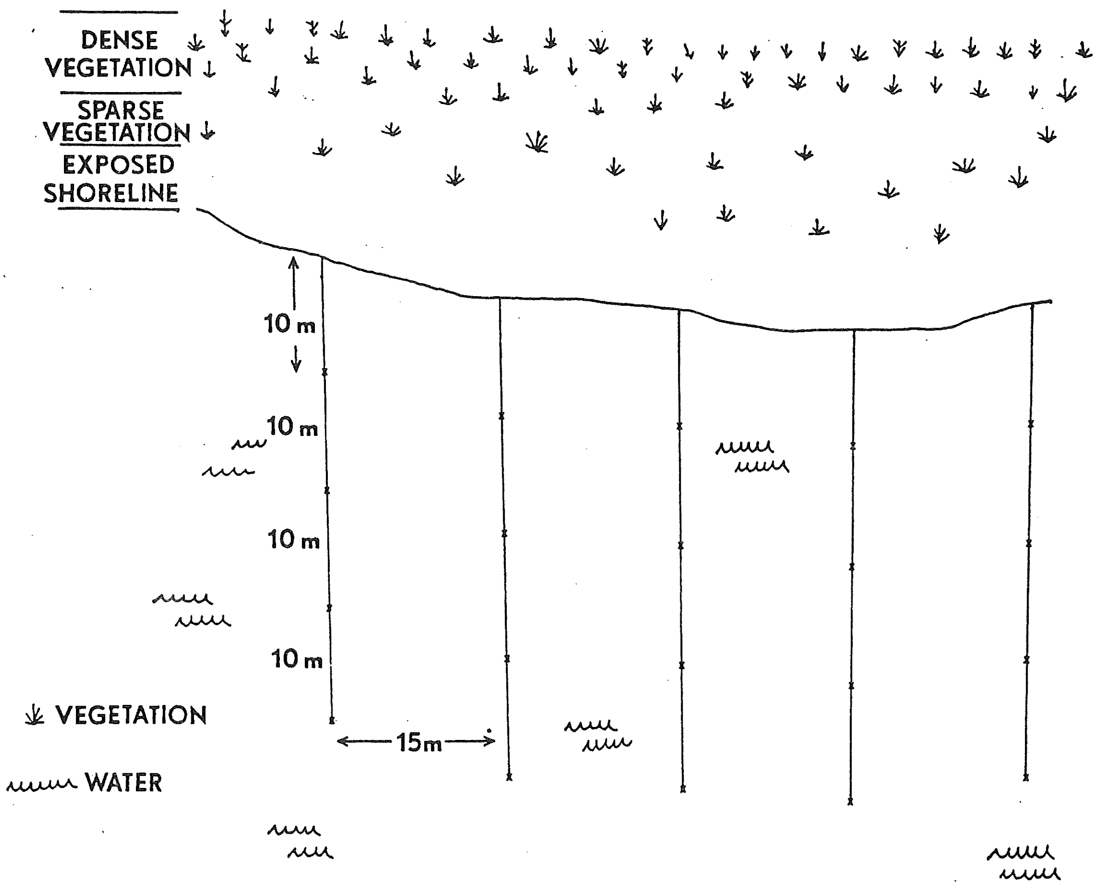


Fig. 1. Systematic transect sampling in the roost area.

We defined exposed shoreline as that area devoid of vegetation. Sparse vegetation was any segment where aboveground plant parts did not contact adjacent plants. Dense vegetation was defined as an area where vegetation contacted the adjacent plants. Dense vegetation was measured to the point where it was classified as choked (i. e., where plants created a visual barrier between the roost and adjacent areas). Other collected information included water depth in the approximate area where the cranes roosted, water turbidity, substrate gradient, visibility, and distance to the nearest active road and active house. An active road was defined as one used by any vehicle when the cranes were at the roost. An active house was defined as one in which human activity occurred while the cranes were at the roost. In each situation the active road/house was classified as "in sight" or "out of sight" of the cranes on the roost site.

RESULTS

Fourteen roost sites were utilized by the two subadult whooping cranes during migration, however only five sites were measured in detail (Fig. 2). Roost 4 was located near Moose Jaw, Saskatchewan, roost 8 near Russell, Kansas, roosts 9 and 10 on the Salt Plains National Wildlife Refuge near Cherokee, Oklahoma, and roost 14 near Sealy, Texas.

The habitat type and physiographic characteristics of these sites exhibited several similarities (Table 1). All but 1 of the 14 sites was located in wetlands. Of the five sites,

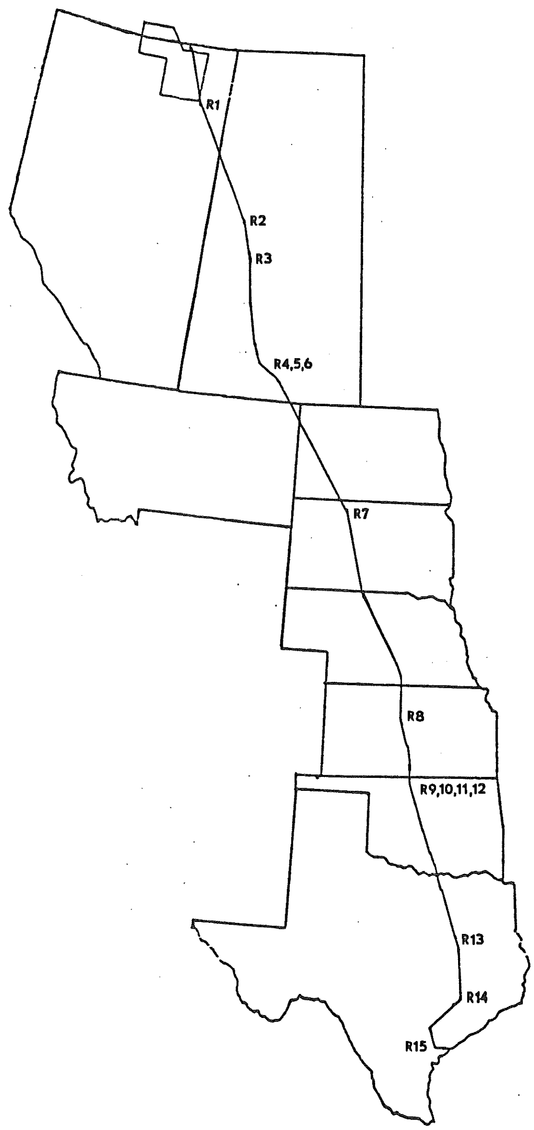
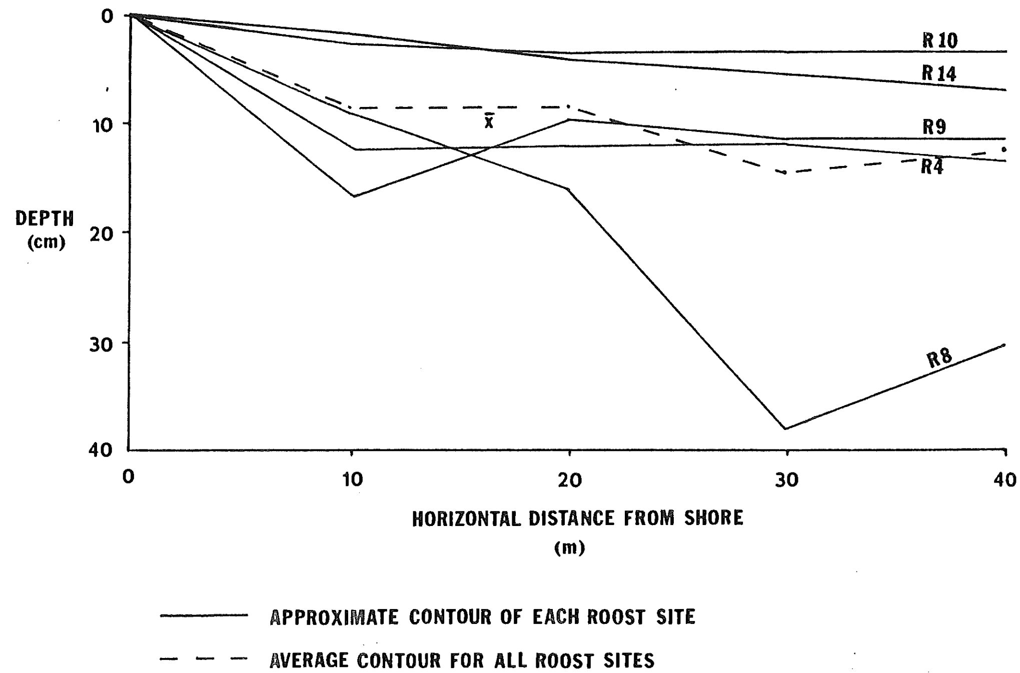


Fig. 2. Locations of roost sites utilized during the fall, 1983.

three were lakes and two were ponds. Four had moderately turbid water and one had clear water. All had mud bottoms with little submergent vegetation. Roosts 8, 9, 10, and 14 had very flat topography and a high degree of visibility of the surrounding area. Although roost 4 had a 15° slope, it still provided a high degree of visibility ($\bar{x}$ = 270 m). All five roosts had some exposed shoreline with the minimum being 8 m. Three of the five roosts contained upland vegetation which provided a visual barrier to adjacent areas.

The substrate at four of the five roosts had a very gradual gradient and relatively shallow depths ($\bar{x}$ = 8.21 cm., SE = ±1.25) (Fig. 3). Roost 8, the exception, had a steeper gradient and was also deeper than the other roosts at the 30 m and 40 m stations. All five sites together averaged depths of 6.6 cm (SE = ±0.94), 8.9 cm (±1.22), 14.9 cm (±2.74), and 13.2 cm (±2.64) at the 10 m, 20 m, 30 m, and 40 m stations, respectively. Overall mean depth was 10.93 cm (±0.98). Water depths and distances from the shore where cranes were observed roosting are approximate because cranes occasionally moved short distances at night. These birds averaged roosting 16.9 m from shore in 9.2 cm of water.



WHOOPING CRANE

ROOST NO.	SITE DEPTH (cm)	FROM SHORE (m)
10	6	15
14	7	25
9	7	17
4	8	10
8	18	15—20
	$\bar{x}$ = 9.75	16.90

Fig. 3. Contours of roost sites utilized by the two whooping cranes.

DISCUSSION

Data gathered from the five roosting sites suggest that in all but one situation the cranes may not have selected a specific water depth to roost, but instead may have been forced to use water depths available in the roosting areas. For these four sites the whooping cranes averaged roosting in 7.0 ± 0.41 cm of water while the average for water depths collected along the transects was 8.21 ± 1.25 cm. At roost 8, however, the cranes had a continuum of water depths to choose from (0 to 51.6 cm) and roosted in 18 cm of water. Whooping cranes apparently will not roost in uplands (based on the 3 year study, we are unaware of the former situation ever being observed, and the latter circumstance occurring only once). Some preference apparently does exist for water depths at roost sites. But, before any conclusions can be drawn based on observations alone, the pond/river/lake bottom gradient must first be characterized. Our first four observations indicate a gradual slope to the roost site bottom, thereby not allowing the whooping cranes a continuum of water depth choices.

The only published research we are aware of that addresses preferred water depths for roosting by migrating whooping cranes involves riverine systems (Shoemaker et al. 1981, Lingle et al. 1984). In our study, palustrine and lacustrine systems were the only habitat types used. Before one can compare the three systems, the assumption must be made that migrating whooping cranes have the same preferences for roosting site water depths.

Shoemaker et al. (1981) measured water depths only in the immediate area where whooping cranes roosted during a migration. However, Lingle et al. (1984) measured water depths across a section of the Platte River (Nebraska) where five migrating whooping cranes roosted one night. The continuum of water depths across this 350 m section of river ranged from 0 to 64 cm. These whooping cranes roosted in 10-13 cm of water located 26 m from the nearest sandbar (120 m from the nearest shore).

Lovvorn and Kirkpatrick (1981) noted that sandhill cranes (_Grus canadensis_) in Indiana usually did not roost in water deeper than their tibiotarsus joint (ca 25 cm high) although deeper water was available. If this also characterizes whooping cranes' behavior then they would not be expected to roost in water deeper than 28 cm. The height of the tibiotarsus is about 28.1 cm (female) and 28.6 cm (male) (Walkinshaw 1973).

Our data and other studies suggest a relationship may exist between water depth and distance to shore or the nearest above-water sandbar. Based on roosts 4, 10, and 14, whooping cranes roosted 10 to 25 m from shore although water depths remained relatively constant past the 25 m point. In other roosts used by these two whooping cranes, but in which physiographic data were not collected, the cranes typically did not roost farther than 20-30 m from shore. This was also true of the roost described by Lingle et al. (1984) although the cranes roosted 26 m from the nearest sandbar. In our study, roost 8 was the only one with a steep gradient. At roost 8, whooping cranes roosted in 18 cm water (instead of the 7 cm average at other roosts) approximately 15-20 m from shore.

This physiographic characteristic may be very important. Regardless of habitat suitability, if the only available roosting site contains water 28 cm in depth beyond 10 m, whooping cranes may be forced to roost closer to shore. Such cranes could be vulnerable to predation. This point should be emphasized if managers consider creating artificial roosting sites for migrating cranes.

CONCLUSIONS

Although this paper is based on a small sample size, the concept the authors are presenting is very important for migrating whooping cranes, and deserves further study. Biologists interested in cranes must be aware of habitat usage and availability and their effect on roost site preference. A whooping crane that selects a particular habitat component is not necessarily indicating that such a component is preferred. Availability of key physiographic parameters must be determined before preference can be identified.

Also, the published research that we are aware of involving whooping cranes' roost use during migration involves only riverine systems. Based on our experience with whooping cranes' migration, almost all the families and groups radiotracked have utilized lacustrine and palustrine systems. If this use is characteristic of the whooping crane population that migrates from Wood Buffalo to Aransas, then biologists should be concerned with these wetland types and try to determine which are preferred and, thereby, which systems/types should be protected for whooping cranes.

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SANDHILL MIGRATION IN THE MID-SOUTH--ITS POSSIBLE SIGNIFICANCE TO MISSISSIPPI SANDHILL CRANES

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Abstract: Migration records of sandhill cranes (Grus canadensis) were reviewed for Louisiana, Arkansas, Tennessee, Florida panhandle, Alabama, and Mississippi. Sightings in the mid-South are dispersed between the migration corridors of the Eastern population of greater sandhill cranes (G. c. tabida), which migrate into Georgia-Florida, and the greater, lesser (G. c. canadensis), and Canadian (G. c. rowani) sandhill cranes, which migrate into eastern Texas. Wintering flocks in Rapides Parish, Louisiana, and Baldwin County, Alabama appear to be migratory. The effects of migratory cranes on the endangered Mississippi sandhill crane's (G. c. pulla) population size and range estimates are discussed.

PROCEEDINGS 1985 CRANE WORKSHOP

The juxtaposition of resident and migrant sandhill cranes (Grus canadensis) in the Mid-South makes interpretation of population sizes difficult (Valentine and Noble 1970). Records of migratory and winter sightings are scattered throughout Louisiana, Arkansas, Tennessee, the Florida panhandle, Alabama, and Mississippi, while breeding records are limited to pockets along the Gulf Coast of Louisiana, Mississippi, and Alabama (Fig. 1). Currently, the only accepted year-round resident populations consist of the Mississippi sandhill cranes breeding in Jackson County, Mississippi and the Florida sandhill cranes in southern Georgia and north-central Florida. Cranes breeding in southern Mississippi were once thought to be an extension of the breeding population of Florida sandhill cranes (G. c. pratensis) (Burleigh 1944, Walkinshaw 1949:5). The Mississippi cranes were originally lumped with the Florida subspecies. Closer examination revealed sufficient taxonomic differences to justify a separate subspecies, Mississippi sandhill cranes (G. c. pulla) (Aldrich 1972).

Sandhill crane sightings in the Mid-South region lie between two major crane migration corridors. The eastern corridor extends from Michigan and Wisconsin, through Indiana, Kentucky, Tennessee, North Carolina, to southern Georgia and Florida (Nesbitt and Williams 1979). The central corridor, to the west, extends from South Dakota, Nebraska (Platte River), Kansas, and Oklahoma, to coastal Texas (Lewis 1974, Johnsgard 1983:174). Cranes migrating in the eastern corridor are all thought to be greater sandhill cranes (G. c. tabida), while the central corridor migrants includes three subspecies: greater, lesser (G. c. canadensis). and Canadian (G. c. rowani). Guthery and Lewis (1979) examined 121 specimens in Texas, and determined the migration composition to consist of 71% canadian, 20% lesser, and 9% greater sandhill cranes. Migratory cranes reported between these two corridors could potentially be any of the three migratory subspecies.

Autumnal migration through the central plains states generally peaks in October, with a majority of the cranes remaining west of longitude 98° W during migration (Lewis 1974). Cranes usually arrive in Texas beginning in late September and remain until late March or early spring (Guthery 1976). Houston, Texas has often been recorded as the eastern-most boundary for wintering cranes; however, a local Texas rancher reported sandhill cranes wintering east of Houston in the 1920's (Guthery and Lewis 1979). Also, small flocks have been recorded infrequently on Anahuac national Wildlife Refuge, Chambers County, Texas (80 km southeast of Houston, 74 km west of Sabine National Wildlife Refuge, Louisiana) (Guthery and Lewis 1979).

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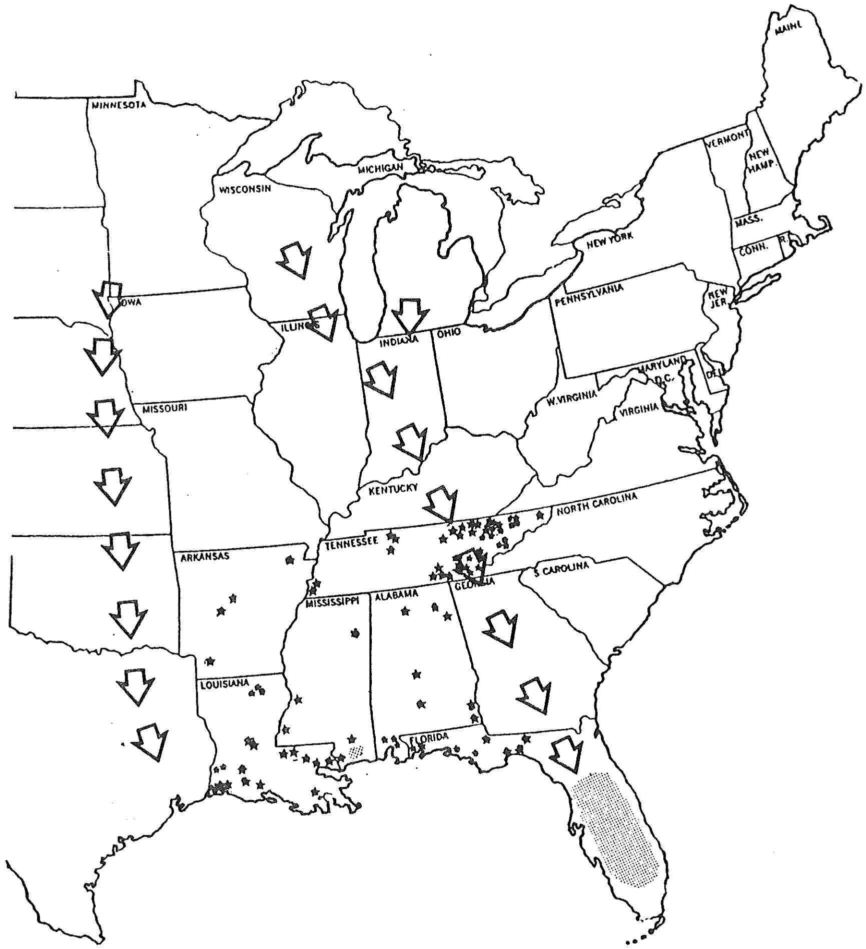

Figure 1. Sightings of sandhill cranes in the mid-South states (stippled) in relation to historical (Louisiana, Alabama) and current (Mississippi, Florida) breeding ranges (diagonal lines). Arrows indicate the eastern and central sandhill crane migration corridors (Lewis 1974, Nesbitt and Williams 1979, Johnsgard 1983:174).

sightings; and R. B. Hamilton, LSU School of Forestry, Wildlife and Fisheries, and J. M. Valentine, Jr., USFWS (retired), for reviewing this manuscript.

SANDHILL CRANE DISTRIBUTION

Louisiana

McIlhenny (1938) reported an abundance of both sandhill and whooping cranes (Grus americana) on Avery Island, Louisiana in the 1870's and provided the earliest detailed documentation for Louisiana. Early in the 1900's, sandhill cranes were recorded on Louisiana bird lists as residing and breeding along the Gulf Coast (Kopman 1907, Beyer et al. 1908, Bailey 1918). The last major breeding populations in Louisiana were recorded in 1907 (Smith 1979), yet scattered breeding occurred in Cameron Parish until 1919 (Walkinshaw 1949:133, Lowery 1974:262). The subspecies composition of cranes that bred in Louisiana was never determined (Walkinshaw 1949:133).

A majority of recently reported crane sightings in Louisiana during the period of normal sandhill crane migration consists of pairs or individual birds (Table 1). However, a group of 17-100 sandhill cranes thought to be of the greater subspecies, have been wintering on or near the farm of D. McNutt, in Rapides Parish, since 1966 (Hamilton 1974, Smith 1979). The McNutt flock usually arrives between mid-October and early November and remains until March or April. This schedule corresponds with the migratory pattern of the central migration corridor.

Arkansas

Infrequent reports of migratory cranes occur in both the northeastern and the southwestern portions of Arkansas (Table 2). The small quantity of records should not be used to delineate a migratory pathway through the state. A small group of sandhill cranes has wintered in Holla Bend National Wildlife Refuge, Pope County, periodically since 1964 (Table 2). No data exist to determine if migratory cranes recorded in Arkansas are associated with the eastern or central migration corridors.

Tennessee

Walkinshaw (1960), using post 1910 records reported a consistent migratory pathway of greater sandhill cranes traveling through Tennessee toward Florida in the eastern migration corridor. The earliest account of migration through Tennessee was a large flock sighted flying over the Chickasaw Bluffs on the Shelby-Tipton County line in November, 1820 (Deaderick 1940). This early location is outside of what is now considered the traditional migratory pathway. The majority of recorded occurrences have been in the eastern portion of the state (Table 3). Although the primary migratory movement appears to be in the eastern part of Tennessee, sightings in other sections indicate that some sandhill cranes may migrate southwest across Tennessee into Alabama, Mississippi, and Louisiana (Fig. 1).

Florida

Bartram (1791:135,175) first documented the existence of sandhill cranes in Florida in the late 1700's. Migratory greater sandhill cranes winter primarily in the central and north-central portions of Florida (Melvin 1977). Migration into Florida from September to December, is more protracted than spring migration when a majority leave during March (Nesbitt and Williams 1979). Madison County, in central Florida, has been considered the western-most boundary for greater sandhill cranes wintering in Florida (Melvin 1977). The earliest sighting in the Florida panhandle occurred on St. Marks National Wildlife Refuge, Wakulla County around 1900 (Table 4). Since that time, sightings have been dispersed across the panhandle, east to the Alabama state line. The subspecies composition of the cranes wintering in the Florida panhandle is not known. Also, habitat assessments indicate that the central Florida wintering grounds are inadequate (Schumann 1977). It is not known if decreasing habitat availability is forcing cranes to winter in other adjacent areas.

Alabama

Records of sandhill crane sightings during the migratory and wintering period have occurred throughout Alabama with a majority reported along the Gulf Coast portion of the state (Table 5). The last recorded breeding occurred in the coastal region of Baldwin County in 1911 (Walkinshaw 1949:133, Imhof 1976:56). The subspecific identity of the historical Alabama breeding cranes was probably either Florida or Mississippi sandhill cranes. Baldwin County also contains the only recorded wintering sandhill crane flock. A group of 10-33 cranes has wintered near Elberta, Alabama, since 1953 (Table 5).

Due to its proximity to Florida, the Baldwin County flock has been assumed to consist of wintering greater sandhill cranes (Imhof 1976:56). No taxonomic investigation has yet been undertaken to confirm this classification.

Mississippi

Audubon (1835:205) reported cranes feeding in agricultural fields around Natchez, Mississippi in November 1821, but provided no information on whether or not they were residents.

Table 1. Sandhill crane sightings reported in Louisiana.

Location- Date- observation details- observer(s)- data source.

W. Feliciana Parish, Bayou Sarah, 12 April 1822, cranes observed feeding, J. J. Audubon (Audubon 1935:205).
Iberia Paris, Avery Island, prior to 1870's, sandhills and whoopers--plentiful, McIlhenny (McIlhenny 1938).
Cameron Parish, Calcasieu Pass, May 1907, cranes--common, H. H. Kopmann (Oberholser 1938:197).
Cameron Parish, 1909, 1 collected, (Smith 1979).
Cameron Parish, Gum Cove, 3 Jan 1911, flock of 34 cranes, W. L. McAtee (Oberholser 1938:196).
Cameron Parish, Chenier au Tigre, 11 March 1918, 4 cranes, A. M. Bailey (Oberholser 1938:196).
Cameron Parish, 1918, 2 captured for Audubon Zoo, (Arthur 1931:233).
Cameron Parish, Black Bayou, Jul 1919, "Florida" cranes breeding. J.D. Figgins (Figgins 1923).
Cameron Parish, 26 km S of Vinton, 1919, several flocks wintered. A. M. Bailey (Oberholser 1938:196).
Morehouse Parish, Mer Rouge, 1926, 1 crane wintered. A. C. Bent (Smith 1979).
Tangipahoa Parish, 7 km E of Covington, 10 Feb 1945, 1 dead in fencewire, G. Lowery and F. Hamerston (LSU Museum Files).
Cameron Parish, Sabine N.W.R.:
- 2 Nov 1945, 2 pairs seen, V. L. Childs (Files, LSU Mus.);
- 15 Feb 1946, 2 pairs seen, V. L. Childs (Files, LSU Mus.);
- 1 Nov 1947, 2 pairs seen, V. L. Childs (Files, LSU Mus.);
- 6 Nov 1948, 2 pairs seen, V. L. Childs (Files, LSU Mus.);
- 2 Nov 1950, 2 pairs seen, V. L. Childs (Files, LSU Mus.);
- 3 Jan 1951, 2 pairs seen, V. L. Childs (Files, LSU Mus.).

Tammany Parish, near mouth of Pearl River, 19 Oct 1957, S. A. Gauthreaux and B. Fiengold (Files, LSU Mus.).
LaFourche Parish, Thibodaux, 21 Nov 1962, 1 flying, A. R. Tabor (Files, LSU Mus.).
Rapides Parish, Dennis McNutt Farm, N of Cheneyville:
- 1966- 1973, wintering cranes, farmers report, (Hamilton 1974);
- 1974, 27 wintered, E. R. Smith, (Hamilton 1974);
- 1975, 17 wintered, R. J. Newman, (Hamilton 1975);
- 1976, 29 wintered, R. J. Newman, (Hamilton 1976);
- 1977, 21 wintered, R. J. Newman, (Hamilton 1977);
- 1978, 26 wintered, R. J. Newman, (Hamilton 1978);
- 1979, 35+ wintered, R. J. Newman, (Hamilton 1979);
- 1980, 45+ wintered, B. Crider, (Hamilton 1980);
- 1981, 100(?) wintered, farmer report, R. J. Newman (Hamilton 1981).

Richland Parish, La. Highway 135, 11 km S of Alto, April 1971, 1 seen. R. J. Newman, H. H. Jeter, D. T. Kee, and D. H. White (Files, LSU Mus.).
Ouachita Parish, near Monroe, 1971, 1 wintered, R. J. Newman (Hamilton 1971).
Rapides Parish, 3 km S of Alexandria, Jan 1974, 4 feeding on Inglewood Plantation, H. Norman and R. Gilliland (Smith 1979).
St. Tammany Parish, 7 km NE of Slidell, just W of I-10 Pearl River Bridge, 4 Jan 1976, 2 flying, H. D. Pratt (Files, LSU Mus.).
Evangeline Parish, Corodine Lake, 29 Dec 1979, 2 seen, H. G. Giullory (Files, LSU Mus.).
East Feliciana Parish, Jackson, 3 Dec 1982, 2 seen, B. Traham (Ortego 1982).
Assumption Parish, just N of Paincourtville, E side of Bayou LaFourche, Dec 1983, 1 seen feeding in field, A. Falterman (Files, LSU Mus.). Jan- April 1984. 1 seen feeding in field. A. Falterman. (Files, LSU Mus.).
Calcasieu Parish, near Holmwood, intersection of La. Highways 14 and 27, Jan 1980, 12 feeding in rice field, D. Carver and C. White (J. M. Valentine, pers. commun.).
Calcasieu Parish, 28 km S of Crowley, Dec 1984-Jan 1985, 3 seen, D. LeBlanc and A. Wilson (J. M. Valentine and R. B. Hamilton, pers. commun.).
Lafayette Parish, Rena Dr. Lafayette, 9 Oct 1984, 40-50 flying S, E. Valentine (J. M. Valentine, pers. commun.).

Table 3. (cont.) Sandhill crane sightings reported in Tennessee.

Location- Date- observation details- observer(s)- data source.

Pickett County (cont.):
Byrdstown, 21 Oct 1968, heard cranes (DeVore 1980);
Byrdstown, 14 Mar 1969, 51 flying (DeVore 1980);
Byrdstown, Oct 1969, 21 + 113 flying, D. Hassler (Files, LSU Mus.);
Byrdstown, 4 Mar 1970, 128 flying (DeVore 1980);
Byrdstown, Mar 1971, 35 + 30 flying (DeVore 1980);
23 Nov 1972, 12 seen (DeVore 1980);
Byrdstown, 23 Nov 1973, 41 flying, R. Hudson (Purrington 1973);
Byrdstown, Nov 1974, 42+ 48+ 42+ 41 flying, R. Hassler (Files, LSU Mus.);
Byrdstown, 14 Mar 1975, 45 flying (DeVore 1980);
Byrdstown, 29 Feb 1976, 40 flying N, R. Hassler (Files, LSU Mus.);
Byrdstown, 23-25 Feb 1977, 45 flying (DeVore 1980);
Byrdstown, March 1978, 51+ 56+ 157+ 23 flying, R. Hassler (Files, LSU Mus.);
Obey River, 7 Mar 1978, 23 seen (DeVore 1980);
Byrdstown, 1 Nov 1978, 10 flying, D. Hassler and R. Hassler (Files, LSU Mus.);
Byrdstown, Nov, Dec 1979, 10+ 25+ (765 in 8 flocks), R. Hassler and D. Hassler (Hamilton 1979);
Pickett State Forest, 25 Nov 1980, flock heard, D. Hammer (Files, LSU Mus.);
Byrdstown, Nov 1980, 537 in 7 flocks, D. Hassler and R. Hassler (Files, LSU Mus.);
Byrdstown, Nov. 1983, 82 flying, R. C. Hassler (Purrington 1984).
Overton County:
Livingston, 15 Mar 1965, 40-53 flying, R. Hinds (Hollister 1965);
30 Nov 1977, 60 flying, R. Hassler, (Files, LSU Mus.);
Rickman, 12 Nov 1980, 40 flying, R. Hassler (Hamilton 1980).
Putnam County:
Cookeville, 29 Nov 1967, 3 seen (DeVore 1980);
Cookeville, 17 Oct 1975, 3 flying, T. Smith (Files, LSU Mus.);
Cookeville, 3 Dec 1975, 5 flying, B. Clarke and B. Jones (Files, LSU Mus.);
Lilydale, 11 Mar 1977, 125 flying (DeVore 1980);
Cookeville, 24 Nov 1977, 98+ 22 flying, K. Coward and S. Coward (Files, LSU Mus.);
9 km S of Monterrey, Dec 1977, 24 flying, K. Coward and S. Coward (Files, LSU Mus.);
Cookeville, 2 Nov 1980, 7 flying, R. W. Simmers, Jr. (Files, LSU Mus.);
Brotherton Mountain, 9 Dec 1980, 42 seen, (Hamilton 1980).
Bradley County, Candie Creek, 13 Nov 1967, 14 seen (DeVore 1980).
Rutherford County, Murfeesboro:
6 Nov 1968, 3 seen, H. D. Todd (Files, LSU Mus.);
9 Dec 1975, 35 flying, R. Hunter (Files, LSU Mus.);
Marion County:
Whitwell, 4 Mar 1970, 12 seen (DeVore 1980);
Nickajack Lake, 22 Nov 1975, 70 flying (DeVore 1980).
Morgan County, Wartburg, 17 Oct 1970, 24 seen (DeVore 1980).
Sequatchie County:
Dunlap, 13 Mar 1970, 8 seen (DeVore 1980);
Daus, 26 Nov 1974, 75 flying (DeVore 1980);
Daus, 3 Dec 1974, 4 seen (DeVore 1980);
Daus, 29 NOv 1977, 289+ 200 flying (DeVore 1980).
Bledsoe County, Fall Creek Falls State Park, 23 Dec 1971, 1 seen (DeVore 1980).
Rhea County:
Yellow Creek, 31 Dec 1971, 50 flying (DeVore 1980);
Dayton, 12 Dec 1972, 18 seen (DeVore 1980);
Old Washington, 6 Mar 1978, 280 flying (DeVore 1980).

(continued next page)

Table 3. (cont.) Sandhill crane sightings reported in Tennessee.

Location- Date- observation details- observer(s)- data source.

Davidson County:
- Nashville, 24 Dec 1971, 1 seen, M. D. Williams (Files, LSU Mus.);
- Nashville, 24 Dec 1972, 1 seen, M. D. Williams (Files, LSU Mus.);
- Harpeth River, 30 Dec 1972, 1 seen (DeVore 1980);
- Nashville, 30 Dec 1973, 1 seen, A. Creech and M. Digger, (Purrington 1973);
- Percy Priest Lake, 20 Dec 1976, 20 flying (DeVore 1980);
- Nashville, 24 Nov 1977, 90 flying, W. Shaughnessy (Files, LSU Mus.).

Humphreys County, Duck River Bottoms, 8 Dec 1975, 8 seen (DeVore 1980).
Sullivan County, Kingsport, 9 Jan-15 Mar 1976, 1 seen (DeVore 1980).
Montgomery County:
- Port Royal, 23-24 Nov 1977, 200 seen (DeVore 1980);
- Red River, 7 Dec 1977, 125 flying (DeVore 1980).

Fentress County, 6 March 1975, 6 seen, D. Hassler (Files, LSU Mus.).
Franklin County:
- Winchester, 19 Nov 1975, 25 seen, A. D. and I. M. (Files, LSU Mus.);
- Woods Reservoir, 9 Dec 1975, 1 seen (DeVore 1980).

Wilson County:
- Old Hickory Lake, 7- 17 Dec 1975, 29 seen, W. Taylor and J. Spurling (Files, LSU Mus.);
- Wilson-Sumner County line, 7 Dec 1975, 28 flying (DeVore 1980);
- Lebanon, 20 Dec 1975-3 Jan 1976, 18 seen (DeVore 1980).

Cannon County, Woodbury, 23 Nov 1977, 12 seen, F. Bryson (Files, LSU Mus. Files).
Clay County, 24 Nov 1977, 150 flying, R. Hassler (Files, LSU Mus.).

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[a]Sightings in Tennessee are organized by county for simplification of recording.

Table 4. Sandhill cranes sightings reported in the Florida panhandle.

Location- Date- observation details- observer(s)-data source.

Wakulla County, St. Marks National Wildlife Refuge:
- 1895, pair seen, (Howell 1932:197);
- 20 May 1913, 2 flying (Howell 1932:197).

Escambia County, Pensacola, 17 March 1929, 2 flying, F. M. Weston (Howell 1932:197).
Madison County, 11 km W of Madison, 1932, 24 seen on ground (Howell 1932:197).
Santa Rosa County, 37 km NE of Pensacola, 25 Nov 1956, 3 seen, F. M. Weston (Files, LSU Mus.).
Liberty County, Sumatra, 1971, Flock wintered (Williams and Phillips 1972).
Bay County, Lynn Haven, 1980, 1 seen with domestic geese, (Hamilton 1980).
Taylor County, 6 km NW of junction on Highway 14 and Highway 98:
- Nov 1980. 3 flying. (N. Eichholz, pers. commun.);
- Nov 1981. 5 flying. (N. Eichholz, pers. commun.).

Gulf County, 9 km NW of Apalachicola, June/July 1981, 1 seen on ground, D. Wood and N. Eichholz (N. Eichholz, pers. commun.).

Table 2. Sandhill crane sightings reported in Arkansas.

Location- Date- observation details- observer(s)- data source.

Hempstead County, Grassy Lake, 5 Jan 1970, 1 sighted, J. R. Hall, R. W. Slattery and W. Skinner (James 1970).
Lawrence County, Hoxie, 27 Sept 1970, 1 flying, H. Dinkelspiel (Files, LSU Mus.).
Pope County, Holla Bend N.W.R.:
17 Feb 1967, 4 seen, B. Blair, D. Holland and G. Peyton (James 1967);
17 Jan 1976, 1 seen, E. N. Halberg and H. H. Halberg (Files, LSU Mus. Files);
20 Jan 1979, 2 seen, E. N. Halberg and H. H. Halberg (Files, LSU Mus.);
1981, 3- 4 seen on Christmas bird count (Hamilton 1981).
Yell County, Garden Bottoms, 30 Nov 1980, 4 seen, H. Parker and M. Parker (Files, LSU Mus.).

Table 3. Sandhill crane sightings reported in Tennessee[a].

Location- Date- observation details- observer(s)- data source.

Shelby-Tipton County Line, Chickasaw Bluff, 30 Nov 1820, Large flock, J. J. Audubon (Deaderick 1940).
Shelby County, Memphis, 1 Feb 1953, 2 flying, H. T. Barbig (Barbig 1953).
Hamilton County:
Chattanooga, 1 Jan 1935 (Butts 1939);
Harrison Bay, 14 Mar 1960, 67 flying (DeVore 1980);
Savanna Bay, 15 Mar 1960, 317+ 10 flying, B. Basham, N. Halverson, and J.A. Tucker (Tucker 1960);
Savanna Bay, 1 Aug 1965, 1 seen (DeVore 1980);
Savanna Bay, 21 Oct, 10 Nov 1968, 3 seen (DeVore 1980);
Chattanooga, 18 Oct 1968, 1 seen (DeVore 1980);
Savanna Bay, 13 Mar 1969, 100 flying (DeVore 1980);
Collegedale, 14 Mar 1971, 56 flying (DeVore 1980);
Hixson, 9 Nov 1971, 276 flying (DeVore 1980);
Savanna Bay, 9 Nov 1971, 17 flying (DeVore 1980);
Hixson, 13 Mar 1973, 55 flying (DeVore 1980);
Savanna Bay, 8-9 Mar 1975, 19 seen (DeVore 1980);
Collegedale, 15 Mar 1976, 18 seen (DeVore 1980);
Savanna Bay, 17 Mar 1976, 4 seen (DeVore 1980);
Signal Mtn., 11 Apr 1976, 6 flying (DeVore 1980);
Savanna Bay, 7 Mar 1978, 30 flying (DeVore 1980).
Bedford County, Shelbyville, Aug 1936, 4 flying, specimen taken, (Edney 1940).
Cumberland County:
Crab Orchard, 13 March 1939, 13 on ground, P. Adams (Adams 1939);
Hebbertsburg Comm., 14 Mar 1961, 1 seen (DeVore 1980);
N of Crossville, 14 Mar 61, 1 seen J. C. Lewis (Lewis 1965);
Cumberland Mtn., 4 Mar 1965, 1 seen (DeVore 1980);
Catoosa Wildl. Manage. Area, 4 Mar 1965, 1 seen, J. C. Lewis (Lewis 1965);
Crossville, 1 Mar 1968, 1 seen (DeVore 1980);
Catoosa Wildl. Manage. Area, 4 Mar 1968, 1 seen (DeVore 1980);
Crossville, 8 Nov 1971, 12 seen (DeVore).
Sevier County:
Seymour, Oct 1942, 50 in wheat field, Ijams (Ijams 1942);
Great Smokey Mtns. Nat'l. Park, 23 Oct 1968, 27 flying (DeVore 1980).

(continued next page)

Table 3. (cont.) Sandhill crane sightings reported in Tennessee.

Location- Date- observation details- observer(s)- data source.

Anderson County:
Oak Ridge Nat'l. Lab., 25 Feb 1950, 4 flying, J. C. Howell (Howell 1952);
Norris Lake, Sequoia Point, 21 Oct 1951, 4 flying, J. C. Howell (Howell 1952);
Clinton, 16 Apr 1958, 4 seen (DeVore 1980);
Norris, 13 Nov 1977, 35 flying (DeVore 1980).

Knox County:
Knoxville, 25 March 1954, 4 flying, M. Brooks (Brooks 1954);
Univ. Tenn. Plant Sci. Far, 1 Apr 1958, small group (DeVore 1980);
Andrew Jackson Lake, 13 Nov 1959-28 Feb 1960, 1 seen, R.B. Hamilton and J.B. Owen (Owen 1960);
Knoxville, 11 Mar 1963, 7 flying, H. Overton (Tanner 1963);
Knoxville, 11 Mar 1964, 11 flying, (DeVore 1980);
Univ. Tenn. Biol. Bldg., 15 Nov 1964, 13 flying (DeVore 1980);
Oak Ridge Nat'l. Lab., 11 Mar 1968, 11 flying (DeVore 1980);
Knoxville, 20 Mar 1968, 11 seen (DeVore 1980);
Tecoa, 28 Mar 1968, 11 seen (DeVore 1980);
Univ. Tenn. Plant Sci. Farm, 15 Nov 1968, 1 seen (DeVore 1980);
Farragut High School, 3 Nov 1970, 3 seen (DeVore 1980);
Andrew Jackson Lake, 13 Nov 1977, 3 seen (DeVore 1980).

Union County:
near Hurricane, 10 Nov 1956, 4 flying, (Brooks 1957);
Norris Lake, 6 Dec 1968, 5 seen (DeVore 1980);
Norris Lake, 16 Nov 1974, 23 seen, 2 heard (DeVore 1980);
Norris Lake, 25 Nov 1976, 3 seen, (DeVore 1980);
Norris Lake, 26 Feb 1977, 3 seen, (DeVore 1980).

Meigs County:
Hiwassee Island, 12 Mar 1961, 1 seen (DeVore 1980);
Hiwassee Island, 19 Nov 1968, 20 seen (DeVore 1980);
Hiwassee Island, 16-22 Mar 1969, 100+ 100+ 100+ 100+ flying (DeVore 1980);
Hiwassee Island, 2 Dec 1969, 38 seen (DeVore 1980);
Hiwassee Island, 2 Mar 1970, 50 flying (DeVore 1980);
Hiwassee Island, 2 Mar 1971, 7 seen (DeVore 1980);
Hiwassee Island, 15 Oct 1971, 40 flying (DeVore 1980);
Hiwassee Island, 18-22 Dec 1971 6 + 14 seen (DeVore 1980);
Hiwassee River Area, 23 Oct 1972, 6 seen (DeVore 1980);
Hiwassee River Area, 5 Mar 1973, 90 + 56 flying (DeVore 1980);
Hiwassee River Area, Nov 1973, 25 + 225 flying (DeVore 1980);
Hiwassee River Area, 11 Dec 1973, 100 flying (DeVore 1980);
Hiwassee Island, 2 Mar 1974, 25 seen (DeVore 1980);
Hiwassee River Area, 23 Feb 1975, 40 + flying (DeVore 1980);
Hiwassee River Area, 29 Oct 1976, 1 seen (DeVore 1980);
Hiwassee River Area, 5 Mar 1977, 40 flying (DeVore 1980);
Hiwassee River Area, 12 Mar 1978, 5 seen (DeVore 1980).

Blout County:
Hwy. 73 at Great Smokey Mtns. Nat'l. Park, 8 Nov 1962, 13 flying, M. C. Farrar (Campbell 1963);
Maryville, 23 Oct 1968, 41 flying (DeVore 1980);
Maryville, 8 Nov 1969, 23 flying (DeVore 1980);
29 Sep 1975, 5 seen (DeVore 1980).

Pickett County:
Byrdstown, 5 Mar 1964, 56 flying (DeVore 1980);
Byrdstown, 15-16 Oct 1966, 66 flying (DeVore 1980);
Byrdstown, 10 Mar 1968, 31 flying (DeVore 1980);

(continued next page)

Additional sightings of cranes have occurred throughout Mississippi (Table 6). In 1974, a dead sandhill crane found west of Vancleave, Jackson County, Mississippi, was examined and first identified as a Florida sandhill crane by Dr. John Aldrich, and then later reclassified as a Canadian sandhill crane (Valentine 1981). Migrating cranes were heard in 1977, near Starkville, Oktibbeha County, in northern Mississippi (Files, Louisiana State University). A banded, immature lesser sandhill crane was sighted in Issaquena County, in December 1975. This crane had been banded by Boise with 127 other lesser sandhill cranes in the Yukon-KuskokwimDelta, Alaska from 1975-1978. Boise (1977) speculated that the unusual migration of the chick might have resulted from the death or separation of the chick from the parents. Other bands from the Boise study were recovered in New Mexico, Mexico, and Texas (Boise 1976). This sighting indicates the possibility of a crane from the central migration corridor migrating into Mississippi.

A group of 10 - 30+ cranes has been sighted each fall and winter since 1957 on the farm of N. Jordan, in Jackson County. Whether this group is migratory or a winter feeding aggregation of Mississippi sandhill cranes is uncertain. Potential taxonomic differences present a possible solution to the migratory question. Much of the taxonomic separation between subspecies has been based on external physical differences. One difference often noted is the Mississippi sandhill cranes' characteristic dark neck color and ear patch which makes the white cheeks stand out distinctly. Less contrast in other subspecies causes apparent blending of the cheek patch and neck color. Overall size, plumage darkness, and buffy breast feather tips provide further subspecies differentiation (Aldrich 1972). After observing the Jordan flock through a 6 X 50 spotting scope on several occasions in November 1983, Dr. Scott Derrickson, Wildlife Behaviorist, U.S. Fish and Wildlife Service, noted that certain individuals in the flock appeared to be larger and had lighter plummage than the rest of the flock. He also noted the absence of the buffy brown tips on the breast feathers of the birds in question. Derrickson speculated that on the basis of these external differences, some members of the flock could possibly be greater sandhill cranes. Conversely, Derrickson did not rule out the possibility of the differences also being due to individual variation within the Mississippi population. Behaviorally, the flock possessed flock cohesiveness not usually observed in feeding Mississippi sandhill cranes during the winter. Based on physical and behavioral differences, the possibility exists that migratory and Mississippi sandhill cranes are present in the Jordan flock.

CONCLUSIONS

The occurrence of sandhill cranes in Baldwin County, Alabama, 80 km east of Jackson County, Mississippi, suggests that migratory cranes could also winter in coastal Mississippi (Valentine 1981). Scattered crane sightings throughout southeastern Louisiana, southern Arkansas, western Tennessee, central Alabama, and Mississippi provide support for this theory. The potential of sandhill migration into Jackson County, Mississippi questions the validity of current crane censusing techniques used to inventory Mississippi sandhill cranes. To date, most of population censusing in Mississippi has been conducted during the winter when cranes are more visible as they concentrate to feed in agricultural fields. Recent population estimates during the winter season range from 32 to 42 (Files, Louisiana Cooperative Wildlife Research Unit). If migrants winter with Mississippi sandhill cranes, population size and winter range estimates may be exaggerated. Correct knowledge of these parameters is crucial for sound management of the endangered Mississippi crane subspecies.

MANAGEMENT RECOMMENDATIONS

Subspecies identification and migratory status of cranes wintering in southern Mississippi must be determined conclusively. Electrophoresis may provide a definitive answer; however, this procedure necessitates collecting a blood or tissue sample, which would involve the capturing of individuals from the flock. Current capture techniques still include a mortality risk factor, which could be significant if dealing with an endangered subspecies. Radio telemetry could also provide information on the migratory status of the flock. Attachment of radio transmitters also requires the capture of individual cranes and has the potential for mishap (Wheeler and Lewis 1972). Measured differences in body size may provide objective subspecific classification. Johnson and Stewart (1973) determined that Canadian, greater, and lesser sandhill cranes were separable on the basis of tarsus length, and Guthery (1975)

Table 5. Sandhill crane sightings reported in Alabama.

Location- Date- observation details- observer(s)- data source.

Autauga County, Prattville, 24 Sept 1932, 6 flying, L.S. Golsan (Imhof 1976).
Baldwin County, Foley, Elberta, Lillian, Gulf Shores:
  Aug 1911, young bird captured with adult, A. H. Howell (Imof 1976);
  1 Dec- 20 March 1953, 10 seen (Elberta), T. A. Imhof (Lowery and Newman 1953);
  20 March 1958, 10 seen (Elberta), F. C. Siebert (Imhof 1976);
  18 June 1958, 2 seen D. Rider (Files, LSU Mus.);
  23 June 1960, J. L. Dorn (Imhof 1976);
  16 Aug 1960, J. E. Keller, (Imhof 1976);
  19 Dec 1963, 25 seen, Bon Secour Christmas Bird Count (Chandler 1964);
  Feb 1968, 25 seen, T. A. Imhof and P. F. Chandler (James 1968, Files, LSU Mus.);
  21 Dec 1968, 15 seen Bon Secour Christmas Bird Count (Chandler 1969);
  8 March 1969, 13 seen (Wolf Bay), C. L. Kingbory (Files, LSU Mus.);
  8 March 1969, 13 seen Wolf Bay, C. L. Kingbory (Files, LSU Mus.);
  Dec 1969, 20-25 seen, T. A. Imhof (Able 1969);
  Jan, Feb 1971, 32 seen, P. F. Chandler (Hamilton 1971);
  Winter 1972, 27 seen (Gulf Shores flock), P. F. Chandler (James 1972);
  7 Jan 1973, 31 seen (Gulf Shores), M. L. Bierly and G. D. Jackson (Purrington 1973);
  31 Dec 1973, 23 seen, Gulf Shores Christmas Bird Count, (D. Cooley, pers. commun. 1984);
  31 Dec 1974, 23 seen, (Gulf Shores), P. F. Chandler (Hamilton 1974);
  3 Jan 1975, 8 seen, Gulf Shores Christmas Bird Count, (D. Cooley, pers. commun.);
  1 Jan 1976, 30 seen, Gulf Shores Christmas Bird Count, (D. Cooley, pers. commun.);
  Winter 1976, 6 seen (habitat change noted), T. A. Imhof (Hamilton 1976);
  1 Jan 1978, 14 seen, Gulf Shores Christmas Bird Count, (D. Cooley, pers. commun.);
  31 Dec 1979, 3 seen, Gulf Shores Christmas Bird Count, (Chandler 1980);
  27 Jan 1980, 9 seen (Gulf Shores), D. Cooley and M. Brown (D. Cooley, pers. commun.);
  Jan 1981, 23 seen (Elberta), R. Ard (D. Cooley, pers. commun, Oct 1984);
  3-12 Dec 1981, 14 seen (Gulf Shores), G. Jackson and B. Traham. (Ortego 1982).
  12 Nov 1983, 6 flying (Fort Morgan), R. A. Duncan, M Floyd, and V. Friend (Purrington 1984);
  29 Dec 1983, 20 seen (Gulf Shores), G. Jackson and D. Jackson (D. Cooley, pers. commun. Oct 1984);
  Dec 1983, 18 seen (Elberta), (D. Cooley, pers. commun. Oct 1984);
  29 Dec 1984, 33+ 11 seen, Gulf Shores Christmas Bird Count (D. Cooley, T. Logan, pers. commun. Feb 1985);
  Feb 1985, 2+ heard, Bon Secour National Wildlife Refuge, J. Carroll and S. Drake (T. Logan, pers. commun. Feb 1985).
Calhoun County, Jacksonville, late fall 1957 or 1958, W. J. Calvert (Imhof 1976).
Baldwin County, Romar Beach, 18 June 1958, 2 seen, D. Rider (Files, LSU Mus.).
Baldwin County, Orange Beach, 23 June 1960, J. L. Dorn (Imhof 1976).
Mobile County, Theodore:
  30 Nov, 1, 2 Dec 1966, 2 seen, L. Bahlman (Woodward 1966);
  26 Dec 1966, 1 seen, J. L. Dorn (James 1967).
Marshall Co., Douglas, 30-31 Dec 1976, 1 seen, R.D. Sloman (Files, LSU Mus., Purrington 1977).
Barbour County, Eufaula N.W.R.:
  13-26 Feb 1977, 1 seen, J. B. Ortego and S. Johnson (Hamilton 1977);
  19 Feb 1977, 2 seen, J. B. Ortego and S. Johnson (Hamilton 1977);
  16 Feb 1980, 2 seen, J. B. Ortego (Hamilton 1980);
  1 Nov 1981, 5 seen, D. M. Brown (Files, LSU Mus.).
Henry County, Abbeville, 12 March 1979, 7 seen, M. Fuller (T. A. Imhof, pers. commun. 1984).
Morgan County, Wheeler N.W.R., 4 Dec 1980, C. Davis and R. Palmer (Hamilton 1981).
Shelby County, Sterrett, 29 March 1982, 7 flying, J. V. Peavy and R. Lowe (T.A. Imhof, pers. commun. 1984.
Baldwin Co., (Northern section), Daphne, 1 seen, T. Thornbill (D. Cooley, pers. commun. 1984).

Table 6. Sandhill crane sightings reported in Mississippi.

Location- Date- observation details- observer(s)- data source.

Adams County, Natchez, Nov 1821, cranes in fields, J. J. Audubon (Audubon 1935).
Harrison County, DeSoto Nat'l. Forest, 1974, 1 seen (Valentine 1975).
Issaquena County, 12-15 Dec 1975, 1 banded, juvenile lesser seen, Bobbs (Boise 1977).
Lafayette County, Sarchis Waterfowl Refuge, 2 Nov 1976, 1 seen among Canada goose flock, R. Wells, W. H. Turcotte, and R. L. Rodgers (Purrington 1977, Files, LSU Mus.).
Oktibbeha County, Starkville, 12 Nov 1977, 3 or 4 heard in flight, R. Loloefener (Files, LSU Mus.).
Forrest County, Hattiesburg Sewage Lagoons, 31 Oct 1981, 1 immature, J. R. Moore and P. S. Rodriguez (Files, LSU Mus.).
Jackson County, Latimer, Vancleave:
- 1940's, Old Fort Bayor Rd, 29 seen, H. Mallette (H. Mallette, pers. commun. 1984);
- 1957 - present, Latimer flock of 30+ cranes originally, now down to 20 cranes, J. Jordan (J. Jordan, pers. commun. Aug 1984);
- Jan 1967, Vancleave, 42 flying (R. E. Noble field notes 1967);
- 20 Jan 1977, Latimer, 26 sighted on H. L. Davis farm (J. M. Valentine, pers. commun. 1984);
- 10 Nov 1978, Latimer, 26 sighted on N. Jordan farm, N. Jordan (Valentine 1980);
- Dec 1979, Latimer, 26 sighted on N. Jordan farm, N. Jordan (Valentine 1980);
- 11 Dec 1979, Latimer, 22 sighted on H. L. Davis Farm, B. Grabill, G. Heet, and J. Valentine (Valentine 1980);
- Nov. 1981, Latimer, 20-22 sighted on N. Jordan farm, J. Kurth (Valentine, pers. commun. 1984);
- Oct-Dec 1982, Latimer, 10+ sighted on N. Jordan farm (D. Dewhurst).
- Sept-Dec 1983, Latimer, 18 peak number sighted on N. Jordan farms (D. Dewhurst).
- Sept-Dec 1984, Latimer, 8-10 sighted, (C. Wilson, pers. commun. Feb 1985);
- Dec 1984-Feb 1985, Gautier Unit- Pensite, Mississippi Sandhill Crane National Wildlife Refuge, 15+ 9 (wild) sighted, (T. Logan, pers. commun. Feb 1985).

reported that tarsus length was significantly correlated (r= 0.76, P 0.01) with footprint length. Comparison of footprint measurements of the Jordan flock with a sample from known subspecies in captivity at Patuxent Wildlife Research Center may provide useful information; however, Lewis (1974) and Guthery (1975) reported that overlap in the tarsus length could invalidate this technique between similar subspecies. Currently, data are insufficient to determine whether the footprint technique could be used to distinquish between Mississippi and greater sandhill cranes.

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HABITAT USE BY MIGRATING WHOOPING CRANES IN THE ARANSAS - WOOD BUFFALO CORRIDOR

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Abstract: During three southbound and two northbound migrations between 1981 and 1984, data were collected on habitat use by 18 radio-marked whooping cranes (Grus americana) migrating between Wood Buffalo National Park, Northwest Territories, Canada, and Aransas National Wildlife Refuge, Texas. Data on habitat variables were collected at most feeding and roosting sites between Aransas and the inaccessible forested regions of central Saskatchewan and Alberta. The majority of wetlands used for roosting were less than 4 ha (75%) and within 1 km of a suitable feeding site. Families (juveniles accompanied by parents) tended to use more vegetated wetlands than nonfamiles. Cropland accounted for 70% of the feeding sites of nonfamilies while wetlands accounted for 67% of the feeding sites of families. Suitable feeding and roosting sites appeared to be widely available throughout the migration corridor.

PROCEEDINGS 1985 CRANE WORKSHOP

Despite considerable research on whooping cranes (Grus americana) since 1954, when the breeding grounds were discovered in Wood Buffalo National Park, Northwest Territories, Canada, very little has been learned about ecological requirements and mortality factors along the migration route to and from Aransas National Wildlife Refuge, Texas. Research and management efforts have focused on the breeding and wintering grounds. The Whooping Crane Recovery Plan (Whooping Crane Recovery Team 1980) noted the deficiency of data on migration and recommended a radio-tracking study be undertaken to better document habitat requirements and mortality of migrants. The groundwork for such a study was laid in the foster-parented population in Grays Lake, Idaho, with the testing and perfection of a radio package attached to a leg band (Drewien and Bizeau 1981). The first application of radios to Wood Buffalo birds took place in the summer of 1981 and one of the three birds radioed was successfully tracked south to Aransas.

Before the tracking program began, organized field studies had not been made of whooping crane migration. In 1977, the U.S. Fish and Wildlife Service began distributing site evaluation forms to state agencies and individuals for the purpose of recording data on habitat use by migrating whoopers encountered opportunistically. On the basis of these and other incidental sightings, Johnson and Temple (1980) described habitat use at over 100 sites in the United States. In the present study, individually radio-marked birds were followed through five migrations and data were collected on habitat use at nearly all stopovers in the United States and Canada. This paper evaluates the habitat characteristics of all feeding and roosting sites used at migratory stopovers in this study.

This project represented a cooperative effort of many dedicated individuals over a 3-year period. Initial design and coordination was provided by Larry Thomas. I am indebted to Maury Anderson, Wally Jobman, and Larry Smith for serving as points of contact for the field operation. For tireless attention to the cranes in the field and for laborious data collection, I thank all the ground crew members: Dave Blankinship, Jay Crenshaw, Carol Dickinson, Howard Hunt, Brian Johns, Steve Labuda, Gary Lingle, Ken Strom, and Lenny Young. In particular, I am grateful to John Smith, Tom Stehn, George Vandel, and John Ward for ground crew work and producing excellent summary ground crew reports for the various trackings. Important logistical support was provided by Larry Kolz, Al Sargeant, Charlie Shaiffer, Don Van Aspern, and personnel of the J. Clark Salyer National Wildlife Refuge. Lynne McAllister provided outstanding assistance with data analyses and prepared the figures. Mike Erwin, George Gee, and Ken Williams reviewed the manuscript. Finally, I thank Scott Derrickson for many helpful consultations during the project.

METHODS

In the summers of 1981-1983, all or a portion of each new cohort of whooping cranes at Wood Buffalo National Park were trapped and marked with radio-transmitters during the prefledging stage. No more than six birds were radio-marked in any year. Transmitters were affixed in advance to colored plastic bands, which were applied to the tibiotarsus in the manner described by Drewien and Bizeau (1981). Radio packages weighed approximately 55 g, were powered by solar cells and nickel-cadmium batteries, and were designed to function for 2 years. Each radio broadcast a unique frequency in the 164 to 165-MHz range and was detectable for up to 160 km air-to-air, 56 km air-to-ground, and several km ground-to-ground, depending on topography. In each of the five tracking efforts, two individual radioed cranes along with their families or other associates were selected to be followed for the entire migration. Trackings were conducted southbound from Wood Buffalo Park to Aransas in 1981, 1982, and 1983 and northbound from Aransas to Wood Buffalo Park in 1983 and 1984.

Before migration, radio-marked cranes were monitored several times daily by ground or aerial reconnaissance. When a bird departed on a migratory flight, it was tracked by an aerial crew consisting of a pilot and a biologist. The aerial crew would radio a ground crew, consisting of two biologists, to report the location of birds in transit and the direction they were flying. When birds landed, the ground crew would locate them with the aid of topographic maps and radio receivers. In circumstances where aerial and ground crews lost contact, one or more field coordinators were on 24-hour call to serve as points-of-contact for telephoned messages. In Canada, birds were tracked only by air in the remote, roadless areas between Wood Buffalo Park and the Saskatchewan prairies.

At each migration stopover, ground crews collected data on habitat characteristics of feeding, roosting, and loafing sites used by the cranes. In the first three trackings, information on 20 habitat variables was recorded on forms based on the U.S. Fish and Wildlife Service (FWS) Use-Site Form distributed to whooping crane observers since 1977. In later trackings, a coded form was devised to facilitate data recording and transfer to computer tape. Two wetland classification systems were used. For analysis of general habitat use, habitat was assigned to one of six wetland or two upland types, comprising most of the general habitat types encountered during migration. Wetlands were further classified according to the scheme of Cowardin et al. (1979), particularly with respect to geomorphologic and hydrologic characteristics and to persistency of water cover through the year. Density and distribution of emergent vegetation were assessed visually and assigned to one of five categories. Water depth was measured at many locations where cranes were roosting or feeding. This variable is analyzed for five sites by Ward and Anderson (this Proceedings). Slope of land surrounding roosting and feeding sites was estimated to the north, east, south, and west and averaged. Ground crews were asked to estimate, from topographic maps and general knowledge of the local area, the degree of availability of similar sites within a 16-km radius of each roosting wetland. Estimates were assigned to one of four categories ranging from "none" to "abundant."

Categorical habitat data are summarized as a series of univariate frequency distribution histograms. Each graph presents frequency distribution of two subsets of a variable (e.g., spring versus fall, feeding sites versus roosting sites). The null hypothesis, that the distributions for each subset are identical, is tested using a chi-square goodness-of-fit test. These values should be interpreted cautiously, because assumptions of independence are violated by focusing on only six juveniles and 12 adults. Three of the juveniles were also tracked again as subadults. Frequency distributions reflect only the number of feeding or roosting sites in each category and are not weighted by the number of hours or days each site was used. For noncategorical data, such as water depth or slope of land, data are summarized by standard descriptive statistics.

RESULTS

Habitat Use

The frequency distributions of roosting sites and feeding sites among habitat categories were significantly different (X^2=45.5, P<0.0001). Fig. 1 shows that, although 42% of all documented feeding sites were croplands, nearly all of the roosting sites were wetlands. Cranes used natural ponds and lakes more for roosting during fall than during spring migration (Fig. 2, X^2=13.4, P<0.05), possibly due to the scarcity of flooded cropland or other transitory wetlands in fall. Cranes used similar (X^2=6.8, P=0.44) feeding habitats during spring and fall. When family groups were compared with nonfamilies, ponds and lakes appeared to be more heavily used for roosting by nonfamilies (Fig. 3, X^2=17.0, P<0.01). Family groups showed a broader roosting distribution among wetland types, making greater use of wetlands that generally were shallow throughout. Whereas 70% of the feeding sites used by nonfamilies were croplands, 67% (N = 49) of the feeding sites used by families were wetlands (Fig. 4, X^2 = 13.9, P = 0.053).

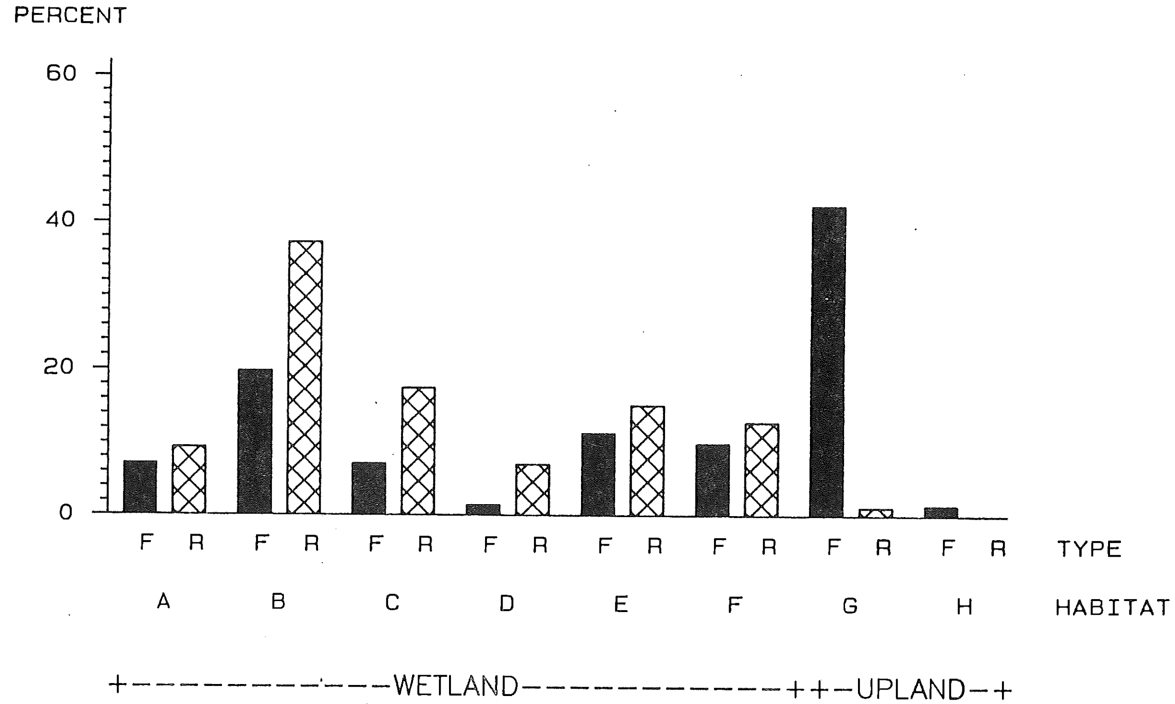

Fig. 1. Frequency distributions of feeding (F, N = 71) and roosting (R, N = 86) sites among six wetland and two upland habitats (A = flooded cropland, B = pond/lake, C = reservoir/impoundment, D = river/creek, E = marsh, F = other wetland, G = cropland, H = pasture/grassland).

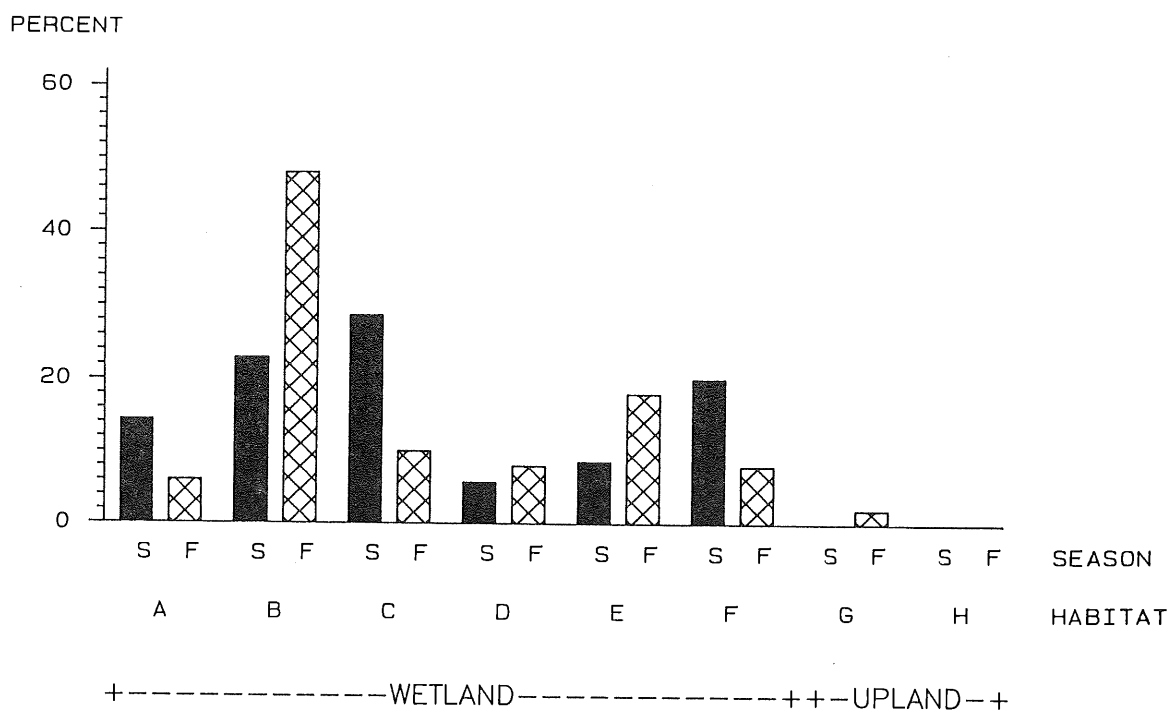

Fig. 2. Frequency distributions of spring (S, N = 35) and fall (F, N = 50) roosting sites among habitat categories (Fig. 1).

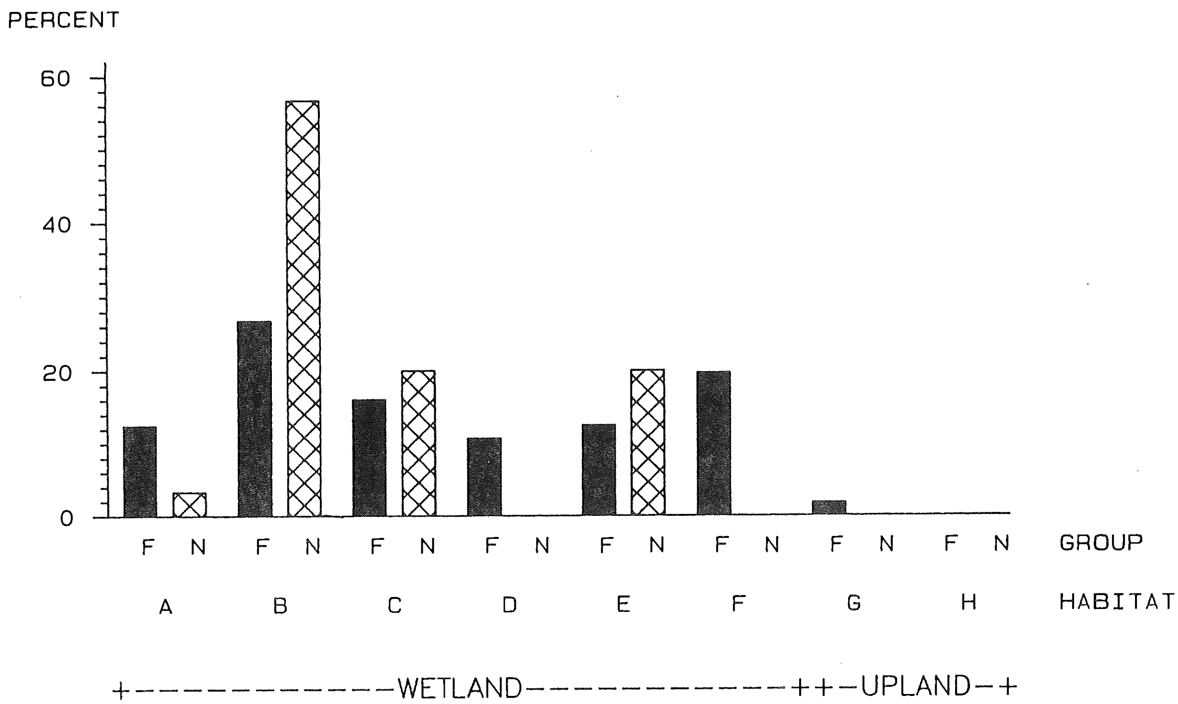

Fig. 3. Frequency distributions of family (F, N = 56) and nonfamily (N, N = 30) roosting sites among habitat categories (Fig. 1).

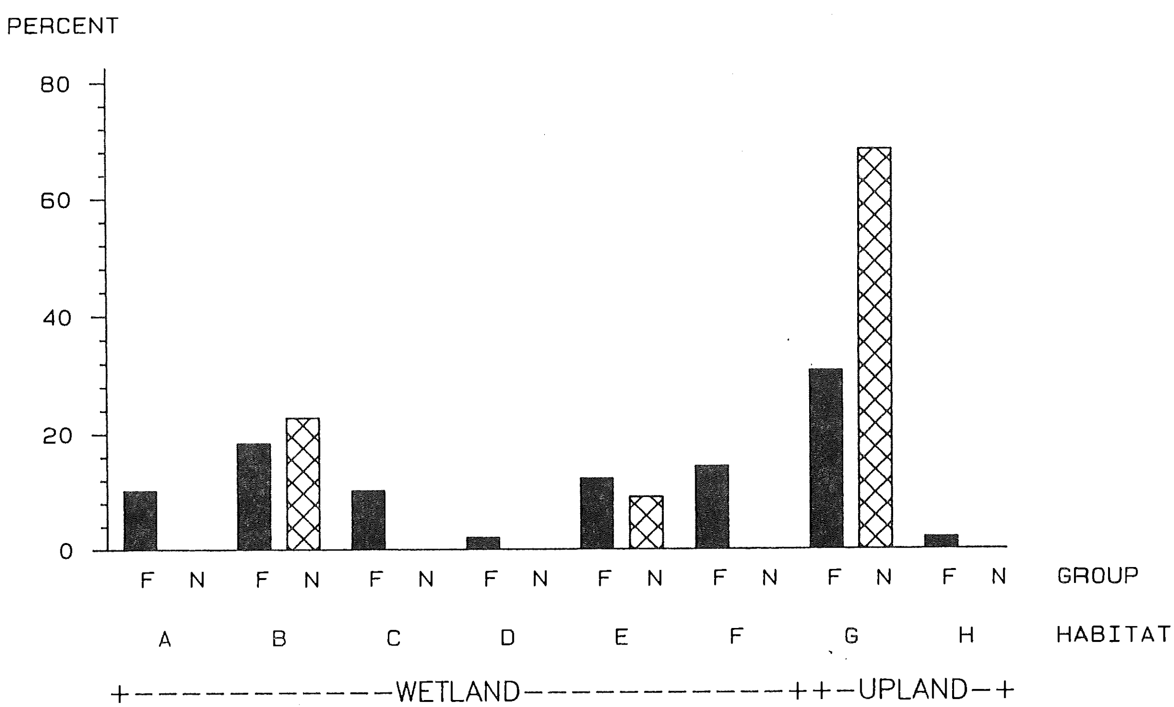

Fig. 4. Frequency distributions of family (F, N = 49) and nonfamily (N, N = 22) feeding sites among habitat categories (Fig. 1).

Wetland System

When wetlands were classified as riverine, lacustrine, palustrine, or "other" (Cowardin et al. 1979), there were no differences between roosting and feeding wetlands (X^2 = 5.3, P = 0.15) or between spring and fall roosting wetlands (X^2 = 6.0, P = 0.11). Lacustrine wetlands were used more in fall than in spring for feeding (X^2 = 6.4, P = 0.05). Seventy-five percent of all sites used were classified as palustrine. Families and nonfamilies used similar wetlands as roosting sites, but families used palustrine wetlands more often than nonfamilies as feeding sites (Fig. 5, X^2 = 7.8, P < 0.05).

Wetland System Modifiers

Using the wetland modifier classification (Cowardin et al. 1979), which classifies according to water persistency, feeding and roosting sites were similarly distributed (X^2 = 3.9, P = 0.56). Intermittently exposed and semipermanent wetlands were used more than any other type. Although temporary wetlands were used extensively for roosting in spring, intermittently exposed wetlands were used more often in fall (Fig. 6, X = 15.3, P < 0.01). This difference may be related to the seasonal availability of wetland types. There were no differences between families and nonfamilies with respect to wetland modifiers (roosting sites: X^2 = 8.1, P = 0.08; feeding sites: X^2 = 4.0, P = 0.55).

Vegetation Density

Generally, wetlands with extensive vegetation seemed to be avoided by whooping cranes. Most of the sites were described by ground crews as having scattered vegetation. There was a statistically nonsignificant (X^2 = 8.9, P = 0.06) indication that wetlands with no vegetation or with a perimeter of vegetation were used more often as roosting sites than as feeding sites, which tended to have scattered or clumped vegetation. Family groups roosted in wetlands with clumped vegetation more often than nonfamilies. Nonfamilies roosted more commonly in wetlands with peripheral vegetation (Fig. 7, X^2 = 17.0, P < 0.01). One crew member reported that dense emergents may be used during periods of high wind.

Miscellaneous Variables

Mean water depths were similar for roosting (X = 18.1 cm, S.D. = 29.4, N = 80) and feeding (X = 20.2 cm, S.D. = 38.9, N = 39) sites. Generally birds did not venture into water deep enough to cover the tibiotarsus-tarsometatarsus joint. Muddy substrates characterized the wetlands most often used by cranes and turbidity levels of roosting and feeding wetlands were similar (X^2 = 4.6, P = 0.10).

Mean slope estimates were 7.1° for roosting sites (N = 77) and 8.5° for feeding sites (N = 55). Visibility from a normal standing position was, however, generally less than 3 km and often less than 1 km for both roosting and feeding sites.

Half of the roosting sites studied (N = 48) were less than 1 ha in total area and three-quarters were less than 3 ha (Table 1). This pattern prevailed throughout the migration route. Nearly all of the large (> 100 ha) roosting wetlands were in Saskatchewan, probably reflecting the greater availability there of large wetlands near suitable feeding sites. Feeding and roosting sites were typically (56%, N = 73) less than 1 km apart, but occasionally (14%) they were separated by more than 8 km (Table 2). Eighty-four percent of the roosting sites, both in Canada and the United States, had abundant or moderate amounts of similar habitat within a 16-km radius, in the subjective estimation of the ground crew members.

Seventy-five to 80% of all feeding and roosting sites were on private land. The remainder were in various other land ownership categories, including Federal and state land. Through interviews with landowners, it was determined that over 80% of the sites were secure for the foreseeable future and only 5% were considered threatened. There were no significant differences between feeding and roosting sites in their apparent short-term security (X^2 = 2.3, P = 0.32).

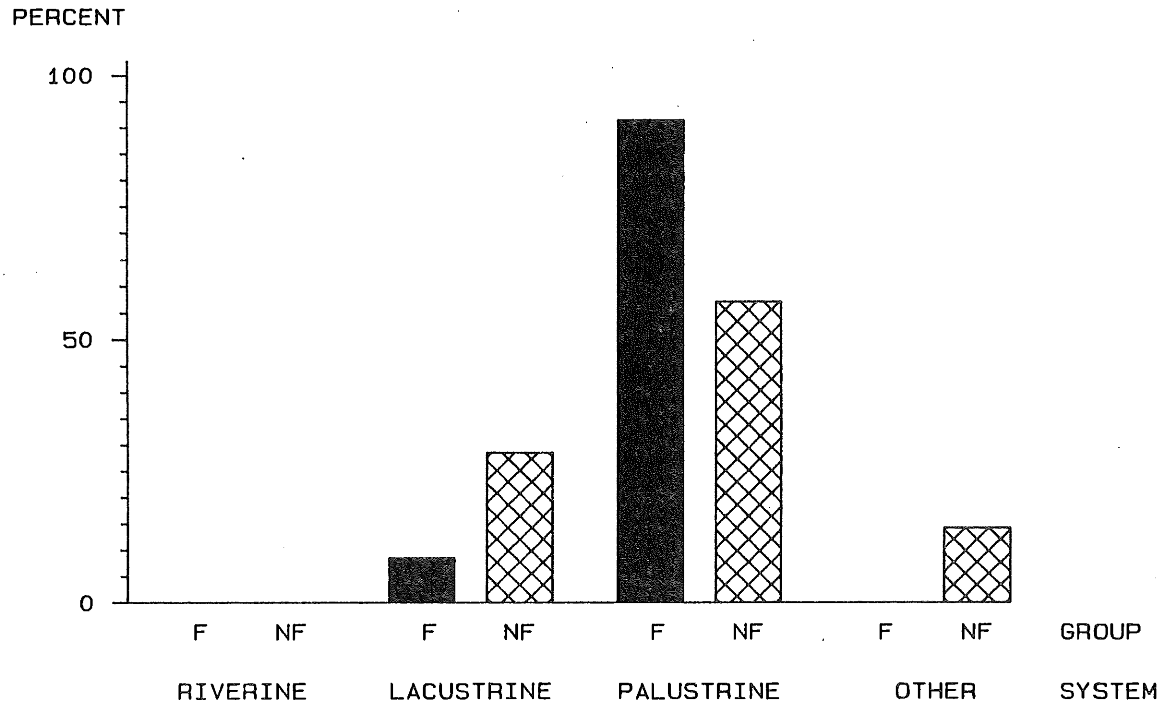

Fig. 5. Frequency distributions of family (F, N = 35) and nonfamily (NF, N = 7) feeding wetlands among wetland classes.

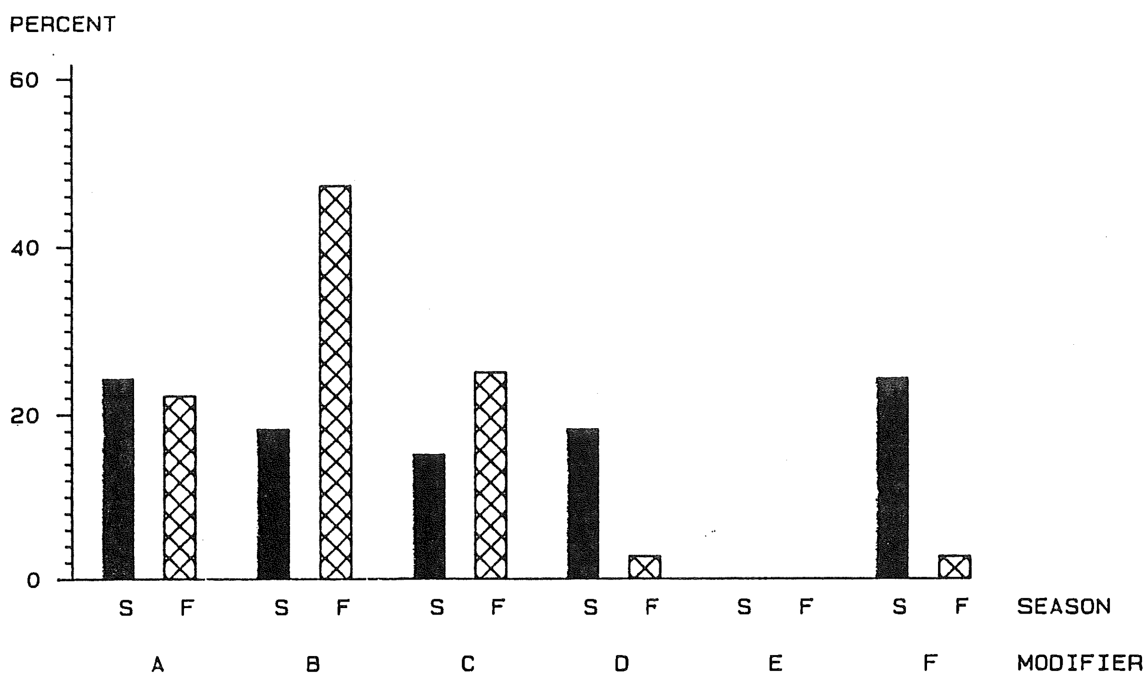

Fig. 6. Frequency distributions of spring (S, N = 33) and fall (F, N = 36) roosting wetlands with respect to modifier categories (Cowardin et al. 1979). A = permanently flooded, B = intermittently exposed, C = semipermanently flooded, D = seasonally flooded, E = saturated, F = temporarily flooded.

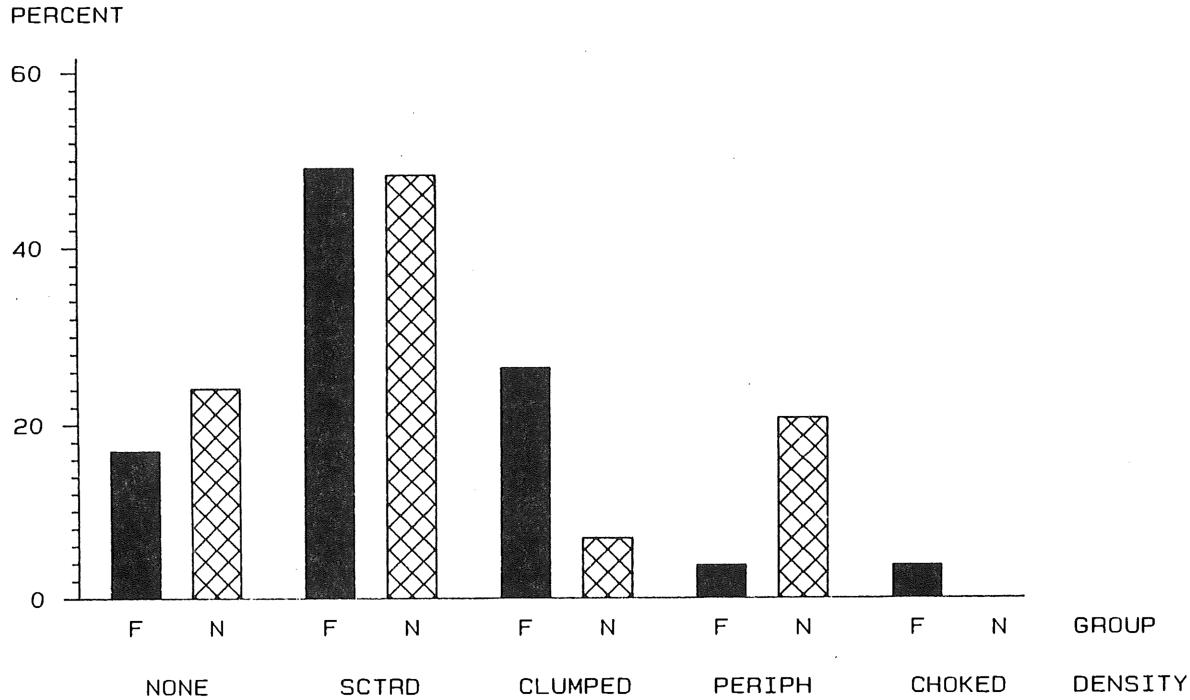

Fig. 7. Frequency distributions of family (F, N = 53) and nonfamily (N, N = 29) roosting wetlands among categories of emergent vegetation density, defined as follows: Scattered: distributed irregularly in no definable pattern and in low enough density that water is clearly visible; Clumped: distributed in discrete dense patches with open water between; Peripheral: distributed around the perimeter of the wetland with open water in the middle; Choked: distributed throughout at a density high enough that water is not clearly visible.

Table 1. Frequency distribution of roosting wetlands among area (ha) categories in states and provinces along the whooping crane migration route.

	Number of wetlands/area category						
State/Province	1 ha	1-3 ha	4-10 ha	11-50 ha	51-100 ha	> 100 ha	Total
Saskatchewan	6	5	1	0	0	6	18
North Dakota	2	0	0	0	0	0	2
South Dakota	2	1	0	0	2	0	5
Nebraska	5	2	1	0	0	0	8
Kansas	4	2	0	0	0	1	7
Oklahoma	2	0	0	0	0	0	2
Texas	3	2	0	1	0	0	6
Total	24	12	2	1	2	7	48

Table 2. Frequency distribution of distances between paired feeding and roosting sites.

	0-100m	101-500m	501m-1km	2-3km	4-5km	6-8km	>8km
Number of sites	12	11	18	9	9	4	10

DISCUSSION

The overall picture emerging from this investigation of habitat use during migration is that the whooping crane uses a broad range of natural and man-modified wetlands and croplands within the prairie system of the central United States and southern Canada. The only clear requirement of all birds at stopovers is some type of wetland. It is impossible to assess whether sufficient natural foods are available to sustain whooping cranes during migration or how these conditions compare with presettlement conditions. However, the species (particularly adults and subadults) has clearly learned to exploit cultivated grains, such as barley and wheat, which are widely available through most of the migration corridor. A similar transition has been made successfully by sandhill cranes (G. canadensis) (e.g., Guthery 1976, Hoffman 1976, Lewis 1979, Melvin 1982, Krapu et al. 1984).

The absence of quantitative data on habitat availability precludes evaluation of whether the habitats that are used are preferred habitats. They may be used simply because preferred habitats are unavailable. Nonetheless, within the habitat spectrum used by cranes in this study, certain patterns of habitat selection are suggested. These must be interpreted cautiously for two reasons: (1) the correlation structure of the variables treated here is not revealed by univariate analysis and (2) the data do not represent a random sample of individuals but, rather, repeated observations of a small number of individuals. With these caveats, the most interesting pattern to emerge was the consistent difference in habitat use between family groups and nonfamilies. Display of the data on habitat use, wetland system modifiers, and density of wetland vegetation strongly suggests that family groups choose more heavily vegetated wetlands for roosting than birds without young. Also, 67% of family feeding sites were wetlands, compared with only 30% for nonfamilies. Several interpretations of these data are possible. Vegetated wetlands may provide better cover for young birds, facilitating hiding from predators. Juvenile birds may require longer feeding bouts than adults and, therefore, have a higher probability of feeding in roosting wetlands -- productivity of vegetated wetlands is presumably higher than that of wetlands with little or no vegetation. Finally, young birds still in the process of growth may require a more proteinaceous diet than adults. The invertebrates found in wetland systems may be a required supplement to the grains that are used by adults without young.

Proximity of feeding and roosting sites appears to be important because 56% of all paired sites were less than 1 km apart. Often the cranes walked from a roosting wetland to a nearby field to feed. However, the impressions of the ground crew biologists, supplemented by examination of topographic maps, indicate that such situations are widely available through much of the migration corridor. Availability of large wetlands does not appear to be critical for migrating whoopers, because half of the wetlands used for roosting were less than 1 ha in total area. Use of wetlands of this size may have management implications for the southern third of the migration corridor, where wetlands are least abundant. Constructing additional small ponds and impoundments in this southern area could expand the number of wetlands suitable for migrating whooping cranes.

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COMMENTS ON WHOOPING CRANE RECOVERY ACTIVITIES

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So far in this conference, we have heard several technical papers on various aspects of whooping crane (<u>Grus americana</u>) biology and recovery. I would like to diverge from that focus for a few moments and take a broader look at recovery of the whooping crane. My job is to step back from day-to-day activities and look to the future. From that perspective, I have one objective in mind--the prime objective for recovery of the whooping crane is to increase the Wood Buffalo National Park population to 40 nesting pairs and establish at least two additional populations, each containing a minimum of 25 nesting pairs.

First, let's look at four recent events that have not been discussed elsewhere in this conference, but will ultimately play a significant role in reaching that prime objective. After a review of these events we will take a crystal ball peak into the future!

RECENT EVENTS

The Death of 82-13

A whooping crane, number 82-13 was captured on Bosque Apache National Wildlife Refuge, New Mexico, on 21 January 1984, after it displayed signs of being sick or injured. On 23 January 1984, it died in medical facilities at Rio Grand Zoological Park in Albuquerque, New Mexico. A necropsy was performed and the cause of death was identified as lead poisoning. Based on electron microscopy conducted by the Federal Bureau of Investigation, the lead was from a common source, plastic coated on one side, and may have been from a small battery. The whooping crane also had three shotgun pellets in the muscle of its left leg. These injuries had healed but they led to confusing newspaper accounts that the bird had been shot and died from the wounds.

The death of this bird focused national attention on the complex problems of managing an endangered species such as the whooping crane. A review team was appointed to develop a set of management recommendations for the middle Rio Grande Valley that would provide the best possible conditions for success of the Grays Lake transplant program, while recognizing the interests of sportsmen, farmers, and others using the Valley. Most of those recommendations were developed and implemented for the 1984-85 winter season. The result was a substantial reduction in disturbance to whooping cranes on the wintering grounds.

Emergence Of Powerlines As The Primary Post-fledgling Mortality Factor

Collisions with powerlines are the principal known cause of death of fledged whooping cranes. As least 13 dead or crippled birds have been associated with powerlines in the last few years, including 3 in the spring of 1984. To address this problem, representatives of the electric utility industry, the FWS, and the conservation community have been meeting periodically to discuss the powerline problem and options that may be available for its resolution. This Crane Study Group includes representatives from Edison Electric Institute, Central and Southwest Corporation, Public Service Company of Colorado, Public Service Company of New Mexico, Houston Lighting and Power Company, Colorado UTE, National Audubon Society, and Fish and Wildlife Service.

The Group has cooperated in some limited studies in the San Luis Valley of Colorado where six of the whooping crane/powerline collisions have occurred. These studies have focused on potential static wire modification (see Brown et al. this proceedings) and photography of flight behavior as cranes approached powerlines.

Through such efforts, we hope to find ways to identify high risk lines and modify them as necessary to reduce the risks. By working in a cooperative manner, we hope to keep costs to the utilities to a minimum, with the associated expenditures going to benefit the cranes and not to lawyers, as occurs when issues become confrontations instead of cooperation. We expect these efforts to continue.

Initiation Of Eastern Studies

An effort is now underway to identify sites for possible future whooping crane introductions. Preliminary studies are being conducted at Seney National Wildlife Refuge in Michigan, Okefenokee National Wildlife Refuge in Georgia, and in central Florida. When completed, these studies will provide information on a wide range of factors that will be evaluated to determine suitability of the sites for an eventual whooping crane release program. The pre-release evaluations include biological studies of the sandhill crane populations in each area, habitat quality and quantity assessments, determination of potential conflicts, and recommendations about overall suitability. Eventually, one or more of these sites may be chosen for a future whooping crane introduction, a significant step towards accomplishing the prime objective to have three self-sustaining wild populations.

The Seney National Wildlife Refuge (NWR) study is being conducted by the Ohio Cooperative Wildlife Research Unit, the Okefenokee NWR study by the Georgia Cooperative Wildlife Research Unit, and the Florida study by the State of Florida. I am confident you will be hearing more about these areas at future crane workshops.

Coordination Activities

The management and coordination of whooping crane recovery efforts is a large and complex task involving Canada, the United States, and Mexico. Within the United States, projects are underway from Florida to Idaho and from Michigan to Texas. There is a wide range of activities from growing corn at Bosque del Apache NWR in New Mexico to determining cryogenic techniques at Patuxent Wildlife Research Center in Maryland. Problems needing attention are as varied as potential hunting season conflicts in the Dakotas, whooping cranes that do not winter where they are supposed to in Texas, and die-offs in captive birds. Superimposed on all this is a constant flow of requests for news, pictures, interviews, and public information.

The Fish and Wildlife Service took a significant step recently to improve the coordination of all these activities by establishing a National Whooping Crane Coordinator. Dr. Jim Lewis, the co-chairman of this workshop, has been appointed to that position. Jim's job is to cross all the normal bureaucratic boundaries to ensure that what we are doing for whooping cranes is done the best way we know how. I think we have plenty of work to keep Jim busy for a few years.

To help with international coordination of whooping crane conservation, the Service recently completed a Memorandum of Understanding (MOU) with the Canadian Wildlife Service. This MOU provides a more formal structure to the working relationships between the two nations and establishes an individual within each agency responsible for coordination of decisions such as disposition of birds and eggs, postmortem analysis, population restoration and objectives, new population sites, recovery planning, and overall consultation and coordination. The two individuals appointed under this MOU are in this room, Dr. Graham Cooch for Canada and Dr. Jim Lewis for the United States.

Now let's get that crystal ball out and look to the future. If current recovery activities continue without a major disaster, 1989 will be a key year for the whooping crane. There are several recovery efforts currently underway or planned that should reach fruition by that time.

FUTURE EVENTS

The Grays Lake Transplant Project

Because of the large year class of birds produced in 1983, there should be a significant cohort of breeding age birds available by 1989. Thus an evaluation of the Grays Lake project should be possible by that year. If natural reproduction has occurred, in all probability the project will be rated a success and will continue towards the goal of having Grays Lake be one of the additional populations called for in the prime objective. If natural reproduction has not occurred, the project will be closely evaluated to determine what is preventing success and whether further work on the project is appropriate.

Captive Propagation

Captive propagation of whooping cranes at Patuxent Wildlife Research Center is transcending from a research program to an operational program. Despite recent setbacks due to the Eastern Equine Encephalitis outbreak, we project that Patuxent could be producing as many as 40 eggs a year by 1989, with the number increasing each year thereafter. Planning is now underway to expand the capabilities of Patuxent to handle a significantly larger production program. Thus it appears that we will be able to support two release programs by 1989.

Eastern Studies

By 1988, the three eastern studies will have been completed and an initial evaluation made about their biological suitability for a whooping crane release. Assuming one or more of the sites is suitable, the necessary coordination with all interested parties can be conducted in 1988 and any required environmental assessments, permits, etc., can be completed. Thus, selection of one or more additional release sites could be made by 1989. This action, in combination with the increased captive propagation just described, means that we could be on our way towards establishing another population of whooping cranes in 1989.

There are, of course, a lot of "what ifs" in the above scenario. One of the biggest question marks is money. As we all know, the Federal purse strings are tight these days. But the whooping crane is often regarded as the symbol of conservation and I am confident that a cooperative effort between Federal, State, and private interests will provide the resources necessary to get the job done. Over the last 40 years, the cranes have certainly shown us that if we give them half a chance, they will do their part. It's up to all of us to ensure that they get that chance.