HISTORICAL NOTES ON WHOOPING CRANES AT WHITE LAKE, LOUISIANA: THE JOHN J. LYNCH INTERVIEWS, 1947-1948

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Abstract: In May 1939 biologist John J. Lynch of the U.S. Bureau of Biological Survey conducted an aerial survey that documented the existence of a non-migratory population of whooping cranes (*Grus americana*) near White Lake in southwest Louisiana. Lynch found 13 cranes, including 2 pre-fledged young, confirming breeding. Lynch's survey occurred, in part, because fur trappers and alligator hunters working in the White Lake marshes had informed the biologist of the cranes' presence and habits. Lynch continued his contacts with these knowledgeable marsh users, and in 1947 and 1948 interviewed at least 7 individuals. In 2001, M. L. Courville, along with her sister Nora Z. Lynch, discovered the interview notes among their father's papers. The notes contain information on the Louisiana non-migratory population's range, abundance, habitat use, feeding behavior, nesting, and young, including survival of twins; they also include a small amount of information on sandhill cranes (*Grus canadensis*) and migratory whooping cranes. Both Lynch and Robert P. Allen relied heavily on this "traditional ecological knowledge" in their accounts of non-migratory whooping cranes in southwest Louisiana. Because of their biological and historical significance, the interview notes are reproduced in this paper. Many marsh users remain in the White Lake area, and their knowledge could aid future research and crane reintroduction efforts in the region.

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Key words: *Grus americana*, *Grus canadensis*, John J. Lynch, Louisiana, non-migratory population, traditional ecological knowledge, White Lake, whooping crane

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Migratory and non-migratory populations of whooping cranes (*Grus americana*) formerly occurred in southwest Louisiana and are well documented (Nelson 1929, Simmons 1937, McIlhenny 1938, 1943, Oberholser 1938, Allen 1952, McNulty 1966, Lynch 1984, Doughty 1989, Gomez 1992, 2001, Drewien et al. 2001). Wintering cranes historically used the Chenier Plain's brackish marshes and cheniers (relict beach ridges that cross the marsh, paralleling the shoreline), as well as the uplands of the Pleistocene prairie terrace to the north. Resident whooping cranes used freshwater marshes located between the prairie uplands and the large lakes of the eastern Chenier Plain; these extensive marshes spanned approximately 30 km, from north of White Lake in Vermilion Parish to north of Grand Lake in Cameron Parish. The marshes and prairies that comprise the crane's former range in Louisiana are located between latitudes 29.5°N and 30.5° N and longitudes 92° W and 94° W (Allen 1952, Gomez 1992, 2001).

Within this range, the presence of a non-migratory, breeding population was confirmed on 15 May, 1939 when biologist John J. Lynch of the U.S. Bureau of Biological Survey (U.S. Fish and Wildlife Service after 30 June 1940) conducted an aerial search in the remote marshes north of White Lake in Vermilion Parish. Lynch had been intrigued by reports of nesting activity in the region, and his aerial survey succeeded in locating 13 whooping cranes, 2 of which were "young-of-the-year, about one-third grown" (Lynch 1984). Detailed accounts of this discovery appear in Drewien et al. (2001).

The reports that had inspired and guided Lynch's search came not only from prominent naturalists like Edward A. McIlhenny (1938), but also from local marsh users, primarily fur trappers, alligator hunters, and waterfowl hunting club operators who resided in or near the wetlands and who knew the marsh intimately as a result of their daily activities in this ecosystem (Allen 1952). In a 19 April, 1939 letter, for example, Lynch requested that George Welsh, manager of the Florence [Hunting] Club north of White Lake, suggest the best time to conduct an aerial search for breeding whooping cranes and mark on a map the most likely areas in which to find them (Drewien et al., 2001).

The marsh users' "traditional ecological knowledge," the knowledge of nature and natural processes gained by local people through longtime, frequent experience and keen observation, continued to provide Lynch with information on southwest Louisiana whooping cranes. These included observations of habitat use, feeding behavior, nests, and young. In 1947 and 1948, Lynch recorded these observations in a set of typewritten interview notes, which he later shared with Robert P. Allen. It is primarily from these "Lynch Records" that Allen constructed his account of the non-migratory population in southwest Louisiana (Allen 1952).

In 2001, Mary Lynch Courville and Nora Z. Lynch, daughters of John Lynch, discovered 6 of these interview notes, which record the observations of 7 individuals who lived and worked in the marsh and prairie regions frequented by whooping cranes.

The notes focus primarily on the non-migratory population, but they also include information on sandhill cranes and migratory whooping cranes. Because of their biological and historical significance, we have reproduced the interview notes in this paper. We have made minor format changes from the original notes, including (1) altered length of sentence lines, (2) omitted page numbers, (3) moved periods and commas inside quotation marks, (4) left-justified all paragraphs, and (5) inserted words in brackets, when necessary for clarification. Spelling (e.g., altho, thru, rice-farming) remains intact except for 8 typographical errors which we corrected. Allen's map (1952: 33) depicts most locations recorded in the interviews; when other place names appear, we have added a note describing these locations. The interview notes follow in chronological order.

1. 8 January 1947—Interview with O'Neil Nunez

Notes on History of Whooping Cranes in Louisiana

(Information supplied by O'Neil Nunez, Gueydan, Louisiana) 1-8-47

The area referred to in these notes includes the lower limits of the Pleistocene prairies in western Vermilion and Eastern Cameron Parishes between Florence, (North of White Lake), and the Mermentau River at its entrance into Grand Lake below Lake Arthur. A series of "islands" or prairie outcrops surrounded formerly by marsh, extends east to west thru this region as follows:

Eagle-nest Island	"Isle nid-d'aigle"
Shoemaker [Island]	Isle Cordonnier
Cherry-tree [Island]	Isle Cerisier
Live-oak Hill	Coteau du Chene
Lost Island	Isle Perdue
Mullet Island	Isle Mulet (called "Mallard Island" on charts)

Three generations of the Nunez family have lived in this region. Cattle ranged the prairies and adjacent shallow marshes since the country was first settled, but agriculture was confined to small farms and garden patches until intensive development of rice-culture began shortly after 1900. The entire region is now given over to rice, with the exception of the deepest marshes.

O'Neil Nunez was born in 1882, and started trapping and hunting gators at the age of eight. He is still very active, running his traps daily and tending cattle. A very good observer, with a keen memory. Following is a summary of his observations.

Recent history of the Whooper

Nunez remembers his father speaking of great "droves" of sandhill cranes, and large numbers of whoopers in this region in the decades following the Civil War. Both birds were still plentiful within his own memory. As a boy (he started trapping at the age of 8 which dates this observation about 1890-95), he saw as many as 10 or 12 nests of whoopers each spring, and that bird was still quite common in the general region. He saw his last whooper nest about 1900. After 1900, both the whooper and the sandhill declined steadily in numbers, and by 1920, only a few pairs of whoopers could be seen, and those only in winter. His last record of whoopers was a single pair seen in flight in the winter of 1935. Eight sandhills were seen 2 years ago.

Migration and movements

Prior to 1900, when whoopers were still plentiful, Nunez is emphatic in declaring that all birds were resident. (I asked him a dozen leading questions in poor English and worse French, and could get no evidence that there was any increase in winter, or decrease in summer. This went for sandhills also.)

By 1920, the few remaining pairs of whoopers showed up only in winter. Interesting conjecture: does this support the theory of the birds being driven off the prairies into the deeper marshes, first for nesting, and then altogether? Rice-farming was becoming extensively developed by this time.

As a rule, these whoopers must have been fairly tame, and would not fly great distances unless heavily gunned. Nunez reports only short local movements between feeding and nesting areas each day.

Courtship

Birds were most noisy on still mornings in winter and early spring, altho they would "crow" any time when frightened by a shot or other loud noise. Nunez saw one pair dancing in December, 1913, near White Lake. "Birds stood about 8 feet apart. One would jump about 6 feet in the air, wings spread and beating slowly, while the other remained quietly on the ground. Then the other would jump in a like manner while the first stood still. The whole performance lasted from 5 to 10 minutes."

Nesting

(Nunez saw his last whooper nest nearly 50 years ago, but as a boy, he reports seeing 10 or 12 whooper nests per year, and large numbers of sandhill nests).

"Whoopers always nested in a "platin," which is a marshy swale in the prairie." (I checked this carefully, and Nunez is certain that all nests were built in standing water. He never saw one on dry prairie.) The "Paille-fine" (*Panicum hemitomon*) marsh of these prairie swales was the preferred nesting site. (These Panicum swales are the deepest and most permanent of the prairie swale marshes, with an average of 5 to 8 inches of standing water and some admixture of peat in the soils. The marshes of the Stanolind Tract above White Lake, last haven of the whooper, are quite similar to this marsh type, altho in this case the peat deposit is much deeper than would ordinarily be the case in the prairie marsh.)

"The nest was built of Panicum stalks and foliage, and was 3 to 5 feet in diameter at base, and about 2 feet in height. The sides were much steeper than a muskrat house. The nesting cavity was about 2 feet across, and 6 inches deep. Eggs were always 2 in number." Nunez couldn't tell whether both birds helped with incubation, but said that one bird wandered about feeding while the other was on the nest. Both would stay by the nest when an intruder approached, but would take wing before he got too close unless young were already hatched, in which case the female would stay and often threaten the intruder.

Most nests were found in May or early June, altho Mrs. Nunez tells of two young, just hatched, that her father picked up early in April.

Young

Couldn't find out much about the period of incubation, but Nunez thought it was about four or five weeks. Chicks took about 12 hours to dry, and left the nest the day after hatching. After leaving the nest, "the male chick always remained with the old male, and the young female with the mother." (Here again the idea that each clutch of 2 eggs produced a male and a female. Nunez couldn't say how he knew this, but did have an answer to the splitting up of the brood. He claims that when crane eggs were brought home and hatched under a setting hen or turkey, the young picked each other to death unless separated immediately. See report of Johnny Gaspard's Grandmother).

The young fed with the adults during the day in shallow swales ("les platins"), and roosted at night on dry prairie knolls, preferable [preferably?] small ridges surrounded by marsh. The adults "mashed down" the tall prairie grasses on those knolls, and squatted to cover the chicks. Each adult covered one of the young (male with poppa, female with momma, goes the report). The brood usually remained for many weeks in the same swale in which it was hatched.

The young were well-developed by August, and "exercising their wings." They were on the wing by September, but remained with the parent birds all the first winter.

The red coloration persisted during the first winter, disappearing first from the wings, gradually from the body, with a few spots on the back (scapulars) the last to remain. By spring, all birds were quite white. Nunez had no idea as to whether year-old birds nested, altho he thought it significant that all cranes, young and old, were paired in the spring months. Probably this merely represented the breaking away of the adults from the brood for their next nesting.

A set of 2 whooper eggs was brought in by Nunez' father when Nunez was a boy. Eggs hatched, and young grew almost to maturity, but had to be killed because they were too rough on the young poultry around the farm, picking and eating any chick that came too close. Two young whoopers, taken from a nest, were raised by Mrs. Nunez' father, and stayed around the farm for 3 or 4 years. This pair made more and more frequent trips to the marsh, and finally stayed away for good. (Apparently none of these trips prior to the last were of long enough duration to permit of [allow] nesting.) The young whoopers were fed grits, and later corn.

Food Habits

Nunez thinks that crawfish (*Cambarus*, spp), were the main food of the whoopers. He remembers seeing tracks and bill-marks around and in crawfish "Chimneys" and holes. "The droppings of cranes were always red after eating crawfish." (This is the case also with egrets, ducks, and raccoon).

He thinks also that small fish and water-insects were eaten, after noting the birds walking in shallow marsh, picking here and there in the water. (Many aquatic Odonata, Coleoptera, Hemiptera, and Diptera would be available in the prairie marsh.)

Among the plant foods, Nunez is absolutely certain that whoopers pulled up and ate the white roots of "marsh onion" (*Crinum americanum*), locally called "Glaieul," from the French for "gladiole."

The small "prairie lily" (*Nothoscordum bivalve*) also was pulled up in spring, and its "onion" (enlarged basal portion), eaten. (Nothoscordum is abundant on low prairie that is frequently flooded, and is known to be a good Canada goose food in this region.)

Whoopers did not seem to bother crops to the extent the sandhills did. Sandhills were bad on sprouting grains and sweet potato, especially on isolated garden patches. (On original prairie, the farm house occupied the highest knoll, and adjacent knolls that were dry enough were farmed.) Whoopers were partial to sprouted corn.

Sandhills were attracted to new "burns" in the prairie vegetation, and also fed in heavily-grazed cattle-pastures. Whoopers, on the other hand, used such places but little, and preferred the swale marshes, including those that were opened up by cattle.

2. 12 January 1947—Interview with John Gaspard and His Grandmother

Authors' note: The "Stanolind Tract" includes the approximately 26,000-ha freshwater marsh north of White Lake. AMOCO and British Petroleum subsequently owned the property; the latter transferred ownership to the State of Louisiana in 2002.

Crane info from John Gaspard, Caretaker at Stanolind Tract, White Lake, January 12; talk with John's grandmother, age 74, who lived on Pine Island next to White Lake marsh as a girl.

Remembers her father bringing in a female whooper and two chicks. Story goes that her father winged the female, which had been defending her nest, and brought the whole works home. The adult died within a few days, probably from wounds, and the two young "picked each other to death." She remarked on the reddish-pink color of the young, and the shiny black legs.

She saw a few nests, but from hearing the men-folk talk, she got the impression that the whoopers nested in abundance. Nests were built in the "Paille-fine" (*Panicum hemitomon*), and also in "Fouets" (lit. "whips" or bulrush, *Scirpus californicus*). The latter must have been used extensively, since she spoke of the birds breaking down and piling the whips in the middle of a stand, leaving the periphery of the stand as a shield for the nest. She claims all the nests were capable of floating, and would do so with every south wind that drove the waters of White Lake over the marsh west of Pine Island.

Reports from John Gaspard

In December, 1935, John ran across a crippled whooper while on his trapline at Stanolind Tract, White Lake. The bird made a couple of passes at John, but John succeeded in pinning the bird down with his trapping stick, and brought it in to Ovid Abshire, then the caretaker, who in turn took the bird to George Welsh at the Florence Club. (This is the bird that George says died in a day or so, due to "overeating.")

In April, 1936, while walking the White Lake marsh with Ovid Abshire, John reports a whooper, not crippled, but jumping on the marsh "like a turkey with a brood." Says the bird fluttered and jumped just ahead of them, finally disappearing behind some dense sawgrass. They were unable to keep up with the bird, but Ovid, who was out ahead when the bird was first seen, "saw two very small young running under the grass." John did not see them. John reports about that same time seeing numbers of small snakes killed and left along the sides of a pirogue trail. He was told by Ovid that this was typical crane work.

Latest report, 2 whoopers seen by Wallace Salzman flying north towards Gueydan on Friday morning, January 10, 1947. One seen flying south that same evening. Observation point is above Intracoastal [Waterway], about two miles due east of Florence Club.

3. 12 January 1947—Interview with Ralph Sagrera

<u>Info from Ralph Sagrera, 1-12-47</u>

Ralph trapped at Mulberry Island (about 10 miles west of Cheniere au Tigre) from 1931 to 35. Reports seeing three whoopers every winter up until 1934, only 2 in 1935, and none thereafter. Birds fed in fresh burns in three-cornered grass (Scirpus olneyi) and coco (Scirpus robustus) marsh. They were always very wary, and would take wing when he had approached to within 200 yards.

4. 27 January 1947—Interview with Duncan Crain

Authors' note.- The Mermentau River broadens north of Grand Lake to become Lake Arthur. The community of Lakeside was located on the lake's southern end, near the boundary between prairie and freshwater marsh. Grand Chenier and Johnson Bayou are communities on chenier ridges south and west-southwest of Grand Lake, respectively.

<u>Whooping crane notes from Duncan Crain, Grand Chenier, 1-27-47.</u>

Says whoopers nested below Lake Arthur (Lakeside) up to 1900. Nests in "Paille rouge" [*Andropogon* sp.] & gazon, in March. Fed in marshy places in prairie.

The whoopers of the coastal cheniers (Grand Chenier & Johnson Bayou region) seem to have been migrants, showing up only in winter. No nesting on the coast. Cranes on wintering marshes were seen to pull Three-cornered grass (*Scirpus olneyi*), "popping cane" (*Spartina alterniflora*), and also went for sweet potatoes on local farms.

5. 27 January 1947—Interview with Alcie Daigle

Authors' note.- The Creole Ferry formerly crossed the Intracoastal Waterway west of Grand Lake, near the boundary between prairie and freshwater marsh. Holmwood and Sweet Lake are rice farming communities on the prairie uplands northwest of Grand Lake.

<u>from Alcie Daigle, Holly Beach, Louisiana, 1/27/47</u>

Says whoopers did not nest in the prairie section north of Creole Ferry and Holmwood. Winter residents only. Tells of killing 12 whoopers in 1918 north of Sweet Lake in rice field. Cranes were eating rice that had fallen from separator door of thresher. Sandhills also common in this region as winter residents, but gradually disappeared a short time after whoopers were wiped out.

6. 15 June 1948—Interview with Ulysse Marceaux

<u>Whooping Crane notes (talk with Ulysse Marceaux), 6-15-48</u>
<u>Ulysse Marceaux, (age 75), has been in the cattle business all his life, and knows the country between Kaplan and Lake Arthur. Used to winter his stock at Cheniere au Tigre.</u>

He knows the cranes well, both the white and the "blue" (sandhill). He recalls that whoopers were commonly seen in pairs at all seasons of the year, while the sandhills were mostly in flocks, and showed up in winter. From his description, I got the impression that the region just below Kaplan and west to Gueydan had very few migrant whoopers. Winter migrants seemed to head "for the coast," and these were the birds that showed up at Chenier au Tigre and Mulberry during the winter months. Marceaux is certain that there were just as many whoopers in summer as in winter on the "paille rouge" prairies (red-grass, Andropogon) below Kaplan.

The whoopers nested "in the edge of the marsh." Marceaux didn't recall seeing nests, but spoke of running down and catching young on several occasions. "They were red, red." He never tried bringing any home, because of the antics of the parents, and because "it was bad luck to harm the white crane." Old folks in the Abbeville-Kaplan region have mentioned this superstition, and apparently left the white cranes alone while taking it out on the blue cranes. Damn shame this particular foible didn't achieve more widespread popularity.

Says the whooper fed on crawfish a good deal, and "pulled roots in the marsh." They were plentiful up until 1900, but the following decade saw a rapid decline (rice culture getting under way then, and the general region was being settled).

DISCUSSION

Allen (1952) praised Lynch's efforts to record the traditional ecological knowledge of the White Lake marsh users, and both men clearly respected and gave credence to the information the trappers and other residents shared with them. According to Allen (1952: 30), "The keen recollections of men and women of that generation, through Lynch's patient and intelligent research, have given us an incomparable picture of the status and habits of the whooping crane in this and other parts of Louisiana in the early days."

The interview notes include marsh users' observations of whooping cranes nesting in the freshwater marshes north of White Lake and Grand Lake, a region that stretched from Pine Island in the east to the Lakeside area in the west, a span of approximately 30 km. The area that retained resident whooping cranes until 1950, however, was the relatively isolated Panicum marsh north of White Lake and south of the town of Gueydan (Allen 1952, Lynch 1984). Ownership of this former crane marsh passed from Stanolind (Oil Company) to AMOCO Production Company to British Petroleum (BP); in 2002, BP donated the 26,000-ha marsh, along with the adjacent 6,000 ha of rice land, to the State of Louisiana (Gomez 1992, 2001, Chaillot 2002).

By terms of the donation agreement, White Lake Preservation, Inc., managed the property for the state in the manner of its predecessors, AMOCO and BP. Land uses, all of which are carefully regulated, include oil and gas production, limited waterfowl hunting in a small section of the marsh, fur trapping and alligator hunting, alligator egg collection, and rice farming and cattle grazing on the prairie uplands. Future plans include expanding access to birders and other ecotourists, as well as to qualified scientific and scholarly researchers (W. Sweeney, White Lake Preservation, Inc., personal communication).

In 2004, the Louisiana State Legislature created the White Lake Property Advisory Board. Under jurisdiction of the Louisiana Department of Wildlife and Fisheries, this board assumed advisory responsibility for the White Lake property in 2005. Dr. Felipe Chavez-Ramirez has proposed a study to determine whether suitable habitat for whooping cranes still exists in the White Lake marshes (F. Chavez-Ramirez, Platte River Whooping Crane Trust, personal communication), and it is hoped that the department and advisory board will approve and provide funding for the study.

In addition to scientific research, traditional ecological knowledge can be a valuable tool for environmental historians and wildlife and habitat restoration scientists (Allen 1952, Gomez 1998, 2002, Bonta 2003). Local people have long been and remain an integral part of the southwest Louisiana wetlands, and any future crane reintroduction effort should both learn from and respect their traditional ecological knowledge and wetland use practices.

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PHILOPATRY AND DISPERSAL IN WHOOPING CRANES

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Abstract: The natal and breeding dispersal of endangered whooping cranes (*Grus americana*) was investigated using information collected between 1978-2002 on the nesting grounds in and near Wood Buffalo National Park, Alberta-Northwest Territories. A minimum of 77% of the juveniles color-banded near their natal sites returned to the breeding grounds. Sex-biased natal dispersal was not observed. At least 76% of first-time breeders nested within 20 km of their natal site. Pioneering was rare and most cranes nested on the primary nesting areas adjacent to the Sass and Klewi rivers. The mechanism enhancing natal philopatry is probably related to learning the migration route from parents, conspecifics and/or congeners. Strong breeding site fidelity and natal philopatry as well as limited dispersal behavior presently ensure that most cranes will return to the current nesting grounds.

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Key words: dispersal, *Grus americana*, philopatry, whooping crane, Wood Buffalo National Park

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Dispersal in animals is an essential component of the population dynamics of a species and is necessary in order to distribute finite resources such as food, space and mates. Greenwood (1980) suggested that the dispersal of the sexes is determined by the mating system of the species. Monogamy is the rule for most avian species (Lack 1968) and dispersal is generally female-biased (Greenwood 1980), however, in some long-term monogamous species, males disperse further than females (see Cooke et al. 1975, Coleman and Minton 1979, Lessells 1985). Some birds with monogamous mating systems, which include territorial defense and care for the young by both sexes, tend to exhibit a strong fidelity to breeding areas (Oring and Lank 1984). In this paper, we examine whether the pattern of philopatry and dispersal of a migratory, monogamous, territorial species, the whooping crane (*Grus americana*), follows the expected pattern of most monogamous species.

STUDY AREA AND METHODS

Whooping cranes nest and summer in and near the northeastern portion of Wood Buffalo National Park (WBNP), in Alberta-Northwest Territories (Fig. 1). Most cranes are found in a 600 km^2 area adjacent to the Sass and Klewi rivers, as well as in a few other scattered nearby areas (Kuyt and Goossen 1987, Johns 1998a). The nesting grounds lie in the boreal forest region and are comprised of a myriad of ponds, marshes and forested ridges (Allen 1956, Novakowski 1966, Kuyt 1981a, Timoney et al 1997, Timoney 1999).

Canadian Wildlife Service (CWS) aerial surveys, carried out over the cranes' summer range since 1967, resulted in information on sighting and nest site locations of unbanded and color-banded birds. Juvenile whooping cranes were captured by means of a ground crew supported by a helicopter and color-banded on their parents' breeding areas from 1977-1988 during late July or the first half of August (Kuyt 1979a, Kuyt and Goossen 1987). Identification of 40 mm or 80 mm long color bands from survey aircraft was difficult because of aircraft speed, light availability, vegetation, birds' movements and apparent loss and interlocking of color bands (Kuyt and Goossen 1987). Fifteen juveniles were also radio-equipped as part of a migration study (Kuyt 1992). The sex of color marked birds was determined by behavioral observations (Bishop 1984, T. Stehn, personal communication), chromosomal analysis (Biederman et. al. 1982) and vocalizations (Carlson 1991). One crane was sexed after its death. Aerial and ground surveys of Aransas National Wildlife Refuge (ANWR), Texas (T. Stehn, personal communication) provided confirmation or information additional to our observations at WBNP.

In this paper, we follow Gratto et al. (1985) in defining natal philopatry as the return of birds to their natal sites, and adult philopatry as the return of birds to a previous breeding area. We define natal sites as the nests from which chicks fledged, and breeding areas are those regions defined as Composite Nesting Areas (CNA - area including all nests of a marked or unmarked pair - Kuyt 1981a). Subadult cranes resighted in WBNP were considered to have returned to their natal site. We use the terms natal and breeding dispersal to mean dispersal from hatching site to the first breeding location and dispersal from the first breeding location to successive breeding locations (Greenwood 1980), respectively.

RESULTS AND DISCUSSION

Breeding Biology

Little was known about the natal and breeding dispersal of the whooping crane before the start of a color-banding program in 1977 (Kuyt 1979a) which allowed for individual recognition

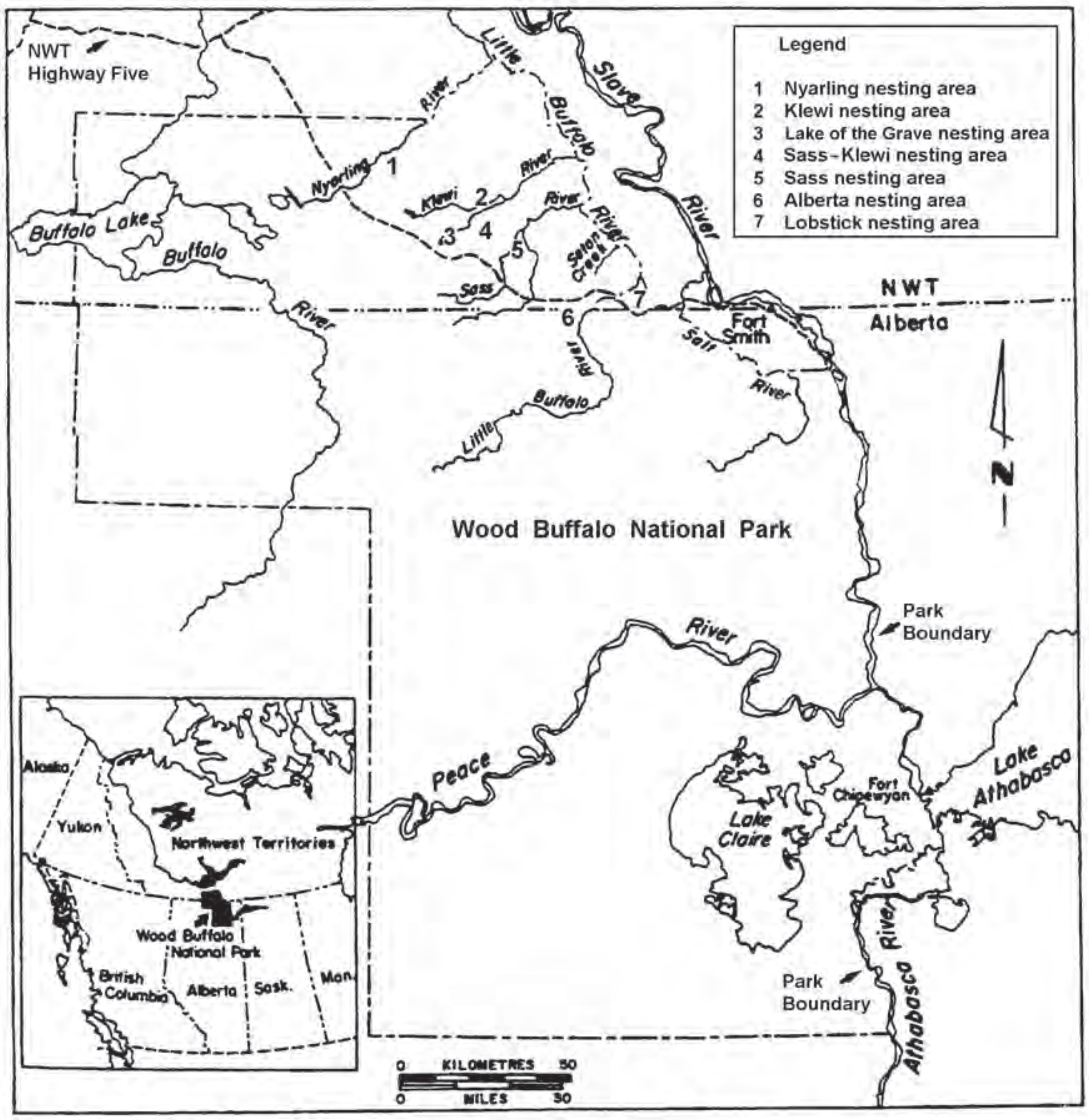

Fig. 1. Whooping crane nesting area in and adjacent to Wood Buffalo National Park, NT., Canada.

and provided an opportunity to investigate the dispersal strategy of this rare crane.

Whooping cranes, like other typically k-selected species (MacArthur and Wilson 1967), have low reproductive rates, delayed breeding and long life spans (Miller and Botkin 1974). These cranes usually lay only 1 clutch of 2 eggs per season (Novakowski 1966, Kuyt 1995) and generally only 1 young is raised, as evidenced by few sightings of 2 siblings (Binkley and Miller 1983, Johns 1998b). Renesting after nest failure is rare (Kuyt 1981b, Johns unpublished). Age at first nesting may be as early as 3 years (Kuyt 1981a) and as late as 10 years (Johns unpublished), but generally birds start to breed at 4 or 5 years of age (Kuyt and Goossen 1987). There is no difference in age of first breeding between the sexes (4.9 years for each). Although a captive whooping crane lived as long as 40 years (Moody 1931), the lifespan of wild birds is unknown but may be up to 25 years (Johns unpublished). During the 2002 breeding season the oldest known males (2) were 24 years of age and the oldest known female was 25.

Cranes return annually to breed in or near WBNP and since the last known prairie nesting in 1929 at Luck Lake, Saskatchewan (Hjertaas 1994), all nests have been found in or near WBNP (Johns unpublished). Nonbreeders were thought to summer away from the breeding grounds (Erickson 1976). Occasional spring and summer reports of whooping cranes from locations other than WBNP (Didiuk 1975, Stephen 1979, Boothroyd 1980, Gollop 1984, Johns 1987, Hjertaas 1994) would appear to substantiate this hypothesis. Kuyt (1979b) however found that 7 of 9 banded juveniles returned near the nesting grounds after their first spring migration and subsequent observations indicate that most nonbreeders (103 of 134 banded birds) summer in or near WBNP.

Spring Arrival

The sexes of migratory species in which males exert dominance over females tend to have different arrival times on the breeding grounds in that males arrive before females (Gauthreaux 1978). Males defend territories and seasonal short-term pairing takes place after the arrival of the females. Although this is true for many migratory birds, it does not-hold for species like cranes that maintain long-term pair bonds. Wild migratory whooping cranes exhibit territorial behavior on both breeding (Kuyt 1981a) and wintering grounds (Blankinship 1976) and male dominance has been observed in captivity (Kepler 1976). Unlike many migratory male-dominated species, most whooping cranes arrive on the breeding grounds already paired (Novakowski 1966). About 89% of the observations recorded during first annual surveys in April (1967-2002) when cranes were seen were pairs, 10% were singles, 1% were families, trios (non-families), or larger groups (Table 1). The presence of breeding pairs, in CNAs with long nesting histories, prior to the arrival of new nesting pairs suggests that experienced breeders return early. Subadult birds in their second year arrived as late as 22 May (Goossen 1987). Migration records through Saskatchewan also indicate that the breeding pairs arrive earlier than subadults (Johns 1992).

Table 1. Group size of whooping cranes seen on first annual surveys when cranes were seen, Wood Buffalo National Park, 1967-2002.

	Percent Seen	
Group Size	April/May[1] Combined	April
Single	17 (211/1227)	10 (12/123)
Pairs[2]	82 (1003/1227)	89 (109/123)
Families	<1 (3/1227)	< 1 (1/123)
Three Birds	<1 (9/1227)	< 1 (1/123)
Five Birds	< 1 (1/1227)	0

[1] **Median first day of surveys and range (1974-2002) were 1 May and 22 April – 23 May, respectively. In some years, nesting was well underway when the first survey was done.**

[2] **Single birds on or near nests were considered to be paired.**

Mate and Territory Selection

Subadults are seen in small groups, prior to nesting at WBNP (Johns unpublished) and ANWR (Bishop 1984, Stehn 1997). Most pair bonding (65.4%) occurs on the wintering grounds, however potential mates are also encountered on the breeding grounds (27.7%) (Stehn 1997; Kuyt 1988) and during migration. Mate selection may be rapid as evidenced by a 4-year-old male that wintered alone at ANWR during 1984-85 (T. Stehn, personal communication) but was found nesting with an unbanded crane near the Klewi River during the spring of 1985. Remating has only been documented on the wintering grounds (Blankinship 1976, Stehn 1997).

Subadult cranes spend several summers on and near nesting areas, possibly assessing potential breeding areas as has been suggested for other precocial species (Coleman and Minton 1979, Lessells 1985). It is not known whether the male, female or both whooping crane sexes select the specific breeding site. Masatomi (in Johnsgard 1983) believes the female Japanese crane (*Grus japonensis*) selects the nest site.

As in sandhill cranes (Walkinshaw 1949), there is little observational evidence for competition and defense for breeding areas among whooping cranes in WBNP. Since habitat does not appear to be a limiting factor and only a small breeding population exists, vigorous encounters should not be expected (Kuyt 1981a). Frequent territorial encounters have been observed in purple gallinules (*Porphyrula martinica*) when limited breeding habitat is available (Hunter 1985) and boundary disputes occur in greater sandhill cranes (*Grus canadensis tabida*) nesting in a high density situation (R. Drewien, personal communication). However, with this in mind, some altercations have been observed between territorial pairs and subadults (especially singles), who venture into an existing territory.

Natal Philopatry

Natal philopatry is strong in whooping cranes. Of 134 juveniles banded on the nesting grounds between 1977-1988, 103 (76.9%) are known to have returned to WBNP. Twelve young are suspected of having died before their first fall arrival at ANWR (Kuyt and Goossen 1987) and 9 young died prior to their first spring migration (Tom Stehn personal communication). Since the sex ratio of young at banding is equal (Kuyt and Goossen 1987) and given a high natality rate, it appears that there is no sex-biased natal philopatry.

Of the 103 returning birds, 66 (64.1%) were seen in WBNP the year following hatching. Twenty-nine were males, 21 were females and 14 were of unknown sex. Eighteen birds (17.5%) were first seen on the summer range during their second year, of which 8 were male, 7 were female and 3 were of unknown sex. Eight birds (7.8%), 5 males and 3 females, were first seen in their third year. Two females were first seen at WBNP as 4-year-olds, and one female was first seen as a 5-year-old. Ten birds, ranges 3 to 7 years old, were not seen in WBNP until their first nest effort. Those birds seen in their third year and on, may have been missed by aerial surveys during the birds' first year.

Occasionally 1 and 2-year-old cranes do not return to their natal sites. These birds usually summer south of the natal area. Of 6 known age banded birds summering in southern Saskatchewan and Alberta, 4 birds were 1-year-old and 2 birds were 2-years-old. In addition, a one-year-old summered north of the natal area near Yellowknife, NT. In most cases, however these birds were seen the following year in WBNP. Four of the 7 eventually bred in WBNP while the remainder (3) died before reaching breeding age.

Of the 82 banded cranes seen in their first or second year at WBNP, 37 birds (45.1%) were first seen in their natal areas, while the remaining 45 birds (55.9%) were located in non natal areas, typically outside the main nesting area. Of the 93 birds observed prior to their first nesting effort, 58 were seen in April/May, 25 were seen in June/July, and 10 were seen in August/September. Since initial sightings of birds were made throughout the nesting and pre-fledging period it appears that subadults in their first year avoid most nesting territories or are discouraged from entering by breeding pairs. Older subadults are also rarely seen in nesting areas.

The fact that whooping crane natal philopatry is so strong suggests that the cost of the offspring's presence adjacent to the nesting grounds is of little significance to the parents (Jones 1986). With plenty of vacant nesting space available, offspring do not pose any threat to parents' breeding areas or reproductive efforts. Indeed the advantage of philopatry in this small population outweighs dispersal as discussed below.

Oring and Lank (1984) hypothesize that sex-biased philopatry should be favored in species that exhibit high breeding site fidelity to counteract inbreeding depression. They suggest that heavy predation, competition and changes in habitat should contribute to this outcome. The WBNP whooping crane population is a classic case for testing this hypothesis. These cranes are monogamous, highly philopatric and with about 185 individuals in the entire population have the potential to encounter serious inbreeding problems This population went through a bottleneck in 1941, with all cranes currently in existence today being related to 6 – 8 founders. It is estimated that about 66% of the original genetic material has been lost and that the current population has retained about 87% of its gene diversity since 1938 (Mirande et al. 1993). Evidence for inbreeding problems in wild populations is small (Greenwood 1980). To date we have no evidence of inbreeding problems in this population but with a long-lived species such as the whooping crane, more generations may be needed for deleterious effects to surface. It is suspected that the population is in an inbred depressed state (Ken Jones pers. comm.). To our knowledge, predation, competition and habitat changes in WBNP do not appear to be significant factors in forcing sex-biased philopatry. Indeed, the advantage of both sexes being equally philopatric in this small population outweighs any benefits gained by sex-biased dispersal, should this behavior occur. Greater dispersal by one sex may be important in small populations to prevent potential inbreeding problems but if dispersal threatens the potential of finding a mate, then the benefits of both sexes returning to natal areas should outweigh the costs of dispersal.

Natal Dispersal

At least 67 (50%) of the 134 banded cranes have nested in or near WBNP. None of these first-time breeders are known to have returned to nest in the CNA in which they were raised. Unlike the establishment of winter territories at ANWR (Allen 1952, Blankinship 1976) where whooping cranes set up territories adjacent to those of their parents (Stehn and Johnson 1987, Stehn 1997), first-time breeders selected areas away from their parents' breeding site but mostly on the periphery of the main nesting areas.

The mean natal dispersal distance for 61 cranes (Table 2) was 16.6 ± 13.8 (SD) km with a median of 11.9 km (range 0.32-54.8 km). The frequency distribution of natal dispersal is skewed with most (75.8%) of the birds nesting within 20 km of their natal sites. The mean male natal dispersal was 16.8 ± 16.6 (SD) km (n = 31, range = 0.32-52.5 km) while that of females was 16.2 ± 10.5 (SD) km (n = 30, range = 4.0-54.8 km).

Table 2. Natal dispersal of whooping cranes.

Natal site	Natal dispersal (km)		
	n	Mean	Range
Klewi River	28	13.4	3.8-52.0
Sass River	19	12.5	0.3-50.2
Sass-Klewi	6	20.1	4.0-54.8
Nyarling River	3	35.1	28.5-43.0
Alberta	3	25.9	1.1-42.0
Lobstick Creek	2	47.4	42.3-52.5

This contrasts with Florida sandhill cranes, where dispersal was female biased (females dispersed an average of 12.6 km, while males dispersed an average of only 3.9 km) (Nesbitt et al. 2002). One bird whose first nest was not found and therefore not included in this section's analysis, nested the following season about 6 km from its natal nest. It is likely that the first nest was in relatively close proximity to the second one. Cranes raised in the Sass and Klewi nesting areas generally dispersed shorter distances than those raised in the outlying or satellite nesting areas (Table 3). Nineteen cranes nested adjacent to the river system near which they were raised while the remaining (48) bred elsewhere (Table 3). Cranes raised in the same CNA

Table 3. Relationship of natal site to location of first nest. The sex ratio of birds is in brackets.

NATAL SITE	LOCATION OF FIRST NEST					
	Sass River	Klewi River	Sass-Klewi	Nyarling River	Alberta	Lobstick Creek
Klewi River	11 (3M : 8F)	9 (6M : 3F)	7 (3M : 4F)	1 (1F)	4 (2M : 2F)	1 (1M)
Sass River	9 (9M)	7 (2M : 5F)	2 (1M : 1F)	0	2 (1M : 1F)	0
Sass-Klewi	4 (4F)	1 (1F)	0	0	1 (1F)	0
Nyarling River	1 (1M)	2 (2F)	0	0	0	0
Alberta	1 (1M)	1 (1M)	0	0	1 (1M)	0
Lobstick Creek	1 (1M)	1 (1M)	0	0	0	0

did not select breeding sites adjacent to natal and non-natal river drainages in similar proportions (17/58, 41/58 respectively). Even though natal dispersal distances were similar for males and females, they differed in their selection of nesting marsh complex. Males nested in similar proportions near natal (16/34) and non-natal (18/34) river systems while females nested in natal river systems less than non-natal areas (3/33), 30/33, respectively). The mechanisms allowing the return of these cranes to their natal site (i.e. WBNP area) are not fully understood. Young cranes are able to return to their natal site at least in part because of the close family bond during migration and on the wintering grounds. Many juvenile migratory birds depart and return to the nesting grounds without parental aid. Whooping cranes, however, have extended parental care lasting up to 11 months and during this period all young benefit from their parents by making their first flight south with them and some young also make their first northward flight back to the nesting grounds with their parents (Kuyt 1992). This same pattern also held for juvenile whooping cranes that migrated between Idaho and New Mexico with their foster sandhill crane parents (Drewien and Bizeau 1978). These latter young, hatched from eggs transplanted from WBNP to Grays Lake National Wildlife Refuge did not fly to WBNP but migrated between their summer and winter ranges in the United States. This suggests that natal philopatry in this species is enhanced by young learning the migration route from parents, conspecifics and/or congeners.

Habitat imprinting may influence young cranes in their selection of nesting sites in WBNP. Whooping crane chicks spend 3.5-4.5 months on the nesting grounds and presumably gain some familiarity with their parents' home range. Before onset of fall migration, cranes occasionally abandon their breeding territory (Kuyt 1984; Goossen 1986) allowing the young to become familiar with other parts of the breeding range. The advantage of delayed maturity coinciding with the annual return of subadults to their future nesting grounds (WBNP) allows them more time to recognize and evaluate nesting areas under varying seasonal and environmental conditions. This contrasts with so called r-selected species (MacArthur and Wilson 1967) that have little time to evaluate future territories, and territory selection is potentially limited to spring or the previous fall (Brewer and Harrison 1975).

Pioneering

Cranes currently nest in 2 main areas adjacent to the Klewi and Sass rivers (Fig. 1). In 2002 the Klewi nesting area contained 19 occupied CNAs, while the Sass nesting area held 14 occupied territories. Habitat does not appear to be a limiting factor in WBNP and therefore the cranes are not restricted to nesting in these core areas (Johns 1998a). Pioneering has been slow but is increasing as the population grows. When the nesting grounds were discovered in 1954 (Allen 1956) cranes were only known to nest in the Sass nesting area. Since that time the nesting area has expanded to include 6 new areas with up to 19 nesting pairs in the largest. The largest area is the Klewi nesting area north and west of the original Sass nesting area. Nests in the Klewi marshes were found each year since 1967, although W. Fuller (personal communication) saw whooping cranes in the Klewi area in 1954. The second area is between Preble Creek and the Little Buffalo River in Alberta, an area that has included up to 8 nesting territories in 3 distinct areas (Johns 1998a). Cranes have nested in Alberta every year since 1977 with the exception of 1980. The Sass/Klewi area is a large marsh complex between the 2 main areas. This marsh has fewer creeks flowing through the area and is somewhat drier than the main nesting area. The number of nesting pairs fluctuates between 3 and 8. Of the 6 banded young (all females from this area that bred, 4 nested in the Sass River area. The Nyarling nesting area began its occupancy in 1971 with a single CNA and has steadily grown to include 5 CNAs in 2002. The only banded bird to disperse to the Nyarling nesting area as of 2002 was a female from the Klewi area. The Lobstick Creek marshes are small and contain only 1 breeding pair, this territory has been occupied annually since 1982. The Lake of the Grave marshes near the headwaters of the Klewi River is also small and contains only 1 breeding pair. This territory has been occupied annually since 1991.

Although suitable habitat appears available for additional pairs near the core areas along the Sass and Klewi rivers some birds elect to move to new areas (Table 3). We believe some of these birds could have nested near their natal sites as there is still plenty of suitable nesting habitat available. Since fidelity to the 2 main nesting areas is strong, and that pioneering areas remote from the current breeding area is rare, it would seem highly unlikely that whooping cranes would disperse to nest in other Canadian regions, such as into former nesting habitat in the Canadian prairies. Subadult cranes occasionally summer in the southern prairies, however they return to WBNP in subsequent years.

Adult Philopatry and Breeding Dispersal

Once cranes initiated nesting in a certain area, they returned to the same breeding site annually and only in exceptional cases, have any banded cranes switched locations (Kuyt and Goossen 1987, Kuyt 1993, Johns unpublished). Restricted breeding dispersal has also been observed (Lessells 1985) in another monogamous species, the Canada goose (*Branta canadensis*). The advantages to returning to the same territory include the familiarity the birds gain with the location of food sources, nest site defense and the reduction in territorial boundary disputes (Hinde 1956). There is no evidence to indicate breeding success or failure influences the return rate of breeders.

Whooping cranes almost always change nest sites, and rarely does a pair use the same nest site (Kuyt 1981a, Johns unpublished). The mean for all breeding dispersal distances was 1304 ± 4362 m (SD) with a range of 0-59 km and median of 570 m (n = 365) (Table 4). Mean dispersal distance for females was 1429 ± 3969 m (SD, n = 223) and 1152 ± 3789 m (SD, n = 285) for males. Of 365 dispersal distances between nesting efforts, only three were greater than 10 km, and occurred after a mate change. When these outliers were excluded from analysis, the mean breeding dispersal distance was 944 ± 1126 m (SD) with a range of 0-10 km and a median of 558 m. Mean female dispersal was 1097 ± 1314 m (SD, n = 221) and mean male dispersal was 925 ± 1002 m (SD, n = 284). Breeding dispersal distances between birds' first four nests were determined (Table 4). When dispersal distances were pooled for all areas the trend was for dispersal distance to decrease with increasing nesting attempts (Table 4). Mate changes affected breeding dispersal. When there was no mate change between nesting attempts the mean dispersal distance was 968 m (n = 334; range 0-10 km). However, a change in mates resulted in mean breeding dispersal increasing to 2018 m (n = 145; range 0-59).

Studies of unmarked pairs (Kuyt and Goossen 1987) show that breeding dispersal is quite variable over a great many years but is limited to the same breeding site. This variation no doubt is dependent upon habitat conditions, territorial boundaries, remating and perhaps other factors.

Allen (1952) indicated that whooping cranes in the past were not abundant. Perhaps limited dispersal patterns have contributed to reduced crane numbers as alteration and occupation of their habitat by early settlers occurred. Also, limited pioneering efforts and dispersal patterns as well as strong breeding site fidelity suggest that the WBNP whooping cranes are remnants of a historic, and perhaps contiguous breeding population, not cranes which moved from the Saskatchewan prairies when pressure from human settlement became too great. In conclusion, the present study has shown that whooping cranes have no sex-biased philopatry and therefore differ from the majority of monogamous birds which are female-biased in dispersal patterns (Greenwood 1980). Lack of sex-biased philopatry has also been found in small shorebirds but sandpipers, like most other monogamous birds, have a resource defense mating system (Oring and Lank 1984). In this type of breeding system birds rely on site tenacity to encourage mate fidelity. Whooping cranes tend to depend on long-term pair bonds to maintain mate fidelity. Our findings support Oring and Lank's (1984) observations in sandpipers (*Scolopacidae*) that monogamy tends to be associated with high fidelity to breeding areas. Strong philopatry and limited dispersal behavior in the whooping crane currently ensure that most of these endangered cranes will return and nest in the WBNP area.

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Table 4. Breeding dispersal of whooping cranes.

Natal site	Breeding dispersal (m)								
	1st to 2nd nest			2nd to 3rd nest			3rd to 4th nest		
	n	Mean	Range	n	Mean	Range	n	Mean	Range
Klewi River	15	1158	9 - 6806	16	668	41-6465	14	580	42-2484
Sass River	13	5716	118-58818	15	4458	212-15742	16	1734	19-4407
Sass-Klewi	5	11557	370-52267	4	9974	95-23980	4	450	149-558
Alberta	3	2525	1616-3288	3	4091	794-10010	3	1043	473-1442
Nyarling River	3	1162	568-2152	3	1454	674-2304	3	2757	2356-3170
Lobstick Creek	1	1655		1	1282		1	2309	
	40	4054	9 - 58818	42	3223	41 - 23980	41	1253	19 - 4407

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USE OF WADING BIRDS AS INDICATORS OF POTENTIAL WHOOPING CRANE WINTERING HABITAT

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Abstract: A search for suitable wintering sites on which to establish another migratory population of whooping crane (*Grus americana*) has been conducted and will continue. In addition to an evaluation of food availability for whooping cranes, wading birds that overlap highly in patterns of habitat utilization with whooping cranes may be useful as indirect indicators of suitable whooping crane habitat. We determined the extent to which several species of wading birds overlap in patterns of habitat utilization with whooping cranes on their current wintering grounds. We conducted aerial surveys of whooping cranes and wading birds at Aransas and Matagorda Island National Wildlife Refuges, Texas. We classified habitats used in order of increasing surface area as pools, ponds, lakes, and bays. We observed species which included whooping cranes (N= 638), great egrets (*Casmerodius albus*) (N=987), great blue herons (*Ardea heroidias*) (N=751), reddish egrets (*Egretta rufescens*) (N=301), snowy egrets (*Egretta thula*) (N=155) and tricolored herons (*Egretta tricolor*) (N=67). Specific overlap indices indicated that great egrets had the highest overlap with whooping cranes (0.97), and tricolored herons also overlapped significantly (0.87). Reddish egrets (0.74), snowy egrets (0.69), and great blue herons (0.60) overlapped to a much lesser extent. We recommend that surveys conducted for the purpose of locating suitable wintering habitat for whooping cranes should focus on habitats utilized by great egrets and tricolored herons.

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Key words: *Grus Americana*, habitat, indicator species, wading birds, whooping cranes

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In 1973, the Endangered Species Act was enacted to preserve and protect species on the verge of extinction. The whooping crane (*Grus americana*), whose population had dropped to an all time low of 16 individuals in the early 1940's, was one of the species listed as endangered (Lewis 1995). The Endangered Species Act also led to establishment of the whooping crane Recovery Team and development of a recovery plan for the species. While the whooping crane population continues to increase from that all time low, it is still at low numbers, with only 174 individuals present in the wild during the winter of 2001-2002.

Today, there are three existing wild populations of whooping cranes (Aransas-Wood Buffalo, Florida non-migratory and Wisconsin-Florida migratory populations). The only non-introduced migratory population nests in Wood Buffalo National Park, Northwest Territories, Canada and winters at the Aransas National Wildlife Refuge and nearby barrier islands, on the central Texas coast. Because of its low population size, this single, migratory population is vulnerable to disease, pollution, and natural or human caused catastrophes. The wintering grounds are of particular concern, since the Intracoastal Waterway runs parallel to the salt marshes of Aransas NWR where whooping cranes spend much of their time feeding during the winter (Stehn and Johnson 1985). A primary objective of the Whooping Crane Recovery Plan calls for the establishment of two new and separate wild populations to decrease the chance of a catastrophic event causing the extinction of the entire species (U. S. Fish and Wildlife Service 1986).

Reintroduction effort using juvenile birds has been underway for several years in central Florida to establish a non-migratory flock of whooping cranes. In addition, scientists conducted a search to identify suitable nesting and wintering areas to establish a second migratory population of whooping cranes (Cannon 1998). This effort was in it's second year of effort when this work was undertaken. Potential habitat areas are the coastal salt marshes that exist in the southeastern United States where this population, managers hoped, would establish itself in suitable wintering grounds. The Whooping Crane Recovery Team is currently considering the idea of reintroducing a non-migratory population to Louisiana and other possible areas may be considered in the future.

Searches for potential reintroduction sites necessitates a quick preliminary evaluation of many sites followed by more intensive studies of fewer sites (Cannon 1998). The quick preliminary evaluations can focus on overall aspect and physical characteristics of potential sites and the distribution and abundance of conspicuous biological indicators. Specifically, detailed studies must evaluate the availability of habitat characteristics and quality of several parameters. For example, for whooping cranes it is important to evaluate the availability of roosting areas and feeding sites in addition to the abundance

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of food items. Because whooping cranes would not be present in possible reintroduction sites, it would be beneficial to have some biological surrogates, or indicators, that provide information on the suitability and availability of habitat conditions for cranes. In the previous work, we evaluated potential habitat areas for suitability in terms of presence and abundance of potential food sources and possibility of disturbance. In addition, we wanted to determine if there was another indirect way to do a quick preliminary evaluation of an area without the need for in depth field studies.

Two separate studies of whooping cranes (Chavez-Ramirez, 1996) and wading birds (Chavez-Ramirez and Slack 1995) conducted in the same coastal marsh suggested that whooping cranes and wading birds appeared to utilize the salt marshes in similar fashion for feeding. There appears to be significant overlap in the characteristics of the open water habitats utilized by both whooping cranes and many wading bird species during the winter months in Texas (Chavez-Ramirez pers. observ.). Overall, whooping crane and wading bird foraging habitat on the Texas coast consists primarily of the coastal salt marsh flats, which are composed of patches of open water and vegetated areas (Chavez-Ramirez 1996; Chavez-Ramirez and Slack 1995). Both whooping cranes and wading birds use adjacent areas to the salt marsh such as bays and uplands are utilized to a considerably lesser extent than the salt marsh flats (Chavez-Ramirez 1996).

Whooping cranes utilize the different salt marsh habitat types of the Texas coast for feeding, loafing and roosting. Many other birds, in addition to whooping cranes, also use the salt marshes of the central Texas coast as wintering grounds. Species of wading birds such as great blue herons (*Ardea herodias*), great egrets (*Casmerodius albus*), reddish egrets (*Egretta rufescens*), snowy egrets (*Egretta thula*), tricolored herons (*Egretta tricolor*), and roseate spoonbills (*Ajaia ajaia*) all utilize open water habitats similar to those used by whooping cranes. If we could show that, indeed, whooping cranes and wading birds showed considerable overlap in habitat use patterns future preliminary surveys for potential reintroduction sites for whooping cranes could focus on the species (or multiple species) that show a high degree of overlap with the cranes. The advantage of this would be that we could conduct quick surveys of larger areas in a shorter period of time using a conspicuous, widely distributed, and easy to survey biological element, as potential indicators of potentially suitable habitat. This preliminary evaluation, which could be conducted via aerial surveys, could then serve to prioritize sites or areas for more intensive field evaluations.

The purpose of this work was to determine the extent to which selected species of wading birds overlap in habitat utilization patterns with wintering whooping cranes on Texas coastal marshes. Specifically, we wanted to: a) determine if any species of wading birds overlapped with whooping cranes; b) which species of wading birds showed the greatest degree of overlap with whooping cranes, and; c) evaluate the possibility that wading birds may be used as potentially useful indicators with which to conduct quick and preliminary evaluations of suitable whooping crane habitat in coastal salt marshes.

STUDY SITE

We recorded whooping cranes and wading birds at Aransas National Wildlife Refuge (ANWR) and Matagorda Island National Wildlife Refuge (MINWR). Aransas NWR is part of the mainland and is located in the Texas Coastal Bend Region, in Aransas and Refugio counties. Matagorda Island NWR is a barrier island located in Calhoun County. It is 62 km long and varies from 1.2 to 7.3 km. wide. The salt marshes are located on the eastern coast of ANWR and on the western side of MINWR. Ground vegetation surveys at both areas showed them to be similar (see Chavez Ramirez and Slack 1995 for details of the study area).

METHODS

We classified open water habitats based on aerial size from the smallest to the largest for the purpose of this study. Habitat categories included pool (< $4m^2$), pond (4-100 m^2), lake (> $100m^2$), and bay (shallow open water area adjacent to the coastline). The "other" category included inlets and cuts. Inlets were narrow, straight or winding, open water areas connecting a body of water and a bay. Cuts were similar except they did not connect at one end to a bay.

We observed whooping crane and wading bird habitat use from a fixed-wing aircraft from 8 December 1992 through 16 March 1993 and from 2 December 1993 and 18 March 1994. We conducted flights on a near-weekly schedule when possible as part of wintering monitoring activities of ANWR. During each survey, we flew transects parallel to the coastline at an altitude between 30 and 50 m. We covered a linear distance of approximately 285 km on each survey for both refuges combined (110 km in ANWR, 175 km in MINWR). We flew the first transect along the coast with successive transects approximately 0.5 km inland from the previous one. We recorded all whooping cranes we detected and noted the habitat type where the crane stood at the time of observation. Due to the large number of wading birds present in the marshes, we could only clearly identify the wading birds observed within 25 m perpendicular to the flight line on the observer's side of the aircraft and we recorded the habitat type in which each was located. We eliminated birds not identified to species from the analysis. We did not use individual observations in the analysis where habitats could not be confidently classified (e.g., pond vs. pool).

We evaluated overall differences in the use of habitat categories among all species using a Chi square test (Zar 1984). To evaluate the degree of overlap among whooping cranes and wading birds we calculated a specific overlap index for whooping cranes and each wading bird species (Ludwig and Reynolds 1988). Specific overlap is based on a comparison of the

Table 1. Number of whooping cranes and wading birds observed, and expected, in different open water habitat categories in Texas coastal salt marsh during winters 1992-93 and 1993-94. Expected frequencies shown here are for Chi-square goodness-of-fit tests calculated for each species separately under the assumption that all habitats were equally likely to be chosen.

Species	Bay	Lake	Pond	Pool	Other	N
whooping crane	100	411	330	525	272	1638
Expected	*327.6*					
great blue heron	234	316	27	72	102	751
Expected	*150.2*					
great egret	54	180	285	310	158	987
Expected	*197.4*					
reddish egret	23	180	35	44	19	301
Expected	*60.2*					
snowy egret	48	32	7	35	33	149
Expected	*29.8*					
Louisiana Heron	6	21	15	23	2	67
Expected	*13.4*					

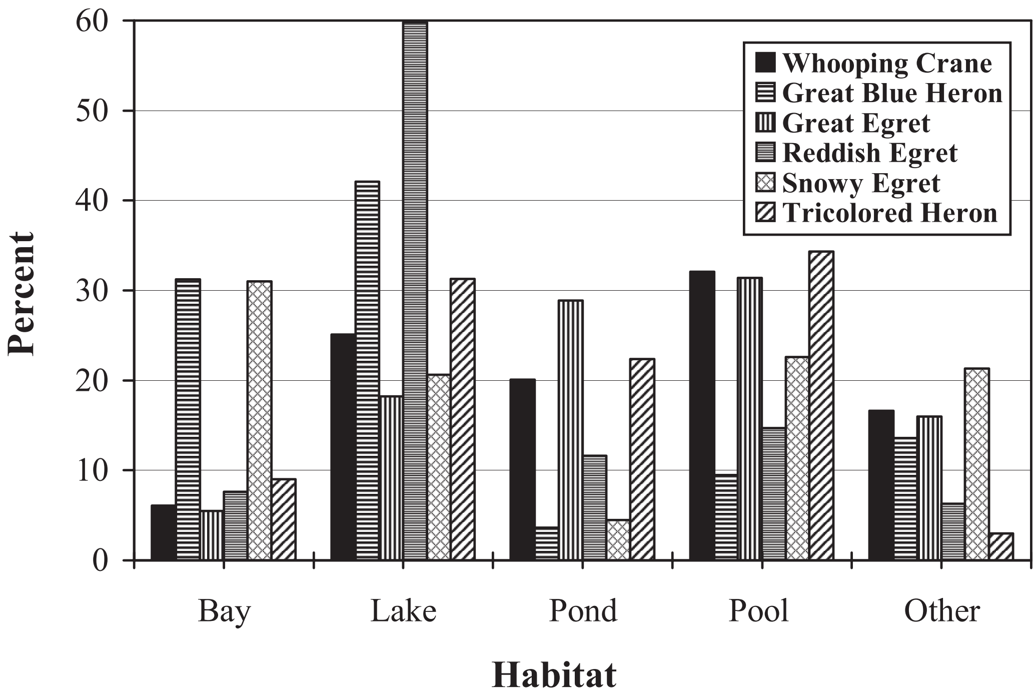

Fig. 1. Patterns of habitat use by whooping cranes and wading birds in salt marsh areas of Aransas and Matagorda Island National Wildlife Refuges during 1992-93 and 1993-94 fall and winter.

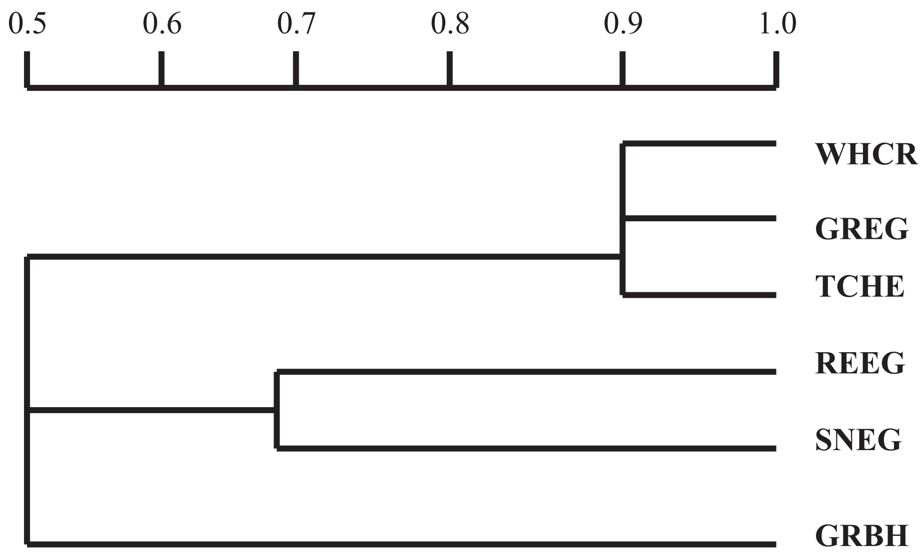

Fig. 2. Dendrogram based on specific overlap indicies calculated on overlap in habitat use by species of wading birds and whooping cranes.

resource utilization curves of two species, with values ranging from 0-1 (1 = complete overlap, 0 = no overlap).

RESULTS

We observed whooping cranes more often than all other species (N=1638), because during surveys our primary objective was to locate all cranes present in the wintering area. The wading bird species we observed included great blue herons, great egrets (N=987), reddish egrets (N=301), snowy egrets (N=155) and tricolored herons (N=67). Other wading birds which were also observed included little blue herons (*Egretta caerulea*), roseate spoonbills, white ibises (*Eudocimus albus*), and black-crowned night-herons (*Nycticorax nicticorax*). We excluded the latter wading birds from the comparisons of habitat use with whooping cranes because they all regularly flushed upon approach by the airplane making it difficult to assign specific habitats that they were using.

Habitat Use Patterns

All wading bird species combined showed differential use of habitat typess for both years of study. Overall, species utilized lakes (29%) and pools most often (26%). They used other habitat categories to a lesser extent (pond = 18%; other = 15%; and bay = 12%).

Whooping cranes used pools and lakes more often than expected, ponds as expected and bays, inlets, and cuts much less than expected (X^2_4 = 307.76, P < .001) (Table 1, Fig.1). Great egrets used pools more often than expected, but they also utilized ponds (X^2_4 = 216.67, P < .001). Great egrets used all other habitats less often than expected. Great blue herons used lakes and bays more often than expected, and all other habitats were used much less than expected (X^2_4 = 387.01, P < .001). Reddish egrets utilized lakes more often than expected but used all other habitats much less than expected (X^2_4 = 304.50, P < .001). Snowy egrets utilized bays, pools, and lakes more often than expected (X^2_4 = 29.97, P < .001). They were also the only species to be found utilizing cuts and inlets more often than expected, whereas, they used ponds much less than expected. tricolored herons utilized pools and lakes more often than expected, ponds as expected, and bays, inlets, and cuts less than expected (X^2_4= 25.16, P < .001).

Whooping Crane - Wading Bird Overlap

Specific overlap indices showed a high degree of overlap between whooping cranes and great egrets (0.973). There was also a significant degree of overlap between whooping cranes and tricolored herons (0.850), however, whooping cranes exhibited slightly less overlap with both reddish egrets (0.747) and snowy egrets (0.725). Whooping cranes overlapped the least with great blue herons (0.584). Overlap among specific pairs of wading bird species have been reported previously (Chavez-Ramirez and Slack 1995).

A dendrogram constructed based on overlap indices shows three distinct groups (Fig. 2). The group representing the highest overlap in habitat utilization patterns with whooping cranes included great egrets and tricolored herons. Reddish egrets and snowy egrets overlapped less, and great blue herons overlapped the least in habitat use patterns with whooping cranes.

DISCUSSION

Our results suggest that the presence of great egrets and tri-colored herons is the best potential preliminary indicator of suitable foraging habitat for whooping cranes during the winter in coastal salt marshes. Whooping cranes and most wading birds do not overlap significantly in diet, since cranes feed extensively on blue crab and wolfberry (Chavez-Ramirez 1996), while most wading birds are primarily piscivorous (Kushlan 1978). However, where whooping cranes, great egrets and tricolored herons do overlap during the winter in Texas, they utilize similar habitats in which to feed- mainly small (< 4m^2), shallow bodies of water. It is likely that a good quality patch of open water habitat could support both the diet items selected by cranes and wading birds.

Reasons for the overlap among cranes and tricolored and great egret may include an extensive overlap between blue crabs (*Callinectes sapidus*) and fish, the primary food items of whooping cranes and these two species of wading birds, respectively. Among competing species high overlap in one resource gradient (i.e. habitat) generally results in low overlap in a second resource (i.e. food) (Dubowy 1988, Ramo and Busto 1993). It may also be due to similar responses by different organisms to similar environmental and physical conditions. There are some indications that both crabs and fish may respond similarly to the same environmental factors. For example, scientists have reported that both fish and crabs burrow or move away from shallow marsh waters when temperatures reached less than 17-19 °C (Frederick and Loftus 1993, Chavez-Ramirez pers. observ.) If whooping cranes, great egrets, and tricolored herons respond to the different prey movements in a similar way, the result could be a high degree of overlap in habitat utilization patterns.

Indicator Species

Species which have generally been used or defined as an ecological indicator species, are usually species whose population attributes are assumed to represent those of other wildlife species and/or entire ecosystems (Morrison et al. 1998). Scientists have identified many problems, however, with this approach (Mannan et al. 1994, Landres et al. 1988). Morrison et al. (1992) suggest that in order to be useful, indicator species must be selected on features that are specific to time, location, and habitat. Our approach avoids the pitfalls mentioned by Morrison et al. (1992). First, we are considering one season (winter) and not the entire year, which reduces variation and eliminates the problem of species-specific changes in behavior due to season. Additionally, we are considering the overlap in terms of foraging habitat areas only. Our data and comparison is also location and habitat type specific. Finally, we will test the application or use of wading birds (great egret and tricolored heron) further by sampling distribution and dispersion of wading birds in an area, followed by sampling for whooping crane food items in those areas. These two species are widely distributed through the entire coastal region of the southeast, are abundant, and, being relatively large, are easy to survey with either ground or aerial methods.

We suggest that the presence of great egrets and tricolored herons can be used as a preliminary and/or additional measure of habitat suitability for whooping cranes. We are not advocating that this species be the only indicator, but rather that they be utilized as a first step of a more complex process. Future research could focus on determining how the distribution of fish and crabs are related to each other in shallow areas of coastal salt marshes and how environmental factors and conditions affects the abundance of these species.

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PATTERNS OF FOOD USE OF WINTERING WHOOPING CRANES ON THE TEXAS COAST

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Abstract: Whooping Crane (*Grus americana*) fecal samples were collected from Matagorda Island National Wildlife Refuge (MINWR) during winter and fall of 1993-94 (Winter-1; n = 59), and Aransas National Wildlife Refuge (ANWR) during winter and fall of 1993-94 (n = 102) and 1994-95 (Winter-2; n = 257) to study crane diets and compare patterns of food use in these areas. Food items varied between areas, across months, and between years in both frequency and percent volume. Blue crab (*Callinectes sapidus*), wolfberry fruit (*Lycium carolinianum*), horn snail (*Cerithidea pliculasa*), razor clam (*Tagellus plebius*), and orthopteran insects were present in feces samples at both ANWR (both winters) and MINWR during parts of the winter. Blue crab increased in both frequency and percent volume throughout the two winters on ANWR, and MINWR (Winter-1), while wolfberry fruit use declined. Horn snail presence in ANWR samples increased in frequency throughout both winters, while percent volume remained constant. No frequency trend was observed for horn snails in samples from MINWR, however, percent volume increased in the middle of the study period. Food niche breadth (dietary diversity estimated by $1/\Sigma p_i^2$) was higher both years at ANWR (4.41 in Winter-1; 5.17 in Winter-2), than at MINWR (3.62). Dietary overlap was higher between Winters-1 and 2 on ANWR (91%) than between ANWR (Winter-1) and MINWR (82%). Dietary overlap between months indicate a change in diet which could be due to a loss of the wolfberry in the diet.

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The largest wild population of whooping cranes (*Grus americana*) winters from mid-October to mid-April on and around the Aransas National Wildlife Refuge (ANWR) and Matagorda Island National Wildlife Refuge (MINWR) along the Texas Gulf Coast. This population, known as the Aransas-Wood Buffalo population, is the only wild, selfsustaining flock of the endangered whooping crane. The population has slowly increased from a low of 16 individuals in 1941 to a high of 181 individuals in 1998. The population numbered 143 individuals in the winter of 1993-94, and 158 individuals in the winter of 1994-95.

While the population of whooping cranes has increased significantly, the amount of crane habitat has remained relatively constant. As newly formed pairs establish territories near their parents, family-group territories have become smaller and more dense (Stehn and Johnson 1985), the potential for resource limitations increases. Potential resource problems are magnified by the ever-present danger of chemical and petroleum spills from ships in the Gulf Intercoastal Waterway, which was cut through the middle of the whooping crane wintering area on ANWR.

The need to accurately determine the food requirements of whooping cranes is essential to both the assessment of current habitat management practices and the influence of future management decisions. Determination of food requirements is also an objective of the Whooping Crane Recovery Plan (USFWS 1986). Most past field studies of whooping crane diets have only identified food items and quantified their importance over broad time periods, in a single area (ANWR), with small data sets. Early studies identified 26 food items based on fecal and stomach sample analysis (Allen 1952; Allen 1954, Uhler and Locke 1969, Blankinship 1976), however, they failed to establish the importance of different food items in the diet over time. In past studies blue crab (*Callinectes sapidus*) was the most important food item consumed by cranes based on total fecal volume (42%) followed by acorns (*Quercus* spp.) (37%) and razor clams (*Tagellus plebius*) (11%) (Allen 1952). Eleven of the original 26 food items were substantiated in a more extensive study (Hunt and Slack 1989). In that study, food use by whooping cranes was divided into 3, 2-month periods over the winters of 1983-84 and 1984-85. Blue crabs were also the most important food items consumed by whooping cranes based on fecal volume (41%), followed by razor clams (36%) and wolfberry fruits (*Lycium carolinianum*) (8%) (Hunt and Slack 1989).

We conducted a study to determine the importance of different food items in crane diets by gathering fecal samples on both ANWR and MINWR from October through April, 1993-94 (winter-1), and on ANWR only in 1994-95 (winter-2). Low sample sizes for October and April forced us to eliminate these months from data analysis for both winters. Because cranes are territorial during winter months, and the distance between Matagorda Island and the Aransas mainland (approx. 5 km), there is little, if any, movement of cranes between the 2 areas

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(Stehn and Johnson 1985). For this reason the 2 areas were considered 2 distinct units. Our objectives were to: (1) determine the importance of food items during the winter by months, (2) compare patterns of food use of whooping cranes residing on MINWR versus ANWR, and (3) compare patterns of food use of whooping cranes residing on ANWR during 1993-94 and 1994-95.

METHODS

STUDY AREA

ANWR is located on the Texas Gulf Coast approximately 60 km north of Corpus Christi, in Aransas and Refugio counties. MINWR, a barrier island 62 km long, varies from 1.2 to 7.3 km wide and lies east of ANWR in Calhoun County. Fecal samples were collected among the 9,000 ha of saltmarsh located on the eastern coast of ANWR and west side of MINWR and among the ANWR upland area (USFWS 1986). The vegetation flats of the salt marsh were dominated by glasswort (*Salicornia virginiana*), saltwort (*Batis maritima*), sea-oxeye daisy (*Borrichia Frutencens*), wolfberry (*Lycium carolinianum*), saltgrass (*Distichlis spicata*), and smooth cordgrass (*Spartina alterniflora*) (Chavez-Ramirez and Slack 1995). The wind tidal flats of the saltmarsh were dominated by mudflat grass (*Eleocharis parvula*), saltgrass (*Distichlis spicata*), and chordgrasses (*Spartina* spp.) (Chavez-Ramirez and Slack 1995). The upland habitat was dominated by live oak (*Quercus virginiana*) and Gulf chordgrass (*Spartina spartinae*) and has been previously described by Stevenson and Griffith (1946), Allen (1952), and, Labuda and Butts (1979).

During 1993-94, fecal samples were collected at irregular intervals each month from ANWR saltmarsh, 2 ANWR upland burn areas, and from MINWR saltmarsh. The burns were conducted on November 17, and December 6, 1993. Collection at all sites began in mid-October and ended in mid-March for ANWR marsh, late December for ANWR burns, and early April for MINWR. Winter-2 data collection began in mid-October and ended early April. Fecal sample collection during winter-2 was restricted to ANWR salt marsh because of time constraints. Subsequent comparisons between ANWR and MINWR refer to winter-1 only, while comparisons between winter-1 and winter-2 refer to feces collected on ANWR.

A fecal sample was collected only if it was located on dry or damp substrate (not submerged in water), and only if it could be positively identified as that of a whooping crane. Identification was based on feces size, general appearance, content, and surrounding footprints. Each feces was classified according to location by microsite (sand flat, mud flat, algae flat, wolfberry flat, burn, or road) to aid in identification of debris accidentally picked up with the samples. The passage rate of food through cranes is slow relative to the potential movement of cranes between habitats (Hunt and Slack 1989), therefore, the fecal samples were not associated with the particular habitat in which they were found, thus the samples gathered on the Aransas burn and in the Aransas salt marsh were combined for analysis. Each sample was placed in a sterile plastic bag and frozen until laboratory analysis. Each was analyzed to determine food item type, to species when possible. Analysis consisted of inspection of each sample through a dissecting microscope to identify items and estimate their volume in the sample to the nearest 5%. Frequency was determined as the number of times a food item was present during a month divided by the total number of fecal samples for that month. Mean percent volume of each item was determined by summing all percent volume values and dividing by the number of samples. Samples gathered from ANWR aided in the identification of crushed food items. Because, the difference in digestibility of food items was unknown, direct comparisons of different food items in samples was not possible. We therefore compared individual food items through time and between locations, not to each other.

STATISTICAL ANALYSIS

No differences were found between parametric and nonparametric test results (α=0.05), therefore, we report our results based on parametric tests. Due to low quantities of other food items, statistical analysis of diets included the major food items only, those being: blue crab, wolfberry fruit, horn snail, and razor clam. Differences in percent volume of specific food items between months were tested with one-way (GLM) analysis-of-variance (ANOVA). Tests showing a significant difference were subsequently tested using Tukey's Studentized Range (HSD) Test. Differences between percent volume of specific foods between sites and between winters were tested using two-way factorial (GLM) ANOVAs and Tukey-Kramer multiple comparison tests. The first of these two-way ANOVAs tested differences between location and months for each of the major food items. The second two-way ANOVA tested differences between year and month for each of the major food items. Chi-square tests were used to determine differences in frequency of occurrence of foods across months, between areas (winter-1), and across winters (ANWR only). Statistics were performed using SAS (1996) statistical analysis software.

Food-niche breadth (FNB) was estimated for areas by winter, and months (except for MINWR due to low monthly sample sizes) using Levins' (1968) modification of Simpson's index: $FNB = 1/\Sigma p_i^2$, where p_i = the frequency of each food item in a diet. We assessed similarities in diets between months, winters, and study areas using a symmetrical overlap index (O) (Pianka 1973): $O = \Sigma p_i q_i/(\Sigma p_i^2 \Sigma q_i^2)^{1/2}$ where p_i = the frequency of a food item in a diet and q_i = the frequency of the same food item in another diet. We report overlap values multiplied by 100 for ease of interpretation (Marti and Kochert 1996). Frequencies of sand and grit were not used for any index calculations since they do not constitute nutritional benefit to cranes.

RESULTS

A total of 17 food items were identified, with blue crab, wolfberry fruit, and horn snail (*Cerithidea pliculasa*) being the most important food items present in feces from both ANWR (both winters) and MINWR based on percent volume and frequency (Table 1). Sand and grit were present often, in low volume, in both study areas. New food items found and never before reported in whooping crane diets included: virgin nerite snails (*Neritina virginea*), harvestman insects (*Opiliones*) and Carabidae insects.

SEASONAL FOOD USE

MINWR – Winter-1

Blue crabs showed an overall increase in both percent volume and frequency and differed significantly among months ($F = 4.44$, $4 = df$; $P < 0.01$) and ($X^2 = 23.86$, $df = 4$; $P < 0.001$) (Table 1A). Percent volume of wolfberry fruit decreased overall throughout the study period and was significantly different among months ($F = 26.21$, $4 = df$; $P < 0.001$) while frequency was high from November through January after which it decreased significantly ($X^2 = 38.49$, $df = 4$; $P < 0.001$). Horn snail increased overall in percent volume throughout the study period and differed significantly among months ($F = 5.77$, $4 = df$; $P < 0.001$) while frequency did not differ significantly among months ($X^2 = 7.64$, $df = 4$; $P < 0.25$). Niche breadth was lowest for all study units (Table 2). No monthly niche breadth or overlap estimates were calculated for these samples due to low sample sizes for some months.

ANWR – Winter-1

An overall increase and significant difference was observed in both percent volume and frequency ($F = 10.34$, $df = 4$; $P < 0.001$; $X^2 = 10.46$, $df = 4$; $P < 0.05$; respectively) of blue crab throughout the winter in Aransas (Table 1B). Wolfberry peaked in December and was not present after January for both percent volume and frequency. Wolfberry significantly differed in percent volume ($F = 24.03$, $4 = df$; $P < 0.001$) and frequency ($X^2 = 63.74$, $df = 4$; $P < 0.001$) throughout the winter. Horn snail increased and significantly differed throughout the winter in both percent volume ($F = 9.46$, $df = 4$; $P < 0.001$) and frequency ($X^2 = 32.22$, $df = 4$; $P < 0.001$). Plant material was present in low percent volumes during the last three months of the study period. Orthopteran insects were only present in November and December but were high in percent volume when present. Niche breadth peaked in January (Table 2), and monthly dietary overlap was highest between February and March (Table 3).

ANWR – Winter-2

An overall increase and significant difference between months was observed for blue crab percent volume ($F = 31.60$, $df = 4$; $P < 0.001$) and frequency throughout the winter ($X^2 = 38.64$, $df = 4$; $P < 0.001$) (Table 1C). Wolfberry decreased and significantly differed in both percent volume ($F = 69.98$, $df = 4$; $P = 0.001$), and frequency ($X^2 = 146.98$, $df = 4$; $P < 0.001$) throughout the year. Horn snail did not significantly change in percent volume ($F = 2.46$, $4 = df$; $P = 0.05$) or frequency ($X^2 = 12.15$, $df = 4$; $0.01 < P < 0.05$) throughout the winter. Percent volume of razor clam was significantly higher in February than all other months ($F = 20.66$, $4 = df$; $\mathbf{P} < 0.001$) while frequency did not significantly change ($X^2 = 70.56$, $df = 2$; $P < 0.25$). Plant material was present in low amounts throughout the study period. Orthopteran insects were present in low amounts during November, December, and February. Monthly niche breadth peaked in December (Table 2), and monthly dietary overlap was highest between November and December (Table 3).

STUDY UNIT COMPARISONS

MINWR versus ANWR – Winter-1

Overall, blue crab percent volume was significantly greater on ANWR than MINWR ($F = 15.88$, $9{,}159 = df$; $P < 0.001$) (Table 1A and 1B). Blue crab significantly differed between dates on the 2 sites ($F = 9.24$, $9, 159 = df$; $P < 0.001$) as a result of more blue crab present in ANWR feces during January than those from MINWR. There was no interaction effect between site and month ($F = 1.59$, 9, 159; $P = 0.18$). The overall wolfberry percent volume was significantly greater on MINWR than ANWR ($F = 17.16$, $9, 159 = df$; $P < 0.001$). Wolfberry also significantly differed between months on the sites ($F = 30.04$, $9, 159 = df$; $P < 0.001$) as a result of significantly more wolfberry present in MINWR feces during January than those from ANWR. There was, however, an interaction effect observed ($F = 3.33$, $9, 159 = df$; $P = 0.01$). No significant difference was observed between percent volume of horn snail in MINWR feces and those from ANWR ($F = 1.36$, $9, 159 = df$; $P = 0.24$). Horn snail differed between sites by months ($F = 8.38$, $9, 159 = df$; $F < 0.001$), however, multiple comparison tests failed to detect a difference. An interaction effect was observed ($F = 2.78$, 9, $159 = df$; $P = 0.03$). Frequency significantly differed between MINWR samples and ANWR samples throughout the study period for blue crab ($X^2 = 61.09$, $4 = df$; $P < 0.001$), wolfberry ($X^2 = 48.72$, $4 = df$; $P < 0.001$), and horn snail ($X^2 = 49.94$, $4 = df$; $P < 0.001$). Dietary overlap showed that diets on MINWR and ANWR were 83% similar.

ANWR - Winter-1 versus Winter-2

Percent volume of blue crab was significantly greater in winter-2 than winter-1 ($F = 30.71$, $9, 361 = df$; $P < 0.001$) (Table 1B and 1C). Blue crab significantly differed between sites ($F = 23.65$, $9, 361 = df$; $P < 0.001$) as a result of more blue crab in winter-2 samples than winter-1 samples during the months

TABLE 1. Percent volume (standard error) and percent frequency of major whooping crane food items by month (n) for (A) Matagorda Island National Wildlife Refuge 1993-94, (B) Aransas National Wildlife Refuge 1993-94, and (C) Aransas National Wildlife Refuge 1994-95.

	1993				1994							
	NOV (5)		DEC (21)		JAN (19)		FEB (4)		MAR (6)		TOTAL (55)	
	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ
BLUE CRAB	tr	20.0	tr	19.1			25.0 (25.0)	75.0	30.8 (19.5)	83.0	5.0 (2.9)	22.8
WOLFBERRY	93.0 (4.6)	100.0	85.2 (4.1)	100.0	89.4 (5.3)	100.0	25.0 (25.0)	50.0	tr	16.7	71.1 (5.1)	86.0
HORN SNAIL			11.4 (3.8)	71.4	7.9 (5.0)	47.4	25.0 (25.0)	50.0	61.7 (20.1)	83.3	15.1 (4.1)	54.4
MELAMPUS			tr	4.8	1.1 (0.6)	26.3					0.4 (0.2)	10.5
RAZOR CLAM	6.0 (4.8)	80.0			tr	5.3	18.8 (18.8)	25.0			1.8 (1.4)	10.5
ORTHOPTERA					tr	5.3					tr	1.8
PLANT MAT.					tr	10.5	tr	25.0	7.5 (4.8)	50.0	0.8 (0.6)	10.5
ACORN												
SAND/GRIT	1.0 (1.0)	100.0	2.9 (1.2)	42.9	1.6 (0.5)	52.6	6.3 (6.2)	50.0			2.1 (0.7)	45.6
OTHER			0.5 (0.5)	61.9	tr	10.5			tr	16.7	0.2 (0.2)	28.1

B.

	1993				1994							
	NOV (8)		DEC (32)		JAN (32)		FEB (30)		MAR (12)		TOTAL (114)	
	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ
BLUE CRAB	25.6 (15.2)	62.5	4.7 (2.7)	46.9	30.6 (7.4)	59.4	47.6 (6.8)	76.7	70.4 (11.0)	91.7	31.7 (3.7)	64.0
WOLFBERRY	36.9 (17.1)	62.5	78.0 (6.3)	90.6	47.3 (8.7)	56.3					37.8 (4.4)	45.6
HORN SNAIL	tr	12.5	2.0 (1.0)	21.9	12.0 (5.1)	46.9	39.5 (6.2)	86.7	21.7 (10.0)	66.7	16.6 (2.8)	50.0
MELAMPUS			tr	3.1							tr	0.9
RAZOR CLAM			tr	3.1	2.3 (2.0)	9.4					0.7 (0.6)	3.5
ORTHOPTERA	37.5 (18.3)	37.5	12.5 (5.9)	15.6							6.1 (2.3)	7.0
PLANT MAT.					0.9 (0.9)	6.3	6.0 (2.5)	23.3	1.7 (1.1)	16.7	2.0 (0.7)	9.7
ACORN	tr	50.0	tr	12.5							tr	7.0
SAND/GRIT	tr	12.5	2.8 (0.7)	59.4	3.9 (1.6)	43.8	6.8 (2.1)	73.3	6.3 (4.2)	83.3	4.3 (0.9)	57.9
OTHER	tr	12.5	tr	34.4	1.1 (0.7)	50.0	tr	6.7	tr	8.3	0.3 (0.2)	27.2

C.

	1994				1995							
	NOV (78)		DEC (65)		JAN (52)		FEB (43)		MAR (19)		TOTAL (257)	
	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ	VOL (SE)	FREQ
BLUE CRAB	24.1 (4.3)	62.8	38.9 (5.2)	76.4	83.6 (4.1)	96.2	66.7 (6.3)	97.7	96.6 (2.6)	100.0	52.4 (2.8)	78.6
WOLFBERRY	74.3 (4.2)	94.9	53.9 (5.3)	89.1	4.8 (2.3)	17.3					37.2 (2.8)	51.4
HORN SNAIL	0.1 (0.1)	11.5	1.3 (0.8)	16.4	3.3 (1.6)	23.1			tr	21.1	1.1 (0.4)	13.2
MELAMPUS	tr	2.6	tr	1.8	3.9 (2.7)	3.9					0.8 (0.5)	2.0
RAZOR CLAM			tr	3.6	3.2 (2.2)	3.9	28.8 (6.4)	41.9			5.5 (1.3	8.6
ORTHOPTERA	0.5 (0.2)	16.7	2.1 (0.8)	23.6			tr	2.3			0.7 (0.2)	10.5
PLANT MAT.	tr	19.2	tr	21.8	0.2 (0.1)	11.5	0.2 (0.2)	14.0	2.6 (2.6)	52.6	0.3 (0.2)	19.1
ACORN												
SAND/GRIT	0.7 (0.4)	61.5	3.8 (1.1)	67.7	0.9 (0.4)	13.5	4.2 (0.6)	65.1	tr	15.8	2.0 (0.3)	50.6
OTHER	0.3 (0.2)	15.4	0.1 (0.1)	9.2	tr	23.1	tr	20.9	tr	15.8	0.2 (0.1)	16.3

Table 2. Niche breadths of monthly diets of whooping cranes for Matagorda National Wildlife Refuge (MINWR) during 1993-94, and Aransas National Wildlife Refuge (ANWR) during 1993-94, and 1994-95. Monthly niche breadth calculations were not calculated for MINWR 1993-94, due to low monthly sample sizes.

	MINWR 1993-94	ANWR 1993-94	ANWR 1994-95
November		3.3	2
December		3.1	3.7
January		4.7	2.5
February		2.9	2.4
March		2.5	2.3
Total	3.6	4.4	3.8

Table 3. Percent dietary overlap of Whooping Cranes between months for Aransas National Wildlife Refuge during 1993-94 and 1994-95.

	1993-94	1994-95
November-December	92.4	98.8
December-January	85.1	76.7
January-February	73.6	89.1
February-March	96.8	84.7

of December and January. An interaction effect between year and month was observed (F = 3.86, 9, 361 = df; P < 0.01). Wolfberry did not significantly differ between years (F = 1.94, 9, 361 = df; P = 0.16), while a difference was observed between months (F = 53.83, 9, 361 = df; P < 0.001) as a result of more wolfberry in winter-1 than winter-2 during December and January. An interaction effect was observed (F = 10.35, 9, 361 = df; P < 0.001). More horn snail was observed in winter-1 than in winter-2 (F = 49.10, 9, 361 = df; P < 0.001). Horn snail differed by month between years (F = 16.5, 9, 361 = df; P < 0.001) as a result of more present in winter-1 than winter-2 samples during February and March. An interaction effect was observed (F = 19.00, 9, 361 = df; P < 0.001). The frequency of blue crab was not significantly different throughout months between winter-1 and winter-2 (X^2 = 6.80, df = 4; P > 0.05), while a significant difference was observed for wolfberry (X^2 = 27.14, 4 = df; P < 0.001) and horn snail (X^2 = 46.09, df = 4; P < 0.001). Dietary overlap showed that diets in winter-1 and winter-2 were 90% similar.

DISCUSSION

The addition of 3 more food items consumed by cranes to the original list of 26, after 30 years of monitoring, is further evidence that these birds are opportunistic feeders (Chavez-Ramirez 1996). This behavior may explain differences in crane diets observed between past studies and this one.

Our data showed that blue crabs were an important dietary constituent (41% total fecal volume for all study units combined), as in past research (Allen 1952, Hunt and Slack 1989). Throughout the winter, however, the general trends observed differed from Hunt and Slack's (1989) who found that percent volume of blue crab decreased (1983-84), and did not significantly differ (1984-85), while ours consistently showed an increase in both percent volume and frequency over the wintering period. The percent volume of clam, however, increased throughout both winters in the former study. Razor clam and blue crab are similar in their nutritional make up in that they both contain low energy and high protein (Nelson et al. 1996). It seems plausible cranes can decrease blue crab consumption if clam consumption is high. Since clam availability is dependent on several variable factors (Holland and Dean 1977, Montagna and Kalke 1992), and due to the opportunistic behavior of the cranes, it is possible that presence of clams in the diets observed in Hunt and Slack (1989) and Allen (1952), and the lack of clams in our study is a result of differences in availability during different time periods. Such switches in diet based on prey density and susceptibility have been observed in white ibis (*Eudocimus albus*) and gray herons (*Ardea cinerea*) (Kushlan 1978).

Our data showed that wolfberry fruit was the most important dietary constituent based on percent volume in feces from all study units combined (42%). Wolfberry fruit generally decreased in percent volume throughout the winter on all study units of our study, as in Hunt and Slack (1989). The trend is expected since the plant completes its fruiting cycle in December or January after which it is scarce to unavailable (Chavez-Ramirez 1996). The influence of phenological stage on presence of wolfberry fruit in whooping crane diets is similar to that observed by Loiselle and Blake (1990) in several fruit-eating birds of Costa Rica. Wolfberry fruit was not present in Allen's (1952) study, however, all his fecal samples, but one, were collected after mid-January. Completion of the fruiting cycle had likely already occurred. The months of lowest dietary overlap (indicating the greatest change in diets from month to month throughout the winter) for both winters, correspond with the months of greatest decrease in wolfberry fruit in the diet. High amounts of wolfberry fruit in crane feces during the first half of the winter suggests this food item is important to the cranes when available.

Results showed horn snail amounted to 7% of total fecal volume of all study units combined; however, its nutritional benefit to the cranes is questionable. While availability of empty shells in whooping crane wintering habitat is high, significant attempts to locate live horn snails have been unsuccessful (Chavez-Ramirez 1996, pers. observ.). A large proportion of horn snail in feces was not significantly crushed in digestion as indicated by many large particles and some complete shells. Cranes have also been observed consuming what was determined to be dead snails from mudflats (Chavez-Ramirez 1996). Due to lack of other hard objects in feces despite the availability of small rocks and crushed oyster shell, it is possible consumption of horn snails is primarily for the purpose of grit. While the extent to which birds use grit depends on many variable factors such as the bird's diet, age, body size, gender and reproductive status (Gionfriddo and Best 1996), birds diets which include hard coarse materials generally contain relatively large amounts of grit (Meinertzhagen 1954; Farner 1960). Given the presence of hard wolfberry seeds, and crab shell in the diet of whooping cranes, it is expected that some type of grit would be needed to aid in the breakdown of these food items. Cranes may also be consuming shells to meet micronutrient needs. The importance of snail shells as calcium supplement in bird diets has been well documented (Korschgen 1964; Krapu and Swanson 1975; Norris et al. 1975; Beasom and Pattee 1978; Ankney and Scott 1980; Turner 1982).

Past studies have emphasized the importance of acorns in the diets of whooping cranes (Stevenson and Griffith 1946; Allen 1952; Allen 1954; Blankenship and Reeves 1970; Hunt and Slack 1989), however, acorn failed to be present in our samples beyond a trace amount and even then only during winter-1. Past burning of upland vegetation has been primarily for the purpose of increasing acorn availability for cranes. Whooping cranes frequented burns during winter-1 despite the lowest acorn estimates on record to date (Chavez-Ramirez et al. 1996). Acorn presence in feces did generally correspond to the times of the two controlled burns conducted that winter. While lack of acorn in the feces may suggest cranes were unsuccessfully searching for acorns in these burn areas, it has been found that acorn production did not significantly effect whooping crane use of upland burns (Chavez-Ramirez et al. 1996), suggesting that acorn consumption was not the primary factor for the use of the upland burns. Furthermore, acorn production during winter-2 was nearly double that of winter-1, yet, acorn failed to be present in feces the second winter despite use of the burns by cranes during that winter (Stehn 1995).

Whooping cranes have been reported to opportunistically use upland burns for the consumption of various food stuffs such as cultivated crops (Shields and Benham 1969), grasses (Stevenson and Griffith 1946), crayfish (Allen 1952; Hunt and Slack 1989), snakes, lizards, and insects (Chavez-Ramirez et al. 1996). Orthopteran insects were the only upland food item observed in significantly greater frequency or percent volume directly following controlled burns, it therefore seems plausible that orthopteran insects may be an important food item obtained in burned areas. The presence of orthopteran insects in whooping crane diets corresponded to the dates following several of the upland burns. During winter-1, orthopteran insects were present in feces in highest amounts following the burn of November 6, 1993. Crane use of this burn was greatest of all burns that winter (Stehn 1994). Winter-2 consumption of orthopteran insects was also greatest following the most heavily used burn that winter (Stehn 1995). Other bird species such as wild turkey (*Meleagris gallopavo*), northern bobwhite (*Colinus virginianus*), mourning dove (*Zenaida macroura*), and others, have been observed on recent burns on which they evidently find an abundant supply of seeds and dead insects (Komarek 1969; Wright and Bailey 1982).

A possible negative relationship was observed between blue crab and wolfberry fruit in our data. When comparing MINWR and ANWR, the amount of blue crab in crane diets differed between the two sites because more blue crabs were present in January for the ANWR site. Wolfberry fruit also differed between sites in January with significantly more wolfberry fruit being present in MINWR diets. This relationship can also be seen when comparing winter-1 with winter-2. Blue crab differed as a result of more being present in crane diets in winter-2 samples during December and January. Wolfberry fruit also differed, but as a result of more being present in winter-1 samples during those same two months. Crab trap data showed that more crabs were available in winter-1 than winter-2 (unpubl. data) during the months of December and January. Furthermore, the general decline of wolfberry fruit in crane diets throughout the winter at all study sites while blue crabs steadily increased add to the plausibility that blue crabs and wolfberry in the diet are somehow related. While the relationship being a result of selection, availability, or some other factor remains unknown, it appears cranes will compensate for the loss of one food item in the diet by increasing consumption of the other. This pattern of diet compensation is similar to that observed in gray herons and white ibis (Kushlan 1978).

The difference in diets, based on the similarity index, between MINWR and ANWR were primarily a result of wolfberry fruit being present longer into the winter in MINWR feces. This difference initially seems somewhat unexpected since environmental factors influencing fruit production are likely the same between the two sites. We believe, however, that wolfberry fruit was available longer in the winter due to higher wolfberry plant densities, later wolfberry fruit availability (unpubl. data) and larger crane territory sizes on MINWR versus ANWR (Stehn and Johnson 1985, pers. observ.). Several studies have shown that birds will establish territories when food sources become scarce (Zahavi 1971; Cronin and Sherman 1976; Tye 1986). While we doubt crane territories have been established in response to wolfberry fruit abundance and distribution, the larger territory sizes of MINWR cranes and greater wolfberry plant densities likely resulted in lower foraging pressures on the plants early in the winter could result in extending the availability of fruit later into the wintering period.

Food niche breadth was lowest on MINWR, as would be expected since this site lacks the upland oak scrub brush, large fresh water lakes, and agricultural fields available to cranes on the ANWR. The greater heterogeneity of the habitat types on ANWR provides more variety of potential foraging habitat, and thus a more diverse food base than expected on MINWR. Begon et al. (1996) noted that one reason more species (hence a more diverse prey base) could occur in one community than another is because there is a greater range of resources (greater heterogeneity) present in one than the other.

There are two areas of research that could greatly add to our understanding of food use by wintering whooping cranes. The first would be the determination of food item selection in context of availability. While we were able to determine trends of food items throughout the winter, determining whether these occurred as a result of selection or availability remains mostly speculative. Food acquisition or foraging can be a demonstration of how an animal actively uses its habitat (Morrison et al. 1992). In addition, it has been noted that, "information on food use is an essential component of research efforts addressing such issues as the impact of predation on prey populations, extrinsic factors that influence reproductive success, and assessments of productivity of local habitats" (Litvaitis et al. 1994). Understanding why cranes eat what they do will help us determine the importance of food items relative to each other and better understand if, and when, the cranes may be experiencing times of low food availability.

The second area of research needed to better understand food use by cranes is determination of how much matter is produced from a known amount of wild food after passing through a crane digestive system. Swanson (1940) reported that differential digestibility of foods may change their relative proportion in the feces; however, studies have been done on gallinaceous birds which suggest that nearly all foods produce some identifiable remains in fecal matter (Jensen and Korschgen 1947). Information on the energetic value of several important crane food items is available (Nelson et al. 1996). Assuming everything consumed is present in the feces, and it can be determined what the amount in the feces represents as pre-ingested material, we could determine the energetic intake of cranes with non-intrusive techniques throughout the winter, and thus determine potential times of energetic stress.

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TECHNIQUES EMPLOYED TO CAPTURE WHOOPING CRANES IN CENTRAL FLORIDA

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Abstract: During the course of re-introduction of a non-migratory flock of whooping cranes to Florida (1993-2002) a variety of techniques were used to capture 105 free-living birds. The most commonly used technique was hand-capture from a feed trough blind (45 birds). Whooping cranes were also captured by use of snares, several types of nets, and by hand. All techniques were relatively safe and posed little risk to the birds, a primary concern when dealing with rare birds. We found it useful to employ a diversity of techniques because some methods work better than others under differing circumstances. Capturing whooping cranes for replacement of radio transmitters is labor intensive and may represent the limiting factor in the successful long-term monitoring of the Florida population.

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Key Words: capture techniques, Florida, *Grus americana*, whooping crane

Long-term studies of long-lived birds require that the birds be captured routinely to replace transmitters and conduct health-checks. There also is a need to capture sick/debilitated individuals. Previously used methods for North American cranes include rocket nets (Ramakka 1979), alpha-chlorolose (Nesbitt 1984, Bishop 1991), night-lighting (Drewein and Clegg 1992), walk-in traps (Logan and Chandler 1987) and helicopter pursuit (Boise 1979, Ellis et al. 1998). Capture of free-living whooping cranes (Grus americana) has been limited to hand-capture of pre-fledged chicks (Kuyt 1978, Kuyt 1979, Drewien and Kuyt 1979) and night-lighting of birds on nocturnal roosts (Drewien and Clegg 1992). Very few post-fledged whooping cranes have been captured. Captures have been limited to 22 birds from the Rocky Mountain experimental flocks (K. Clegg, pers. comm.) and several other individuals.

We began reintroducing non-migratory whooping cranes to central Florida in early 1993 (Nesbitt et al. 1997). The primary method used to capture whooping cranes in Florida has been by hand-capture from a trough-blind (Folk et al. 1999), but we have also employed other techniques. In this paper we summarize the techniques used to capture non-migratory whooping cranes in central Florida.

METHODS/STUDY AREA

We captured whooping cranes in widely differing habitats, circumstances, and locations within central Florida. We tested new methods for safety and efficacy on sandhill cranes prior to using them on whooping cranes. We usually conducted captures early in the morning when the birds were hungriest and the temperatures coolest. We often videotaped capture attempts to allow slow-motion playback. In this paper we do not deal with captures of penned (brailed) birds.

RESULTS

We employed 10 techniques during attempts to capture whooping cranes (Fig. 1). The most commonly used technique was by hand-capture from a feed-trough blind (45 birds). Whooping cranes and sandhill cranes, being opportunistic, routinely eat from the feed troughs of livestock in central Florida. A specially built trough was used to hide a biologist until the target bird was eating from a specific location on the trough. The technique involved having the hidden biologist grasp the target bird by the leg until the bird could be safely restrained

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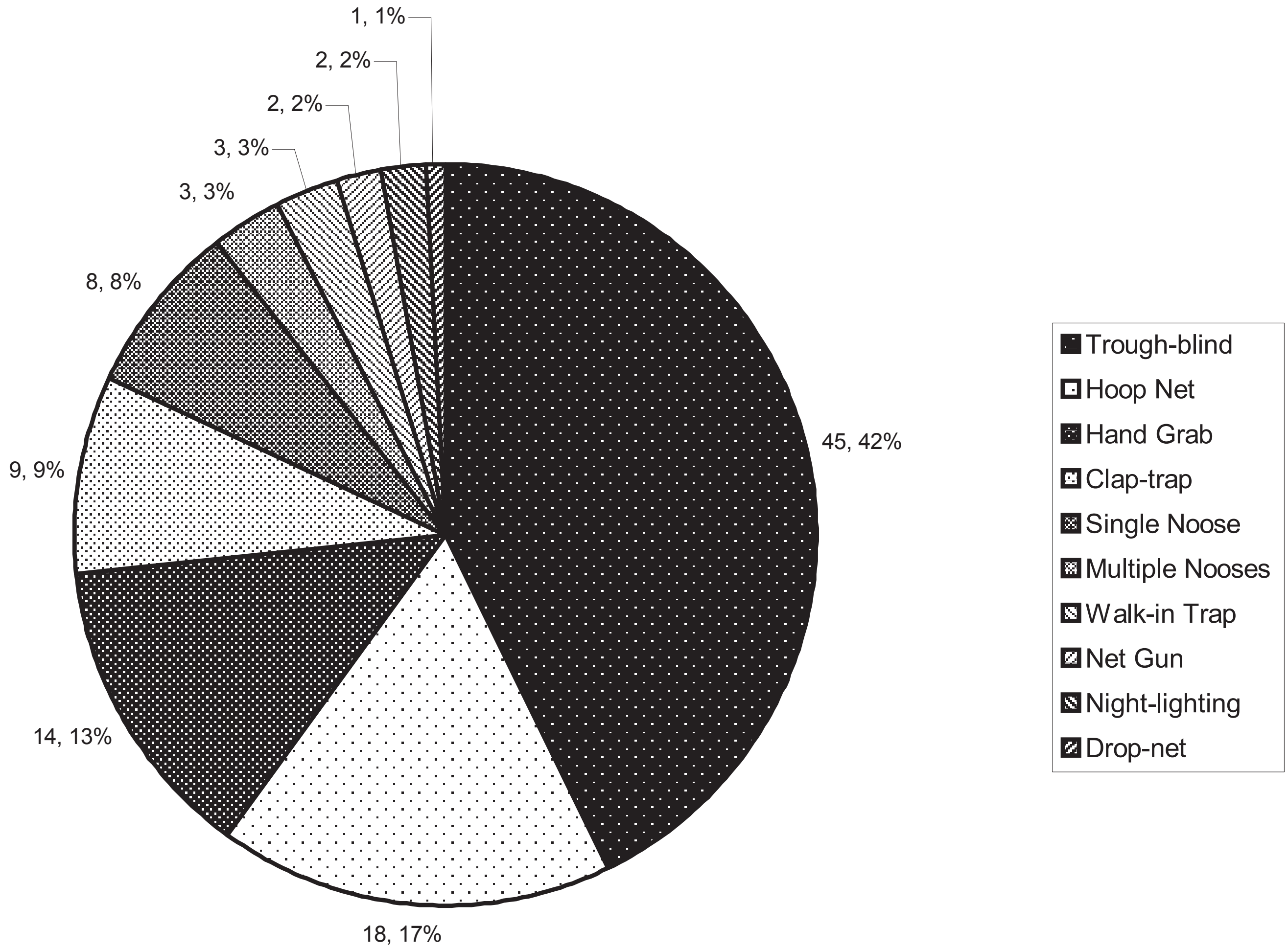

Fig. 1. Numbers of whooping cranes captured by various techniques in Florida 1993-2002. Of 105 captures, 18 were re-captures of some of the same birds.

(Folk et al. 1999).

Another technique (18 captures) involved using a long (2 m) handled hoop net (1 m in diameter). The net is used to pin the bird until we can effectively restrain the bird. This method requires that a biologist be within several meters of the target bird. Sometimes the biologist would wear a costume, such as those used for isolation rearing in captivity (Nagendran et al.1996), to facilitate close approach to the target bird. We captured 14 birds by approaching close enough to grab them by the neck, wing, or leg. These birds were usually incapacitated by sickness or injury, or had learned panhandling skills from Florida sandhill cranes and would allow close approach by humans. For those "tame" individuals, a secondary benefit of the capture was negative conditioning with humans.

The clap-trap consisted of gill-netting (10 cm mesh size), rope, and 4 supporting sticks. The netting was staked to the ground and, when triggered, assumed the shape of a long pup-tent that closed over a bird or birds that had been baited to the middle of the trap. The trap was triggered by a biologist holding tension on 2 ropes from a nearby blind. The clap-trap and multiple-snare techniques (described below) were presented by Hereford et al. (2001). The clap-trap was the only technique we used that allowed the simultaneous capture of more than one individual bird. In 2 attempts to capture 2 birds simultaneously, we were successful once; the other attempt resulted in the capture of a single bird. During an attempt to capture 3 birds, we caught 2 in the clap-trap.

Two techniques involved nooses or snares. We caught 8 birds by snaring one or both of their legs in a simple snare. We used a nylon cord (2-3 mm in diameter) with a loop (using a slip-knot) at one end. We baited the target bird into position so that one or both feet were within the loop. When possible, we hid the loop in loose sand. When the bird was in position, the biologist pulled the string to close the loop around the bird's leg(s). We laid the string on the ground for birds that would approach us within 3-5 m. We were able to extend the range up to 35 m by enclosing the string in ½-inch pvc conduit. The conduit protected the string from becoming entangled in vegetation or livestock.

A second method consisted of 100-200 snares (heavy monofilament fishing line) tied to a long cord (Hereford et al. 2001). The row of snares, each anchored by its own small stake, could be placed in the predicted path of the target bird. As the bird stepped through a snare, it tightened around the bird's foot. The response of the bird was to flee the nooses, thereby keeping tension on the noose, holding the bird until biologists gained control of it.

For a short time we employed a small version of the drop-door walk-in trap that was used to successfully capture Mississippi sandhill cranes (Logan and Chandler 1987). During 2 of the 3 captures with this trap, we did not use the drop-door, but pinned the birds inside the trap with the use of a hoop net.

We captured 2 whooping cranes by means of a net-gun. We brought one of these into captivity for a broken leg (from an unidentified cause). The bird died of asphyxiation unexpectedly a number of days after repair of the leg. Apparently it had inhaled a kernel of corn that was used to bait the bird within range of the net-gun. It is possible that the noise of the net-gun caused the bird to aspirate the corn. It is not known if this was a "fluke" accident or if the net gun may pose the threat of this on a regular basis.

We captured 2 whooping cranes by night-lighting. These were birds that during the first year of the release program were roosting on dry ground. They were captured in uplands at night and returned to the safety of the soft-release pen. We did not routinely attempt night-lighting captures of whooping cranes because the roosting habitat used by Florida cranes did not present the same structure that contributed to successful night-lighting of birds in the western U.S. by Drewien and Clegg (1992). There also was a danger in flushing birds from their roost if they were unfamiliar with alternate roost sites.

We captured 1 whooping crane under a drop-net that was suspended from a tubular metal framework. That bird had monofilament line constricting one leg and would not approach a feed-trough blind.

We tried 2 techniques that proved unsuccessful for capture of whooping cranes. We made an unsuccessful attempt to chase a crane into a large (3 m high x 20 m long) mist net. Finally, we also made an unsuccessful attempt at approaching within hoop net range by using a Holstein cow costume. Two biologists in the costume entered a pasture to approach the cranes. As soon as we donned the costume, all cranes flushed from the area and the livestock stampeded so we gave up on the cow costume. We were not the first to attempt such an approach; Robert Porter Allen, when studying whooping cranes in Texas, built a blind in the shape of a bull and named it Bovus absurdus (McNulty 1966).

Immediately after capturing all cranes, we hooded, examined, and weighed them. We also collected blood and fecal samples. After replacing radio transmitters and color bands we released the captive birds back to their social group. Typically, we released birds that did not require medical attention within 0.5-0.75 h after capture.

Most of the successful capture tools were not particularly expensive ($100 or less), but the net gun was $300. The greatest expense for each capture was the labor involved with baiting the birds to a vulnerable setting.

We captured 18 birds more than once. Fourteen birds were caught twice, 3 were caught 3 times, and 1 bird was caught 4 times. On 5 occasions we recaptured an individual using the same technique (feed trough blind) but most recaptures required the use of varying techniques. Birds became wise to a given technique and were difficult to bait to situations where they had been captured in the past.

DISCUSSION

The capture techniques we employed were safe, resulting in possibly one mortality (bird that aspirated corn), and only very minor injuries (scratches). Because safety is paramount when dealing with extremely rare birds, we did not attempt to capture whooping cranes with techniques that presented risk to the birds (e.g., oral tranquilizer alpha-chlorolose, rocket-propelled nets). The benefit of those techniques is the routine ability to catch multiple individuals.

We found it useful to employ a diversity of capture techniques because some work better than others in different settings. Some techniques, like the feed-trough blind, offer complete selectivity of which bird was captured. In contrast, the multiple-noose technique often was hampered with "by-catch" such as non-target whooping cranes, sandhill cranes, livestock, and small mammals.

Each capture attempt, regardless of the technique employed, presented its own set of challenges. Universally, the challenge is getting the wary birds accustomed to something new in their environment. Due to their varying "personalities", some whooping cranes were never in a position for capture while others were "trap-happy". Most fell somewhere in between. The greatest cost of these techniques is the time necessary for getting the cranes accustomed to a site and capture situation. It often took several weeks before a capture could be attempted. Even after several weeks of "baiting", a capture opportunity may not present itself.

Recapturing soft-released whooping cranes is perhaps the greatest challenge for this re-introduction project. The intensive labor required to recapture cranes represents the greatest limiting factor to the long-term monitoring of the population. Several bad batches of transmitters have resulted in premature radio failure and/or limited transmitting range. Routine breakage of the transmitting antennas (by the birds obsessively preening them) also often reduces the effective transmitting range of the antennas. Through the life of the project, the proportion of the population that carries fully functional radio transmitters has declined. At present, about 33% carry functioning transmitters. Our priority has been to keep at least 1 bird per pair or group with a functioning transmitter, which effectively allows the tracking of the entire group. Established pairs are given the highest priority for maintaining radio contact. This necessitates a reduced sampling of the rest of the population and could only be rectified by adding project personnel.

In the future, in attempts to increase the proportion of the population with functioning transmitters, we anticipate increased use of the clap-trap. The clap-trap is the only technique we've found that allows the capture of multiple individuals.

Ideally what we need is a safe method of attaching a transmitter without capturing/handling and the usual lengthy process of baiting the birds and getting them used to a site and situation. This might be accomplished through the use of an air rifle that shoots a tiny (several gram) transmitter that is equipped with a rapid-drying adhesive that binds the radio to the feathers. The transmitter would ideally last the life of the feathers that it was adhering to. The challenge would be to have a transmitter streamlined enough to be shot from an air gun and be less likely to be simply preened from the plumage by the bird. To discourage the latter, the transmitter should be white and feather-shaped. In the future as technology progresses and components become more miniaturized, perhaps such a tool could be developed.

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CROP DEPREDATIONS BY CRANES AT DAURSKY STATE BIOSPHERE RESERVE, SIBERIA

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Abstract: Crop depredations by staging cranes have been an annual problem at Daursky State Biosphere Reserve in southern Siberia. In September 2001 we met at Daursky when crane populations peaked to investigate the problem and suggest methods to reduce damages. Peak of crane staging coincided with grain harvest. We counted ≈ 30,000 cranes of 5 species, primarily demoiselles (*Anthropoides virgo*), in the area. Poor grain yields and cooperative farming systems discouraged efforts to reduce damage. Moving crops further from roost areas may be the most reasonable short term control method, but it's effectiveness is yet untested. Hazing, lure crops and alternate food plants also may work.

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Key words: *Anthropoides virgo*, common crane, crop depredation, Daursky State Biosphere Reserve, demoiselle crane, *Grus grus*, *Grus monachus*, *Grus vipio*, hooded crane, Russia, Siberia, white-naped crane

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As in North America, Russian wetland nature reserves often attract staging cranes in the fall becoming the foci of crop depredation. Farmers near Daursky State Biosphere Reserve (hereafter SBR) in southeastern Russia, near the borders with Mongolia and China (Fig. 1), have been pressuring the Reserve staff to solve crop depredation problems attributed to cranes. Daursky SBR is an important breeding area for white-naped cranes (*Grus vipio*) and demoiselle cranes (*Anthropoides virgo*), whereas common cranes (*G. grus*) rarely breed there. Daursky SBR is an important summering area for these species, plus non-breeding hooded cranes (*G. monachus*) and a few Siberian cranes (*G. leucogeranus*). The breeding and summering birds are joined in fall by large numbers of migrants. Peak populations of cranes and waterfowl coincide with harvest, and damage is alleged to be considerable at times. Thousands of ducks and geese are present during fall and contribute to depredation problems, but complaints were focused primarily on cranes. Our objectives were to visit Daursky SBR during peak fall populations to observe and suggest potential methods to reduce crop damage by cranes.

STUDY AREA

Daursky was established as a Nature Reserve in 1987, became a RAMSAR Site in 1994, and was designated a State Biosphere Reserve in 1997. It is an important reserve support-

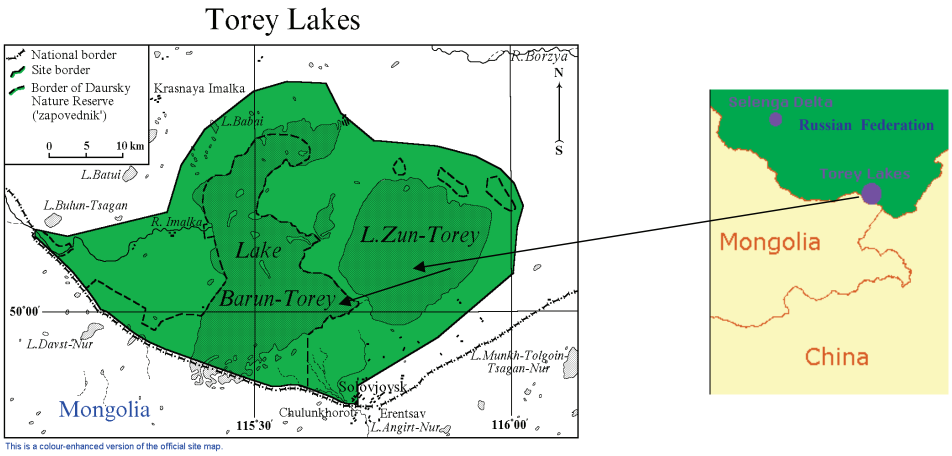

Fig 1. Map of Daursky State Biosphere Reserve and RAMSAR Site. Crane depredation problems occurred north and west of Lake Barun Torey and on the cape extending into the lake opposite the mouth of the Imalka River. Insert shows geographic location of Torey Lakes (UNESCO 2001, Wetlands International 2003).

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ing many endangered, threatened, and endemic species of birds, mammals, plants, and invertebrates (UNESCO 2001). The reserve is 700 km southeast of Lake Baikal in the Mongolian-Manchurian Steppe Biogeographic Region (Fig 1). Elevations range from 598 - 769 m above sea level. The climate is continental with winter and summer extreme temperatures ranging from -40 to 40 °C. The reed marshes (*Phragmites australis*) at the mouths of the Imalka and Uldz Rivers in and near Mongolia support ≈ 15 pairs of breeding white-naped cranes and 1,500 pairs of demoiselle cranes nest on the steppe of the Big Torey Depression (Goroshko 2002). Biosphere reserves are organized into 3 zones; the core area, the buffer zone, and the transition area. Only the core area requires legal protection. Daursky SBR is a cluster reserve covering 227,700 ha (UNESCO 2001). The core area is 45,700 ha, the buffer zone is 92,000 ha, and the transition area is 90,000 ha. The Reserve lies within the Torey Lakes RAMSAR Site (Fig.1). Barun Torey and Zun Torey (also spelled Zoon), are the largest lakes in the Trans-Baikal region and support up to a million migrating waterfowl and waterbirds including several threatened species. The lakes are sodic and have no outlet (UNESCO 2001, Wetlands International 2003). Daursky SBR has also been designated as an Internationally Important Bird Area (Goroshko 2000).

The steppe resembles mid-grass prairie of the United States with a mix of grasses and forbs. Dominant steppe vegetation included *Stipa baicalensis, S. krylovii, S. grandis, S. klemensii, Festuca lenensis, F. litvinovii, Koeleria cristata, Filifolium sibiricum,* and *Polygonum divaricatum* (UNESCO 2001, Wetlands International 2003). About 2,000 people live in 2 villages at the edge of the RAMSAR site, and in scattered dwellings every few km within the site. In 2001, most of the land was grazed, but some areas were cut for hay and about 20% was dryland grain fields, primarily wheat, and some oats. Most land was communally or government owned. Grazing, haying, and grain production seemed to be interconnected in an overall communal system. Most of our observations and counts were completed in the Buffer Zone of the SBR.

METHODS

We counted cranes near Barun Torey Lake and scattered wetlands adjacent to the Imalka and Borzya Rivers during September 2001. O. Goroshko collected fecal samples for dietary studies. We observed crane foraging and resting behavior from blinds located in croplands and on the lake shore. J. Cornely, who has experience with grain harvest in the Great Plains and western United States, visually evaluated crop quality. We discussed depredation problems with reserve staff, and with officials from the grain farming cooperative. O. Goroshko counted the area again in 2002.

RESULTS

We estimated ≈ 30,000 cranes (primarily demoiselles with lesser numbers of other species) were in the study area during our visit (Table 1). Thousands of geese, primarily swan geese (*Anser cygnoides*) and bean geese (*A. fabalis*), and ducks, primarily mallard (*Anas platyrhynchos*) and ruddy shelduck (*Tadorna ferruginea*), were also foraging in grain fields in September 2001. In September 2002, the combined estimate of cranes and waterfowl in crop fields was 52,700 - 60,700 birds (Goroshko 2003).

Most depredation problems stemmed from placement of the crop fields. Fields on a cape projecting into Barun Torey Lake experienced the worst damage. Most of the cranes were in fields < 1 km from roost sites. Demoiselle cranes roosted on pebble beaches whereas other species roosted in shallow marshes.

Cranes mainly fed in harvested fields, but unharvested wheat fields were also used. Unharvested oat fields did not seem to attract many birds. Waterfowl showed a similar pattern of field use as cranes. O. Goroshko's visual evaluation of fecal droppings suggested that in harvested fields cranes consumed mostly waste grain. In unharvested fields cranes selected 2 grasses, foxtail (*Setaria viridis*) and a self-seeding subspecies of millet (*Panicum miliaceum ruderale*). About 50% (range 10% - 90%) of the food intake from unharvested grain fields was seeds of these grass species (Goroshko 2002). Even when selecting other food items cranes still cause extensive crop losses in unharvested fields by shattering heads and knocking over stems.

Our cursory evaluation of grain crops suggested that they were marginal, a situation that may be contributing to the depredation problem. There is less incentive to expend additional effort to haze cranes from fields when potential yields are marginal. The fields had yields ranging from poor to very poor when compared with dryland grain crops in America. Stems were short, heads were small, and seeds were small and somewhat shriveled. Harvest was ≈ 50% complete during our visit. Assuming the best crops were harvested first, our evaluation of overall crop yields may be biased low. It appeared that only about 50% of the grain fields were planted in any year, with the remaining fields being fallow.

DISCUSSION

Our observations and discussions indicated that farmers were unwilling to expend much effort hazing migratory birds from fields. With poor grain production, there is little incentive and probably little return for depredation control work. Grain cooperatives often delayed harvest in poorer fields, hoping for early snows which would render them a complete loss (O. Goroshko, personal observation). Then they would be eligible for government crop loss payments without having to harvest.

Hunting as a control method is not an option, as crane hunting is prohibited in Russia. However, we heard reports of people shooting cranes to scare them from crops. Of the species using the area, Siberian cranes are listed as critically en-

Table 1. Number of cranes counted at various sites in the Torey Lakes area of Siberia, September 2001.

	15 Sept	22 Sept	22 Sept	22 Sept	22 Sept	
Location	demoiselle crane	common crane	white-naped crane	hooded crane	Siberian crane	Total
Between Zun Torey & Barun Torey Lakes (50°08' N; 115°35' E)	21,800	266	176	813	2	23,057
Novaya Zaria Village (50°20' N; 115°40')	210					210
Borzya River (50°17' N; 115°49' E)	490					490
Imalka River, Aru-Torum Lake (50°12' N; 115°18' E)	1,185					1,185
Imalka River, Bulum-Tsagan Lake (50°08' N; 115°10' E)	1,500	679	8	208		2,395
Ukshinda Lake (50°21' N; 114°50' E)	115					115
Total counted	25,300	945	184	1,021	2	27,452
Total estimated (x 1000)	26.8 - 29.3	1.05 - 1.35	1.95 - 2.04	1.12 - 1.23	0.002	29.167 - 32.086

dangered, whereas white-naped and hooded cranes are listed as vulnerable (Birdlife International 2000).

Scaring cranes might be done economically by using children of local herders who are scattered throughout the area. Children on horseback, possibly assisted by dogs, could haze cranes from unharvested fields. Hazing works best if efforts begin as soon as the cranes arrive and before they become accustomed to foraging in specific fields. Hazing is more effective if lure crops or harvested fields are nearby. As with sandhill cranes in North America (Littlefield 1986, Sugden et al. 1988), cranes at Daursky seem to prefer short vegetation as long as food was available.

There are several options to produce lure crops. Sharecropping commonly is used on reserves in the United States and Canada. The land management agency provides the land, the cooperator provides the rest. The cooperator then leaves a percentage, usually ≈ 25%, of the standing crop for wildlife. If Daursky SBR can provide the land the farming cooperative may agree to sharecropping. Another alternative is to pay for lure crops or to have them donated. The farming cooperative is willing to plant lure crops if paid for the seed. The Cooperative may also want to be paid for the use of their equipment, as the Reserve has none. However, without a steady source of annual monetary support his approach appears unlikely at Daursky SBR. Overall, lure crops coupled with hazing can be effective in reducing crop damage (Knittle and Porter 1988).

Changing crops may present a partial solution. Oat fields appeared less attractive to cranes than wheat. If oats have similar nutritional value to livestock as wheat, then converting some wheat fields to oats may reduce damage without impacting livestock feeding operations. Whether this is feasible also depends on relative crop yields between oats and wheat as well as maturity dates. Later maturity would risk the crops to longer periods of depredation and greater risk of loss from early snow. Oat fields in the study area also appeared to have poor grain production. Varieties of corn tested near Torey Lakes have been unsuccessful (O. Goroshko, personal observation).

Moving grain fields further from the lakes is perhaps the best option to reduce depredations (Goroshko 2002). The larger fields are in the worst possible locations and encourage depredations, as cranes prefer to forage in fields near roost sites (Iverson et al. 1985, Littlefield 1986, Sugden et al. 1988). The larger fields are on a cape surrounded on 3 sides by water < 1 km away. In 1999, O. Goroshko recommended this method to local farmers and since 2000 the farming cooperative has starting moving fields further from the lake. This trend is likely to continue. There is sufficient arable land to accomplish this. Since cranes will fly nearly 50 km from roost sites to feed, this strategy may work only as long as some food, either waste grain or lure crops are left near the lake (C. D. Littlefield 2004, personal communication). For now this approach appears to be working, but will need further evaluation as less food becomes available near the lakes.

Encouraging or planting foxtail grass and millet in lure areas while discouraging their growth in grain fields may be an option to reduce depredations. Cursory examinations by O. Goroshko of feces from roost sites suggested that these grasses were preferred food. This food preference needs additional investigation. If corroborated, ways to incorporate this information into cultivation schemes could be developed. At the suggestion of O. Goroshko some farming cooperatives tested lure plantings of millet in 2001. Cranes fed in the millet and stayed out of adjacent wheat fields until after harvest (Goroshko, personal observation).

Another option that could be used in outlying areas away from the Torey Lakes is to haze birds off wetland roost sites. This method has reduced crop damage by sandhill cranes in North America (Stephen 1967, Lovvorn and Kirkpatrick 1981). This is unlikely to work at Torey Lakes as there is a large area available for roosting and it is questionable whether wildlife, especially endangered and vulnerable species, should be hazed from a Biosphere Reserve. Away from the Reserve, where cranes roost on small, isolated wetlands, this technique might work in protecting local crops, but it could be counterproductive overall. More cranes might concentrate on the Reserve, thus increasing damage near there. Instead it may be desirable to protect small isolated roosting areas to encourage cranes away from the larger croplands near the Torey Lakes.

Ecotourism is a potential funding source that might support lure crops. This may be the only site in the world where 5 species of cranes can be seen in 1 field. With good blinds cranes often approach within 20-30 m providing excellent viewing and photographic opportunities. There may be some ecotourism companies that would organize tours, however, the difficulty of travel to this region plus the lack of infrastructure means that ecotourism may not provide substantial funding on a regular basis in the near future.

In conclusion, we believe that depredation problems are unlikely to ever be totally resolved. Some progress has been made and there is potential for much more. Starting in 2002 private individuals were allowed to purchase Russian farmland (Knight Ridder News Service 2002). If some of the croplands were privatized, one would expect that private owners should have greater incentive to undertake depredation control than cooperative members. The Daursky SBR should continue its cooperative work with farmers and cooperatives to use farm fields further inland from roost sites and to continue experimenting with alternative food crops, both for cranes and for livestock. The Reserve should investigate whether sharecropping is possible given the land designation and management constraints. In addition, the Reserve, concerned non-governmental organizations, and farmers should explore ways to develop monetary incentives for providing crane habitat. Ecotourism could help provide funds for lure crops, or even provide funds to assist farmers. The Reserve should continue efforts to educate the local populace about the value of both cranes and wetlands, and to seek ways for cranes and farmers to coexist.

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