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FIRST COHORT OF MIGRATORY WHOOPING CRANES REINTRODUCED TO EASTERN NORTH AMERICA: THE FIRST YEAR AFTER RELEASE

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Abstract: We describe the post-release movements and survival of the first cohort in the eastern migratory whooping crane (*Grus americana*) reintroduction from release the first winter through return the second winter. Six cranes were led behind ultralight aircraft from Necedah National Wildlife Refuge (NWR), Central Wisconsin, to Chassahowitzka NWR, Gulf Coast of Florida. After release in Florida, 1 of these cranes and another transported there by truck were killed by bobcats (*Lynx rufus*). The winter management protocol was modified and no further predation occurred. The 5 remaining cranes migrated unassisted back to Necedah NWR in spring, left the refuge during a spring wandering period, and then 4 returned to Necedah NWR to spend the summer. All 5 birds migrated back to Florida to winter, and 4 returned at least initially to Chassahowitzka NWR or adjacent salt marsh before 3 dispersed to suitable habitat inland. One yearling remained at Chassahowitzka NWR with the newly released juveniles from the second year's release. Of the other 4 birds, 2 wintered separately with sandhill cranes (*G. canadensis*) in northern Florida, and 2 wintered as a pair on ranchland 62 km from the original winter release site. After the bobcat predation problem was solved, the subsequent survival, migration, summering, and wintering of these reintroduced whooping cranes were favorable for a successful reintroduction.

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Key words: whooping crane, *Grus americana*, reintroduction, migratory population, ultralight aircraft, migration, Wisconsin, Florida.

Walkinshaw (1978) was one of the first to propose the reintroduction of an eastern migratory population of whooping cranes (*Grus americana*), and he recommended the Upper Peninsula of Michigan to be the site of this reintroduction. During most of his crane research, which began in the early 1930's, there were only a small number of whooping cranes surviving in the single viable population that migrated between Wood Buffalo National Park in the Northwest Territories of Canada and Aransas National Wildlife Refuge on the Gulf Coast of Texas. There was no captive propagation program, and the whooping crane hovered on the brink of extinction. In 1966, a captive propagation program began at Patuxent Wildlife Research Center (Patuxent) in Laurel, Maryland. In 1975, the first reintroduction was attempted at Grays Lake National Wildlife Refuge, Idaho. This was to be a migratory flock wintering in New Mexico. In 1983, Bookhout (McMillen 1988) initiated a series of studies involving sandhill cranes in the Upper Peninsula of Michigan in preparation for reintroduction of an eastern migratory flock. However, by 1988 cross-fostering, the primary technique used in the Rocky Mountain reintroduction, had proven to be ineffective, survival in that migratory flock was low, and that effort would eventually be discontinued. Initiation of an eastern migratory whooping flock was dropped from consideration in favor of a non-migratory flock on the Kissimmee Prairie of Central Florida. In 1993 this second reintroduction attempt was begun. That effort to establish a non-migratory flock has continued, but, survival has been low (Nesbitt et al. 1997, 2001). In 2001, after an 18-year effort of proposals, development of new techniques using sandhill cranes (Horwich 1989, 2001; Urbanek and Bookhout 1992, 1994; Lishman et al. 1997; Ellis et al. 2000, 2001, 2003; Duff et al. 2001), planning, and persistence, an initial cohort of reintroduced migratory whooping cranes was led behind ultralight aircraft from Necedah NWR, Central Wisconsin, to Chassahowitzka NWR on the Central Gulf Coast of Florida. Reintroduction of an eastern migratory population of whooping cranes was finally underway.

This report documents the survival, movements, and general behavior of the first cohort of whooping cranes in the eastern migratory whooping crane reintroduction. The period covered begins with release of these birds in Florida for their first winter and continues through spring migration, summering in Wisconsin, fall migration, and their second winter in Florida. This paper is a contribution of the Whooping Crane Eastern Partnership, a consortium of federal and state agencies and nonprofit organizations committed to reestablishment of a migratory population of whooping cranes in eastern North America.

STUDY AREAS

Central Wisconsin Reintroduction Area

The core reintroduction area consists of a large shallow wetland complex in watersheds in Juneau, Wood, Jackson, Monroe, Clark, and Adams Counties. Approximately 20,170 ha of marsh occur in federal or state ownership on Necedah NWR, Necedah Wildlife Management Area (Meadow Valley State Wildlife Area [SWA]), Sandhill SWA, and Wood County SWA. At least as much shallow wetland is present on other lands, including cranberry properties, within this core area. The landscape is an interspersion of shallow wetlands, forests, and farmlands on poorly drained, sandy soils of low relief. Corn is a major crop. The specific site of the reintroduction, Necedah NWR, contains approximately 7,725 ha of suitable crane habitat in marshland (6,860 ha) or pools with water-control structures (865 ha) (Trick 2001). Dominant plants include sedges (*Carex* spp.), cattails (*Typha* spp.), willows (*Salix* spp.), and reed canary grass (*Phalaris arundinacea*). Refuge lands also include 695 ha of scrub-shrub, 8,530 ha of forest, and 686 ha of grasslands. The dominant forest type is Hill's oak (*Quercus ellipsoidalis*) along with red pine (*Pinus resinosa*), jack pine (*Pinus banksiana*), and quaking aspen (*Populus tremuloides*).

Migration Route

The reintroduced whooping cranes would share the migration route used by the wild sandhill crane population (Toepfer and Crete 1979, McMillen 1988, Urbanek 1988). The latter route extended from Central Wisconsin to stopovers at Jasper-Pulaski State Fish and Wildlife Area (Jasper-Pulaski) in northwestern Indiana and Hiwassee Wildlife Refuge (Hiwassee) in eastern Tennessee to wintering areas in southern Georgia and peninsular Florida. The route used by ultralight aircraft to lead juveniles on their first migration deviated significantly from the sandhill route by avoiding Chicago. The aircraft took a wide berth to the west to avoid flying through congested airspace of that large metropolis. Also, the ultralight aircraft did not fly near Jasper-Pulaski, a major sandhill crane stopover site.

Central Gulf Coast of Florida Wintering Area

The release pen on Chassahowitzka NWR was located in an area representative of the surrounding salt marsh. Typical salt/brackish marsh habitats characteristic of the Central Gulf Coast were located within 2.4 km of the pen. Dominant vegetation consisted of extensive monotypic stands of black needlerush (*Juncus roemerianus*) with scattered islands of cabbage palm (*Sabal palmetto*). Surface access was by airboat, and airboat operation by the public on this part of the refuge was prohibited. The pen was expanded from 0.6 ha in winter 2001/02 to 1.6 ha in winter 2002/03. The expanded portions included (1) a deeper pool, (2) an artificially constructed oyster bar (on top of an existing natural oyster bar), and (3) an area of salt grass (*Distichlis spicata*), originally just outside the southeast boundary of the old pen, that was a favorite loafing area for the hatch-year 2001 birds during their first winter and on which they frequently attempted to roost. With the improvements, water of suitable roosting depth was present somewhere in the pen at almost any tidal level in winter 2002/03.

Prescribed burned areas were also present adjacent to and in the vicinity of the pen. These amounted to several hundred ha in winter 2001/02 but were less extensive in winter 2002/03. These burns constituted most of the area outside of the pen that was usable by the cranes until early March. By that time needlerush had regrown and rendered much of the burned areas again unusable.

METHODS

Whooping cranes were hatched (7-24 May 2001) at Patuxent and then trained from shortly after hatching to follow ultralight trike aircraft (Cosmos, Dijon, France) according to techniques developed by Operation Migration, Blackstock, Ontario (Lishman et al. 1997, Duff et al. 2001). On 10 July at 47-64 days of age, chicks were transferred to large, top-netted outdoor pens with adjacent aircraft training areas on Necedah NWR, Juneau County, Wisconsin. Each pen included separate wet and dry portions, which the juveniles had access to during morning through afternoon. Juveniles were, however, locked in the dry pen overnight as a safety precaution against predators. On 11 September birds were individually marked with colored legbands and equipped with legband-mounted VHF (164-166 MHz) lithium battery (Advanced Telemetry Systems, Isanti, Minn.) or solar/NiCad (Telemetry Systems, Mequon, Wis.) transmitters.

The initial (2001) cohort left Necedah NWR on 17 October, arrived at an inland site near Chassahowitzka NWR on 3 December, and then arrived at the salt marsh release pen on 5 December (50 days) (J. W. Duff, personal communication). Six birds had completed the migration behind ultralight aircraft. Another bird with early wing problems never successfully completed flight training and was transported by truck for the entire migration. They were enclosed in a small top-netted holding pen within the larger 0.6-ha pen. On 6 December 3 birds, including the male transported by truck, were each equipped with a leg band-mounted satellite transmitter (PTT) (Microwave Telemetry, Columbia, Md.). On the following day the holding pen was removed, and the cranes were released in the larger pen as free-flying birds. They were allowed to roam during the day at will. A costumed dummy, used successfully in previous studies with sandhill cranes to control roost site location (Urbanek and Bookhout 1992, Urbanek et al. 2005) was positioned in the center of the pool within the pen. Cranes were initially also allowed to roost at will until mortalities necessitated a protective roost strategy.

After they were released, cranes were tracked by conven-

tional (VHF) telemetry with scanner receivers (Advanced Telemetry Systems, Isanti, Minn.; Telonics, Mesa, Ariz.). Most of this tracking was done from vehicles on the ground, although Cessna aircraft were sometimes used, especially during migration and to search for missing birds. Each ground tracking vehicle was equipped with a through-the-roof, 7-element yagi antenna (Cushcraft Corporation, Manchester, NH). PTT's were used to identify distant search locations in areas not routinely covered by VHF tracking.

RESULTS

First Winter

Seven juvenile whooping cranes were released into the remote, open-topped pen on Chassahowitzka NWR, Central Gulf Coast of Florida, on 7 December 2001. Six of these birds (males nos. 1, 5, and 6 and females nos. 2, 7, and 10) were led by ultralight aircraft from Necedah NWR in Central Wisconsin and reached Chassahowitzka NWR on 5 December. Another bird (male no. 4), transported in a box by truck during migration, had arrived at Chassahowitzka NWR the previous day.

Predation. - The male transported by truck was killed just outside the pen perimeter by a bobcat on 17 December. Female no. 10 was killed while attempting to roost in a narrow tidal creek on the night of 9 January. The offending bobcats were trapped and removed from the area, and a continuous trapping effort was implemented. Although bobcat sign occasionally reappeared near the pen site, no additional bobcats were captured. After the second mortality, more rigorous overnight protection measures (i.e., ensuring that the birds roosted either within the predator-proofed pen or in water more than 6 m from shore) were implemented, and no further mortalities occurred.

Roosting. - During the 2001/02 winter the released juveniles occupied the original 0.6-ha release pen. Based on behavior at roost time, cranes initiated roosting in water as deep as 23 cm but optimal depth was 15 cm or less. They showed little or no attraction to the costumed dummy. They did not roost on exposed mudflat. Data on water depth in the pool in the pen are available for each night (n = 81) at roosting time during the period 18 January-8 April 2002. During this period, water depth at dusk was optimal for roosting on 17 nights (21%), marginally suitable, i.e., adequate but somewhat high on 8 nights (10%), too low on 4 nights (5%), too high (but within banks) on 43 nights (53%), and the entire surrounding landscape was flooded, i.e., tidal creeks and pools exceeded their banks, on 9 nights (11%). The adjoining part of the pool southwest of the original fenced part was deeper; therefore, this larger part of the pool, unfenced in winter 2001/02, was rarely usable by the cranes at roosting time. On the majority of nights, there also appeared to be few or no safe places to initiate roosting in the surrounding tidal landscape because water was too deep (i.e., the bays, creeks, and pools to the west were even deeper than the pool at the release pen).

The cranes frequently flew out of the pen at roosting time, landed on the adjacent salt grass area that was unsuitable for roosting, and then had to be led back into the pen by a costumed caretaker as darkness fell. During the period of consistent data collection, 18 January-8 April 2002, birds were led back into the pen on 37% of nights. Except on 3 of these nights, all 5 birds needed to be led into the pen. Birds occasionally roosted safely outside of the pen. This roosting occurred on 17% of nights. These nights were usually characterized by extremely low tides, when birds usually roosted in a tidal pool 0.24 ha east of the pen, or extremely high tides, when birds were allowed to roost on the flooded salt grass loafing area adjacent to the pen. Cranes went to roost in water a safe distance from shore on 34% of nights. Otherwise, they roosted on land.

Salinity. - Whooping cranes will drink water with salinity less than 23 parts per thousand (ppt) (Allen 1952, Hunt 1987). Salinities near the pen site were too high to provide a good source of drinking water: January (19-21), February (17-24), March (19-23), April (23-25). Salinity usually decreased briefly only after heavy rains. Cranes were largely dependent on fresh water artificially provided in a drinking receptacle.

Foraging and Movements. - In winter 2001/02 cranes ranged 0-2.5 km from the pen. The small size of the pen and large amount of burned habitat in the vicinity of the pen contributed to their movement. However, by mid-February needlerush had regrown on the burn, rendering most of this habitat unusable. In late winter until migration, cranes focused their away-from-pen movements on 2 barrens (i.e., open dry land with sparse vegetative ground cover). These areas were 1.6 km east near Rose Creek and 0.8 km south at Pumpkin Creek Impoundment. Cranes were frequently observed foraging on natural foods, including blue crabs (*Callinectes sapidus*). However, most feeding was on commercial pellets provided at a feeding station within the pen.

Spring Migration

The 5 cranes that survived the winter (nos. 1, 2, 5, 6, and 7) began migration as a single flock on 9 April and flew to Wilcox County in southcentral Georgia (Fig. 1, Table 1). After being grounded for 2 days with rain, they made a short flight to Henry County, Georgia, just south of Atlanta on 12 April. After another day of rain, they resumed migration on 14 April, when a female (no. 7) separated in flight from the other 4 birds over northern Georgia. She landed in McMinn County, southeastern Tennessee, while the main group of 4 proceeded to Fentress County, northeastern Tennessee. On 15 April the group of 4 flew to Johnson County, southcentral Indiana. The following day they migrated through northern Indiana and being pushed eastward by a strong west wind, the group encountered Lake Michigan at Indiana Dunes. After circling the shoreline for 2 hours (they had never before encountered a large obstacle in their flightpath), they correctly flew westward. They landed to roost in a pool in a gravel pit that was closed to public access in a forest preserve

Fig. 1. Migration route of hatch-year 2001 whooping cranes from Chassahowitzka NWR, Florida, to Necedah NWR, Wisconsin, spring 2002. Stopover sites are identified in Table 1.

Table 1. First spring migration of reintroduced whooping cranes, 2002. Cranes left Chassahowitzka NWR, Citrus Co., Florida on 9 April. Crane no. 7 separated from the other 4 cranes during flight in northern Georgia on 14 April.

Flight date	Crane nos.	Stopover site	Site (Fig. 1)	Distance (km)	Time (hrs)
9 April	1,2,5,6,7	Wilcox Co., Georgia	1	349	6.9
12 April	1,2,5,6,7	Long Branch Reservoir, Henry Co., Georgia	2	174	4.9
14 April	1,2,5,6	Cumberland Plateau, Fentress Co., Tennessee	3	322	8.0
14 April	7	Rodgers Creek Unit, Chickamauga WMA, McMinn Co., Tennessee	7	232	6.8
15 April	1,2,5,6	Johnson Co., Indiana	4	382	8.5
15 April	7	north-central Kentucky (site undetermined)	8		
16 April	1,2,5,6	Schuth's Grove Forest Preserve, Cook Co., Illinois	5	344	8.0
16 April	7	Jasper Co., Indiana	9		
18 April	1,2,5,6	Shaw Marsh SWA, Dodge Co., Wisconsin	6	198	5.0
18 April	7	Avon Bottoms SWA, Rock Co., Wisconsin	10		
19 April	1,2,5,6	Necedah NWR, Juneau Co., Wisconsin		150	6.4
30 April	7	Wisconsin River, Wauzeka, Crawford Co., Wisconsin	11	142	
3 May	7	Necedah NWR, Juneau Co., Wisconsin		124	

in the Chicago metropolitan area, Cook County, Illinois. They resumed migration on 18 April and proceeded to Dodge County, southeastern Wisconsin. On 19 April under overcast and a low ceiling, they resumed migration but proceeded northward and stopped to land twice. In mid-afternoon the sun appeared, and the flock abruptly changed course westward and then completed migration to Rynearson Pools (their rearing area of the previous year), Necedah NWR. The entire migration had taken the group 11 days, of which 7 were flight days. The route was roughly direct; distance covered per flight day varied from 150 to 383 km (mean = 274 km). Meanwhile, crane no. 7 stopped in northcentral Kentucky (exact location unknown) and Jasper County, northwestern Indiana, before landing at Avon Bottoms SWA, Rock County, southcentral Wisconsin, on 18 April. She remained at that location until 30 April when she moved to Crawford County in southwestern Wisconsin. She completed migration to Rynearson Pools, Necedah NWR, on 3 May.

Spring Wandering

The whooping cranes, after returning to Necedah NWR and like previously released experimental sandhill cranes led on fall migration by ultralight aircraft (Urbanek et al., 2005), moved to other locations in Wisconsin, generally south and east of Necedah NWR, during spring 2002. After return and 1 night of roosting on Necedah, all of the cranes left the following day. The group of 4 (nos. 1, 2, 5, and 6) moved to several sites south and southeast, spending the largest amounts of time 27 km south near Mauston, southern Juneau County (23 April-ca 5 May) and 174 km southeast near Cold Spring, Jefferson County (ca 10 May-1 June for 3 birds, until 8 June for crane no. 6) (Fig. 2). No. 6 had remained separate from the other birds after he sustained a minor leg injury ca 20 May. The group of 3 returned to Necedah NWR on 2 June, moved back to Mauston on 12 June, then returned to the refuge on 26 June. No. 6 returned to Necedah NWR on 9 June but did not associate with the other whooping cranes. When off refuge, the cranes typically inhabited agricultural lands, feeding on waste corn and roosting in wet areas or ephemeral pools in or near the fields.

No. 7 may have spent 5-26 May in southern Wisconsin (exact location unknown, but she was tracked northward from this area), moved to Leola grasslands in Adams County on 27 May, then to Rush Lake, Winnebago/Fond du Lac Counties) ca 29 May, where she remained until ca 22 June. She then moved to Radke Pool, Horicon NWR, in southern Fond du Lac County, 131 km eastsoutheast of Necedah NWR (Fig. 2).

Summer Home Range

After his return on 9 June, no. 6 settled in the Rynearson Pools area of the refuge and remained there for the summer. The group of 3 also returned to the Rynearson Pools area, and after some interference with training of the current year's juveniles to follow ultralight aircraft, efforts by project personnel to frighten them away from the training site apparently resulted in separation of no. 5 from the group. He remained apart and by 10 July settled for the remainder of the summer about 10 km north at Sprague-Mather Pool on the northern part of the refuge.

Fig. 2. Major spring and summer locations, fall staging areas, fall migration stopovers, and wintering areas of hatch-year 2001 whooping cranes, spring 2002-winter 2002/03. Sites described in text: (1) Mauston, (2) Briggsville, (3) Cold Spring, (4) Walworth, Kenosha, and McHenry Counties, (5) Resaca, (6) Concord, (7) Lake Butler.

Nos. 1 and 2, a male and female that remained together, briefly left the refuge to the northwest but returned to Rynearson on 7 July and remained for the summer. All of the whooping cranes associated with sandhill cranes, and nos. 1, 2, and 6 consistently roosted with sandhill cranes from mid-July onward. No. 7 remained on Radke Pool, Horicon NWR, and adjacent areas after arriving there in late June.

Autumn Staging

Nos. 1 and 2 left Rynearson Pools, Necedah NWR, on 8 October and returned to the same area west of Mauston which they had used in late June. That night they roosted in wetlands south of Castle Rock Lake just northeast of Mauston. During the next week they made several trips between the refuge and recently harvested cornfields, usually near Mauston. From 14 October they remained on Rynearson Pools, roosting with either sandhill cranes or near one of their former rearing sites, before returning to the Mauston cornfields on 1 November. Except for trips to a cornfield on 2 and 12 November, they remained on drawn down East Rynearson Pool, where they fed extensively on fish, mainly bullheads (*Ictalurus* sp.) trapped in the shallows. They migrated on 21 November.

Unlike nos. 1 and 2, the 3 single yearling whooping cranes each became integral members of staging sandhill crane flocks: No. 5 left Necedah NWR on 7 October and joined a flock of sandhill cranes staging northeast of Mauston. That flock fed in local cornfields and roosted in wetlands south of Castle Rock Lake. On 2 or 3 November he joined the staging flock at Quincy Bluff, 11 km eastward in Adams County. On 4 November he moved 29 km southeast to a large staging area at Widow Green Marsh, near Briggsville, southwestern Marquette County, where he usually roosted in marsh along Neenah Creek or South Branch (Fig. 2). He migrated on 23 November. No. 6 also left Necedah NWR on 7 October and joined the staging sandhill cranes north of Briggsville. At that time the flock fed in local cornfields and roosted mainly in Widow Green Marsh. By 3 November he was foraging 6 km northeast of Widow Green Marsh and roosting in Endeavor Marsh 6 km east of that feeding area. He migrated on 9 or 10 November. No. 7 remained in the northern Horicon NWR area and by late September had joined large sandhill crane flocks that were roosting in Teal and Luehring Pools (just south of Radke Pool), Dodge County, and feeding in recently harvested cornfields east of the refuge. She migrated on 15 November.

Autumn Migration

Four of the 5 cranes followed the same general pattern (Fig. 2), i.e., a direct migration consisting of 6 consecutive flight days with 1-night stops at the major crane congregation areas of Jasper-Pulaski, Indiana, and Hiwassee, Tennessee, and 3 opportunistic stops (1 between Jasper-Pulaski and Hiwassee; 2 between Hiwassee and the Central Gulf Coast of Florida). No. 6 followed a different pattern; he spent several days on a staging area at the Wisconsin-Illinois border before passing through Jasper-Pulaski and then spending 1.5 months at Hiwassee. All whooping cranes apparently migrated with sandhills except during the final approach in Florida. Specific itineraries were as follows:

Nos. 1 and 2 flew from Necedah NWR to Jasper-Pulaski on 21 November and left Jasper-Pulaski the next morning. The pair arrived at Hiwassee on 23 November, left the next morning, and made overnight stops near Concord, Georgia, and Lake Butler, Florida, before arriving at St. Martins Marsh Aquatic Preserve in early afternoon of 26 November.

Crane No. 5 left the Briggsville staging area on 23 November and arrived at Hiwassee on 25 November. He left the next morning and arrived at the pen on Chassahowitzka NWR on 28 November. After leaving Endeavor Marsh on 9 or 10 November, no. 6 moved to a staging area that included parts of Kenosha and Walworth Counties, Wisconsin, and McHenry County, Illinois. He flew to Jasper-Pulaski on 16 November, left the next morning, and arrived at Hiwassee on 18 November. He remained there with wintering sandhill cranes until, in apparent response to depletion of corn on the refuge, he departed southbound with sandhill cranes on 3 January. He roosted that night in Gordon County, Georgia, and resumed migration the next morning. He arrived in the Hixtown Swamp area, Madison County, Florida, after dark on 4 January and joined the group containing whooping crane no. 7 and 50 sandhill cranes on 5 January.

Crane No. 7 left Horicon NWR on 15 November and apparently arrived at the pensite on Chassahowitzka on 20 November (observed there the following morning). She remained a few days and then joined wintering sandhill cranes 217 km northnorthwest at Hixtown Swamp, Madison County, Florida (found there on 28 November).

Second Winter

Cranes Nos. 1 and 2: After arriving at St. Martins Marsh Aquatic Preserve on 26 November and then spending about 3 days exploring the 32 km of St. Martins/Chassahowitzka coastline, they settled on St. Martins Marsh just east of Ozello, 11 km north of the pen site. They roosted in the upper Greenleaf Bay area and typically spent daytimes foraging in openings between the Bay and palm hammock to the east. A favorite area was a large open patch of salt grass with no needlerush, little surface water, and surrounded by brush and palm hammock. They foraged by probing in mud in small wet areas. The pair left St. Martins Marsh on 14 or 15 December. Their departure occurred immediately after high tides which raised water levels in their roosting area in Greenleaf Bay on 13 December. On 17 December they were found inland on a private cattle ranch 63 km south near Land o' Lakes, Pasco County, where they stayed for the remainder of the winter.

Crane No. 5: After he arrived at the Chassahowitzka pen site on 28 November, the hatch-year 2002 flock of 16 juveniles, led by ultralight aircraft, completed their migration to the pen 2 days later. No. 5 joined the flock in the pen as the dominant bird. Like the juveniles, he usually roosted in the pen, ate from the feeder, and approached the costumed caretaker. The larger pen provided improved conditions at the release site in winter 2002/03, and no. 5 and the 16 new juveniles usually roosted of their own volition within the pen. The birds showed strong

preference for roosting on the smooth, firm constructed oyster bar even when it was not or only partially covered with water. Salinities (ppt) near the pen site were generally lower (December [9-15], January [11-20], February [13-20], March [9-15]) than in the previous winter, but still high enough that cranes strongly preferred supplemental fresh water. In winter 2002/03 the cranes only ranged to 0.5 miles from the pen, the farthest points being south to E-Creek and Pumpkin Creek Impoundment. Unlike the previous winter, only a small burned area occurred just northeast of the pen.

Crane No. 6: After joining the group containing no. 7 and 50 sandhill cranes at Hixtown Swamp on 5 January, no. 6 remained in the group through the morning of 7 January. By the afternoon of 9 January, he had moved to a different wetland in the same complex but 7 km west. The latter wetland was a major sandhill crane roosting area. No. 7 remained with wintering sandhill cranes in Plant Pond, Hixtown Swamp area. She used a small area and apparently did almost all foraging in the wetland. All whooping cranes remained sedentary on their final selected wintering areas. This behavior was typical of wild migratory sandhill cranes (Urbanek et al. 1988) and whooping cranes (Stehn 1991).

DISCUSSION

Survival and Management Strategy to Avoid Predation

In winter 2001/02, 2 of 7 juvenile whooping cranes were killed by bobcats within 1.5 months of release on the wintering site. Before these mortalities, birds were usually allowed to roost at locations of their own choosing. After the second mortality, security was increased by making sure that the cranes were in the pen or in water at least 6 m from shore at roosting time. This management strategy was successful, and no additional mortalities occurred at the winter release site. Cranes returning to Florida during the following winter had in the interim learned sufficient survival skills to successfully cope with the high threat of predation by bobcats.

Habitat Limitations on the Winter Release Area

Whooping crane juveniles demonstrated inconsistent water roosting behavior at Chassahowitzka NWR. The main impediment to safe roosting on Chassahowitzka NWR was that consistently usable roosting habitat was not available. Tidal variation both during the night and from night to night often made roosting in water at any single location impossible. The tides in conjunction with poor natural substrate, i.e., jagged oyster rock or extremely soft muck, encouraged whooping cranes at the pensite to often roost on land in winter 2001/02 and on the smooth, firm, artificially constructed oyster bar in winter 2002/03.

One reason for inconsistent water roosting may have been that the birds had not been conditioned to consistently roost in water and a safe distance from shore. In previous studies with sandhill cranes (Urbanek and Bookhout 1992; Urbanek et al. 2005), a costumed dummy was successfully used to attract and hold released juveniles at a desired roost site. In winter 2001/02, however, released whooping cranes, unlike sandhill cranes, showed no attraction to a costumed dummy. In summer 2002, chicks being reared at Necedah were provided with water roosting opportunity in their rearing pens and were also given fulltime exposure to a plastic whooping crane decoy. In winter 2002/03 decoys were placed at the end of the newly constructed oyster bar and at the roosting area in the old part of the pen. Some cranes, mainly the same few individuals, showed attraction to the decoy, but the attraction was weak and insufficient to influence roosting behavior of most of the birds.

Most whooping cranes did not remain on the Central Gulf Coast during their second winter. Not only the tidal fluctuations, but salinity, unstable or rocky bottom substrates, and general habitat dominance by needlerush also contributed to poor habitat conditions. However, wintering of the population in coastal wetlands, although desirable, is not biologically necessary for success of this reintroduction. Attaining the necessary goals of survival, reproduction, and human avoidance can also be achieved by other wintering strategies.

Although Chassahowitzka NWR appeared unsuitable as an ultimate wintering area for reintroduced whooping cranes, it did prove to be an excellent release site. Cranes over-wintering at the pensite could be successfully protected from predators and effectively isolated from human activity, the latter of which could compromise their wildness during the critical period just after release. Occupation of the Chassahowitzka site during their first winter also had no adverse effect on selection of habitat by cranes in their subsequent winter. The returning cranes selected appropriate wintering habitat inland. [Subsequent results after this paper was written indicate an important additional benefit of using Chassahowitzka NWR as a release site. Namely, older cranes completing fall migration have returned to the Chassahowitzka release site, but then, because of the limitations of the habitat, they remained at most a few weeks before moving to nearby quality habitat inland. This pattern allows the same well-built and protected pensite on Chassahowitzka NWR to be used again with minimized interference by older birds harassing the newly arrived juveniles. Domination of the pen site by older birds could be detrimental to this reintroduction by forcing subordinate juveniles outside of the pen where they are susceptible to predation by bobcats. Using the Chassahowitzka pensite as the winter release area for naive juveniles greatly facilitates the strategy of protecting the cranes to ensure survival during their highly vulnerable first winter. After initiating spring migration, they then have 8 months in areas containing few or no bobcats in which to develop the survival skills they will need before returning again to winter in Florida.]

Spring Migration and Subsequent Spring Wandering

These whooping cranes migrated directly back to Wisconsin during their first spring migration. They did not necessarily follow the exact route used during fall migration while following ultralight aircraft. They flew on each day with favorable winds and clear to partly cloudy skies and also on a few days with less than optimal migration conditions. Their migration stops were opportunistic, generally consisting of whatever ponds or other wetlands were present in their flight path at the end of each migration day. This pattern was similar to that of whooping cranes in the natural Aransas-Wood Buffalo population (Howe 1989).

After returning to Necedah NWR, all of the yearlings embarked on a spring wandering period that lasted through May and June. This wandering was characterized by frequent and/or extensive flights that familiarized the cranes with their reintroduction area. Spring wandering, especially of females, may be characteristic of migrating cranes and has been previously noted in sandhill cranes (Urbanek 1990, Urbanek et al. 2005). However, to date this phenomenon has been poorly studied.

Roosting Behavior of Yearlings

Inconsistent roosting in water or roosting in water too near shoreline was sometimes evident. During spring and early summer these yearling whooping cranes sometimes chose safe roosting sites, but at other times they roosted on land, in small wetlands near shore, or in farm fields with a very limited extent of standing water. This roost site selection may have been related to lack of appropriate conditioning to roost in water at Chassahowitzka NWR during the first winter or at Necedah NWR during the previous summer. During their yearling summer, however, the whooping cranes began associating with wild sandhill cranes. From that time on, they consistently selected safe roosting habitat.

Human Avoidance

Costume/isolation-reared cranes are sometimes prone to tolerate presence of humans after release. This behavioral corruption can be largely avoided if costume-rearing is done according to rigorous standards and the birds remain isolated from uncostumed humans during the release process and subsequent period of adjustment to the wild. The latter period may be long and of undetermined length depending on the history and psychological disposition of each bird. Although the released whooping cranes were never attracted to uncostumed humans, they occasionally demonstrated inadequate fear of humans and vehicles, especially while on farmlands in spring and early summer. However, after returning to the refuge and/or joining wild sandhill cranes in summer, wildness increased and no significant problem was apparent.

Cranes Nos. 1 and 2 demonstrated some attraction to sites subject to limited human activity, especially when food was present, e.g., a duck-banding site baited with corn on Necedah NWR. This opportunity for exposure to humans at the reintroduction site can be effectively or at least partially controlled. More difficult to deter is exposure to human activity on some of the wintering grounds. Nos. 1 and 2, for example, spent their second winter near a human residence on a private cattle ranch that contained non-migratory sandhill cranes that were tolerant of people. That site did little, therefore, to reinforce human avoidance behavior. In addition, development pressures in Pasco County and other areas in west-central Florida could compromise some wildness of these birds as well as result in significant habitat loss.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Leading by Ultralight Aircraft

This technique has been successful in leading these and other birds to winter on a protected release area during their first winter (Ellis 2003). A migration route was learned that effectively resulted in released whooping cranes returning to the reintroduction area in Central Wisconsin. When combined with a rigorous costume/isolation-rearing protocol, leading cranes behind ultralight aircraft appears to be a highly effective reintroduction technique for a migratory population.

Winter Release Procedure

The management strategy of protecting the released birds during their first winter at Chassahowitzka NWR has been highly successful. When employed, this strategy has resulted in 100% survival of naive, newly released birds while they occupied areas with high bobcat densities. Once birds leave on spring migration, they are not subject to high densities of this predator (Anderson and Lovallo 2003; R. P. Urbanek, personal observation). By their return to Florida the following winter, they have adapted to the wild and become more predator wary. Association with sandhill cranes on the summering areas seemingly facilitates this process.

Chassahowitzka NWR and the adjacent Gulf Coast of Florida appear to be unsuitable for maintaining a wintering population of whooping cranes. Most of the whooping cranes returned to the salt marsh after the second southward migration and then left shortly thereafter to inhabit nearby areas inland. The most preferred habitat appears to be large cattle ranches containing extensive, large, shallow ponds (described by Nesbitt et al. 1997). Some whooping cranes winter with migratory sandhills and use the same habitats (Urbanek 1988). However, use of a release site for juveniles that is separate from the wintering area of older birds has been highly advantageous by allowing use of the same isolated, well-constructed, and protective pensite for multiple years. This winter release strategy minimizes the problem of dominant older birds interfering with the feeding by the

juveniles and driving them into unprotected roosting habitat.

Management during Summer and Migration

Once the birds began migration from the winter release site, this cohort required no further assistance from monitoring personnel to ensure survival or improve behavior. Concerns involving exposure to human activity occurred mainly during spring wandering and were largely resolved after the birds returned to the refuge and associated with sandhill cranes. Some interference with training of the new juveniles by the yearlings occurred on the refuge training sites. However, the latter required minimal intervention (i.e., frightening the older birds from sites).

Evaluation of Reintroduction after the First Year

Survival of the migratory whooping crane flock was 100% after additional measures to protect juveniles from predators at the winter release pen were implemented. The initial cohort completed their unassisted first migration cycle from Florida to Wisconsin and back to Florida with no mortality. Development of adequate foraging, roosting, social association, and human avoidance behaviors raises the probability that a self-sustaining population can be established by these methods. Three requisites are necessary for a reintroduction to be successful:

(1) Suitable reintroduction area (particularly the breeding area in a migratory population).

(2) Effective reintroduction techniques.

(3) Experienced, skilled, and talented personnel who can implement these techniques and understand how to effect the transition from captive-reared to wild birds.

These three determinants of success are met in the eastern migratory whooping crane reintroduction.

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