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PROMOTING WILDNESS IN SANDHILL CRANES CONDITIONED TO FOLLOW AN ULTRALIGHT AIRCRAFT

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Abstract: During the 1998 field season, we developed and tested a new protocol to teach sandhill cranes (*Grus canadensis*) to follow ultralight aircraft yet avoid humans. Although successful in teaching the cranes a migration route, our previous migration (1997) resulted in birds that were overly tame and sought association with humans. For this study, 16 sandhill cranes were costume-reared at USGS Patuxent Wildlife Research Center and transported to Ontario shortly before fledging. After the birds learned to follow the aircraft, 14 were transported to an isolated wintering site in South Carolina, 1300 km south of the training area. Twelve arrived safely. Eleven of 12 birds survived the winter. All of these 11 cranes moved north to Cape Hatteras in early May. Thereafter, 6 of the cranes were captured and translocated to northern New York state. The remaining 5 returned to South Carolina, autumn 1999. Prior to capture, although the cranes sometimes allowed humans to approach them, none of the cranes approached buildings or humans.

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Key words: human avoidance, migration, sandhill crane, ultralight aircraft, whooping crane, wild behavior.

In the early 1940's, only 16 whooping cranes (*Grus americana*) remained of the thousands that once inhabited much of North America. The slow recovery of the species has paralleled the evolution of a conservation ethic in the United States, and the whooping crane has become a symbol for the conservation of all endangered species. Today there are approximately 250 birds in propagation centers in Canada and the U.S. About 180 survive in the single wild, migratory flock and another approximately 80 birds remain in an experimental release program in Florida.

To promote recovery of the species, the U.S./Canada Whooping Crane Recovery Team has recommended that additional populations, each of at least 25 breeding pairs, be established. Toward this goal, Operation Migration and others have conducted a series of experimental migrations using sandhill cranes as research surrogates (Clegg et al. 1997, Ellis et al. 1997 and other papers in this proceedings). This investigation was a further step in this process. Our 1997 study (Duff et al. 2001), like some of the earlier motorized migrations cited above, showed that cranes led south by aircraft would initiate a return migration to their fledging grounds without the aid of wild cranes. Unfortunately, our 1997 birds became too tame and often landed in schoolyards and other areas near humans. This behavior may be the result

of similarities between the schoolyards and the chain-link fences and large areas of cut grass at USGS Patuxent Wildlife Research Center (Patuxent).

Other factors that may have contributed to the taming of the cranes in 1997 were the short poncho-type costume we used; it was not long enough to completely disguise the human form. Protocol violations in Canada and on migration (i.e., the crew would sometimes talk in the presence of the birds) likely also contributed.

Further, we conditioned the birds to follow handlers instead of the aircraft. During the early training at Patuxent, the birds were led ca 200 m from the aviary to the aircraft behind walking handlers. This problem became evident once the birds were transported to Canada where they were reluctant to follow the aircraft unless it was accompanied by running handlers. Additional human contact time was required to correct this problem, and this may have further contributed to the birds' tameness. Conversely, in other studies (e.g., Urbanek and Bookhout 1992), contact with costumed humans was lengthy (however these caretakers never spoke aloud in the cranes' presence) without resulting in excessive tameness.

The 1998 study was designed to correct these shortcomings and to condition the cranes to follow an ultralight aircraft yet successfully integrate into the wild and avoid humans. To test for wildness, we provided the birds with an isolated wintering area. To avoid unnecessary cost and time, we did not lead the birds with the aircraft for the full distance

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of the migration, but instead we transported them most of the distance to the wintering site in a trailer. To provide at least a minimum of orientation clues, the cranes were led by aircraft the last 108 km to the southern terminus.

METHODS

Rearing

At Patuxent, we hatched 16 greater sandhill crane (*G. c. tabida*) chicks from captive breeders and reared them according to the techniques outlined by Ellis et al. (1992) except live imprinting models were not used because they were intolerant of the aircraft. Tape recordings of the aircraft engine were played 4 times daily (ca 15 min/bout) to pre-hatch eggs (beginning 3 days prior to hatching) and chicks (Lishman et al. 1997). Recordings of natural wetland sounds were used in the aviary to mask the noise of human activity. Handlers refrained from talking and wore costumes that extended to mid-calf. We also replaced the red cap used in 1997 with gray fabric to avoid drawing attention to the handler's head. A hand puppet was used extensively to provide mealworms while interacting with the chicks (Horwich 1989, Archibald and Archibald 1992). The chicks were grouped together in small cohorts at about 33 days of age.

At a mean age of 7 days (Table 1), we introduced the chicks to the aircraft. First introduction was the first time they were fed mealworms with the puppet head extended from the parked aircraft while the engine was running. This familiarized them to the sight and sound of the aircraft and the wind created by the propeller. To allow us to taxi the craft directly to the aviary, we removed the wing from one of the Cosmos aircrafts. We also built a circular pen of plastic fence 60 cm high and 10 m in diameter at Patuxent. At a mean age of 15 days (Table 1), the handlers began leading the chicks behind the aircraft while in this enclosure. The wingless aircraft was taxied around the outside, and the birds could follow from the inside while remaining protected from injury by the fence. A second, smaller pen was erected in the center of the circle: birds that would not follow were placed in this area to watch the training. This form of "abandonment conditioning" (Ellis et al. 2001) encouraged reluctant chicks to follow the aircraft. Beginning at a mean age of 25 days (Table 1), one handler would use the wingless aircraft to lead small groups of birds in an open field. These practices eliminated the need for extra people and avoided having the birds follow walking handlers. Sessions with the aircraft lasted for 15–20 min for each chick and occurred every 2–3 days, weather permitting. Training was conducted in the early morning to avoid overheating. All birds were handled

Table 1. Rearing history of 16 greater sandhill crane chicks reared at Patuxent, 1998.

	Age ^a	Range
First exposure to aircraft	6.6	4-10
First followed aircraft in circular pen	14.5	8-24
First followed aircraft in open field	25	19-31
Cohorts formed in group pen	33	32-41
Shipped to Canada	40	36-54

^aAge in days since hatching.

and examined/treated in costume and no human avoidance training was conducted while the birds were at Patuxent.

The Canadian Armed Forces, Air Command transported the 16 birds to Canada on 10 June 1998 at a mean age of 42 days (Table 1). The shipping containers had plywood tops, bottoms, and doors but corrugated cardboard sides and an Astroturf substrate. The smooth sides reduced feather damage.

Flight Conditioning, Ontario

We began flight training on 14 June 1998. The training schedule was altered to promote following. If the birds were reluctant to follow the aircraft, additional sessions were added until they showed little hesitation. Thereafter, we curtailed training for 2 days to avoid unnecessary human contact. We penned and trained the birds in 3 groups (5, 5, and 6 birds). They were exposed to the aircraft at least every third day, weather permitting.

To provide a less-like-a-schoolyard environment, we constructed a portable pen made of 1.98 x 3 m panels covered in heavy camouflage fabric to act as a visual barrier. We placed tree limbs in and around the pen to disrupt pen lines. Feeders and shade shelters were painted in earth-tones and the back of the pen was made of open fencing to allow a view of the wetlands. We removed all human paraphernalia and restricted the number of handlers. A double strand of electric-fence wire protected the perimeter of the pen from predators. The top-netted enclosure measured ca 18 x 20 m and was divided to accommodate the 3 groups. On 3 August 1998, we removed partitions to allow the birds to integrate. The staff left a 5 m long free-standing fence in the center of the enclosure. Open at both ends, this barrier allowed smaller birds to escape the aggression of those more dominant. We

constructed our runway directly beside the pen. This allowed the pilots to control the release of birds, eager to fly after being confined overnight.

After each training session and on days when the weather disallowed flight training, we released the birds to forage in the fields and marsh. The flock was regularly left unattended for 10-14 hours, but was encouraged to return to the pen each night by withholding food. Each evening, stragglers were herded into the pen.

During the week preceding departure, the crew fitted all birds with conventional radio transmitters and two birds received satellite transmitters (PTTs). Conventional radios were placed on the left leg above the hock. Colored ID bands were placed above the right hock: USFWS metal bands were placed on the left tarsus (i.e., just above the toes).

Equipment

Two Cosmos, Phase II, "weight-shift" controlled, ultralights known as "Tikes" powered by Rotax 503, 50 hp engines with 4 to 1 reduction drives and 6-blade propellers (much quieter than propellers with fewer blades) were used as lead planes. This aircraft was selected because of its maneuverability, its capability for short field landings, and its ease of transport. Several wings of different sizes are available for this trike. They can be changed easily to control airspeed. Initial training with the birds was conducted using an Atlas 21-m² wing with a speed of 40–65 km/hr. Once the birds matured and during migration, a Zoom 19-m² wing was used with a speed of 48–95 km/hr. For moving the aircraft quickly, it was fitted with an Echo 12-m² wing with a speed of 56–128 km/hr. Both aircraft were fitted with bird guards, radios, and G.P.S. (Global Positioning System) navigation units.

Migration

We left for the wintering area on 15 October 1998. Fourteen birds were transported in a custom-built trailer measuring 4.3 x 1.8 x 1 m. We divided the container into 3 equal sections, each with top ventilators. We made 3 stops during the first leg of the trip, arriving in Maryland in the early morning of the following day. During 1 of these stops, we released the birds into a temporary pen to allow them to rest for 3 hr. One bird was lost to aggression. To avoid further aggression, we put each bird into a cardboard shipping box for the remainder of the trip. On 17 October, we led the birds on a 17-min exercise flight, then continued to Green Sea, South Carolina. After allowing the birds to recover for 2 more days at Green Sea, we used 2 ultralight aircraft to lead the flock the last 108 km to the wintering site at the Tom Yawkey Wildlife Center (Yawkey Center) in South Carolina.

Overwintering

At first, the birds were allowed to fly free during the day and confined at night in a holding pen constructed within a large release pen. After 4 days, the holding pen was removed, allowing the birds full freedom. We used the aircraft to lead the birds on several local flights to familiarize them with the area. No human avoidance training was conducted and all handling was done in costume.

We encouraged the flock to stay in the area by placing a costumed dummy in the pen and by providing ample food. A costumed handler monitored the birds over the winter and visited the pen area twice daily for the first 3 weeks. We reduced these visits to once per day for an additional 3 weeks and then to once every third day. This contact was ended in early March 1999, and thereafter we monitored the birds only from afar (with binoculars and radio receivers).

STUDY AREAS

Propagation Site

Birds were hatched and reared for the first month at Patuxent (39°N 77°W), part of the 500 ha Patuxent National Wildlife Refuge, a controlled access, research refuge near Washington, D.C.

Fledging Grounds

Ontario became the northern terminus because of its convenience to the senior authors and lack of an existing population of wild sandhill cranes. The USFWS permit required that the birds be removed from the wild at the completion of the study, therefore a possible long-term impact on the flyway was not factored into the study area selection. We selected a fallow field on the southern tip of Scugog Island (44°N 79°W) near Port Perry, Ontario as the fledging grounds. This isolated upland provided flat ground from which to operate our aircraft and was bordered on 3 sides by 3,250 ha of privately owned wetland. The pen was situated next to the flying field. The nearest buildings were 600 m to the north and hidden by 2 tree lines. Predators on the area included red foxes (*Vulpes vulpes*), coyotes (*Canis latrans*), raccoons (*Procyon lotor*), and feral dogs.

Wintering Grounds

The Yawkey Center in South Carolina (33°N 79°W) was selected as the wintering grounds because its managers invited and offered to host the project. Other favorable factors were its lack of wild cranes and the isolation it provided. This facility, maintained by the state of South

Carolina, encompasses 8,100 ha of controlled wetland. Surface access to the island is by appointment only and limited to a ferryboat crossing of the Intracoastal Waterway.

The release pen, erected in an area known as the Goose Pasture, was constructed 400 m from the access road and in water from 7 to 35 cm deep. The pen was built of 1.5-m white plastic fencing, was tie wrapped to "T" posts, and measured 77 x 46 m. Three stands of electric wire protected the outside perimeter. In the center of the enclosure, we used black "flight netting" to create a temporary circular holding pen, 12 m in diameter.

Potential predators on the center include golden eagles (*Aquila chrysaetos*), bald eagles (*Haliaeetus leucocephalus*), bobcats (*Lynx rufus*), raccoons, and alligators (*Alligator mississippiensis*). Several bobcats were seen in the immediate area. This species was believed to be the greatest threat to our birds.

Managers control water salinity in the area. They had raised salinity to 10 ppt by the time of our arrival. Due to a local drought, the brackishness naturally increased to 20 ppt by November. In response, we dug a 0.5 m deep (4 m wide) hole on higher ground 100 m south of the pen to provide a nearby source of fresh water.

Birds were monitored by daily visits to the pen area. When the birds were absent, we recorded locations reported by land managers in the vicinity.

RESULTS

Rearing and Training

While the birds were at Patuxent, our modifications of the training protocol produced birds that were more anxious to follow the aircraft than in 1997. This resulted in a significant reduction in the amount of human contact time. In 1997, we spent approximately 181.5 hr (from when the birds arrived in Canada until the start of the migration) interacting with the flock and performing flight-conditioning exercises. By comparison, this involvement was reduced to 63.7 hr in 1998.

Sixteen birds were transported to Ontario on 10 June 1998. Subsequently, one bird was attacked by pen mates and euthanized (Table 2). Despite a propeller guard, another bird was struck by the propeller of the taxiing aircraft. The injury limited this crane's flight ability and it too was removed from the study (Table 2).

By mid-August, the birds began to follow the aircraft in the air. Initially these exercises consisted of a short flight around the field and a landing back at the pen area. As endurance improved and distances increased, the birds continued to return to the pen after each flight. This established a habit which became a problem when we tried to

Table 2. Training, migration, and dispersal history of 16 greater sandhill cranes involved in the 1998 experiment.

ID	Fall and Winter	Fate
351	wintered at Yawkey	returned to Yawkey, fall 99
352	wintered at Yawkey	translocated to NY, July 99
353	wintered at Yawkey	returned to Yawkey, fall 99
354	wintered at Yawkey	returned to Yawkey, fall 99
355	wintered at Yawkey	translocated to NY, July 99
356	wintered at Yawkey	translocated to NY, July 99
357	wintered at Yawkey	returned to Yawkey, fall 99
358	wintered at Yawkey	translocated to NY, Jul 99
359	lost 26 Nov 99	recovered dead at Yawkey, 27 Nov 98
360	euthanized 15 Oct 98	struck by UL propeller
361	wintered at Yawkey	returned to Yawkey, fall 99
362	wintered at Yawkey	translocated to NY, Jul 99
363		removed from study
364	euthanized 3 Aug 98	attacked by penmates
365	lost during migration 21 Oct 98	recovered dead in Florida, 24 Nov 99
366	wintered at Yawkey	translocated to NY, Jul 99

make longer flights: very often the birds turned back shortly after take off. We corrected this problem by transporting selected groups in a trailer to neighboring airfield unfamiliar to the birds. After release, the flocks immediately lifted off and showed no hesitation in following the aircraft over new territory. Maximum flight duration prior to migration was 1 hr 40 min, and that bout ended due to rough air rather than any visible signs of fatigue in the flock.

After each training session, the flock was released to forage afield. The cranes frequented a marsh adjacent to their pen and spent much time in water about 15–20 cm deep. An hour before sunset, we opened the door to the roost pen so that by sunset each day the birds had entered the pen. Thereafter, we closed the pen door.

Migration

We postponed the start of the migration because of delays in obtaining permits. Fourteen birds, having been preconditioned to ride in the trailer, were loaded before dawn on 15

October 1998. After about 5 hr in the trailer, we found that 1 of the subordinate birds had been attacked by a penmate: the injured bird was euthanized immediately. The aggressor, identified by its bloodied bill and breast, was moved to a transport box.

After several unexpected delays and fearing continued aggression, we made an unscheduled stop in Pennsylvania where we set up the temporary pen. While at this location, the crew purchased cardboard shipping containers of the correct size and boxed the birds individually for the remainder of the trip. In total, the birds were boxed for 18 hr in 2 bouts. We allowed the birds to recuperate for 3 days at the Patuxent River Park in Maryland. During this stay, Glenn Olsen, D.V.M. at Patuxent, examined the birds for injuries. During the second leg of the trip, the birds were crated for 10 hr while we traveled to Green Sea, South Carolina. This location is 108 km north of our destination and on a direct line between the fledging area and the wintering grounds.

On 21 October 1998, after allowing the birds to recover for 2 days, we led the flock the remaining distance using 2 ultralight aircraft. Local winds were 10–15 Kt. from the north and the temperature was a cool 16°C. Low-level turbulence made flying close to the birds difficult, but the flock did follow the aircraft. Ten km to the south and while struggling to gain altitude, one bird broke away from the group and headed north. The senior author continued on with the main flock, while chase pilot Clark intercepted the errant bird and redirected it. During this maneuver, another bird (Table 2) broke away from the lead aircraft and also headed north. Although in radio communication, Clark was unable to locate the second bird. We continued on course, but we recorded the location of the disappearance using a G.P.S. receiver.

Above 300 m, the air was smoother and the tail wind allowed a ground speed of 107 km/hr. Total duration of the trip was 1 hr 15 min. Once at the Yawkey Center, the birds (now numbering 12) were penned in an isolated field. High winds prevented an aerial search for the missing bird, but after landing, part of the crew drove to the location and detected a strong transmitter signal. A group of dogs flushed the bird before it was captured. Despite an exhaustive 2-day search of the area, the bird was not located again. It was recovered dead in central Florida in November 1999 (location 29.96.00°N, 81.16.20°W).

Overwintering

The birds were moved to the newly constructed release pen. They were contained in the holding pen only during the night. After 4 days, we rolled up the side most 2 m of the net leaving a net only over the feeding station. This allowed the birds their freedom plus access to their feed, while protecting

them from overhead predators such as golden eagles. We used the aircraft to lead the flock on 3 local flights (over a 4-day period) to familiarize them with the area. Handlers encouraged the flock to stay in the area using a costumed dummy, daily visits by a costumed handler, and an ample food supply. By positioning the costumed dummy ca 18 m from shore, we encouraged the birds to roost in water.

On 26 November 1998, four birds were seen foraging 100 m from the release pen. Later that day, we noted that these same 4 birds were absent. The following day, we discovered the carcass of one of the missing birds (Table 2). Based on its condition, we concluded that the bird was taken by a bobcat. It was not until 3 days later that the rest of the missing birds returned to the pen area.

Wildness

Two criteria were considered in evaluating wildness. First, how closely could the cranes be approached, and second, what was their propensity for associating with people after they left the isolation of the wintering area.

On 19 March 1999, the senior author returned to the Yawkey Center to apply the first test before the birds were expected to depart on spring migration. During the visit, the birds spent most of their time ranging over a wide area. They moved as a cohesive flock. While they were away from the release pen, it was dismantled and removed. While the pen was being removed, the birds began approaching the workers. When the birds were 100 m away, they were flushed using a pickup truck.

The following day, the senior author and 3 members of the Yawkey Center staff (all uncostumed) tried to approach the flock while the cranes foraged in an open upland 300 m from where the pen had been located. At a distance of 75 m, the birds appeared to be alert and displayed pre-flight posture (Ellis et al. 1998). Two members of the team proceeded to close in on the flock while the others remained behind. At 50 m, the birds flushed and landed 500 m to the north in open water ca 45 cm deep. After the birds took off, 1 of the crew fired a shotgun as human-avoidance conditioning. These 2 instances were the only tests of wildness and the only bouts of human-avoidance conditioning performed prior to spring migration.

In mid-April, the birds began moving into and out of range of the radio tracking devices. Later, they moved to undetermined locations and returned approximately every 4 days. Although corn, a favored food, was broadcast on the ground in the area that the birds frequented, they appeared to be consuming only small amounts. This was taken as a positive sign and as an indicator that they were finding sufficient natural food.

On 6 May 1999, the flock left the Yawkey Center for an

extended period. Prior to their departure, they were seen in the company of a wild sandhill crane. Satellite fixes indicate that both of the PTT-equipped birds, and presumably the remainder of the flock, moved north up the Atlantic Coast to North Carolina.

From 8 May 1999 until 19 May 1999, the flock remained in the Croatan National Forest and Cedar Island National Wildlife Refuge (35°N 76°W) in Carteret County, North Carolina. All of the birds, including a wild sandhill crane, were also seen on a 20,000 ha farm near Beaufort, North Carolina. Here they reportedly were feeding on soy beans and were unapproachable. On 21 May 1999, it was confirmed that all 11 birds plus 1 wild bird were again at the Yawkey Center. In June they move back to Beaufort.

The study officially ended in July 1999. However, some members of the U.S./Canada Whooping Crane Recovery Team believed that much could be learned by transporting the birds to a northern summering area. A Patuxent crew captured 6 of the birds (Table 2) on 20 July 1999. The birds were trucked north and released at the Iroquois National Wildlife Refuge in New York (43°N 79°W). This cohort then moved east to the Never Sink River district (42°N 75°W) northwest of New York City. They were later reported near Grimsby, Ontario, Canada. Unfortunately, at this location these birds were hand-fed by well-meaning people and became rather tame. In summary, although the birds appeared tolerant of people, reports indicated that they did not initiate contact with humans and with each move they stopped in an isolated spot in proper habitat. Later that summer, the 5 birds that were not transported to New York (Table 2) plus the wild sandhill crane returned to the Yawkey Center and subsequently moved 160 km further south to the Donnelly Wildlife Management Area, also in South Carolina. These birds never approached humans although they did sometimes allow human approach.

As expected, the birds from this study did not complete a northern migration. The flock did, however, show a tendency to move north (although the wild crane could have initiated this movement). They did display behavior we hoped to encourage. They foraged like wild sandhill cranes on natural foods or in farmlands, they showed a preference for proper habitat and avoided high grass or brushy vegetation, and they roosted in water. We never received any report that they ever approached schoolyards or other zones of human habitation.

DISCUSSION

To reestablish migratory flocks of whooping cranes in eastern North America, the initial flock will be conditioned to follow an ultralight aircraft. Achieving this requires extensive human interaction. Most of the experiments to date have

resulted in birds with little or no fear of humans. This "tameness" can be corrected to some degree by releasing the birds with wild cranes (Clegg et al. 1997; Ellis et al. 1997, Ellis et al. 2001). Unfortunately, there are no wild whooping cranes in the eastern flyway, so other methods of promoting wildness were sought in this study.

To achieve the goals of promoting a strong association with the aircraft while still having the cranes avoid humans, we focused on reducing human contact and providing the birds with opportunities to follow the motorized craft rather than humans. Our modifications to the 1997 training protocol achieved these results. Changes included redesigning the costume, refraining from talking, extensive use of hand puppets and brood models, removing the aircraft wing to allow it closer access to the aviary, and using a circular pen to reduce the number of handlers required and to allow the colts to follow the aircraft rather than the caretakers. Once in Canada, we used a more isolated fledging area and situated the pen closer to the airfield to allow for coordinated takeoffs without requiring the birds to first follow humans, then the aircraft. Our pen had minimal human paraphernalia and we restricted the presence of handlers and visitors.

We also released the flock to forage for long periods during the day. Although stressful for the crew, these daily release sessions served several purposes. First, the birds learned to forage on their own and contend with natural predators. Second, they were free from human interaction. Third, they established their dominance structure in a more natural environment. The social hierarchy functions on the ground and when the birds are flying. We have learned that if birds are reared and conditioned to follow the ultralight in separate groups, when 2 or more cohorts are integrated, the dominant members struggle for leadership. This often results in birds breaking away from the aircraft and calling others to join them. Carefully monitoring and managing the dominance hierarchy can greatly reduce the amount of human interaction with the cranes and encourage the flock to follow the aircraft.

A final aid to promoting wild behavior was selecting an isolated wintering site and using a large release pen. This allowed the birds to fly free yet be protected from predators while they were learning to forage afield and roost in water.

Additional study is needed to further reduce human interactions and to further develop a human avoidance training protocol. With the changes that are likely to accompany a shift to working with whooping cranes, it will become more difficult to avoid too much human contact and the resultant taming. This shift to whooping cranes will also increase interest from the public communication media and make controlling the birds' experiences with humans even more difficult.

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