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PROCEEDINGS OF THE THIRTEENTH NORTH AMERICAN CRANE WORKSHOP-- Abstracts

David A. Aborn

Richard P. Urbanek

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ASSESSMENT OF THE EASTERN POPULATION GREATER SANDHILL CRANE FALL SURVEY, 1979-2009

COURTNEY AMUNDSON, University of Minnesota, St. Paul, MN 55108, USA

DOUGLAS JOHNSON, U. S. Geological Survey, Jamestown, ND; and University of Minnesota, St. Paul, MN 55108, USA

SEAN KELLY, U.S. Fish and Wildlife Service, Region 3, St. Paul, MN 55437, USA

TOM COOPER, U.S. Fish and Wildlife Service, Region 3, St. Paul, MN 55437, USA

Abstract: The Eastern Population of sandhill cranes (*Grus canadensis tabida*) has been monitored since 1979 with a ground-based survey that involves counting cranes at staging areas throughout their fall migratory range. The fall count suggests the Eastern Population is rapidly increasing, and recently a management plan was developed that includes provisions for harvesting cranes. We analyzed the fall survey data and compared results to the Breeding Bird Survey and Christmas Bird Count to assess a) the population trajectory of eastern cranes, and b) whether the fall survey is adequate to establish harvest limits in the Mississippi and Atlantic flyways. All 3 surveys indicate the Eastern Population has increased 3.4-10.0% annually. The fall survey seemed adequate for tracking population change but did not portray the geographic expansion of the population as well as either the Breeding Bird Survey or Christmas Bird Count. The fall survey lacks statistical rigor and could be improved by revising criteria for site selection, standardizing protocols, and adjusting for counting bias. An aerial survey similar to that used for Midcontinental sandhill cranes could replace the existing fall survey and provide more reliable results but would be expensive to implement and maintain. The Christmas Bird Count is an unattractive alternative to the fall survey because Eastern Population cranes cannot be distinguished from the resident Florida population. The Breeding Bird Survey, in contrast, can distinguish and account for both range expansion and varying density within the breeding range, has a long-term history and standardized protocols, and would involve minimal additional cost.

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Key words: Eastern Population, fall survey, *Grus canadensis tabida*, sandhill crane.

FACTORS INFLUENCING GREATER SANDHILL CRANE NEST SUCCESS IN NEVADA

CHAD AUGUST, University of Nevada-Reno, Reno, NV 89557, USA

JAMES SEDINGER, University of Nevada-Reno, Reno, NV 89557, USA

CHRIS NICOLAI, U.S. Fish and Wildlife Service, Reno, NV 89502, USA

Abstract: The Lower Colorado River Valley population of greater sandhill cranes (*Grus canadensis tabida*) that nests primarily in northeastern Nevada, is the smallest population of migratory sandhill cranes and has the lowest reported recruitment rate (4.8%) of any crane population in North America. No studies exist that have estimated demographic parameters for this population. Accurate parameter estimates are vital to management of this population. To identify factors limiting recruitment in this population, we monitored 160 greater sandhill crane nests in northeast Nevada during 2009-2010. We used maximum likelihood based approaches in Program Mark to assess models of nest survival and estimate parameters. We estimated daily survival rates from the best supported model corresponding to Mayfield nest success of 36 and 29% for 2009 and 2010, respectively. We found the best supported model describing nest success contained the explanatory variables, year, water depth, vegetation height, and a trend in daily nest survival over a 30-day nesting cycle. Water depth and vegetation height had a significant positive impact on daily survival rates. We found key factors limiting greater sandhill crane nest success may also have the greatest potential for management to improve recruitment. We suggest that landowners reduce rate of water withdrawal and protect areas of dense vegetation.

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Key words: *Grus canadensis tabida*, Lower Colorado River Valley population, nest success, Nevada, sandhill crane.

INFLUENCE OF FOOD AND PREDATOR ABUNDANCE ON STRESS LEVELS OF SANDHILL CRANES WINTERING IN NORTHERN MEXICO

INGRID BARCELO, Platte River Whooping Crane Trust, 6611 West Whooping Crane Drive, Wood River, NE 68883, USA

FELIPE CHAVEZ-RAMIREZ, Gulf Coast Bird Observatory, Lake Jackson, TX 77566, USA

Abstract: Intense and prolonged stress among birds affects survival and productivity. Stress levels, measured as levels of corticosterone hormones, may be influenced by food resources and predator recognition. However, few studies have explored the effects of such conditions on stress in wild birds. We evaluated the relationship between food and predator abundance on stress levels of sandhill cranes (*Grus canadensis*) wintering in wetlands in Northern Mexico during 2 winters, 2007-08 and 2008-09. Corticosterone was measured from fecal samples using an Enzyme Immunoassay (EIA). Cranes wintering in wetlands with low food abundance had higher levels of corticosterone ($\bar{x} = 1149.0 \pm 328.0$ SE), than those in areas with high food ($\bar{x} = 99.3 \pm 3.4$ SE). Cranes wintering in wetlands with high predator abundance showed higher levels of corticosterone ($\bar{x} = 1953.0 \pm 373.0$ SE) versus those in wetlands with low predator abundance ($\bar{x} = 116.7 \pm 6.2$ SE). Our results demonstrate the influence of 2 key environmental factors on stress among wild birds and represent the first account of such influences in cranes.

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Key words: corticosterone, food resources, *Grus canadensis*, Northern Mexico, predator abundance, sandhill crane, stress.

A SUSTAINABLE SOLUTION FOR CROP DAMAGE BY CRANES AND OTHER BIRD SPECIES TO PLANTED SEED

JEB BARZEN, International Crane Foundation, Baraboo, WI 53913, USA

ANNE LACY, International Crane Foundation, Baraboo, WI 53913, USA

Abstract: Our objectives were to determine if sandhill cranes (*Grus canadensis tabida*) selected emerging corn within and between anthraquinone-treated or non-treated fields, and then to evaluate the efficacy of chemical deterrent methods. We studied the location, habitat, number and behavior of cranes in a 6,500-ha study area during 2006-2009 in south-central Wisconsin. Cranes used corn fields when they were vulnerable to damage (corn emerging day 1-17) more than non-vulnerable corn (emerging day 18-35, $F = 4.39$, $P = 0.04$). Within the period of corn vulnerability to crane damage, no damage to emerging seedlings occurred in treated fields while most non-treated fields were damaged extensively ($F = 45.0$, $P < 0.001$). Crane numbers in treated fields, however, did not differ from cranes using non-treated fields ($F = 0.009$, $P = 0.92$). When in non-treated fields, crane numbers correlated inversely with corn seedling density ($R^2 = 0.84$) but were uncorrelated with seedling density in treated fields ($R^2 = 0.03$). While cranes generally prefer emerging cornfields (i.e., between field selection), the treatment of planted corn *within* a field effectively reduced damage. Unlike other abatement methods, seed treatments reduce damage to germinating corn without affecting crane distribution. Measuring preference at both scales of selection identified key ecological constraints that damage control activities must incorporate to design successful abatement protocols. Most importantly, this technique has been deployed by individual landowners statewide in relation to crane distribution at an ecologically significant scale. Over 57,000 acres of corn were treated in Wisconsin during 2010 alone.

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Key words: anthraquinone, chemical deterrent, corn, crop damage, *Grus canadensis*, sandhill crane, Wisconsin.

MODELLING THE EFFECT OF LANDSCAPE AND ENVIRONMENTAL FACTORS ON SANDHILL CRANE DISTRIBUTION IN THE CENTRAL PLATTE RIVER VALLEY OF NEBRASKA

TODD J. BUCKLEY, University of Nebraska-Lincoln, Lincoln, NE 68588, USA

FELIPE CHAVEZ-RAMIREZ, Gulf Coast Bird Observatory, Lake Jackson, TX 77566, USA

LARKIN A. POWELL, University of Nebraska-Lincoln, Lincoln, NE 68588, USA

ANDREW J. TYRE, University of Nebraska-Lincoln, Lincoln, NE 68588, USA

Abstract: Each spring, most of the midcontinent population of sandhill cranes (*Grus canadensis*) stage in the Central Platte River Valley (CPRV) in Nebraska due to its importance in their annual cycle. The purpose of this study was to model the landscape and environmental factors effecting observed habitat use by cranes. Habitat use models were developed and ranked using Bayesian Information Criteria (BIC) and discriminated using the Receiver Operating Characteristic (ROC) curve. This study suggests cranes show a high preference for alfalfa fields as feeding habitat, but preferences for corn and sorghum fields are similar. Soybean fields were less likely to be used than both corn and sorghum, while winter wheat was the least likely row crop used for feeding. Cranes also showed a low preference for grassland habitats, however, this is likely due to limited grassland availability in the survey area and sampling protocol. The location of these habitats was also an important factor influencing crane use. Habitat use was greatest within bridge segments 2 to 7 and 9, but use decreased as distance from the river increased. Bridge segments 1 and 8 were used similarly, while bridge segments 10 and 11 had the lowest likelihood of use. Overall, it is evident cranes have a higher preference for certain habitats in certain areas. Models developed in this study provide baseline data with a practical use to directly value land for cranes within the CPRV, locate areas with the potential to support cranes, and develop management plans for areas currently used.

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Key words: Central Platte River Valley, *Grus canadensis*, habitat, landscape, Nebraska, sandhill crane.

DIFFERENCES IN HABITAT USE BY WHOOPING CRANES OBSERVED IN NATURAL AND URBAN AREAS OF TEXAS DURING WINTER 2009-2010

MERY CASADY, University of Nebraska at Kearney, Kearney, NE 68849, USA

LETITIA M. REICHART, University of Nebraska at Kearney, Kearney, NE 68849, USA

Abstract: Since 1938 the wild whooping crane (*Grus americana*) population has grown from 18 individuals. Although population growth occurred, available habitat for cranes has decreased, especially on wintering grounds. In response, some cranes now use urban areas in addition to natural winter habitat. Typical winter habitat in natural areas includes bay, marsh, and upland habitats; however, in urban areas these differ from those in natural areas. In urban areas, bay and marsh habitats are reduced and upland habitat includes agricultural fields or private yards where corn feeders are often present. Currently, research is needed to determine habitat use and potential negative threats for cranes frequenting urban areas compared to cranes using natural areas. Here we examine habitat use by whooping cranes in urban and natural areas near Aransas National Wildlife Refuge (ANWR), Texas. Behavioral observations of whooping cranes were collected in natural and urban areas during winter 2009-10. We recorded observations in natural areas ($n = 112$ observations) and in urban areas ($n = 99$ observations). Family groups (2 white birds and 1 brown juvenile), adult and/or sub-adult groups (3 or more white individuals), pairs (2 white individuals) and single animals were observed in both areas. In natural areas we observed birds in marsh ($n = 91$ observations), upland ($n = 16$ observations), and bay habitats ($n = 5$ observations), although access to the bay within ANWR was limited. In urban habitats we observed birds in upland ($n = 51$ observations), marsh ($n = 31$ observations) and bay habitats ($n = 17$ observations). Thus, preliminary analysis suggests whooping crane habitat use differs between urban and natural areas.

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Key words: Aransas, *Grus americana*, habitat use, urban areas, whooping crane.

MEASURING FECAL CORTICOSTERONE IN WILD WHOOPING CRANES

MERY CASADY, University of Nebraska at Kearney, Kearney, NE 68849, USA

LETITIA M. REICHART, University of Nebraska at Kearney, Kearney, NE 68849, USA

ANDREW K. BIRNIE, University of Nebraska at Omaha, Omaha, NE 68182, USA

JEFFREY A. FRENCH, University of Nebraska at Omaha, Omaha, NE 68182, USA

Abstract: Non-invasive measures of hormones in animals can be a useful tool for understanding physiological mechanisms that may lead to changes in behavior, survival, and reproduction. Specifically, measures of fecal corticosterone metabolites (CORT), the primary stress hormone in birds, have been correlated with environmental changes, such as food abundance, habitat alteration, and human disturbance. In this study we provide the first measure of fecal CORT for individuals from the wild population of whooping cranes (*Grus americana*). Habitat alteration and urbanization on the wintering grounds are major threats to the wild population of whooping cranes, thus it is important to determine a possible method to assess physiological health of the population using a non-invasive technique. During winter 2009-10, fresh fecal samples ($n = 32$) (i.e., less than 1 hour old) were collected from accessible areas where whooping cranes were observed within and around Aransas National Wildlife Refuge, Texas. We used an ethanol extraction to isolate endogenous CORT from fecal samples. The enzyme-immunoassay (EIA) was validated by showing parallel immunoactivity of endogenous CORT to that of the assay standards. Fecal CORT was measurable in wild whooping cranes where mean CORT concentration was 2.14 ng/g feces (± 1.96 SD). Measures of fecal CORT ranged from 7.08 to 0.16 ng/g feces, although there was no significant difference between samples collected from different locations ($F_{8,23} = 0.898$, $P = 0.534$). Future studies will determine whether measures of fecal CORT vary with respect to foraging behavior and structure of whooping crane social groups.

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Key words: Aransas, fecal corticosterone, *Grus americana*, whooping crane, wild population.

POTENTIAL IMPACT OF CLIMATE CHANGE SCENARIOS ON WHOOPING CRANES

FELIPE CHAVEZ-RAMIREZ, Gulf Coast Bird Observatory, Lake Jackson, TX 77566, USA

Abstract: The whooping crane (*Grus americana*), a rare and critically endangered species, is wetland dependent throughout its life cycle. The whooping crane's small population size, limited distribution, and wetland habitat requirements make it vulnerable to potential climate changes. Climate change predictions suggest overall temperature increases and significant changes in precipitation regimes throughout North America. At the individual level temperature changes should have neutral to positive effects on thermoregulation and overall energy expenditure throughout the whooping crane's range. In the breeding grounds, earlier snow melt and increasing temperatures should improve food resources. However, increased precipitation and more extreme rainfall events could impact chick survival if rainfall occurs during hatching. Increased precipitation may also alter fire regimes leading to increased woody plant abundance thus reducing nesting habitat quality. During winter, higher temperatures will lead to a northward shifting of freeze line which will decrease habitat quality via invasion of black mangrove (*Avicennia germinans*). Large portions of current winter habitat may be lost if predicted sea level changes occur. Stopover wetland availability during migration may decrease due to drier conditions in the Great Plains. Current and future conservation actions should be planned in light of not only current needs but also considering future expectations.

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Key words: climate change, *Grus americana*, whooping crane.

WHOOPING CRANE MIGRATION THROUGH THE GREAT PLAINS: CONSERVATION ISSUES

FELIPE CHAVEZ-RAMIREZ, Gulf Coast Bird Observatory, Lake Jackson, TX 77566, USA

Abstract: The whooping crane (*Grus americana*) is a critically endangered species with less than 300 individuals left in the wild. Whooping cranes breed in Wood Buffalo National Park in Canada and winter along the Texas coast at Aransas National Wildlife Refuge and surrounding areas. Whooping cranes migrate south every fall and north every spring through the Great Plains. Whooping cranes use shallow wetlands as stopover roost sites while in migration. Information gathered to date via several sources has defined the migratory route and has allowed for identification of important stopover areas which will be presented. Only 4 migratory stopover sites have been designated as critical habitat for whooping in the entire migratory corridor. Therefore, a significant gap remains in regards to protection of migratory stopover areas for whooping cranes. The migration period is the time of the yearly cycle during which most of the whooping crane mortality occurs and is the period of most concern from a conservation standpoint. Issues of conservation concern during migration include high mortality, stopover habitat loss, lack of protection of important stopover areas, and potential future conflicts with renewable energy source infrastructure. The identification and characterization of stopover areas is of critical concern and some suggestions are made for their evaluation, categorization, and prioritization for protection.

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Key words: Great Plains, *Grus americana*, migration, stopover areas, whooping crane.

VIDEO SURVEILLANCE OF NESTING WHOOPING CRANES

TIMOTHY DELLINGER, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

MARTIN FOLK, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

STEPHEN BAYNES, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

KATHLEEN CHAPPELL, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

Abstract: From 1995 to 2010 we monitored 81 whooping crane (*Grus americana*) nests; of those, only 37 chicks hatched and 11 fledged. It often was not apparent why nests failed and it was not practical to conduct labor-intensive observations at nests; therefore we collected behavioral data using video surveillance cameras at 15 nests from 2000 to 2009. Seven of 15 nests were successful in hatching chicks, while the remaining nests failed during the incubation period. Overall, 1,537.5 and 1,023.5 hours of incubation recordings were examined for successful and failed nests, respectively. No differences were detected in mean incubation bouts (time consecutively sitting on eggs) between successful and failed nests at similar stages in the incubation cycle, suggesting incubation behavior was not the sole cause of nest failure. Average time spent not incubating, however, was significantly different on 4 of 6 days. At failed nests, birds returned to the nest to incubate less frequently due to drought conditions and/or disturbances; likewise, pairs at failed nests appeared to exchange incubation duties infrequently and did not share the duties equally. Among successful nests, mean incubation bouts were 32.5 minutes, although there was a decreasing trend throughout the incubation period. When not sitting on eggs, adults spent on average 1.4 minutes turning the eggs and the mean time neither adult was on nest platform was 1.5 minutes. Video surveillance is a valuable tool for the efficient gathering of behavioral data at whooping crane nests.

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Key words: *Grus americana*, incubation, nests, video surveillance, whooping crane.

COPULATION OF NON-MIGRATORY WHOOPING CRANES IN FLORIDA

TIMOTHY DELLINGER, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

MARTIN FOLK, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

STEPHEN BAYNES, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

KATHLEEN CHAPPELL, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

MARILYN SPALDING, University of Florida, Gainesville, FL 32611, USA

Abstract: Information on copulatory behavior and timing before egg laying is poorly known in wild whooping cranes (*Grus americana*). We monitored 10 crane pairs for breeding behavior prior to and during the 2010 breeding season to document timing of copulations and pre- and post-copulatory behavior. We observed pairs at different times of the day and under differing weather conditions to determine if copulations were more frequent during certain daylight hours or during precipitation. Monitoring began 111 days prior to the start of incubation for the first nest of the season. Pairs were observed for 125.78 hours (mean = 75 min) during 100 observation periods; 17 observation periods occurred on days with precipitation. Three copulations were observed, 2 by the same pair and another by unpaired individuals. The copulations by the same pair occurred 9 and 18 days prior to incubation. The third observation was an extra-pair copulation, first ever documented for the species, which occurred between a paired female and lone male. This copulation occurred 3 days after the female's 20-day-old chick was depredated. No copulations were observed on days with precipitation. Due to a low number of copulations, opportunistic accounts ($n = 18$) within this population also were examined and showed whooping cranes copulate up to 62 days prior to incubation and between 0610 and 1345 hours EST. Our data suggest copulations occur on days without precipitation between early morning and early afternoon hours. Moreover, although cranes are a long-lived, monogamous species, extra-pair copulations do occur.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:85

Key words: copulation, copulatory behavior, Florida, *Grus americana*, incubation, non-migratory, whooping crane.

USING ECOREGIONS TO QUANTIFY CHANGES IN BREEDING SANDHILL CRANE DENSITIES FOR WISCONSIN

FORREST EAST, International Crane Foundation, Baraboo, WI 53913, USA

ANNE LACY, International Crane Foundation, Baraboo, WI 53913, USA

Abstract: To better understand the dynamics of breeding sandhill crane (*Grus canadensis*) densities, we used Annual Midwest Crane Count (AMCC) data and U.S. EPA Ecoregions within Wisconsin to describe potential breeding distribution changes. Crane Count is a long-term citizen science program aimed at providing an estimation of crane densities in Wisconsin through a spring census. We used both the number of pairs (representative of potential productivity) and the total number of cranes (representative of overall crane use) counted per site. Ecoregions, in addition to providing a broad intrinsic descriptor of habitats, have the advantage of providing a more accurate representation of the parts of the landscape that may be relevant to cranes. Though the overall population of sandhill cranes in the state is still increasing, it is not changing uniformly among ecoregions. Crane densities and pair densities increased in several northwestern ecoregions of the state, but densities in the southcentral ecoregions, which hold the highest concentration of cranes, did not change; 1 ecoregion even indicated a significant decline in the number of pairs. The feature common to the regions that show an increase in cranes is a high abundance of lakes; the only ecoregion showing a decrease in cranes is specifically mentioned as having a lower density of lakes than its surrounding regions, evidence that cranes may be adapting to marginal habitats as more characteristic habitats become fully occupied. Ecoregions appear to describe population change in Wisconsin better than political boundaries; future work will include extended areas of the Midwest covered by the AMCC.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:85

Key words: Crane Count, densities, ecoregions, *Grus canadensis*, sandhill crane, Wisconsin.

STATUS OF THE FLORIDA RESIDENT FLOCK OF WHOOPING CRANES

MARTIN FOLK, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

TIMOTHY DELLINGER, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

STEPHEN BAYNES, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

KATHLEEN CHAPPELL, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

MARILYN SPALDING, University of Florida, Gainesville, FL 32611, USA

Abstract: As of 15 January 2011 we are continuing to monitor the remaining 21 (12 females, 9 males) whooping cranes (*Grus americana*) in the reintroduced Florida population. Most birds currently are paired (8 pairs) facilitating continued research on their breeding challenges. Last breeding season we conducted a pilot study to determine the efficacy of using artificial eggs containing temperature loggers to measure incubation temperature in nests of whooping and Florida sandhill (*G. canadensis pratensis*) cranes. The technique will be used to compare incubation temperature and behavior between successful vs. unsuccessful nests and between sandhill and whooping cranes. A single artificial egg was placed into the nests of 5 whooping cranes and 1 sandhill crane, the first time the procedure has been done with any wild crane species. All pairs accepted and incubated the artificial eggs. The most important finding from preliminary examination of plots of incubation temperature showed that in 4 whooping crane nests there was a single large downward spike in incubation temperature that occurred on 1 night. Amount of time off the eggs ranged from 3.12 to 15.30 hours during which the eggs dropped up to 23°C (41°F) below mean incubation temperature (for the period data was recorded). Unusually long lapses in incubation likely affect the hatchability of eggs. This spring we will deploy cameras capable of night-vision near nests to determine the cause of these lapses in incubation. We also will continue to deploy artificial eggs into nests to collect data on incubation temperature.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:86

Key words: artificial eggs, Florida, *Grus americana*, incubation temperature, reintroduced population, whooping cranes.

HISTORICAL BREEDING, STOPOVER, AND WINTERING DISTRIBUTIONS OF A WHOOPING CRANE FAMILY

KARINE GIL-WEIR, Platte River Whooping Crane Trust, 6611 West Whooping Crane Drive, Wood River, NE 68883, USA

FELIPE CHAVEZ-RAMIREZ, Gulf Coast Bird Observatory, Lake Jackson, TX 77566, USA

BRIAN W. JOHNS, Canadian Wildlife Service, Saskatoon, Saskatchewan S7N 0X4, Canada

LEA CRAIG-MOORE, Canadian Wildlife Service, Saskatoon, Saskatchewan S7N 0X4, Canada

THOMAS STEHN, U.S. Fish and Wildlife Service, P.O. Box 100, Austwell, TX 77950, USA

ROBIN SILVA, 109 Hollydale Drive, Bryan, TX 77845, USA

Abstract: Between 1977 and 1988, 134 whooping cranes (*Grus americana*) were banded in Canada's Wood Buffalo National Park (WBNP). The historical information collected from 4 banded cranes that hatched from the same nest, at NY-1 (nesting area Nyarling 1), allowed us to track the history of a multi-generation family of whooping cranes. Nine offspring were banded, and 7 other banded cranes were related to them. Thirty years of historical records showed 59 unbanded individuals exhibiting bonds to the banded family. In total, 79 cranes related to the same unbanded nesting pair were reported at WBNP, wintering ground in Aransas National Wildlife Refuge (ANWR), Texas, and along the Central Flyway during migrations. We integrated this information to build a whooping crane family tree, which represents all familial relationships among them up to 4 generations, the number of mates and offspring, years of hatch and death, and other behavioral information. Spatial and temporal information from this family shows the historical distribution and dispersion pattern of winter territories and nesting areas by all descendents of the same family, and site fidelity was shown by males. Nests were established in the Sass River and Klewi nesting areas, and wintering territories were held in Matagorda Island and San Jose within ANWR. Banded family members tended to use the same stopovers repeatedly along the Central Flyway, some of which are not now classified as critical habitat. Evidences of potential inbreeding, adoption, and migration as "extended" family units were obtained. Nesting success and failure synchronicity was observed among family members.

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Key words: Aransas, family, *Grus americana*, historical distribution, whooping cranes, Wood Buffalo National Park.

GIS DATABASE DESIGN FOR ANALYSIS OF SUB-SAHARAN AFRICAN CRANE RESEARCH

AMY RICHERT GOODALL, James Madison University, Harrisonburg, VA 22807, USA

KERRY MORRISON, International Crane Foundation/Endangered Wildlife Trust Partnership, Parkview, South Africa

NATHAN STINETTE, James Madison University, Harrisonburg, VA 22807, USA

Abstract: Much of Sub-Saharan Africa is geographically complex due to significant seasonal differences in precipitation, short- and long-term climate variability, and a diverse cultural and political make-up. Avian responses to dynamic natural systems and ecologists' needs to communicate cross-culturally make it challenging for researchers to accurately map and assess crane populations. The project presented is part of an on-going study geared toward understanding the distribution of Sub-Saharan Africa's 4 crane species (*Balearica pavonina*, *Balearica regulorum*, *Bugeranus carunculatus*, *Anthropoides paradisea*) and where cranes are in need of protection. The objectives of this project were to 1) develop a GIS data layer that depicts Sub-Saharan African crane research, 2) review the data layer for information about crane populations, and 3) find spatial gaps in research. We investigated approximately 300 refereed journal articles and other published literature including technical documents from the International Crane Foundation and the African Endangered Wildlife Trust. We found it challenging to obtain other published information and even more challenging to find spatial information in published records. Analysis of the database revealed that patterns of crane populations are closely linked to the research conducted by only a few researchers that publish most regularly. In addition, most information published involved only 2 of the 4 crane species (*Bugeranus carunculatus* and *A. paradisea*). Presented are the details of the data layer and fields constructed, results of the data analysis to date, and plans for continuation of the project.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:88

Key words: African cranes, GIS database, Sub-Saharan.

THE EFFECT OF WEATHER ON PRODUCTIVITY IN A GREATER SANDHILL CRANE POPULATION IN SOUTH CENTRAL WISCONSIN

ANDREW GOSSENS, International Crane Foundation, Baraboo, WI 53913, USA

JEB BARZEN, International Crane Foundation, Baraboo, WI 53913, USA

MATT HAYES, International Crane Foundation, Baraboo, WI 53913, USA

Abstract: Since 1991 the International Crane Foundation has been marking greater sandhill crane (*Grus canadensis tabida*) breeding pairs and juveniles in a dense population in south central Wisconsin. Currently, 389 individuals have been marked on private lands within a study area of 6,800 ha. In this analysis we focus on the effect of weather on yearly productivity (number of chicks fledged/territory) of marked territorial pairs from 1993 to 2010. Prior to 1993 the number of marked territories was <13 and too small for analysis. Over 18 years, 84 total territories were marked with an average of 40.17 (range = 13-60) territories observed per year. Marked individuals persisted on territories 1-18 years (mean = 8.43). The average productivity was 0.32 chicks fledged per year per territory, with yearly variability ranging from 0.14 to 0.47. Many climatological factors might cause this variation in productivity of greater sandhill cranes. In this study we will show how some specific weather events (snowfall during the previous winter and precipitation, Palmer Drought Severity Index [PDSI], and temperature during the breeding season) influence territory productivity of this dense breeding population.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:88

Key words: greater sandhill crane, *Grus canadensis tabida*, productivity, weather, Wisconsin.

THE USE OF SATELLITE TELEMETRY TO EVALUATE MIGRATION CHRONOLOGY AND BREEDING, MIGRATORY, AND WINTERING DISTRIBUTION OF THE EASTERN POPULATION OF SANDHILL CRANES

EVERETT HANNA, Department of Biology, University of Western Ontario, London, Ontario N6A 5B7, Canada

DAVID FRONCZAK, Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St. Paul, MN 55455, USA

Abstract: The Eastern Population (EP) of sandhill cranes (*Grus canadensis*) is rapidly expanding in size and geographic range. The core of the EP's breeding range spans much of Wisconsin and Michigan in the United States, and most of Ontario in Canada; however, the EP has expanded in all directions as the population has continued to grow. As a result, little is known about the geographic extent of the breeding, migratory, and wintering range of EP cranes as well as migratory chronology and use of primary staging areas. In December 2009, we began trapping EP cranes and deploying solar-powered Global Positioning System satellite transmitters to assess spatial and temporal variation in annual movements. To date, we have trapped and attached transmitters ($n = 30$) at Manitoulin Island, Ontario; Jasper-Pulaski Fish and Wildlife Area, Jasper and Pulaski Counties, Indiana; and Hiwassee Wildlife Refuge, Meigs County, Tennessee. GPS data are currently being received from CLS America Inc., Maryland, translated by software developed by North Star Science and Technology, Virginia, and analyzed using Environment System Research Institute (ESRI) ArcGIS software. In 2011, preliminary data show that 1 crane remains in Indiana, 1 in Kentucky, 12 in Tennessee, 2 in Georgia, and the remainder in Florida. These data provide the first comprehensive representation of the annual habitats that EP cranes frequent. While subsequent seasons of data collection will provide more robust estimates of range boundaries, these initial data remain particularly pertinent due to the unknown nature of the EP in general.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:89

Key words: Eastern Population, *Grus canadensis*, migration, sandhill cranes, satellite telemetry.

HABITAT USE, MIGRATORY BEHAVIOUR, AND VITAL RATES OF SANDHILL CRANES ON THE NORTH SHORE OF LAKE HURON, ONTARIO

EVERETT HANNA, Department of Biology, University of Western Ontario, London, Ontario N6A 5B7, Canada

SCOTT PETRIE, Long Point Waterfowl, Port Rowan, Ontario N0E 1M0, Canada

Abstract: The Eastern Population (EP) of sandhill cranes (*Grus canadensis*) has increased substantially within the last 30 years. In Ontario, numbers have increased from occasional sightings in the early 1980s to nearly 9,000 birds during fall migration in 2009. This rapidly expanding population is now causing agricultural damage, but conservation and management are constrained by the fact that little is known about crane habitat use and migratory movements in Ontario. During July and August 2010, cranes ($n = 9$) were captured on Manitoulin Island, Ontario, at baited rocket net sites and fitted with solar-powered GPS transmitters. From July to October 2010, age-ratio data were collected and used as an index to fall recruitment (productivity: proportion of juvenile birds). Data from July and August represent southern breeding birds (local), whereas those from September and October represent northern breeding birds (migrant). Lastly, weekly roost surveys were conducted at focal roost sites ($n = 6$) to determine how roost site characteristics contribute to variation in levels of use (i.e., number of birds). Preliminary results suggest that most local marked birds ($n = 6$) departed the study area prior to the peak in fall migration (i.e., local birds departed earlier). Marked birds travelled west along Manitoulin Island and south through central Michigan to wintering grounds in southern Florida. In addition, local birds showed lower productivity (mean \pm SE) than migrants ($n = 889$; 8.8 ± 0.41 , and $n = 4,674$; 15.0 ± 0.66 , respectively). These preliminary data will provide a basis for future management decisions.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:89

Key words: Eastern Population, *Grus canadensis*, habitat use, Manitoulin Island, Ontario, sandhill cranes.

SEASONAL FECAL CORTICOSTERONE MEASUREMENTS IN WISCONSIN SANDHILL CRANES

BARRY K. HARTUP, International Crane Foundation, E-11376 Shady Lane Road, Baraboo, WI 53913, USA

ALLISON GUTWILLIG, School of Veterinary Medicine, University of Wisconsin, 2015 Linden Drive, Madison, WI 53706, USA

Abstract: Corticosterone is the primary glucocorticoid hormone released by the adrenal gland in birds. Levels of corticosterone exhibit diurnal and seasonal variation, as well as fluctuate under stressful conditions. From May to November 2008 and March to May 2009, fresh fecal samples were collected biweekly at a sandhill crane (*Grus canadensis*) roost on the Wisconsin River near Briggsville, Wisconsin. The birds were visually healthy and in either non-breeding/non-migratory or migratory condition. Fecal samples were analyzed by radio-immunoassay to measure corticosterone. The overall mean corticosterone concentration observed was 13.69 ± 0.83 (SE) ng/g. Corticosterone concentrations varied across collection dates ($F = 8.15$, $P < 0.01$) and season ($F = 11.04$, $P < 0.01$). The mean corticosterone concentration during spring migration was greater than the other 4 seasons ($P < 0.01$). The mean corticosterone concentration during summer was greater than during fall staging ($P = 0.02$). Corticosterone concentrations tended to increase during fall migration compared to the fall staging season ($P = 0.05$). Peaks in corticosterone during spring and fall migratory periods were consistent with similar elevations known from other birds, as well as coincided with colder temperatures known to influence corticosterone levels. Our study provides a preliminary understanding of seasonal baseline corticosterone levels in a well described, healthy, free-ranging crane population. We successfully used a non-invasive sampling scheme that may find applicability to conservation assessments of threatened crane populations.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:90

Key words: corticosterone, *Grus canadensis*, hormone, monitoring, radio-immunoassay.

POPULATION GENETIC STRUCTURE OF THE EASTERN FLYWAY POPULATION OF SANDHILL CRANES

MATTHEW HAYES, International Crane Foundation, Baraboo, WI 53913, USA; and University of Wisconsin, Madison, WI 53706, USA

JEB BARZEN, International Crane Foundation, Baraboo, WI 53913, USA

MARK BERRES, University of Wisconsin, Madison, WI 53706, USA

Abstract: The Eastern Flyway Population (EFP) of sandhill cranes (*Grus canadensis*) suffered a demographic bottleneck in the 1930s. Currently, this population is growing both in population number and geographic range through diffusion from local concentrations that survived the population bottleneck. To determine how these concentrations were historically connected as well as potential source populations for re-colonized areas, we employed Amplified Fragment Length Polymorphisms (AFLP) to determine population genetic structure. DNA samples were collected from 9 areas throughout the range of the EFP. These samples were compared to DNA collected from the Mid-Continent Population (MCP), Central Valley Population (CVP), Pacific Flyway Population (PFP), and non-migratory Florida Population. Within the EFP, there was definite hierarchical structure (average pairwise $F_{st} = 0.1795$). Rather than following an isolation-by-distance model, the concentrations were structured based on latitudinal similarity. Concentrations in southern Michigan were clustered together and most similar to a cluster formed by concentrations in south-central Wisconsin and northern Illinois. Concentrations in northwest Wisconsin, Michigan's Upper Peninsula, and southeastern Ontario were also clustered together. Concentrations in central Wisconsin and eastern Minnesota were outliers, but still within the overall cluster of the EFP. The EFP cluster was most closely related to the MCP, the CVP and PFP formed their own cluster, and Florida constituted an outgroup. This latitudinal stratification is interesting considering the belief that Lake Michigan and dense forests in northern Wisconsin serve as barriers to gene flow. Understanding population genetic structure and interactions between these concentrations can be useful in directing management scenarios for the EFP.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:90

Key words: AFLP, bottleneck, Eastern Flyway Population, *Grus canadensis*, population genetic structure, sandhill cranes.

EVALUATION OF THE GENETIC MANAGEMENT OF THE ENDANGERED MISSISSIPPI SANDHILL CRANE

JESSICA HENKEL, Tulane University, New Orleans, LA 70118; and University of New Orleans, New Orleans, LA 70148, USA

KENNETH JONES, University of Georgia, Athens, GA 30602, USA

SCOTT HEREFORD, U.S. Fish and Wildlife Service, Gautier, MS 39553, USA

MEGAN SAVOIE, Audubon Center for Research on Endangered Species, New Orleans, LA 70118, USA

JEROME HOWARD, University of New Orleans, New Orleans, LA 70148, USA

Abstract: The minimization of kinship in captive populations can be achieved through the use of pedigree information. Pedigree knowledge alone, however, is not sufficient if pedigree information is missing, questionable, or when the founders of the captive population are related to one another. If this is the case, higher levels of inbreeding and lower levels of genetic diversity may be present in the captive population than those calculated by pedigree analyses alone. In this study, we analyzed the genetic status of the critically endangered Mississippi sandhill crane (*Grus canadensis pulla*) using studbook data from the U.S. Fish and Wildlife Service managed captive breeding and release program. In addition to traditional pedigree analyses, we used microsatellite DNA data to provide information on shared founder genotypes, allowing for refined analysis of genetic variation in the population, and providing a new DNA-based studbook pedigree that will assist in the genetic management of the Mississippi sandhill crane population. The genetic variation observed in the Mississippi sandhill crane was then contrasted with the variation observed for Florida sandhill cranes (*G. c. pratensis*). Results show far less variation in the Mississippi population and suggest that while gene flow no longer occurs between the 2 populations, the introduction of cranes from the Florida population would increase the genetic diversity of the Mississippi sandhill crane population.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:91

Key words: genetic management, *Grus canadensis pulla*, microsatellite DNA, Mississippi sandhill crane, pedigree.

MISSISSIPPI SANDHILL CRANE UPDATE 2009-2010

SCOTT HEREFORD, U.S. Fish and Wildlife Service, Mississippi Sandhill Crane NWR, Gautier, MS 39553, USA

LAUREN BILLODEAUX, U.S. Fish and Wildlife Service, Mississippi Sandhill Crane NWR, Gautier, MS 39553, USA

Abstract: The Mississippi sandhill crane (*Grus canadensis pulla*) is an endangered non-migratory subspecies found on and near the Mississippi Sandhill Crane National Wildlife Refuge in southeastern Mississippi. We continued conservation efforts for the recovery of this population in 2009-2010. To maintain open savanna, we burned 7,600 acres including 76% during the growing season. To restore open savanna, 1,109 acres of woody vegetation were removed using mechanical methods. To bolster the population, we released 19 captive-reared juveniles in 2008-09, and 15 in 2009-10. To protect cranes, nests, and young, we conducted 2,672 trap-nights in 2009, removing 11 large predators and 21 raccoons (*Procyon lotor*). In 2010, contractors conducted 4,954 trap-nights, removing 50 large predators and 98 raccoons. Crane and habitat monitoring assessed life history parameters including radio-tracking, visual observations, and an annual nest census. We collected 3,274 observation records including 1,124 radio-fixes. We captured 6 AHY cranes to band or replace worn or nonfunctional radio-transmitters, all using toe nooses. We discovered 20 AHY carcasses. Of 18 with known or suspected causes of death, 61% were due to predation and 39% to trauma. There were 31 nests in 2009 and 29 in 2010, with 5 total fledglings. The use of 0.4-ha nest barriers showed promise in increasing productivity. The population remained stable at 100-110 cranes.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:91

Key words: *Grus canadensis pulla*, Mississippi sandhill crane, National Wildlife Refuge, update.

USE OF INDIAN TOE NOOSES TO CAPTURE MISSISSIPPI SANDHILL CRANES

SCOTT HEREFORD, U.S. Fish and Wildlife Service, Mississippi Sandhill Crane NWR, Gautier, MS 39553, USA

LAUREN BILLODEAUX, U.S. Fish and Wildlife Service, Mississippi Sandhill Crane NWR, Gautier, MS 39553, USA

TRACY GRAZIA, USDA Forest Service-Savannah River, New Ellenton, SC 29809, USA

MEENAKSHI NAGENDRAN, U.S. Fish and Wildlife Service, Office of International Affairs, Arlington, VA 22203, USA

ALI HUSSAIN, Bihar, India

Abstract: In 1998 master bird trapper Ali Hussain traveled to Mississippi to demonstrate traditional trapping techniques including the clap trap, norbans, and toe nooses. Hussain is the last of a tribe of bird trappers from Bihar. He caught over 500 species of birds using their traditional methods with local materials. Each toe noose consists of a 10-cm diameter fishing line loop tied to a 4-mm thick, 6-cm tall support stick. Each noose line consists of 80-120 nooses tied in series. One or multiple noose lines were deployed around bait or in known walking areas to passively capture 1 to 3 target Mississippi sandhill cranes (*Grus canadensis pulla*). We captured 76 AHY cranes using nooses. Since 2005, nooses accounted for 86% of captures. There were no known injuries related to the use of nooses. We recommend nooses as an effective passive capture technique.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:92

Key words: capture technique, *Grus canadensis pulla*, Mississippi sandhill crane, toe noose.

EFFECT OF REARING TECHNIQUE ON AGE OF FIRST REPRODUCTION OF RELEASED MISSISSIPPI SANDHILL CRANES

SCOTT HEREFORD, U.S. Fish and Wildlife Service, Mississippi Sandhill Crane NWR, Gautier, MS 39553, USA

TRACY GRAZIA, USDA Forest Service-Savannah River, New Ellenton, SC 29809, USA

LAUREN BILLODEAUX, U.S. Fish and Wildlife Service, Mississippi Sandhill Crane NWR, Gautier, MS 39553, USA

Abstract: By the 1970s, there were only 30-35 Mississippi sandhill cranes (*Grus canadensis pulla*) in the wild. To bolster the population of this endangered non-migratory subspecies, 456 captive-reared juveniles were released onto the Mississippi Sandhill Crane National Wildlife Refuge (refuge) from 1981 to 2011 in the largest crane augmentation to date. Both hand and parent-reared cranes were released using an acclimated technique developed for the refuge. Here we continue an earlier comparison in survival between hand and parent-reared cranes to assess age of first reproduction between the 2 rearing techniques. We included 114 nests between 1985 and 2010 involving 53 hand-reared (HR), 54 parent-reared (PR), and 7 wild-hatched cranes. The mean age of first egg was 5.9 years for HR and 5.5 for PR ($P = 0.29$). The mean age at first hatch ($n = 85$) was 6.6 years, with a range of 3-17. Only 24 nests fledged a chick and there was no difference ($P = 0.26$) in mean number fledged/years active nest between HR (0.27) and PR (0.36) cranes. However, in nests with at least 1 wild-hatched adult, recruitment was twice as high as nests where both adults were captive-reared. This may suggest challenges for success in re-introduction versus supplementation efforts.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:92

Key words: *Grus canadensis pulla*, hand-reared, Mississippi sandhill crane, parent-reared, rearing technique, reproduction.

ANNUAL RECRUITMENT AND BROOD SIZE OF GREATER SANDHILL CRANES IN MICHIGAN

RONALD H. HOFFMAN, 6142 Territorial Rd., Pleasant Lake, MI 49272, USA

Abstract: Documenting long-range recruitment rates is important for understanding population fluctuations and trends of the Eastern Population of greater sandhill cranes (*Grus canadensis tabida*), especially now that hunting is proposed for this population. Counts of cranes in juvenile or adult plumage were made in south central Michigan fields. Brood size was recorded 15 August through September, 1988-2010. Recruitment was estimated from age ratio (juveniles/total cranes \times 100) counts of all cranes sampled 15 August through November, 2003-2010. Mean annual recruitment rate weighted by year was estimated at 11.0 ± 2.0 (SE) juveniles based on a sample of 12,057 cranes. During the pre-staging period (15 Aug-Sep) recruitment was estimated to be 10.5 ± 2.4 compared to the staging period (Oct-Nov) recruitment rate of 11.6 ± 2.1 . The mean brood size weighted by years for 407 pairs with young was 1.30 ± 0.14 young/pair with 71% of the pairs fledging 1 young, 29% 2 young, and 0.2% fledged 3 young. The annual percentage of broods with >1 young was positively correlated with annual fall age ratios ($r = 0.99$, $P < 0.01$) during 2003-2010.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:93

Key words: brood size, Eastern Population, greater sandhill cranes, *Grus canadensis tabida*, recruitment.

GENETIC INFLUENCES ON FERTILITY AND LONGEVITY IN THE CAPTIVE BREEDING POPULATION OF THE MISSISSIPPI SANDHILL CRANE

JEROME HOWARD, University of New Orleans, New Orleans, LA 70148, USA

Abstract: Data from the studbook for the captive breeding population of the Mississippi sandhill crane (*Grus canadensis pulla*) was analyzed to determine if genetic factors influenced the fertility of eggs and survival of hatched individuals. A total of 19 sires and 23 dams were represented by enough offspring for analysis. Egg fertility was generally high among both sires and dams, although a few sires produced few or no fertile eggs. This is likely not representative of the true variability in fertility, as low fertility individuals were quickly excluded from the breeding program. Longevity was highly variable, with mean longevity of offspring reaching a maximum of 6.7 years for 1 sire. However, 2 sires and 1 dam produced offspring surviving less than 1 year on average. The results suggest that genetic factors may influence the life history traits of captive-bred individuals. A quantitative genetic analysis to estimate heritability of life history traits is currently underway.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:93

Key words: captive breeding, fertility, genetic factors, *Grus canadensis pulla*, longevity, Mississippi sandhill crane.

MOVEMENTS AND HOME RANGE SIZE OF GREATER AND LESSER SANDHILL CRANES WINTERING IN CENTRAL CALIFORNIA

GARY L. IVEY, Oregon State University, Department of Fisheries and Wildlife, 104 Nash Hall, Corvallis, OR 97731, USA

BRUCE D. DUGGER, Oregon State University, Department of Fisheries and Wildlife, 104 Nash Hall, Corvallis, OR 97731, USA

MICHAEL L. CASAZZA, U.S. Geological Survey, Western Ecological Research Center, 6924 Tremont Road, Dixon, CA 95620, USA

JOSEPH P. FLESKES, U.S. Geological Survey, Western Ecological Research Center, 6924 Tremont Road, Dixon, CA 95620, USA

CAROLINE P. HERZIGER, Oregon State University, Department of Fisheries and Wildlife, 104 Nash Hall, Corvallis, OR 97731, USA

Abstract: We assessed landscape use of sandhill cranes (*Grus canadensis*) wintering in the Sacramento-San Joaquin Delta region of California and compare movement patterns of sympatric greater (*G. c. tabida*) and lesser sandhill cranes (*G. c. canadensis*). State-threatened greaters showed stronger fidelity to wintering sites and moved between discrete wintering areas less frequently as 8% of the greaters used more than 1 wintering region compared to 43% of the lessers. Average flight movements (commuting distance) between night roost sites and feeding areas were about half the distance for greater sandhill cranes (2.1 km) compared to lesser sandhill cranes (5.0 km), and winter home ranges were nearly one-ninth the size (2.2 km²). These results have application for conservation of wintering cranes at a landscape scale, and we recommend that habitat protection and restoration for the threatened greater subspecies be prioritized for areas within 2 km of existing traditional roost sites to ensure a high probability of use. In addition, providing new roost sites towards the edge of the current range of greater sandhill cranes will allow them access to additional agricultural fields and will possibly increase the carrying capacity of their winter range. Conservation of habitat for lessers could take a broader landscape approach, with a focus on sites within 5 km of roost sites.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:94

Key words: California, greater sandhill cranes, *Grus canadensis canadensis*, *Grus canadensis tabida*, lesser sandhill cranes, movements, Sacramento-San Joaquin Delta, wintering.

HEALTH MANAGEMENT FOR REINTRODUCED WHOOPING CRANES IN WISCONSIN 2005-2010: DIRECT AUTUMN RELEASE

DOMINIQUE L. KELLER, School of Veterinary Medicine, University of Wisconsin, 2015 Linden Drive, Madison, WI 53706, USA

BARRY K. HARTUP, International Crane Foundation, E-11376 Shady Lane Road, Baraboo, WI 53913, USA

Abstract: Between 2005 and 2010, 63 (27 male, 36 female) costume-reared whooping cranes (*Grus americana*) were assigned to the Direct Autumn Release project of the Whooping Crane Eastern Partnership for intended release in October of their hatch year. Regular preventive health screening and pre-release evaluations were used to maximize survival and fitness prior to release and to minimize transfer of potential disease agents to native habitats. A total of 44 clinically normal birds were released at the Necedah NWR in central Wisconsin following extensive hematological, blood biochemical, toxicological, serological, parasitological, and microbiological evaluation. Instances of morbidity during captivity were categorized by primary body system affected (in descending order of occurrence): musculoskeletal, respiratory, systemic, integumentary, gastrointestinal, oral, and ocular. Musculoskeletal abnormalities included linear limb rotation, angular limb deformity, carpometacarpal rotation (angel wing), muscle rupture, and fracture. Five birds were removed from the project prior to scheduled release, all for musculoskeletal abnormalities that prevented normal function. Fourteen birds died or were euthanized prior to release; pre-release mortality was attributed to developmental abnormality, predation, trauma or infectious disease. Cases of infectious disease were dominated by chronic respiratory aspergillosis ($n = 7$). Post-release mortality was caused by predation and trauma; no evidence of infectious disease of captive origin was detected. The data collected from this project have helped produce a picture of captive whooping crane flock health, provided hematological and biochemical reference ranges, elucidated the main causes of project morbidity and mortality, and should aid in evaluating management factors impacting pre- and post-release success.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:94

Key words: aspergillosis, *Grus americana*, health management, pathogen transfer, preventive medicine.

LANDSCAPE USE AND MOVEMENTS OF SANDHILL CRANES USING THE HORICON MARSH, WISCONSIN, DURING FALL ROOSTING AND STAGING

EILEEN KIRSCH, USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI 54603, USA

RICHARD SOJDA, USGS, Northern Rocky Mountain Science Center, Bozeman, MT 59715, USA

ROBERT DIEHL, USGS, Northern Rocky Mountain Science Center, Bozeman, MT 59715, USA; and University of Southern Mississippi, Department of Biological Sciences, Hattiesburg, MS 39406, USA

MANUEL SUAREZ, USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI 54603, USA

MICHAEL WELLIK, USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI 54603, USA

WENDY WOYCZIK, USFWS, Horicon National Wildlife Refuge, Mayville, WI 53050, USA

JAMES LUTES, USFWS, Leopold Wetland Management District, Portage, WI 53901, USA

JON KRAPFL, USFWS, Horicon National Wildlife Refuge, Mayville, WI 53050, USA

Abstract: The Horicon Marsh in southeastern Wisconsin is the largest cattail (*Typha latifolia*) marsh in the lower 48 states, providing important habitat for sandhill cranes (*Grus canadensis*) during fall roosting and migration staging. Adjacent agricultural fields, small wetlands, and grasslands offer essential food resources. Eighty-six commercial wind turbines have been erected 3.2 km northeast of the marsh in areas cranes are known to use. We studied crane movements across this landscape in fall 2009 and 2010 to assess the risk of turbine encounters and habitat avoidance associated with wind energy development. Timing of flights to and from the roost were predictable with sunlight, but shifted slightly during inclement weather. Foraging cranes primarily were found in harvested corn and soybean fields, although cranes habitually used certain areas regardless of crop type. Over 70% of observations were within 3.2 km of the refuge boundary. Using portable marine radar, we observed that cranes flew lower than 250 m, directly to and from the refuge at about 53 km/hour. Flight directions were mostly east-west in 2009 and more variable in 2010. In 2009 fewer fields were available because very wet weather greatly delayed harvest, whereas 2010 harvest was 30% ahead of normal due to dry conditions. Furthermore, the location of the main roost was static in 2009, and in 2010 the main roost moved several hundred meters north after an extreme windstorm during late October 2010. Cranes seem to perceive and avoid turbine rotors but were rarely found in fields with turbines.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:95

Key words: *Grus canadensis*, Horicon Marsh, migration staging, sandhill cranes, wind turbines, Wisconsin.

THE ROLE OF THE CENTRAL PLATTE RIVER VALLEY TO THE MIDCONTINENT POPULATION OF SANDHILL CRANES IN THE 21ST CENTURY

GARY KRAPU, U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 37TH SE Street, Jamestown, ND 58401, USA

DAVE BRANDT, U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 37TH SE Street, Jamestown, ND 58401, USA

Abstract: The Midcontinent Population (MCP) of sandhill cranes (*Grus canadensis*) is the largest and most wide ranging population of cranes in the world with major breeding grounds located on 2 continents and 3 nations. I examine underlying factors that have led to development of this exceptionally strong spring staging tradition in the Central Platte River Valley (CPRV), describe temporal and spatial aspects of use by each subspecies and subpopulation, and evaluate factors that are limiting crane use. Cranes have successfully adapted to massive habitat change in the CPRV over the past 70 years and continue to be challenged by new developments which I will address. Aided by new technology, I follow the cranes throughout the annual cycle, identifying major breeding grounds, key spring and fall stopovers, and wintering areas, along with key habitat resources supporting the MCP. We have documented a much larger number and wider breeding distribution of sandhill cranes in northern Russia than previously thought, and I will describe a 2009 expedition that led to the discovery of the species breeding westward to near the Lena River Delta. The focus will be primarily on research results having important implication to sandhill crane management. Although the trajectory of MCP growth over the past 70 years reflects a major conservation success story, climate change, energy development, and intensification of agriculture could pose potential long-term threats to the Population which I will discuss. [Plenary presentation at opening of Workshop]

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:96

Key words: Central Platte River Valley, *Grus canadensis*, Midcontinent Population, Russia, sandhill cranes.

IMPLEMENTATION OF THE WHOOPING CRANE MONITORING PROTOCOL ALONG THE PLATTE RIVER, NEBRASKA

GARY LINGLE, AIM Environmental Consultants, Gibbon, NE 68845, USA

Abstract: Assessment Impact Monitoring Environmental Consultants (AIM) was contracted by the Platte River Recovery Implementation Program to implement the protocol entitled *Monitoring Whooping Crane Migrational Habitat Use in the Central Platte River Valley* during the spring (21 Mar-29 Apr) and fall (9 Oct-10 Nov) migrations. During 2001-2011, we aerially surveyed a 145-km (90-mile) stretch of the Platte River from Lexington to Chapman near sunrise. In any given survey 62-94% of the scheduled flights were completed. Of transects scheduled, 2,163 of 2,920 (74%) were flown covering about 156,646 survey km (97,335 miles). A total of 167 individual whooping cranes (*Grus americana*) was documented (135 adults: 32 chicks). The frequency of sightings was: FO = 0.09 (0.1-0.35) sightings per transect and 1 sighting per 760 km flown. The largest group = 11; most seen in a migration = 36; most crane-use days = 121 days. There were 738 crane-use days (spring = 407; fall = 331). From 0.5% to 13% (mean = 4%) of the population stopped along the Platte River. Totals of 750 hours of time-budget and 897 hours of habitat use data were collected. Diurnal activities ranged from 0 to 10.3 km from nocturnal roost sites. Over 67% of diurnal habitat use was corn, river was 19%, and lowland grass was about 2%. Corn was used nearly 2.5 times more in spring than fall, and river was used 9 times more in fall than spring. Length of stay for a group was 2-26 days.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:96

Key words: *Grus americana*, migration, monitoring protocol, Platte River Recovery Implementation Program, Platte River Valley, whooping crane.

NEW RECORDS OF WINTERING GROUNDS FOR SANDHILL CRANES IN MEXICO

EDGAR LOPEZ-SAUT, Centro de Investigaciones Biologicas del Noroeste, La Paz, Mexico

FELIPE CHAVEZ-RAMIREZ, Gulf Coast Bird Observatory, Lake Jackson, TX 77566, USA

RICARDO RODRIGUEZ-ESTRELLA, Centro de Investigaciones Biologicas del Noroeste, La Paz, Mexico

Abstract: Although the sandhill crane (*Grus canadensis*) is considered a threatened species in Mexico, there is no detailed information on its present winter distribution and on the description of wetlands where cranes had not been previously recorded. This information would be important for making decisions for management and conservation plans. Our objectives were to update current range and identify new wintering areas for the sandhill crane in Mexico and to characterize wetlands where they roost in winter. Wetlands were surveyed by ground (52) and by air (83) covering the Chihuahuan Desert in the states of Chihuahua, Coahuila, Nuevo Leon, Durango, San Luis Potosi, Zacatecas, and Guanajuato. Sandhill cranes were recorded in 31 wetlands of which 13 were new location records for Mexico and extended the present distribution 237 km farther south. All wetlands have human activities surrounding them and some are near urban centers, which give insights about the threats that wetlands are facing at present. Studies to assess the wintering areas and sandhill crane migratory pathways are important, not just for conservation of the cranes, but also to protect other species that depend on the desert wetlands in northern Mexico.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:97

Key words: *Grus canadensis*, Mexico, sandhill crane, wintering areas.

SANDHILL CRANES BREEDING IN NEW ENGLAND: AN UPDATE

SCOTT MELVIN, Massachusetts Division of Fisheries and Wildlife, Westborough, MA 01581, USA

Abstract: Sandhill cranes (*Grus canadensis*) breeding in New England have slowly increased in abundance and distribution since the first documented nesting in Maine in 2000. At least 6 territorial or nesting pairs were present at 6 sites in Maine in 2010, and single pairs nested in 2009 and 2010 at single sites in Massachusetts and Vermont where nesting has occurred since at least 2007. Of 23 nests observed in 9 wetlands in Maine, Massachusetts, and Vermont between 2001 and 2010, 6 were in lakeside marshes, 5 were in riverine marshes, 8 were in lakeside fens or bogs, and 4 were in beaver-impounded palustrine marshes. Dominant vegetation within 5 m of nests was either cattail (*Typha* spp.), or varying proportions of sedges (*Carex* spp.), leatherleaf (*Chamaedaphne calyculata*), sweetgale (*Myrica gale*), and sphagnum. Wetlands used for nesting ranged in area from 2 to 200 ha. Measures of pH within 50 m of nests ranged from 4.8 to 9.7. At least 22 of 29 (76%) nest attempts between 2000 and 2010 hatched 1 or 2 eggs. In at least 14 instances, chicks survived to at least 8 weeks of age, including 5 2-chick broods. Chick survival was higher for pairs nesting and raising chicks on large, open wetlands along edges of lakes and rivers than for pairs at smaller palustrine wetlands. Reports of sandhill cranes in all 6 New England states have increased in frequency over the past 2 decades. Observed patterns of habitat use suggest that New England can support a large and widely distributed breeding population of sandhill cranes.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:97

Key words: breeding, *Grus canadensis*, New England, sandhill cranes.

EFFECTS OF WIND FARMS ON WINTERING SANDHILL CRANES IN THE SOUTHERN HIGH PLAINS OF TEXAS

LAURA NAVARRETE, Texas Tech University, Lubbock, Texas, 79407, USA

KERRY L. GRIFFIS-KYLE, Texas Tech University, Lubbock, Texas, 79407, USA

DAVID HAUKOS, Texas Tech University, Lubbock, Texas, 79407, USA

Abstract: Texas has been shown to have a superior annual capacity for wind power and this capacity has led to the erection of multiple wind farms across Texas with many more facilities planned. Wind energy is vital for a shift to carbon-emission free energy, however there has been relatively little research investigating the effect of wind farms as disturbance factors across the landscape. This project examines how wind energy infrastructure affects sandhill crane (*Grus canadensis*) behavior including landscape level habitat uses. Sandhill cranes are known to avoid human disturbance, and wind farms have been shown to render surrounding habitat of up to 1 km unsuitable through direct effects (destroying habitat) and indirect effects on bird behavior (avoidance). We examined the distribution of cranes at multiple wind farms in the southern High Plains of Texas. We evaluated the effects wind farms have on roost occupancy, habitat use, and crane behavior by comparing areas with wind turbines to those without for presence of cranes at roosting sites and behavior of cranes at foraging sites. Preliminary findings showed that cranes were found less likely to forage within 2 km of the wind farms and exhibited a clumped distribution when found near wind farms. Additionally, cranes foraging within 2 km of the wind farms spent more of their time being vigilant and less time loafing than the cranes outside the 2 kilometers. These findings, along with further analysis, can be used to predict areas of avoidance and help preserve important crane habitat in a rapidly developing landscape.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:98

Key words: *Grus canadensis*, High Plains, New England, sandhill crane, Texas, wind farms.

TERRITORY HISTORIES OF FLORIDA SANDHILL CRANES: 1980-2006

STEPHEN NESBITT, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

STEPHEN SCHWIKERT, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

Abstract: Fifteen nesting territories of Florida sandhill cranes (*Grus canadensis pratensis*) were monitored for a total of 132.3 crane nesting years during the 1980s and 1990s. During this time 105 nesting attempts produced 34 fledged chicks; there were 26 mate changes among the pairs. Seven territories were abandoned by the original pair but were reoccupied by another pair, sometimes after an interval of only a few days. Territory boundaries remained unchanged during the nearly 20 years we observed these territories. Rapid repairing following death or divorce or the quick occupation of an abandoned territory by another pair are likely reasons we found the boundaries of the 15 territories to be more constant than individual pair membership. We revisited the 15 longest monitored territories in fall 2005 and during the 2006 nesting season. Seven of the territories appeared to have a sufficient amount of the wetland and upland habitat needed to support a nesting pair of cranes, and 6 of them were occupied during the 2006 nesting season. The remaining 8 territories appeared to be unusable; 6 had upland foraging habitat but no suitable nesting habitat, in 1 both wetland and upland foraging habitats were overgrown, and in the other, upland foraging habitat had been converted to a series of small fenced paddocks.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:98

Key words: *Grus canadensis pratensis*, Florida sandhill crane, territory histories.

UPDATED EASTERN SANDHILL CRANE RANGE MAPS

KRISTIN NORRIS, International Crane Foundation, Baraboo, WI 53913, USA

ANNE LACY, International Crane Foundation, Baraboo, WI 53913, USA

Abstract: The breeding, wintering, and migrating range of the Eastern Migratory Population (EMP) of greater sandhill cranes (*Grus canadensis tabida*) is located within the Mississippi and Atlantic Flyways. Historically, the majority of the EMP bred across the Great Lakes Region (primarily Wisconsin and Michigan) and wintered in southern Georgia and Florida. The population is currently expanding and re-colonizing former breeding and wintering areas. We attempt to delineate the expansion of the EMP by developing an updated breeding and wintering range map for the subspecies. Christmas Bird Count (CBC) data from 2006 to 2010 was used to determine the current status and migratory trends of bird populations during the winter season. The North American Breeding Bird Survey (BBS) from 2000 to 2010 was used to describe breeding areas. Data sets were sorted by location and mapped by density. The majority of the winter distribution of EMP cranes (86%) winter in Alabama, Georgia, Florida, and Tennessee. Smaller concentrations of birds are expanding their wintering ranges east into the Carolinas and west into Mississippi and Louisiana. More and more EMP birds are also remaining later in more northerly areas of the wintering range (Michigan, Ontario, Wisconsin). BBS data confirm that the breeding range has expanded to include many northeastern and midwest states and Maritime Canadian provinces. Accurately measuring the expansion of this subspecies population is an important step in fine-tuning future management plans.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:99

Key words: Eastern Migratory Population, expansion, greater sandhill cranes, *Grus canadensis tabida*, range.

HEMATOLOGY AND SERUM CHEMISTRY RESULTS FROM EXPERIMENTAL EXPOSURE OF SANDHILL CRANES TO WEST NILE VIRUS

GLENN OLSEN, USGS Patuxent Wildlife Research Center, Laurel, MD 20708, USA

Abstract: West Nile virus is a deadly virus for young cranes. In testing 2 different vaccines on both adult and juvenile sandhill cranes (*Grus canadensis*), we discovered that some blood parameters are altered by exposure to the virus. White blood cell counts were the most obvious and may be used as an indicator of West Nile virus exposure in cranes. Other hematology and serum chemistry results were studied and only hematocrit, percent heterophils, and percent lymphocytes were of interest, along with the already published information on titers encountered in experimental infections. Clinical pathology results showed challenged cranes, whether vaccinated or not, had a decrease in their hematocrits and an elevation of 2.5-fold in their white blood cell counts as compared to unchallenged control sandhill cranes. No differences were apparent in the differential counts of heterophils and lymphocytes. Our work would suggest that a combination of white blood cell counts and antibody titers can be used to diagnose and assess the severity of West Nile virus infections in cranes.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:99

Key words: flavivirus, *Grus canadensis*, hematocrit, hematology, sandhill crane, WBC, West Nile virus, white blood cell count.

PHOTOPERIOD AND NESTING PHENOLOGY OF WHOOPING CRANES AT TWO CAPTIVE FACILITIES

GLENN OLSEN, USGS Patuxent Wildlife Research Center, Laurel, MD 20708, USA

Abstract: Increasing daylight is known to be a breeding stimulus in many avian species breeding in northern latitudes. This is thought to be true for cranes that breed in such latitudes including the whooping crane (*Grus americana*). For this reason, the captive breeding centers use artificial light to lengthen daylight hours, but no study has been done to examine the effect of such lighting on the reproductive season. We examined the past light cycles and breeding season results from whooping crane pairs at USGS Patuxent Wildlife Research Center and the International Crane Foundation (ICF). At Patuxent 2 lights were used to produce light of 170 lux in the pens. On average, photoperiod lights were turned on 17 February (range 11-24 Feb). With 2 lights per pen, whooping cranes laid their first egg on average 10 days earlier than when 1 light was used and 16 days earlier than when no lights were used. At ICF the difference between lights on a pen and no lights was only 8 days difference in first lay dates, but still this was statistically significant.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:100

Key words: artificial light, captive breeding, *Grus americana*, photoperiod, whooping crane.

PROTOCOL AND RESULTS FROM THE FIRST SEASON OF CAPTIVE REARING WHOOPING CRANES FOR A NON-MIGRATORY RELEASE IN LOUISIANA

GLENN H. OLSEN, USGS Patuxent Wildlife Research Center, Laurel, MD 20708, USA

JANE N. CHANDLER, USGS Patuxent Wildlife Research Center, Laurel, MD 20708, USA

Abstract: During 2010 we successfully reared 10 whooping cranes (*Grus americana*) for a non-migratory release at White Lake Wetlands Conservation Area, Louisiana. The last wild whooping crane in the flock that inhabited that area was captured in 1950. Once in private corporate hands, the area is currently owned and managed by the Louisiana Department of Wildlife and Fisheries. That organization, along with Louisiana State University, USGS Louisiana Cooperative Fish and Wildlife Unit, and USGS Patuxent Wildlife Research Center (PWRC) partnered to arrange this reintroduction. Eggs originated from Audubon Species Survival Center, Calgary Zoo, PWRC, and abandoned nests of the Eastern Migratory Population (EMP) and were incubated under either whooping cranes or sandhill cranes for the first half of incubation before transfer to artificial incubators. Twelve chicks hatched in May and June 2010; one with scoliosis was euthanized and another was retained in captivity due to genetic considerations. PWRC caretakers costumed-reared chicks with modified procedures used to rear Mississippi sandhill cranes (*G. canadensis pulla*) and whooping cranes for the Florida Non-migratory Population and EMP. All chicks were housed near adult whooping crane imprint models. At 6.4 ± 1.4 days of age, chicks were taken on foraging trips. Socialization with other chicks was initiated at a mean age of 15.5 ± 5.0 days. Exposure to water during the foraging walks was also initiated during the third week. Foraging and walking trips continued until 46.1 ± 5.6 days-of-age. Formal socialization activities ended at 49.7 ± 10.1 mean days-of-age. Health examinations continued twice weekly and included vaccinations for eastern equine encephalitis and West Nile virus. Chicks were moved to outdoor pens, first to dry pens, and by 53.2 ± 3.4 days of age to pens with 10-m-diameter ponds. The 10 whooping cranes were flown to Louisiana in mid-February and released in early March.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:100

Key words: captive rearing, *Grus americana*, Louisiana, non-migratory, protocol, reintroduction, whooping crane

COMPARISON OF BEHAVIORS OF CRANE CHICKS THAT WERE PARENT-REARED AND REARED BY COSTUMED HUMANS

GLENN OLSEN, USGS Patuxent Wildlife Research Center, Laurel, MD 20708, USA

LANI MATTHEWS, Montgomery Blair High School, Silver Spring, MD 20901, USA

SARAH CONVERSE, USGS Patuxent Wildlife Research Center, Laurel, MD 20708, USA

Abstract: USGS Patuxent Wildlife Research Center in Laurel, Maryland, uses 2 primary methods to rear crane chicks. Some chicks are reared by parent or foster parent whooping cranes (*Grus americana*) or sandhill cranes (*G. canadensis*), while other chicks are reared by humans wearing mock crane costumes and holding puppet heads. We have used both techniques to successfully rear and release Mississippi sandhill cranes (*G. c. pulla*) and whooping cranes for release in non-migratory situations. However, for the migratory releases of the Whooping Crane Eastern Partnership (WCEP) population, we have always costumed-reared birds and trained them to follow ultralight aircraft or other whooping cranes on their first southward migration. We are planning to use parent-rearing methods to supplement the eastern migratory population of whooping cranes in the future. In 2010, in preparation for parent-rearing whooping crane chicks, we gave 6 pairs of captive whooping cranes a sandhill crane chick to rear. We then compared results for survival, behavior, and health testing with costume-reared chicks from the same year. All 6 parent-reared chicks survived to fledge, versus only 25 of 30 costume-reared chicks. In addition, parent-reared chicks spent significantly more time hock-sitting and less time standing than did the costume-reared chicks. Parent-reared chicks also spent significantly more time foraging and being vigilant and less time preening. In the future, we hope to test the parent-rearing technique with whooping crane chicks that can then be released with wild adults in the fall and learn the migration route.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:101

Key words: costume-rearing, crane chicks, parent-rearing, Patuxent.

MIGRATION ECOLOGY OF THE ARANSAS-WOOD BUFFALO POPULATION OF WHOOPING CRANES

AARON PEARSE, U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 37th SE Street, Jamestown, ND 58401, USA

DAVE BRANDT, U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 37th SE Street, Jamestown, ND 58401, USA

FELIPE CHAVEZ-RAMIREZ, Platte River Whooping Crane Trust, 6611 West Whooping Crane Drive, Wood River, NE 68883, USA; and Gulf Coast Bird Observatory, Lake Jackson, TX 77566, USA

WALTER WEHTJE, Platte River Whooping Crane Trust, 6611 West Whooping Crane Drive, Wood River, NE 68883, USA

Abstract: The Aransas-Wood Buffalo Whooping Crane Tracking Project is a collaborative effort among the Platte River Whooping Crane Trust, U.S. Geological Survey, Platte River Recovery Implementation Program, U.S. Fish and Wildlife Service, and Canadian Wildlife Service. Project objectives include identifying and describing migratory pathways, migration chronology, habitat use, and stopover sites used by whooping cranes during fall and spring and assessing potential risks to the birds during migration. GPS-platform transmitter terminals deployed are able to acquire 4-5 locations per day for 2+ years; thus, data gathered using this new technology will be useful for informing future recovery efforts. During spring 2010, 2 birds departed Aransas on 19 March, moved separately through the migration corridor, and arrived at Wood Buffalo on 17 and 18 April. After successful marking of juveniles in late summer 2010, we monitored 11 birds during fall migration. Birds departed from breeding grounds between 15 September and 2 November and migrated for an average of 35 days. These preliminary results will be updated as the project progresses and more data are collected.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:101

Key words: Aransas-Wood Buffalo Population, migration, Whooping Crane Tracking Project.

ASSESSING BREEDING WHOOPING CRANE HABITAT USE TO CHOOSE ALTERNATIVE RELEASE SITES IN WISCONSIN

NATHAN SCHMIDT, International Crane Foundation, Baraboo, WI 53913, USA

JEB BARZEN, International Crane Foundation, Baraboo, WI 53913, USA

ANNE LACY, International Crane Foundation, Baraboo, WI 53913, USA

J. MICHAEL ENGELS, International Crane Foundation, Baraboo, WI 53913, USA

Abstract: In fall 2010, the Whooping Crane Eastern Partnership (WCEP) began its second decade of introducing a migratory population of whooping cranes (*Grus americana*) to eastern North America. This population has had high subadult and adult survivorship but very low productivity (3 fledged chicks over the course of the project), generally thought to be a result of the cranes abandoning their nests part-way through incubation. Using monitoring data from the core reintroduction area of Wisconsin, we analyzed the habitat selection of breeding whooping cranes of the reintroduced eastern migratory flock. First, a spatially based regression was used to model the habitat use of the whooping cranes. Key findings include that breeding whooping cranes are strongly choosing cropland as their preferred habitat outside of Necedah NWR, and open water is consistently associated with increased likelihood of breeding whooping crane presence. The results of this model were then used, along with average size of current breeding territories in Necedah NWR (166 ha), to identify potential reintroduction sites in other areas of Wisconsin by searching for wetlands meeting criteria developed from actual crane habitat use. Six areas were identified in the east-central portion of the state that met basic biological criteria we could measure. We ran a habitat suitability model (HSM) comparing the habitat composition of east-central Wisconsin with the average characteristics found in reintroduced whooping crane nesting territories from Necedah NWR. The HSM identified 3 large wetland complexes in the study area, roughly corresponding to areas associated with the Fox, Wolf, and Rock rivers.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:102

Key words: eastern migratory flock, *Grus americana*, habitat suitability model, reintroduction sites, Wisconsin, whooping crane,

WHOOPING CRANES IN FLORIDA: WEATHER OR NOT CLIMATE MATTERS?

MARILYN SPALDING, University of Florida, Gainesville, FL 32611, USA

MARTIN FOLK, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

STEPHEN NESBITT, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Rd., Gainesville, FL 32601, USA

Abstract: Historical evidence suggests that numbers of reproductive whooping cranes (*Grus americana*) were never very large in the southern United States. Because the genetic source of cranes reintroduced into Florida originated mostly from much higher latitudes than in Florida, we might expect that birds would be predisposed to greater reproductive success in cooler climates during laying and incubation. Warmer extremes of temperature and higher humidity might explain the poor reproductive success of reintroduced birds breeding in Florida. A retrospective look at the reproductive parameters of the reintroduced flock indicated that a number of factors were contributing to the overall low success. They include low survival, especially of males (high predation, traumatic death), reproductive dysfunction (congenital defects, inappropriate pairing behavior, infertility), and poor nest survival (low hatching rate, nest disturbance, intraspecific aggression). To address the low hatching rate we examined historical weather parameters for any association between hatch failure and extreme temperature, rainfall, and humidity events and failed to find them. However, a strong positive correlation association with winter rainfall and water levels prior to nest initiation was discovered. This indicates that physiologic and behavioral condition (neuroendocrine health) of the pair may be more important than the direct impact of weather conditions on the incubation process. In addition to its impact on hatching success, rainfall and water level variations may account for some of the reproductive dysfunction observed. Thus the forecasted increase in frequency of periodic droughts is likely to be a significant limiting factor in the survival of reproducing whooping cranes in Florida.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:102

Key words: Florida, *Grus americana*, reintroduced, reproduction, weather, whooping cranes.

CHANGING RAINFALL PATTERNS VERSUS WETLAND ATTRITION: WHAT AFFECTS LARGE WATERBIRD BREEDING SUCCESS MORE IN THE GANGETIC FLOODPLAINS, INDIA?

K. S. GOPI SUNDAR, Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St. Paul, MN 55108; and International Crane Foundation, Baraboo, WI 53913, USA

Abstract: Waterbird breeding success, especially in cultivated landscapes, is affected by rainfall and agricultural intensification. Extreme rainfall events and agricultural expansion are predicted to occur in north India following global temperature rise. How will these changes affect breeding success of 2 resident large waterbirds of conservation concern: black-necked storks (BNS, *Ephippiorhynchus asiaticus*) and Sarus cranes (SC, *Grus antigone*)? I explored this question with observations on territorial pairs (BNS = 29; SC = 253) over 8 years between 1999 and 2010 in the southwestern Gangetic floodplains. I used logistic regression and generalized linear mixed models to understand factors (wetland extent and attrition in territories, 2 variables describing rainfall) affecting breeding success (whether or not pairs succeeded in raising chicks), and employed multi-model selection with Akaike's Information Criteria to make inferences. Annually 7-10% of territories of both species suffered wetland attrition, and urbanization permanently displaced 0.7% of SC pairs. Model selection supported the combination of habitat quality and rainfall as affecting breeding success of both species. Ability of pairs to successfully have chicks improved with increasing territory quality and rainfall, but declined with wetland attrition in territories. Increased cultivation, wetland attrition, and extreme rainfall occurred during the study, providing insights into future conditions. Predicted future increase in dry years can reduce waterbird breeding success, and wet years can likely buffer this effect. However, while climate change adaptations are deserving of focus, habitat loss due to agricultural intensification deserves far more urgent attention here if large waterbirds are to continue persisting.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:103

Key words: agricultural intensification, black-necked storks, breeding success, Gangetic floodplains, *Grus antigone*, India, rainfall, Sarus cranes.

CRANES AND CLIMATE CHANGE: A FACT SHEET

ZSOLT VÉGVÁRI, Hortobágy National Park Directorate, University of Debrecen, Debrecen, Hungary

MIRIAM HANSBAUER, Kranichschutz Deutschland, Seefeld-Hechendorf, Bavaria, Germany

Abstract: Due to increasing human activities and climate change, wetland habitats are worldwide disappearing, and many water bird species experience serious population declines. The family of cranes mostly depends on wetland habitats and is accordingly sensitive to climatic fluctuations. The objective of our project is to gather information on the 15 crane species, and to summarize actual facts and predictions about climate change effects on cranes. Further, conservation implications shall contribute to wetland conservation, using cranes as flagship species. The preliminary results consist of information on 4 species. For the Eurasian crane (*Grus grus*), increasing temperatures lead to a northward shifting of wintering grounds and earlier spring arrival dates, but also to a higher risk of drought on the breeding grounds. The whooping crane (*G. americana*) is affected by reduced precipitation and warmer temperatures leading to habitat loss on breeding, stop-over, and wintering sites. In India and Western China, the Sarus (*G. antigone*) and the black-necked crane (*G. nigricollis*), respectively, seem not as much affected by climate change as by intensification of agriculture. In contrast to the high variability of existing climatic scenarios, the effects of global change on cranes might lead to 3 major trends: Breeding habitat loss is expected for several species due to decreasing spring precipitations. Wetland loss along the flyways might reduce the survival rates of migratory species. Wintering ranges of several species might shift northward due to warmer temperatures. One major conservation implication to prevent wetland loss is an enhanced water management in all crane habitats.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:103

Key words: black-necked crane, climate change, Eurasian crane, *Grus*, Sarus crane, water management, wetland loss, whooping crane.

MOVEMENTS AND HABITAT USE OF THE BROLGA IN SOUTH WEST VICTORIA, AUSTRALIA

INKA VELTHEIM, School of Science and Engineering, University of Ballarat, Victoria, Australia; and AEDA, School of Botany, University of Melbourne, Victoria, Australia

SIMON COOK, School of Science and Engineering, University of Ballarat, Victoria, Australia

RICHARD HILL, Department of Sustainability and Environment, Victoria, Australia

MICHAEL MCCARTHY, AEDA, School of Botany, University of Melbourne, Victoria, Australia

Abstract: The south-western Victorian region of Australia supports a threatened population of the brolga (*Grus rubicunda*). The species is under threat from loss of habitat and poor breeding success and recruitment due to predation and collision with fences and power lines. A new potential threat has recently emerged due to the proliferation of wind farm developments within the brolga's key habitats. The species is considered to be at risk of collision with wind farm infrastructure. Disturbance and displacement from key habitats may also negatively affect the species. Lack of information on the brolgas' movements makes it difficult to assess the potential impact of wind farms on this population and to develop appropriate management strategies and mitigation measures. This study investigates movements of brolgas to define their spatial requirements, habitat use, and movement corridors. Brolgas were captured and fitted with GPS satellite transmitters and colour bands. GPS transmitters were programmed to log the location of the bird 4 times a day. Preliminary results indicate that brolgas utilize an area of up to 5-6 km at non-breeding sites and 2 km at breeding sites, and that they utilize similar flight paths between non-breeding and breeding areas. The outcomes of this study will be used to design turbine-free buffer zones around key breeding and non-breeding areas, thus aiding in wind farm planning to avoid long term population impacts.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:104

Key words: Australia, brolga, *Grus rubicunda*, habitat use, movements, Victoria, wind farms.

AERIAL CENSUS OF BROLGA NEST SITES IN SOUTH WEST VICTORIA, AUSTRALIA

INKA VELTHEIM, School of Science and Engineering, University of Ballarat, Victoria, Australia; and AEDA, School of Botany, University of Melbourne, Victoria, Australia

MARK VENOSTA, Biosis Research, Victoria, Australia

RICHARD HILL, Department of Sustainability and Environment, Victoria, Australia

SIMON COOK, School of Science and Engineering, University of Ballarat, Victoria, Australia

MICHAEL MCCARTHY, AEDA, School of Botany, University of Melbourne, Victoria, Australia

Abstract: The south-western Victorian region of Australia supports a threatened population of the brolga (*Grus rubicunda*). The species has suffered from loss of breeding habitat, predation of eggs and chicks, and poor breeding success. Little is known about current breeding density and key breeding areas within Victoria. Nest sites of brolgas in south-western Victoria are widely distributed, with majority occurring on private land. The sites are often difficult to access, survey, and monitor using ground-based survey methods. Aerial surveys were used to locate brolga nest sites for the first time in 2010 as part of a wind farm assessment. The current study employed and refined the methodology used in the wind farm assessment to locate and establish the density of brolga nests in 4 areas of south-west Victoria. Historical data was used to select survey areas with highest density of previous nesting records. Three blocks of 400 km² were surveyed in 2010 and 2011, flying transects at 500 meters apart, at 500 feet high, and with a flight speed of 60-70 knots. The results indicate that breeding density differs between survey areas and survey years. Some areas in south-west Victoria also appear to have higher density of nest sites overall than other areas, a result that was consistent over the 2 survey years, and that will aid in managing and protecting key breeding areas.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:104

Key words: Australia, brolga, *Grus rubicunda*, nest sites, Victoria.

MICROBIAL WATER QUALITY EFFECTS OF MIGRATORY BIRDS IN THE PLATTE RIVER, NEBRASKA 2009-2010

JASON VOGEL, USGS-Nebraska Water Science Center, Lincoln, NE 68512, USA

MATT MOSER, Oklahoma State University, Stillwater, OK 74074, USA

Abstract: The U.S. Geological Survey has collected information to investigate microbial water-quality effects of migratory birds in the Platte River during spring bird migration in central Nebraska within a study reach between Grand Island and Overton. The focus of the study was to make comparisons between fecal indicator bacteria (related to crane and waterfowl use of the river) and pathogen concentrations. The study area that is within the Critical Habitat reach of the Platte River is a bottleneck portion of the Central Flyway utilized by cranes and several types of waterfowl. During the height of the migration season, hundreds of thousands of cranes and other waterfowl roost in the river in central Nebraska. Understanding the effects of varying flow conditions on water quality during these migrations is important to aiding managers and researchers of the Central Platte flyway. Samples were collected weekly in the study reach from 3 sites (upstream, middle, and downstream) during the springs of 2009 and 2010. The samples were analyzed for avian influenza, *Escherichia coli*, *Cryptosporidium* spp., *Giardia* spp., *Campylobacter* spp., and *Legionella* spp. Analysis indicates that peak *E. coli* and *Campylobacter* concentrations were concurrent with the peak population of migrating sandhill cranes (*Grus canadensis*) taken from bird counts from the Central Flyway. Concentrations of *E. coli* were significantly greater at the downstream site compared to the upstream site. Avian influenza was not detected in any sample during the study. To date, data collection has been completed and the analysis and interpretation is currently underway.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:105

Key words: Central Flyway, fecal bacteria, *Grus canadensis*, migratory birds, Nebraska, Platte River, sandhill cranes, waterfowl, water quality.

AN UPDATE ON THE DIRECT AUTUMN RELEASE OF WHOOPING CRANES INTO THE EASTERN MIGRATORY POPULATION

MARIANNE WELLINGTON, International Crane Foundation, E-11376 Shady Lane Road, Baraboo, WI 53913, USA

RICHARD P. URBANEK, U.S. Fish and Wildlife Service, Necedah National Wildlife Refuge, N11385 Headquarters Road, Necedah, WI 54646, USA

Abstract: The whooping crane (*Grus americana*) is an endangered species endemic to North America with a native remnant population of less than 270 birds. The International Whooping Crane Recovery Plan has recommended the establishment of 2 separate self-sustaining populations, 1 migratory and 1 non-migratory. In 1999 the Whooping Crane Eastern Partnership (WCEP) was created to implement activities necessary for the establishment of a second migratory population separate from the Wood Buffalo/Aransas flock. In 2005 WCEP approved the development of the Direct Autumn Release (DAR) experiment. Young whooping crane chicks were hatched and costume-reared by humans at the International Crane Foundation until they were 3 to 7 weeks old. The young cranes were transferred to Necedah National Wildlife Refuge in central Wisconsin to be raised in the wild and soft-released in the fall. The DAR experiment released 33 birds in 2005-2009. This paper presents the results of the DAR releases thus far. Twenty-five birds (75.7%) survived their first migrations, overwintered, and successfully completed their first migration north. Eighteen returned to the core reintroduction area. Although the DAR population is relatively young, 2 females were in breeding situations in 2010; both successfully laid eggs and incubated full-term. One chick hatched and survived for 3-4 weeks. The DAR methodology continues to improve and appears to be a feasible means of reintroducing birds into the wild.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 12:105

Key words: costume-reared, DAR, Direct Autumn Release, *Grus americana*, Necedah National Wildlife Refuge, whooping crane, Wisconsin.
