Whooping Crane Eastern Partnership
2011 Annual Report

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PREFACE

Since 2001, the Whooping Crane Eastern Partnership (WCEP), an international coalition of public and private agencies, has been working to establish a self-sustaining migratory population of whooping cranes in eastern North America.

WCEP founding members are the International Crane Foundation, Operation Migration, Inc., Wisconsin Department of Natural Resources, U.S. Fish and Wildlife Service, the U.S. Geological Surveyôs Patuxent Wildlife Research Center and National Wildlife Health Center, the National Fish and Wildlife Foundation, the Natural Resources Foundation of Wisconsin, and the International Whooping Crane Recovery Team.

Whooping cranes were on the verge of extinction due to hunting and habitat loss in the 1940s and were listed as federally endangered by the U.S. Fish and Wildlife Service in 1967. The recovery goal for this project is a self-sustaining population of at least 120 adult whooping cranes and 30 breeding pairs. Successful establishment of this population will help meet one of the primary recovery objectives identified in the International Whooping Crane Recovery Plan.

WCEP underwent an external review in 2010, leading to the development of a revised strategic plan that outlines project goals and guidelines for 2011 - 2015. The Five Year Strategic Plan is available on the partnership website:
http://www.bringbackthecranes.org/whoweare/pdf/WCEP5YearStrategicPlan.pdf

WCEP implements its activities through coordinated joint and individual efforts by partners that have jurisdiction over the whooping cranes and/or the habitats they use. The partnership works through a ñteam approachò where key areas of WCEP activity and day-to-day decisions are addressed by one or more project teams that include individuals from partner groups with expertise and decision-making responsibilities in that area.

Project teams coordinate the planning, budgeting, operational, and field aspects of the WCEP project and implement management recommendations of the partnership. A WCEP Guidance Team conducts strategic planning and ensures the functioning of the project teams.

Guidance Team members are: Billy Brooks, U.S. Fish & Wildlife Service; Joe Duff, Operation Migration; Peter Fasbender, U.S. Fish & Wildlife Service; John French, USGS Patuxent Wildlife Research Center; Barry Hartup, International Crane Foundation; Rebecca Schroeder, Wisconsin Department of Natural Resources; and Doug Staller, Necedah National Wildlife Refuge.

WCEP Annual Reports for 2001-2008 are available on the WCEP website: www.bringbackthecranes.org/technicaldatabase/index.html#AnnualReports (annual reports were not produced in 2009 and 2010).

2011 Annual Report compiled by Joan Garland, International Crane Foundation
June 2012

REARING AND RELEASE TEAM

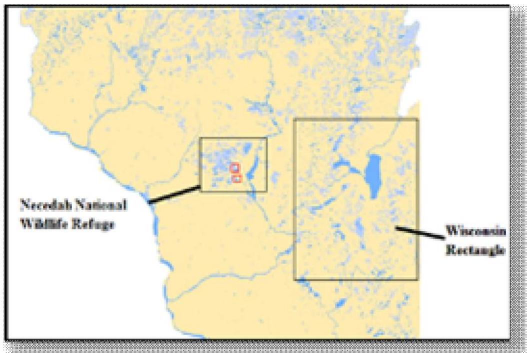
Team members: Brooke Pennypacker, Chair, Operation Migration; Barb Clauss, USGS Patuxent Wildlife Research Center; Brian Clauss, USGS Patuxent Wildlife Research Center; Joe Duff, Operation Migration; Michael Lusk, Chassahowitzka NWR; Kelly Maguire, International Crane Foundation; Glenn Olsen, USGS Patuxent Wildlife Research Center; Terry Peacock, St. Marks NWR; and Marianne Wellington, International Crane Foundation.

In 2010, the International Whooping Crane Recovery Team advised that no more whooping cranes should be released in the Necedah National Wildlife Refuge area until the cause of nest abandonment was identified and a correction applied. At the same time WCEP was undergoing a restructuring in response to a recommendation from an independent evaluation team. One of those recommendations was to apply a more scientific approach to future decisions, including release site evaluations. Assessing a new release site is time consuming and the WCEP was put under pressure to complete the needed work quickly.

The WCEP Research and Science Team 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. Minimum convex polygons were formed around data points gathered from nesting birds from April through July of a given year to define territories. Variables analyzed were selected based on knowledge of crane biology and on a prior analysis which identified those habitat characteristics that best predicted crane presence. The HSM identified three large wetland complexes in the study area, roughly corresponding to areas associated with the Fox, Wolf, and Rock rivers. This region, dubbed the Wisconsin Rectangle, includes wetland complexes that provide appropriate nesting habitat. It also has a low population of the species of black flies thought to be a factor in the nest abandonment that has occurred in and around the Necedah NWR.

Biologists, hydrologists, land use experts and managers from the Wisconsin Department of Natural Resources (DNR) provided information on several potential sites. They evaluated each for habitat type, water levels, public use pressure, food supply and other criteria.

Ultralight-led Migration



Facilities at White River State Wildlife Area

Jim Holzwart, DNR Bureau of Wildlife Management, coordinated the permit submissions and site surveying with cooperation from DNR Water Regulations and Zoning and the Army Corps of Engineers. The DNR also built an access road and installed a water control structure.

A low, wide ridge was graded slightly to create a 500 foot grass runway. A scrape was dug on the northern side to provide water for the wet pen, which was constructed of chain-link fence and top net. When mink were seen in the area, a band of chicken wire fence was wrapped around the lower portion of the wet pen and extended out from the pen horizontally under the water.

A dry pen was constructed of posts and stringers and lined on the inside with steel siding. These panels extended into the ground one half meter to deter digging predators. Both enclosures were protected by electric fences. All components of the pen complex were painted natural colors. Because of security gates and the distance from public roads, this area is well protected. A web linked camera added to that security. The development of this site was funded by OM through a grant from the Charles Fipke Foundation.

Early imprinting and conditioning at USGS Patuxent Wildlife Research Center
Eleven birds were hatched at the USGS Patuxent Wildlife Research Center, Laurel, Maryland and allocated to the ultralight led project. Hatch dates ranging from April 28 to May 14, gave an age range of sixteen days. As in past years, extensive training was conducted by the Patuxent and Operation Migration crew to train the chicks to follow the ultralight aircraft. Records are kept on the training process and medical history for each chick. Some of the information is summarized below.

Chicks start their training even before they hatch, by being exposed to the recorded sounds of the ultralight engine, in addition to recorded natural sounds. This makes the chicks less apprehensive when they are first introduced to the ultralight aircraft.

Taking the chicks for a walk first occurred on average at 7.3 days-of-age this year (standard deviation ±0.95 days, range 7 to 9 days-of-age). Chicks were led in this activity for an average of 565 minutes (±62 minutes) over the next 30 days. Next chicks are introduced to the ultralight aircraft for an average of 22 minutes (±11 minutes, range 15 to 45 minutes). After one or two trips to the ultralight aircraft for the introduction, in subsequent days chicks were led around a circle pen by the ultralight and costumed handler on the outside of the circle. Each chick participated in this activity for an average of 198 minutes (±64 minutes, range 113 to 297 minutes) over a period starting on average at 9.5 days-of-age (±1.3 days, range 7 to 11 days-of-age) and lasting until on average 23.2 days-of-age (±4.3 days, range 18 to 31 days-of-age).

As the chicks get larger, we begin to train them in a large open field. Chicks are led out from their pen to the open field runway by costumed people. Then the chicks run up and down the runway with the costumed handler in the ultralight aircraft. This started in 2011 on average at 24.3 days-of-age (±4.3 days, range 20 to 32 days-of-age), lasted until 49 days-of age on average (+5.3 days, range 41 to 57 days-of-age), and each chick received an average of 5.17 hours (±0.83 hours, range 4.02 to 6.07 hours of training).

Pond training in 2011 started at an average of 43.4 days-of-age (±5.5 days, range 36 to 52 days-of-age) for a total of 76 hours for each chick. This training continued as they were housed in a wet pen at the training site in Wisconsin. Socialization training started in 2011 at 14.6 days-of-age (±3.6 days, range 11 to 24 days-of-age), for an average of 338.4 hours per chick (±45.6 hours, range 289.3 to 385.6 hours per chick).

One chick, 8-11 was unusually aggressive and difficult to socialize. Fear that it would injure other birds led to a decision to transfer it to the group destined for release in Louisiana. This bird eventually calmed down, lost its aggressiveness and became a cohesive part of the release group for the non-migratory Louisiana flock.

All of the birds were socialized at Patuxent and eventually penned as one group. The average age spread for a cohort is normally 10.63 days. Despite the 16 day age spread of this single cohort, aggression was not unusually high and no birds were injured.

All whooping crane chicks receive extensive medical attention, starting with a health examination shortly after hatching. Health examinations continue on a daily schedule during the first critical 10 days, then biweekly. In addition, extensive laboratory tests are conducted to monitor health and parasite counts and sexes are determined by genetic testing. Vaccinations for West Nile virus and eastern encephalitis are given and survey x-rays taken of all chicks prior to departure for Wisconsin.

NUMBER	HATCH DATE	GENDER	ORIGIN
1-11	4/28	M	Patuxent WRC
2-11	4/29	F	Patuxent WRC
3-11	5/4	M	Eastern Migratory Population (09-03* & 3-04)
4-11	5/5	F	Eastern Migratory Population (09-03* & 3-04)
5-11	5/7	M	Calgary Zoo
6-11	5/8	M	Calgary Zoo
7-11	5/9	F	Eastern Migratory Population (16-07 * & 16-02
9-11	5/11	F	Eastern Migratory Population (15-04* & 5-05)
10-11	5/12	M	Eastern Migratory Population (26-07* & 7-03)
12-11	5/14	F	Species Survival Center

At an average age of 52.3 days-of-age (±5.3 days), ten birds were relocated from Maryland to Wisconsin by private aircraft provided by Terry Kohler of Sheboygan, Wisconsin. This was the 29th flight the Windway crew has made to Baltimore and back in support of this project and we are forever grateful. The aircraft landed at Wittman Field in Oshkosh and the birds were transported in an air conditioned van 28 miles to White River Marsh. They were checked by Barry Hartup, DVM from the International Crane Foundation and a number of associates. No injuries or behavioral issues resulted from this trip.

During the early summer, water levels in the wet pen remained high, but as the temperature climbed, the water table dropped. A 1,000 gallon water tank on a trailer was used to deliver up to 4,000 gallons per day. This fresh water was transferred to the wet pen by pump through approximately 200 meters of large diameter hose. Because the wet pen had a capacity of nearly 50,000 gallons, this system was labor intensive and barely able to keep up with evaporation and the dropping water table. Wildlife Area Manger, James Holzwart obtained a permit for us to install a well and a pump. Thereafter the pump was run at least once per day to maintain a fresh water supply and keep the wet pen level high.

The birds were trained with the aircraft every day that the weather allowed and the season progressed at training levels similar to other years. They were at the White River State Wildlife Area for a total of 103 days and able to roost in water every night.

Number 1-11 developed a behavioral problem and would not fly for more than a few hundred meters or a short circuit around the pen. In one attempt to get the bird to join the aircraft, it landed in tall brush and had to be retrieved. During that process, the handler who had located the bird became disoriented in the thick undergrowth and uneven terrain. The problem was exacerbated by a dead radio battery and a wet cell phone. In an attempt to fly from the thick brush, the bird became entangled in branches. After four and a half hours they were found. The bird was carried from the brush and crated for the return trip to the pen. No permanent injuries occurred although the bird did not participate in flight training and was weary of the handlers for several days. Despite intensive efforts, its reluctance to fly was not corrected prior to the start of the migration.

Migration 2011

With only one cohort and no socializing to do, we hoped to depart early this year. However the reluctance of number 1-11 to fly, and the short endurance of the birds, prompted us to delay our target date. The weather allowed us to begin on October 9 which was three days earlier than the average departure date of October 12.

After three attempts over three days, only four birds successfully completed the flight to the first stopover. The remainder were transported the four miles in crates. Ten days of poor flying conditions followed. On October 21, on a failed attempt to lead the birds to the second stopover location in Marquette County, an aerial rodeo ensued and number 2-11 went missing. Despite having two tracking vehicles and three aircraft, one equipped with tracking antennas, we were not able to locate number 2-11 or even pick up a faint signal from its leg band transmitter.

When the birds are handled to affix permanent bands and transmitters, they become temporarily reluctant to follow the aircraft and weary of the costumed handlers. To avoid this delay in our training and the possibility of injury, snap-on bands and transmitters are used until the migration is complete and weariness to handlers is no longer an issue. These snap-on transmitters have been used repeatedly and some have failed. The team checks them regularly, and particularly before each flight. However, that morning the transmitter on number 2-11 failed, and we were unable to locate her. She was reported with sandhill cranes in Waushara County on October 26 but could not be recaptured. The WCEP Rearing and Release Team determined that number 11-02 was deemed released and no further attempts were made to retrieve her. She migrated appropriately with sandhill cranes and arrived in Lake County, Florida by November 27.

The early stages of the migration progressed slowly due to poor flying weather. These delays did not help to encourage reluctant birds to follow our aircraft, but slowly they began to get the idea. Only a few birds dropped out and had to be crated.

When we arrived in Livingston County, Illinois we were grounded by high winds for fifteen days. That wind also made it difficult to release the birds regularly for exercise and enrichment. Despite that delay, the birds did well, with very little aggression noticed. We were able to lead the birds 59 miles to Piatt County, Illinois and were again grounded, this time for ten days. By December 11, the migration had progressed through Illinois, Kentucky, and Tennessee and had reached Russellville, Alabama, where we faced another nine down days. On December 20, with a forecast of poor flying weather for the next week, we decided to break for Christmas and allow some of the team members to return home after a three month absence. During this break the FAA questioned the legality of our flight operations and further flights were curtailed until a waiver was issued on January 9, 2012.

The team reassembled on January 11, but poor flying conditions prevailed for another two weeks. During that time we were able to lead the birds on two flights in less than perfect conditions. On both occasions we found that they were reluctant to follow us, likely due to their long stay at one place. On January 29, we took off again on a clear morning in ideal conditions. The birds followed perfectly for five miles and turned back. For two and a half hours we struggled to even get them back to the starting point. A week of poor flying weather was forecast to follow.

With no good weather in the forecast and the birds reluctant to follow us, the team decided that it would not be possible to lead the birds to Florida in time to acclimate them to the wintering grounds and perform a gentle release into the wild. The 2011 migration was ended in northern Alabama on January 29, 2012. The nine whooping cranes were released on Wheeler National Wildlife Refuge in Alabama on February 10, 2012.

Fig. 1. Comparison of Training and Migration History of First eleven Generations of WCEP UL Whooping Cranes

EVENT	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001
First / Last Hatch Date	Apr 28 May 14	May 1 May 26	May 3 Jun 5	May 6 Jun 15	Apr 29 Jun 10	May 5 May31	Apr20 Jun3	Apr20 Jun5	Apr21 May23	Apr12 May21	May7 May24
Age spread (days)	16	25	33	40	42	26	44	46	32	39	17
Age-first exp. To Aircraft (days)	9.5	NA	NA	NA	NA	8.1	7	8	8	9	7
Gender	5M ï 5F	7 F- 6 M	9F ï 11M	8F-12M	8F-10M	9F-9M	9F-12M	5F-11M	6F-11M	10F-7M	4F-6M
Avg. # training hrs at PWRC	8.9	NA	NA	NA	NA	3:55	5:06	7:45	11:02	11:56	7:18
Pond exposure at PWRC (hh:mm)	43.4	NA	NA	NA	NA	32:24	39:48	55:26	21:42	180:40	19:06
Tot. chicks trans to NNWR	10	13	23	20	18	18	21	16	17	17	10
Avg. age at shipping (days)	53.3 days	56.75 days 51.6 days	51.0 | 44.5 36.7	44.8 ш43.6 47.8	44.7 l 44.6 46	48 | 47 52	49 | 49 42	53 | 46 41	51 | 43	54 | 45	56
Shipping Date (m/d)	June 29	6/30, 7/9, 7/28 (*12)	6/25 | 7/02 7/10	6/25 ш7/9 7/29	6/19 l 7/3 7/18	6/26 | 7/6 7/20	6/15 | 7/6 7/13	6/19 | 6/30 7/15	6/19 | 7/1	6/12 6/27	7/10
Cohort One (C1)	1,2,3,4,5,6,7,9, 10,12,	1, 2, 3, 4, 5, 6, 8, 9,	1,3,4,5,6,7,8,10 ,11	3,4,5,7,9, 10,11	3,6,7,9,10,12,1 3,14	1,2,4,5,6,7,8,10	1, 2, 3, 5, 6, 7	1, 2, 3, 5, 6, 7, 8	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 7, 8	1, 2, 3, 5, 6
Cohort Two (C2)	NA	10, 11, 15, 16, 17	12,13,14,15,18, 19	12, 13, 14, 15, 16, 18, 19	16,17,18, 21, 22, 24	11, 12, 13, 14, 15	8, 9, 10, 11, 12, 14, 15, 16	12, 14, 15, 16, 17, 18	7, 9, 10, 11	9, 10, 11, 12	4, 7, 9, 10, 11
Cohort Three (C3)	NA	NA	22,24,25,26,27, 28,29, 31	24, 26, 27, 28, 29, 30	26, 27, 33, 35	18,19, 20, 22, 23	19, 20, 21, 22, 23, 24 26	19, 20, 22	12, 13, 14, 16, 17, 18, 19	13, 14, 15, 16, 17, 18	NA
Total days at intro site	102	102 , 93	112/106/97	114/100/80	115/101/86	102 | 91| 77	121 | 100 93	117 | 103 88	118 | 106	112 | 107	98
# days trained at intro site	64	61, 41	63 | 58 | 51	61 |55 |40	67 l 50 l 40	59 | 52 |41	56	57	69	52	41
# nights water-roosting available	102	NA	101|97|89	106|84|74	109 l 96 l 82	84 | 75 | 72	93 (M)	76 (M)	99 (M)	82 (M)	9 (M)
Fledging Date C1,C2,C3(m/d)	Aug 18	Aug 8 / Aug 26	7/20, 8/17 9/1	8/2, 15, 31	7/28 l 8/6 l 8/31	7/28 | 8/10 8/20	7/15 | 8/1 | 8/14	7/17 | 8/02 9/16	7/19 | 7/22 7/30	8/18 | 8/24 9/30	8/29 | 9/6
Pre-mig. health check (m/d)			Sept 9/10	9/2, 3	9/5	9/6, 7	8/30, 31	9/5 & 6	8/27	8/26,27,29	9/11
Cohorts united	June 29	Sept 17	Sep 18 Oct 7	Sep 18 Oct 5	Sep 13, 28	Sep 5, 21	Sep 15, 23	Sep 6, 21	Aug 14, 29	Aug 25 Sep 16	Sep 5

Longest pre-migration flight	18 min	34 min	44 min	41 min	28 min	26 min	32 min	47 min	33 min	24 min	27 min
Migration departure	Oct 9	10/10	10/16	10/17	10/13	10/5	10/14	10/10	10/16	10/13	10/17
# Cranes began migration	10	12	20	14	17	18	20	14	16	17	8
Total migration distance (miles)	703	1285	1094.5 1238.6(*8)	1093.3 1255.26 (*7)	1211.6	1239.1	1209.1	1204.4	1191	1204	1227.28
Total Flight Time	28.2		36.45(*9)	34:13.8 (*6)	37:37	33:40	31:46	33:07	31:53	38:36	35:46
Total flight days	17		22 / 24 (*10)	19 / 21(*5)	25	22, 24(*2)	21 25(*1)	21	20	22	26
Total days to complete mig.	89	St M 66 days Chass 73 days	82 / 89 (*11)	82 / 88 (*4)	96	76 78(*2)	61 ï 64(*1)	64	54	49	48
Longest flight dist. (miles)	67		116	117.1	138	101	115	157	200	107.2	94.7
Longest flight duration. (h/mm)	2:43		3:10	2:52	2:20	2:45	2:24	3:00	3:03	2:15	2:09
Arrival Date	Feb 4 (Wheeler)	Dec 15 St M Jan 15 Chass	Jan 13 Jan 20,10	Jan 17 & 23/09 (*3)	Jan 28/08	Dec 19 & Jan12/07 (*2)	Dec13 & Jan11/06 (*1)	Dec 12	Dec 8	Nov 30	Dec 3
Division between wintering sites Chass / St M	NA	Chas 3, 9, 15,16, 17 St M 1,5,6,8,10									
Total cranes to complete migration.	9	10	20	14	17	18	19	13	16	16	7 (1 crated)

(*1) = Arrived 13 Dec 2005 at Halpata. Moved birds 26.1 miles to Chassahowitzka NWR on Jan 9, 10 and 11 2006
(*2) = Arrived 19 Dec 2006 at Halpata. Moved birds 26.1 miles to Chassahowitzka NWR on Jan 11, 12 2007
(*3) = Arrived 17 Jan 2009 at St. Marks NWR. Arrived 23 Jan 2009 at Chass NWR
(*4) = 82 Days to St. Marks / 88 days to Chass (excluding 10 day break at Christmas)
(*5) = 19 flights to St. Marks / 21 flights to Chass
(*6) = 30 hrs 34.5 min to St. Marks / 34 hrs 13.8 min to Chass
(*7) = 1093.3 miles to St. Marks / 1229.26 miles to Chass
(*8)= 1094.5 to St Marks / 1238.6 to Chass
(*9)= 31 hrs 47 min to St Marks / 36 hrs 45 mins to Chass
(*10)= 21 flights to St Marks / 24 fights to Chass
(*11) = 82 days to St Marks / 89 days to Chass
(*12) 2010 number 04-10 and 11-10 were shipped out late due to health concerns that cleared up.

Direct Autumn Release

Year 2011 was the seventh year in which whooping crane chicks were specifically reared for release on the northern reintroduction area. A total of 52 juveniles have been released during the autumn staging period to learn survival skills and the migration route from older, more experienced cranes. The following report combines efforts of the Rearing and Release Team and the Monitoring and Management Team in order to provide a cohesive report on the Direct Autumn Release (DAR) project in 2011.

2011 was the first year of a modified Direct Autumn Release (mDAR) of whooping cranes on Horicon National Wildlife Refuge (NWR). The modification to the DAR project revolved around two objectives. First was the desire to release birds in new areas consistent with the WCEP Five Year Strategic Plan, while taking advantage of existing facilities. The second objective was to learn more about the philopatry of captive-bred and released whooping cranes.

Until this year, all of the WCEP whooping cranes were raised on the targeted breeding grounds for a period of time and then released (DAR) and/or migrated from the same location (ultralight-led migration). It is generally believed that cranes learn to identify characteristics of their rearing and future breeding grounds during their early flights above the tree tops, gaining landmark information and possibly combining this with the night sky. The mDAR project began to test this theory by transferring chicks to a new location after they fledged (observed to fly 100 m without touching the ground), but prior to their ability to fly large loops or above the tree tops. Once relocated, the chicks were encouraged to fly, thus having their early, extended flights occur at the new potential breeding location.

Facilities

This was the seventh year using the Felburn- Leidigh Chick Rearing Facility at the International Crane Foundation as well as the facilities at Site 3 on Necedah NWR. Due to a sandhill crane project undertaken by the Necedah staff, and limited amount of disinfectant to clean between moving the sandhill project and the DAR chicks moving to Necedah, the DAR project focused on using the field facilities (i.e. wet pen), and used the chick yard and house on a very limited basis.

New facilities were constructed on the Horicon NWR in late August/early September. These facilities were similar to the release pens used in Florida with the non-migratroy flock. A few modifications in fencing materials provided better protection from smaller predators such as mink versus alligators in Florida. An open-topped pen measuring ~70ô x 90ô was erected on the edge of the main channel on the east central part of Horicon NWR, just north of the education barn. A portion of the pen (30ô x 50ô) was later enclosed to provide an area where chicks could be maintained when personnel were not available to monitor them (during inclement weather or providing additional experiences for the interns). A monitoring blind and storage area were constructed at the edge of the woods ~300ô from the pen. The blind was placed on a platform ~3ô high in order to provide better viewing of the birds when roosting or foraging along the edge of the water. Camouflaged tarps and netting were draped throughout the woods to provide a visual barrier for costumed personnel to approach the blind without being seen by the chicks.

Ten whooping crane chicks were hatched and reared as mDAR release candidates at ICF. Two chicks died prior to transfer to Necedah NWR. Eight chicks (4 female and 4 male), ranging from 42 to 67 days old, were transferred to Necedah NWR Site 3 (Table 1). The move to Site 3 was later than previous years due to a couple of factors: In 2011 Necedah NWR used Site 3 facilities for a sandhill crane adoption project. Sandhills were moved away from Site 3 on July 20, and preparation for moving the mDAR birds began at that time. Another factor was the high water in the day pen and additional rains slowed the site preparation, therefore the birds were moved to Necedah NWR on August 11 (Table 2).

Table 1. 2011 Whooping cranes hatched at ICF and relocated to Necedah/Horicon NWR

WCEP ID	Gender M.F.U	Hatch Date	Dam Sire	Final Disposition	Date	ICF ID	Comments
13-11	1.0.0	5 June	13-37 OôMalley 13-28 Bosque	Released	21 Oct	Pandoro 13-284	Released on Horicon NWR
14-11	0.1.0	6 June	13-14 Stella 13-40 Bubba	Released	21 Oct	Scotcharoo 13-285	Released on Horicon NWR
15-11	0.1.0.	11 June	13-71 Oobleck 13-05 Gee Whiz	Released	21 Oct	Lamington 13-286	Released on Horicon NWR
16-11	1.0.0	15 June	13-14 Stella 13-40 Bubba	Released	21 Oct	Grasshopper 13-287	Released on Horicon NWR
17-11	0.1.0	17 June	13-37 OôMalley 13-28 Bosque or 13-176 Luna	Released	21 Oct	Zanzibar 13-288	Released on Horicon NWR
18-11	1.0.0	18 June	13-35 Josh 13-29 Kohler	Released	21 Oct	Nougat 13-289	Released on Horicon NWR
19-11	1.0.0	30 June	13-14 Stella 13-40 Bubba*	Released	21 Oct	Gelato 13-292	Released on Horicon NWR
20-11	0.1.0	30 June	13-35 Josh 13-29 Kohler	Released	21 Oct	Chiffon 13-294	Released on Horicon NWR

*Potential sires listed in order of highest probability. Both Zanzibar and Gelato need paternity tests run to determine sire.

Once transferred to Necedah, three of the eight chicks (17-11, 19-11, and 20-11) were housed in the chick building where they were maintained in individual runs and locked inside overnight. The other five were housed in the night pen (top covered pen). Two birds (13-11, 14-11) were maintained on the south portion while the other three (15-11, 16-11, and 18-11) had access to the middle section of the pen. On 17 August, chick nos. 17-11, 19-11, and 20-11 were moved into the north section of the night pen, leaving the chick building empty. Socialization of the three cohorts began first with the younger five birds. Costumes exercised the two groups together monitoring their interactions and making sure everyone was able to eat, drink and rest as needed without concerns of aggression. Once the younger five were together, the process continued by including the two oldest birds. On 11 September, the eight chicks were given access to the entire night pen as a single cohort.

Costumed caretakers worked with the whooping crane chicks in the natural environment, encouraged foraging, roosting, and monitored interactions with adult whooping and sandhill cranes. Once the chicks fledged, between the ages of 80-107 days old, they were kept in the covered pen until transferred to Horicon NWR. This prevented the young cranes from flying large distances or above the rearing site at Necedah. While the birds were kept in the covered marsh pen, staff would perform daily AM and PM checks on the birds and spend the day constructing the chick pen and staff viewing blind at Horicon NWR. On 15 September all eight chicks were handled for a pre-transfer physical exam and Avid chip transponders were implanted in the neck/shoulder region of each chick (Table 3).

On 20 September, the chicks were transferred to Horicon NWR. The stated goal was to transfer the birds to the final release site when the majority of the chicks were between the ages of 90-100 days (Table 2). Once at Horicon, the program continued as in previous years. Costumed caretakers encouraged flight and slowly decreased their time spent with the birds, allowing the chicks to become more independent from the costumes.

Table 2. Age of chicks when transferred to Necedah and Horicon NWR

ICF ID	WCEP ID	Age when Transferred to Necedah NWR, Aug. 11	Age when Transferred to Horicon NWR, Sept. 20
13-284	13-11	67	107
13-285	14-11	66	106
13-286	15-11	61	101
13-287	16-11	57	97
13-288	17-11	55	95
13-289	18-11	54	94
13-291	19-11	43	83
13-294	20-11	42	82

Interactions between adult cranes and chicks

Resident whooping crane pair, nos. 11-02 and 30-08 had frequent interactions with the chicks while at Site 3 at Necedah NWR. The adult pair displayed more territoriality this year compared to last year and confronted the costumed caretakers and chicks regularly. A few aggressive interactions with the chicks occurred, but all without injury. On August 18th, a yearling male, 1-10 landed at Site 3 but was quickly chased off by 11-02/ 30-08. Once transferred to Horicon NWR, the chicks interacted with a sandhill crane family which frequented the marsh near the pen site.

Chick health in the field

Minor health issues were exhibited by various chicks while in the field. Splints were maintained on 20-11ôs toes. Due to the increase in handling to manage the splints, blood feathers were damaged. It was decided that the rotation of the toes was not severe enough to risk injury during handling and thus the splints were removed. Number 19-11 had a swollen culmen from pacing the fence of the chick run. Number 14-11 was found the morning of September 16th with a fractured bill tip and went off food for a couple of days. The transfer to Horicon was delayed until she was eating again. On October 15th, the morning of banding the birds, 17-11 was found to be favoring her right leg and had a superficial wound on the front of her hock where the band was rubbing.

Banding

The young cranes were banded mid-October, including auxiliary color markers and VHF transmitters (Table 3). Weights and measurements of tibiotarsus were taken while the birds were in hand (Table 4). Three females also received GPS-enabled satellite transmitters. During this banding session, Dr. Richard Urbanek observed/coached Rich King, Eva Szyszkoski and Marianne Wellington band one chick each. An error was made in color bands on 17-11 which was corrected by cutting off the incorrect bands and replacing them with the correct color combination. The entire banding session lasted ~3 hours.

Release of DAR juveniles

The release of the eight juveniles was conducted near a large sandhill crane roost location shortly before dark on the evening of 21 October. The group took flight after release and split up in the air. Nos. 13, 14, and 16 landed back near the release location to roost. Nos. 15 and 19 were found to the west on one of the refuge dike roads. They were boxed and brought back to the release location where they joined the three roosting birds. No. 18 was discovered along a dike road to the south, boxed, and released to roost with the other five. No. 17 roosted in a small tall grass marshy area just to the north of the main roosting location. No. 20 landed in an inaccessible and non visible location to the WNW where she roosted for the night.

On 22 October no. 17 returned to the pen site. She briefly joined the other seven juveniles later in the day before returning to the pen site again. After regrouping, the other seven juveniles remained mainly on or near Teal Pool, north of their release location and made occasional large circles over the northern half of the refuge. All birds were occasionally seen associating with or in close proximity to sandhill cranes.

On 24 October, all eight juveniles were observed at the pen site and roosted there that night. They remained together and were observed off of the refuge for the first and only time on 26 October when they were seen in a cornfield with a flock of ~200 sandhill cranes just to the west of the refuge.

Table 3. Complete identification of mDAR birds 2011

WCEP #	ICF ID Name	Sex	Avid Microchip ID	Bird banding Lab ID	Color combo	VHF	Satellite
13-11	13-284 Pandoro	M	067 017 835	599-56330	gwg/GR*	164.969	
14-11	13-285 Scotcharoo	F	067 046 045	599-56327	Wptt/GR	164.981	38634
15-11	13-286 Lamington	F	067 019 097	599-56328	RWptt/GR	165.033	62170
16-11	13-287 Grasshopper	M	067 021 024	599-56331	rwg/GR	165.093	
17-11	13-288 Zanzibar	F	067 051 839	599-5632	GR/wgw	164.486	

18-11	13-289 Nougat	M	067 048 007	599-5633	GR/rgw	164.123	
19-11	13-291 Gelato	M	024 350 258	599-56334	GR/wrw	164.933	
20-11	13-294 Chiffon	F	067 052 879	599-56329	WGptt/GR	165.432	10398

*Capital letters stand for 1.5òbands, lower case letters represent 1òbands.

Table 4. Weight and morphometry of HY 2011 mDAR chicks, 14 October 2011

WCEP ID.	Sex	Tarsus (mm)	Weight (kg)
13-11	M	310	6.2
14-11	F	301	5.6
15-11	F	308	6.7
16-11	M	313	7.1
17-11	F	259	5.1
18-11	M	322	7.8
19-11	M	290	6.9
20-11	F	285	5.9

Migration and wintering

On the morning of 27 October no. 19 separated from the group. Later that day, the other juveniles (nos. 13, 14, 15, 16, 17, 18 and 20) left the refuge and headed southwest, eventually landing with a small group of sandhill cranes southwest of Oregon in southern Dane County. On 10 November, they were joined at this location by pair nos. 16-02/16-07. The two adults migrated from this location on 20 November, but the juveniles remained. They began migration with a group of sandhill cranes on 29 November however their signals were lost north of Ottawa, LaSalle County, Illinois, later that day. The rest of their migration is described below:

A PTT satellite reading from no. 15 indicated a location north of Terre Haute, Vigo County, Indiana, on 30 November but was likely a flight point and no signals were detected at this location that evening.

PTT satellite readings for nos. 14 and 20 indicated a roost location at the Hiwassee WR, Meigs County, Tennessee, on the night of 1 December where they were later confirmed with no. 17. No. 14 continued migration into Georgia on 4 December and remained with sandhill cranes along the border of Floyd County, Georgia, and Cherokee County, Alabama, through at least 16 January 2012.

A PTT satellite reading for no. 15 on the night of 30 November indicated a roost location W of Hartford, Ohio County, Kentucky. Nos. 15 and 18 were reported at the Wheeler NWR in Alabama on 2 December and have remained at this location through at least 16 January. There are five older whooping cranes currently at this location and the juveniles are closely associated with no. 19-09.

Nos. 13 and 16 have not been detected since beginning migration.

No. 19 left the Horicon NWR on 29 October. He was reported near the Avon Bottoms SWA, Rock County, Wisconsin, on 3 November and began migration from this location on 16 November. He has not yet been relocated.

Fig. 2. DAR Summary of Release and Migration Cohort Size and Companion Species

Year	Number Released	Groupings at Release	Groupings at start of migration	Species observed migrating with: SH, WC, or on own
2005	4	Singles	4 birds	Sandhills
2006	4	2 Groups	2 Birds 2 Birds	2 WC WC & SHs
2007	10	2 groups of 4 1 group of 2	3 birds[1] 6 birds	On Own On Own
2008	6	3 Groups of 2	4 birds[1] 1 single	1 WC 7 WC
2009	9	1 Group of 4 2 groups of 3	7 birds 1 single 1 single	4 WC 5 WC 1 WC
2010	11	Group of 3 2 Groups of 4	3 Birds 2 Birds 4 Birds	On own[2] On own 3 WC
2011	8	1 group of 8	1 Group of 7 1 Single	On own

[1] Mortality of 1 bird night of release

[2] Birds roosted first night of migration with adult whooping cranes

Acknowledgments

Ultralight project:

USGS Patuxent Wildlife Research Center crew:

Dr. John B. French, Research Manager; Dr. Sarah Converse, Research Biologist; Jonathan Male, Aviculturist; Jane Chandler, Crane Flock Manager; Sharon Peregoy, lead crane crew member; Brian Clauss, lead crane crew member and trainer; Barbara Clauss; Robert C. Doyle; Ali Angel Lopez; and Charlie Shafer, ground trainer

Patuxent veterinary crew:

Dr. Glenn H. Olsen; Dr. Samantha Gibbs; Carlyn Caldwell, veterinary technician; and Martine Angel

Patuxent volunteers:
Maddie Buresh; Taylor Callicrate; Lillian Carter; Mary Edwards; Susan Kryszak; Ken Lavish; Diana Ogilvie; Jenny Shinn; Maria Smith; Paula Wang; Megan Brown, University of Maryland; Kayla Hanada, Sacramento Zoo; and Melissa Waterman, Disney Animal Kingdom

Operation Migration crew at Patuxent:
Brooke Pennypacker, pilot for ground training; Geoff Tarbox and Caleb Fairfax

Migration crew:
Joe Duff, Richard van Heuvelen, Brooke Pennypacker, Walter Sturgeon, Liz Condie, David Boyd, Lou Cambier, Linda Boyd, Geoff Tarbox, Caleb Fairfax, John Cooper, Gordon Perkinson, Christine Barnes, and Gerald Murphy

Operation Migration home team:
Chris Danilko and Heather Ray

We owe a debt of thanks to the Wisconsin Department of Natural Resources who stepped forward and provided expertise, staff, property, and permits to identify and develop the White River Marsh State Wildlife Area as the UL reintroduction facility.

We would like to thank our wonderful volunteers who dedicated their time, expertise and equipment to make this project possible. We are also forever grateful to our stopover hosts who have endured our delays along with us.

mDAR project:
Horicon NWR staff for welcoming the whooping crane project and assistance throughout the season: Patty Meyers, Refuge Manager; Dianne Kitchen, Assistant Refuge Manager; Wendy Woyczik, Wildlife Biologist; Jon Krapfl, Wildlife Biologist; John Below, Law Enforcement Officer; Mike Madel, Maintenance; and the rest of the crew.

International Crane Foundationŝs Crane Conservation Department: Bryant Tarr, Kelly Maguire, Kim Kehoe, Megan Kennedy, Taffy Bannon, and Marianne Wellington. Interns: Brittany Murphy, Christine Behring, James DeNuchi, and Kyle Tainter, and volunteer Meredeth Selden.

ICF DAR team members: Marianne Wellington, Kim Kehoe, Taffy Bannon, Matthew Dugan, Jaclyn Ramsey, and Morgan Wealti.

ICF Site Maintenance crew: Dave Chesky, Tom Davis and Michael Schwerman.

ICF Tracking Team: Eva Szyszkoski, Team Leader; Jen Davis, Intern.

Necedah NWR: Doug Staller, Refuge Manager and son Dalton who assisted with mowing at Site 3; David Trudeau, Assistant Refuge Manager; Rich King, Wildlife Biologist; Richard Urbanek, Wildlife Biologist; Nate Merk, Maintenance; Dan Peterson, Volunteer Coordinator; and the rest of the staff who have welcomed us and provided support, expertise and a sense of humor on those long, trying days in costume.

The Natural Resources Foundation of Wisconsin has provided funding for the DAR interns since 2005.

Operation Migration: Brooke Pennypacker and Geoff Tarbuck assisted with building panels for the new release pen and Brooke consulted on the support posts for the enclosed pen.

USGS Patuxent Wildlife Research Center: The entire Crane Crew for their expertise and collegial working environment, Dr. Glenn Olsen and Robert Doyle for arranging the transfer of pen materials from Maryland to Wisconsin.

Many thanks to our supporters and volunteers who remain dedicated to the recovery of cranes and the ecosystems on which they depend. Your time and expertise are extremely valuable and appreciated.

MONITORING AND MANAGEMENT TEAM

Team members: Joel Trick, Chair, U.S. Fish & Wildlife Service; Billy Brooks, U.S. Fish & Wildlife Service; Nancy Businga, USGS National Wildlife Health Center; Mike Engels, International Crane Foundation; Marty Folk, Florida Fish & Wildlife Conservation Commission; Rich King, Necedah NWR; Davin Lopez, Wisconsin Department of Natural Resources; Kim Miller, USGS National Wildlife Health Center; Eva Szyszkoski, International Crane Foundation; Lori Steckervetz, Wisconsin Department of Natural Resources; Walt Sturgeon, Operation Migration; and Richard Urbanek, Necedah NWR.

This report documents the activities of the WCEP Monitoring and Management Team in monitoring whooping cranes in the reintroduced eastern migratory population during the calendar year of 2011. The distribution of cranes during this report period is shown in Figure 1. Identification information for all whooping cranes in the eastern migratory population as of 31 December 2011 appears in Appendix A.

Winter 2010/2011

Movements and distribution

The wintering population as typified by status on 8 February 2011 included 106 birds (55 males and 51 females). Distribution was Indiana (4), Kentucky (1), Tennessee (14), Alabama (17), South Carolina (4), Georgia (6), Florida (51), undetermined (3) and no recent reports (6). The total in Florida included 10 recently-released ultralight-led juveniles and four birds that were detected by the Homosassa Datalogger but whose final wintering locations in the state were not determined. These totals exclude a juvenile that was later found dead in Alabama and had been killed before 8 February. Winter distribution is shown in Figure 2.

Hatch Year (HY) 2010 ultralight-led cohort

The ultralight-led (UL) migration departed from the Necedah NWR in Wisconsin on 10 October 2010. The flock of 10 juveniles was separated into two groups after arriving at the stop in Jefferson County, Florida, on 12 December 2010. Five juveniles completed migration to the St. Marks NWR, Wakulla County, Florida, on 15 December. Bands and transmitters with permanent color identification codes were attached to five juveniles on 17 December at the St. Marks NWR and to the remaining five juveniles at the stopover location in Gilchrist County, Florida, on 20 December. The remaining 5 juveniles completed migration to the Chassahowitzka NWR, Citrus County, Florida, on 15 January. Juveniles were retained during a period of acclimation in a top-netted enclosure at each site before release on 25 December at St. Marks and on 18 January at Chassahowitzka.

HY2010 Direct Autumn Release cohort

Four Direct Autumn Release (DAR) juveniles were killed on their wintering ground in 2010/2011. Nos. 20, 24 and 28 were found dead on the morning of 30 December 2010 in Calhoun County, Georgia. Examination of the carcasses confirmed cause of death as gunshot in nos. 24 and 28 and suspected gunshot for no. 20. Two additional juveniles (nos. 23 and 26) remained in the area for the rest of the wintering period. The remains of no. 22 were found at her wintering location at Weiss Lake, Cherokee County, Alabama, on 12 February but she had likely been dead since at least 26 January. Cause of death is suspected gunshot.

Three juveniles (nos. 19, 25 and 27) wintered with older birds at Weiss Lake, Cherokee County, Alabama. The group moved to Madison County, Alabama, by 4 February after the deaths of nos. 12-04 and 22-10.

One juvenile (no. 21) remained with breeding pair nos. 15-04 and 5-05 at Hiwassee WR, Meigs County, Tennessee, throughout the winter.

Spring 2011 Migration

The majority of birds initiated spring migration during mid-February to mid-March (Table 1). Nos. 16-04 and 4-09 were the first whooping cranes confirmed back at the Necedah NWR (by 9 March). Of documented cranes 2-years-of age or older returning to central Wisconsin, 51% did so by 21 March, and an additional 28% arrived on or before 30 March, 16% by 8 April and the remaining 5% by 25 April.

Ultra-light juveniles departed from the Chassahowitzka pensite in two groups on 4 April (3) and 17 April (2) and from the St. Marks pensite in two groups on 20 March (2) and 3 April (3). April 17th marked the longest any ultra-light juveniles have remained at their release pen before initiating migration back north. Nine of the ten birds completed migration to central Wisconsin in four groups during 7 April ï 24 May. One bird, no. 10-10, did not return to the core area and remained in the southeastern part of the state.

Spring, Summer and Autumn 2011

The 2010 juveniles exhibited typical spring wandering movements, moving into locations outside the core reintroduction area: Dodge, Sauk, Portage, Marathon, southern Juneau, Columbia, Wood, Adams, Dunn and Buffalo Counties, Wisconsin, and Rice and Goodhue Counties, Minnesota.

As of 9 July, maximum size of the eastern migratory population was 100 birds consisting of 52 males and 48 females. Distribution included approximately 90 birds in Wisconsin, 1 in Indiana, 1 in Lower Michigan, 2 at undetermined locations and 6 long term missing. An additional 8 juveniles were added to the population by the DAR (direct autumn release) method on 21 October. They were released at the Horicon NWR, Dodge County, Wisconsin. This year was the first year that birds were released at this location. Seven juveniles left the Horicon area on 27 October and landed in southern Dane County where they remained until migrating on 29 November. One juvenile left the Horicon area on 29 October and was reported in southwestern Rock County from 3-15 November. He left the area on 16 November and has not been relocated.

On 21 October, while the ultralight-led juveniles were en-route to their stop in Marquette County, Wisconsin, one juvenile broke off and could not be relocated. She was reported with sandhill cranes in Waushara County on 26 October but could not be recaptured and was considered released. She has since migrated appropriately with sandhill cranes and was reported in Bartow County, Georgia, on 19 November and Lake County, Florida, by 27 November.

Cranes from the HY2001-09 cohorts generally returned to summer in the core reintroduction area after completion of the spring wandering period. Four birds, however, (3 from HY2009, 2 from HY2008) summered at other locations: Marathon County (1), Dodge County (3). Most older cranes summered as usual on or near the Necedah NWR. Summer distribution is shown in

Table 2 and Figure 3. Autumn distribution was similar to summer distribution for most cranes in the population. Some bird birds left the core reintroduction area to use autumn areas previously used at remote locations, e.g., sites in Minnesota and Rock County, Wisconsin.

One crane (no. 17-07) was captured on 15 October to remove a piece of fishing line wrapped around her right leg. Examination of the wound indicated that the medial and caudal areas of the leg were the most affected. There was no bleeding after the line was removed and there were no signs of infection. She was released at the capture location and over the next month, showed significant improvement. By 17 November, her limp was hardly detectible.

Autumn 2011 Migration

Most autumn migration departures occurred from mid-November to early December, with exodus again coinciding with the typical late fall weather events that trigger migration. Of known migration dates or ranges, 51% (41 birds) of the cranes had left on migration by or on 20 November, with the highest known concentration of birds (17) leaving on 16 November. An additional 41% (33 birds) left between or on 23 November and 2 December.

Available migration departures in date order were as follows:

16 November: nos. 8-04 and 19-05; 27-06 (DAR) and 26-09; 28-08 and 5-10; 19-09; W1-10, 23-10 (DAR) and 26-10 (DAR); 3-10, 9-10 and 17-10; 6-10, 19-10 (DAR), and 25-10 (DAR); 19-11 (DAR)
17 November: nos. 18-03 and 36-09 (DAR); 1-04 and 8-05
20 November: nos. 16-02 and 16-07; 11-09, 15-09, 34-09 (DAR), 38-09 (DAR) and 27-10 (DAR)
27 November: nos. 1-01 and 14-09; 2-04 and 46-07 (DAR); 16-04 and 4-09; 14-08 and 24-08
29 November: HY2011 DAR nos. 13, 14, 15, 16, 17, 18 and 20
30 November; no. 37-07 (DAR)
2 December: nos. 17-07, 6-09, 10-09, 12-09, 18-09, 25-09, 29-09, 35-09 (DAR) and 1-10

Migration date ranges were recorded for the following birds:

4-10 November: nos. 12-02 and 19-04
12-17 November: nos. 11-02 and 30-08; 13-02 and 18-02; 17-03 and 7-09 and 21-10 (DAR); 10-03 and W1-06; 12-05 and 22-07
23-27 November: nos. 9-03 and 3-04; 13-03 and 9-05
29 November ï 2 December; nos. 33-07 and 5-09; 24-09 and 42-09 (DAR)
2-4 December: nos. 27-08, 8-09, 29-08 and W3-10
1-5 December: nos. 26-07 and 4-08

Specific date/date range not recorded: nos. 11-03 and 12-03; 5-05 and 15-04; 6-05 and 37-09 (DAR); 28-05 (DAR); 3-07 and 38-08 (DAR); 32-09 (DAR) and 41-09 (DAR); 10-10; 16-10; 2-11; 7-07 and 39-07 (DAR); 12-07

No record of migration: no. 8-10, 27-07 and 13-08

Long term missing: nos. 16-03, 14-05, 13-07, 33-05 and 13-09

The mild winter weather caused many birds to shortstop at migration stopover locations for extended periods of time and many remained in Indiana or Illinois by early January 2012. The greatest concentration of birds occurred at Goose Pond FWA, Greene County, Indiana, where 20 birds were located on 9 January.

Winter 2011

Temperatures during the beginning of the winter were mild, causing many whooping cranes to shortstop at migration stopover locations through at least early January 2012. Maximum size of the eastern migratory population through the end of December 2011 was 103 birds (53 males and 50 females). Distribution at the end of the year or last record included 42 whooping cranes in Indiana, 7 in Illinois, 5 in Georgia, 7 in Alabama, 2 in South Carolina, 2 in North Carolina, 6 in Tennessee, 10 in Florida, 14 at unknown locations, 1 with no record of migration, 1 with no recent report, and 6 long term missing.

Survival

As of 31 December 2011, 187 whooping cranes have been released as juveniles since the reintroduction began in 2001. This value excludes 17 HY2006 ultralight-led juveniles that died during confinement in a storm and 1 HY2007 ultralight-led juvenile that was removed from the project after being unable to fly after handling at the winter release site. Addition of 3 naturally produced juveniles (one in 2006, two in 2010) resulted in a grand total of 190 individuals, of which 103 (54%) of those individuals may currently survive (Table 3).

The following 10 mortalities were recorded in 2011:

No. 12-04: Found dead at Weiss Lake, Cherokee Co, AL, on 28 January, suspected gunshot
No. 22-10: Remains found at Weiss Lake, Cherokee Co, AL, on 12 February, suspected gunshot
Nos. 24-05/42-07 (DAR): Breeding pair, Adams County, WI, causes unknown, no. 24-05 decomposed, carcasses collected 13 June
Nos. 27-05 (DAR)/31-08 (DAR): Breeding pair, Juneau County Forest, Juneau County, WI, carcasses collected 7 July, no. 27-05 decomposed; no. 31-08 killed by predator, carcass
No. 7-03: Necedah NWR, carcass collected 21 July, cause of death unknown (decomposed)
No. 3-03: Found injured on 16 August near summering territory, Necedah NWR, euthanized
No. 15-10: Spring wandering, Juneau County, cause unknown (limited remains found 18 August)
No. 6-05: Found shot in Jackson County, IN, on 30 December

Additionally four long-term missing birds have been removed from the population totals. Date of mortality is assumed as the same year the bird went missing:

No. 20-05: Missing since spring 2009
No. 27-09: Missing since spring migration 2010
No. 33-05: Missing since spring migration 2010
No. 7-01: Missing since spring 2010

As of 31 December 2011, there have been 85 recorded mortalities (Table 4). The primary known or suspected cause of mortality was predation (39%), followed by gunshot (11%). Of the remaining mortalities, 21% were presumed dead (no carcass recovered) and 13% were from unknown causes (remains found but cause could not be determined). Contrary to what is expected, birds less than one year since release only comprised 20% (2/10) of mortalities in 2011 (see above). The majority of mortalities in 2011 were of birds three years of age or older (80%).

Reproduction

Twenty-two nests by twenty pairs were initiated in 2011; twenty first nests and two renests. Over half of the first nesting attempts were initiated during 6-12 April. The latest first nest was initiated in early May by a pair which included a two-year-old female (nos. 33-07 and 5-09). This is the first time in this population that a two-year-old female has ever laid an egg. Four nests hatched out at least one chick each while two other nests were incubated past full term before their eggs were pulled. Examination of the eggs (3) from these latter two nests determined that they were infertile. Renesting attempts by two pairs were initiated on 17/18 May and both nests failed shortly after. Summary of nesting from 2005-2011 is displayed in Table 5 and nest distribution in 2011 is shown in Figures 4a and 4b.

The four wild hatched chicks died on approximately 10 May-1 July (aged 1-46 days). One of the chicks was the prodigy of no. W1-06 who is the first wild hatched crane in the eastern migratory population.

At least four new pairs, including one with a DAR male, built nests without eggs in 2011. In most of the cases (3/4) the female was only 2 years old.

Pair Formation in 2011

Pair as used in this section refers to consistent association between a male and a female, each in the second year after hatch year or older, and exclusive of other individuals. All pair formations and dissolutions in 2011 occurred in the core reintroduction area of central Wisconsin. As in the past, the most active period of this process occurred just after the cranes returned from spring migration.

Formed:
Nos. 14-08/24-08, late winter 2010/2011
Nos. 13-03/9-05, spring
Nos. 18-03/36-09 (DAR), spring
Nos. 8-04/19-05, spring (repaired)
Nos. 6-05/37-09 (DAR), spring
Nos. 27-08/8-09, spring
Nos. 6-09/35-09 (DAR), spring
Nos. 10-09/17-07, spring
Nos. 11-09/15-09, spring (from group of 5)
Nos. 24-09/42-09 (DAR), spring
Nos. 32-09 (DAR)/41-09 (DAR), spring
Nos. 34-09 (DAR)/38-08 (DAR), spring
Nos. 33-07/5-09, spring (from group of 4)
Nos. 17-03/7-09, summer (after death of no. 3-03)
Nos. 18-09/25-09, summer (from group of 4)
Nos. 1-01/14-09, late summer
Nos. 4-08/26-07, late summer/autumn (after death of no. 7-03)

Dissolved:
Nos. 19-05/FL 1343, spring
Nos. 13-03/18-03, spring
Nos. 7-03/26-07, summer (with death of no. 7-03)
Nos. 17-03/3-03, summer (with death of no. 3-03)

Current Population Structure

The population contained a maximum of 103 individuals in January 2012 as noted below:

Adult, confirmed breeding pairs (i.e., have produced eggs): 32 (16 pairs)
Nos. 11-02/30-08, 12-02/19-04, 13-02/18-02, 16-02/16-07, 9-03/3-04, 10-03/W1-06, 11-03/12-03, 13-03/9-05, 1-04/8-05, 2-04/46-07 (DAR), 8-04/19-05, 15-04/5-05, 12-05/22-07, 3-07/38-08 (DAR), 7-07/39-07 (DAR), 33-07/5-09

Pairs (most with young females) that were on territory and built nests in 2011: 8 (4 pairs)
Nos. 27-06 (DAR)/26-09, 27-08/8-09, 14-08/24-08, 16-04/4-09

Other subadult or newly formed adult pairs: 22 (11 pairs)
Nos. 1-01/14-09, 17-03/7-09, 18-03/36-09 (DAR), 17-07/10-09, 26-07/4-08, 6-09/35-09 (DAR), 11-09/15-09, 18-09/25-09, 24-09/42-09 (DAR), 32-09 (DAR)/41-09 (DAR), 34-09 (DAR)/38-09 (DAR)

Currently unpaired males that summered in the central core area containing other whooping cranes: 3
Nos. 12-07, 12-09, 29-09

Currently unpaired males that summered outside the core area with other whooping cranes: 2
Nos. 28-08, 29-08

Currently unpaired males that summered in areas without other whooping cranes: 2
No. 37-07 (DAR), 19-09

Currently unpaired females that summered in the central core area containing other whooping cranes: 1
No. 37-09 (DAR)

Currently unpaired females that summered in areas without other whooping cranes: 1
No. 28-05 (DAR)

Yearlings (HY2010): 2 wild hatched, 9 UL, 6 DAR

Juveniles (HY2011): 9 DAR (includes one bird raised as ultralight bird but released in DAR style)

Long-term missing (status unknown): 6
Nos. 16-03, 14-05, 13-07, 27-07, 13-08, 13-09

Human Avoidance and Conflicts with Human Activity

A few cases of lack of human avoidance behaviors occurred in 2011. They are described below.

No. 1-01 continues to winter in a population area just north of Crystal River, Citrus County, Florida. In the winter of 2010/2011, he was routinely seen in yards around the neighborhood, usually with two or three sandhill cranes. His new summering territory is on and near Volk Field Air Force Base, Juneau County, Wisconsin, and he has been occasionally reported near the airplane runway. He has also been observed very close to, and sometimes on, a county road that runs along the west side of the base.

No. 5-01: In early 2007 after the death of his first mate (no. 4-02), no. 5-01 landed in the captive Whooping Crane exhibit at the Homosassa Springs Wildlife State Park, just north of the released site on the Chassahowitzka NWR, Citrus County, Florida. Through 2010, he had landed at the park a total of five times (twice in early 2007, once in late 2008, and twice in early 2009). During both occasion in 2009, he also brought his mate (no. 1-05) to the park with him.

On 8 January 2011, no. 5-01 once again landed in the wildlife park. He was captured and transported to a temporary holding pen in the Withlacoochee State Forest until 14 January when the decision was made to remove him from the EMP and remand him into captivity. Arrangements were made for him to live at the Homosassa Springs Wildlife State Park.

Nos. 11-02/30-08, 37-09 (DAR), and HY2010 DAR juveniles 19, 25 and 27 moved from Cherokee County to Madison County, Alabama, by 4 February where they spent the next 14 days in close proximity to an elementary school. The cranes were frequently seen near the playground of the school and spent a significant amount of time in a small wetland adjacent to the schoolôs driveway which received high traffic activity. After leaving this location on or around the morning of 18 February, no additional human avoidance problems have been noted.

HY2010 juveniles nos. 1 and 8 exhibited inappropriate avoidance behaviors during the spring wandering period. By the night of 21 May, they had moved into Rice County, Minnesota, and began frequenting areas very close to a busy highway. They were not adverse to the heavy flow of traffic or the attention they received by passersby. Reports from observers indicated that they frequently were seen less than 100 meters from the highway. They returned to Wisconsin after 31 May and made a few subsequent trips back into Minnesota, but they did not return to this highly visible location for any extended period of time.

Interactions with Nonmigratory Whooping Cranes

On 6 March, female no. 19-05 was observed associating with a Florida Non-Migratory male, no. 1343, at Paynes Prairie Preserve State Park in Alachua County, Florida. No. 19-05ôs mate, no. 8-04, had already left on spring migration and was located in Greene County, Indiana. Nos. 19-05 and 1343 remained together at Paynes Prairie through at least 24 March. They were observed together in Monroe County, Indiana, on 6 April and no. 19-05 was confirmed back on the Necedah NWR on 17 April and quickly returned to her previous mate. The location of no. 1343, who had a nonfunctional transmitter, was unknown until 22 April when he was found west of New Lisbon, Juneau County. He was also observed at this location the following day. He was confirmed back in Florida on 5 May, but had likely arrived by the 3rd of the month. This has been the strongest interaction between a member of the EMP and a member of the FL NMP to date.

Nos. 12-07, 17-07 and 31-08 (DAR) spent the winter of 2010/2011 in Polk County at a location where nonmigratory cranes were present. There were occasional documented interactions between the birds from the two different flocks, however no strong relationships developed.

Summary and Conclusions

Survival was 100% at the release sites on Chassahowitzka and St. Marks NWRôs during winter 2010/2011.

Returning yearlings exhibited extensive but typical spring wandering in 2011. As typical for the last few years, the majority of yearlings (12/18) summered outside the core reintroduction area of Central Wisconsin.

There were ten confirmed mortalities in 2011 and 4 missing birds that may also be dead. By the end of the year, there had been 85 recorded mortalities in the population.

Twenty breeding pairs produced eggs in 2011. Only four nests produced chicks and none reached fledging age. There were two renests.

Social behavior was normal, and pair bond formation progressed. Mortality of two breeding pairs (both members), one breeding female, and one breeding male over the summer reduced extant, established breeding pairs to 16. Up to 15 new pairs could nest in 2012.

This was the first year the White River SWA (Green Lake/Marquette Counties) and the Horicon NWR (Dodge County) were used to raise or release birds. Ten birds were raised by the ultralight method at White River and 8 birds were raised and released via the Direct Autumn Release method at Horicon.

Human avoidance remained generally adequate however continued unacceptable behavior by male no. 5-01 resulted in his removal from the population in January 2011.

At the end of 2011, the eastern migratory population consisted of an estimated maximum of 103 individuals. Number of individuals in each year class was as follows: HY2001 (1), HY2002 (5), HY2003 (8), HY2004 (7), HY2005 (7), HY2006 (2), HY2007 (13), HY2008 (9), HY2009 (25), HY2010 (17), and HY2011 (9).

Acknowledgements

We especially thank the following individuals who were involved with tracking released cranes, captures, isolation-rearing DAR chicks, or other field support: Annette Aeschbach, Barry Hartup, Marianne Wellington, Morgan Wealti, Matthew Dugan, Jacklyn Ramsey and the Field Ecology Staff and interns (ICF); Gator Gates, Mark Purcell, Larry Hartis, Rich King, Richard Urbanek and Lisa Lehnhoff (USFWS); Bev Paulan, Luke Wuest and Mike Callahan (Wisconsin DNR); Peggy Coontz (PWRC); Ben Weiss (Chassahowitzka NWR); Holly Smith, Danielle Buck and Donna Bear-Hull (Jacksonville Zoo and Gardens); Nancy Businga (Wisconsin DNR); Alan Isler (Georgia DNR); Marty Folk, Tim Dellinger, and Steve Baynes (Florida Fish and Wildlife

Conservation Commission [FWCC]); Dean Harrigal (South Carolina DNR); Brad Feaster and Travis Stoelting (Indiana DNR); Rob Klippel (Tennessee Wildlife Resources Agency); Jay Therien, Jaimie Barnard, Rosaria Di Meglio, Becky Abrew, Scott Tidmus, Scott Terrell, and Scott Tidmus (Disneyôs Animal Programs); Anne Ballmann and LeAnn White (National Wildlife Health Center); and Dan Kaiser, Larry McIntosh, John Pohl, Rick Houlk, Ron Hoffman, Lee Sterrenburg, Bob Huguenard, Susan Braun, Gordon and Christine Barnes, Gordon Perkinson, and Shaun Tidmus We are grateful to the landowners that allowed us access to their properties. To the many other individuals and staff of cooperating agencies who supported the monitoring effort, we also extend our sincere thanks.

We greatly appreciate the contributions and aircraft support provided by Terry Kohler, Mike Frakes, Tom Trester, Matt Waage, and Rob Siedl (Windway Capital Corporation) as well as additional aircraft support provided by the Florida FWCC and the Wisconsin DNR.

We thank the following individuals and their staffs for essential physical and logistical support at field sites: Doug Staller (Necedah NWR, USFWS), Patti Meyers and Diane Kitchen (Horicon NWR, USFWS); Michael Lusk and Boyd Blihovde (Chassahowitzka NWR, USFWS), Terry Peacock (St. Markôs NWR, USFWS), Jim Holzwart (White River Marsh, Wisconsin DNR), Charlie Luthin (NRFW), and Billy Brooks (USFWS).

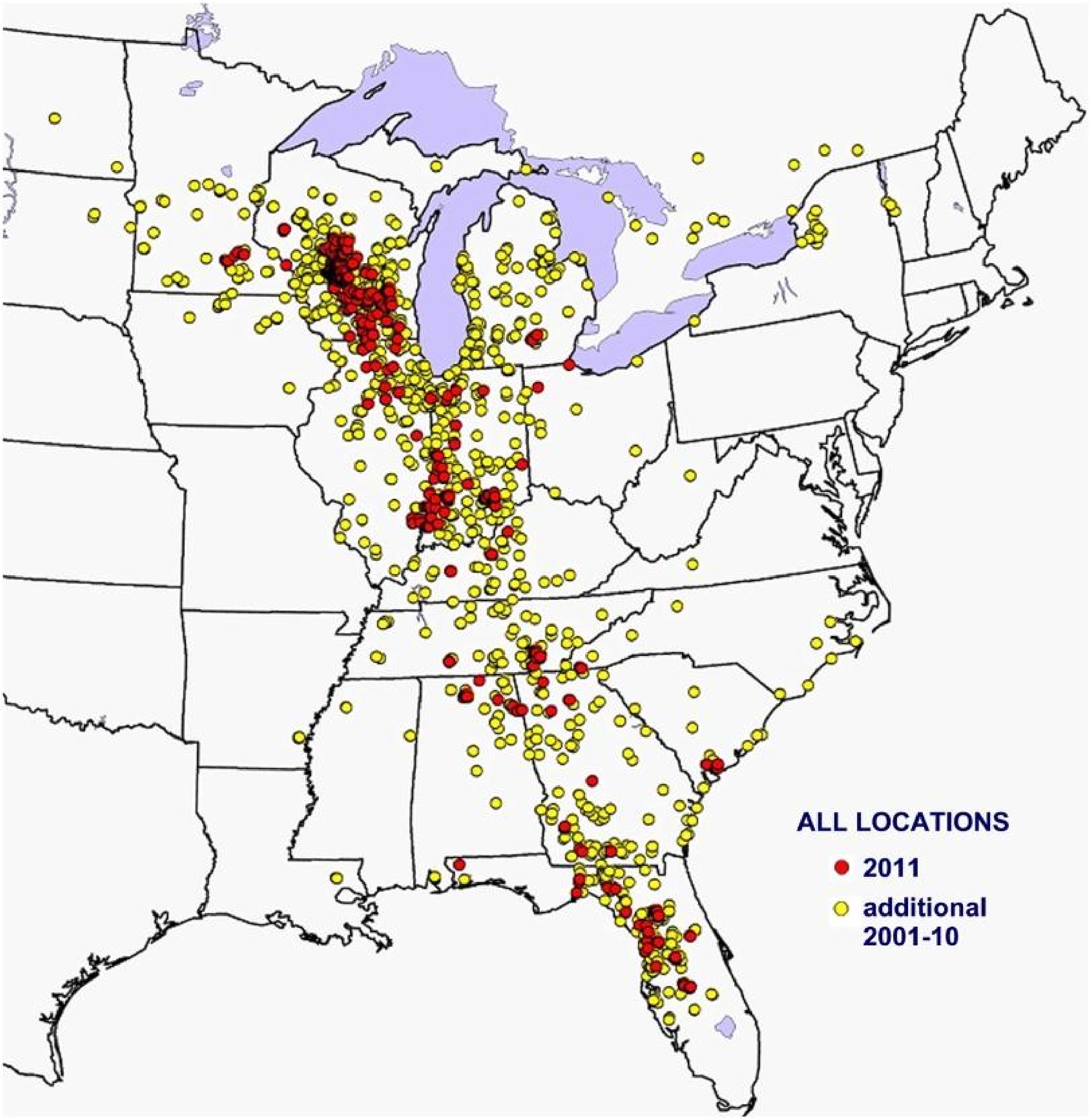


Figure 1: Distribution of whooping cranes in the reintroduced eastern migratory population, 2011

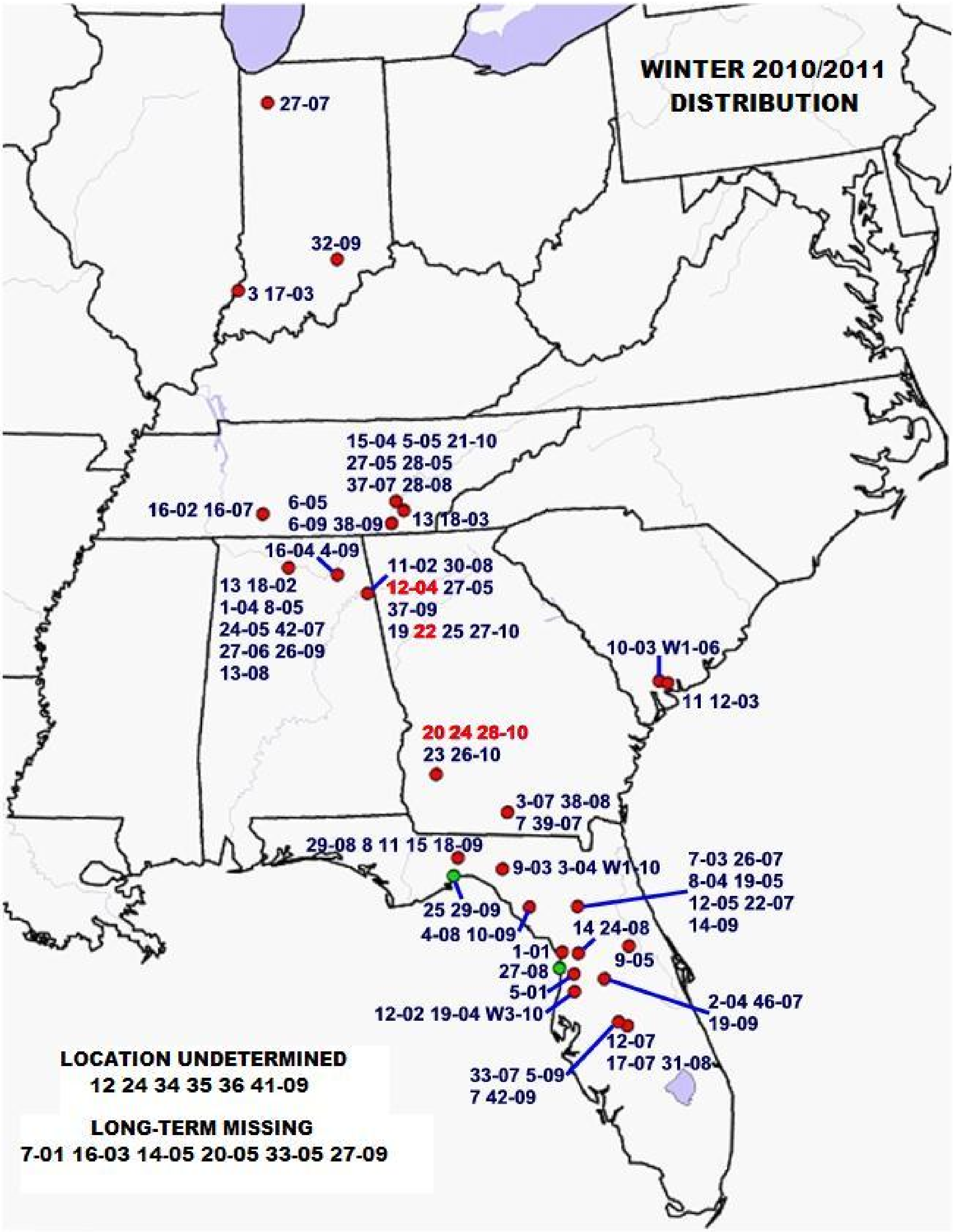


Figure 2: Winter use areas of whooping cranes in the eastern migratory population, winter 2010/2011. Cranes indicated red died over the winter.

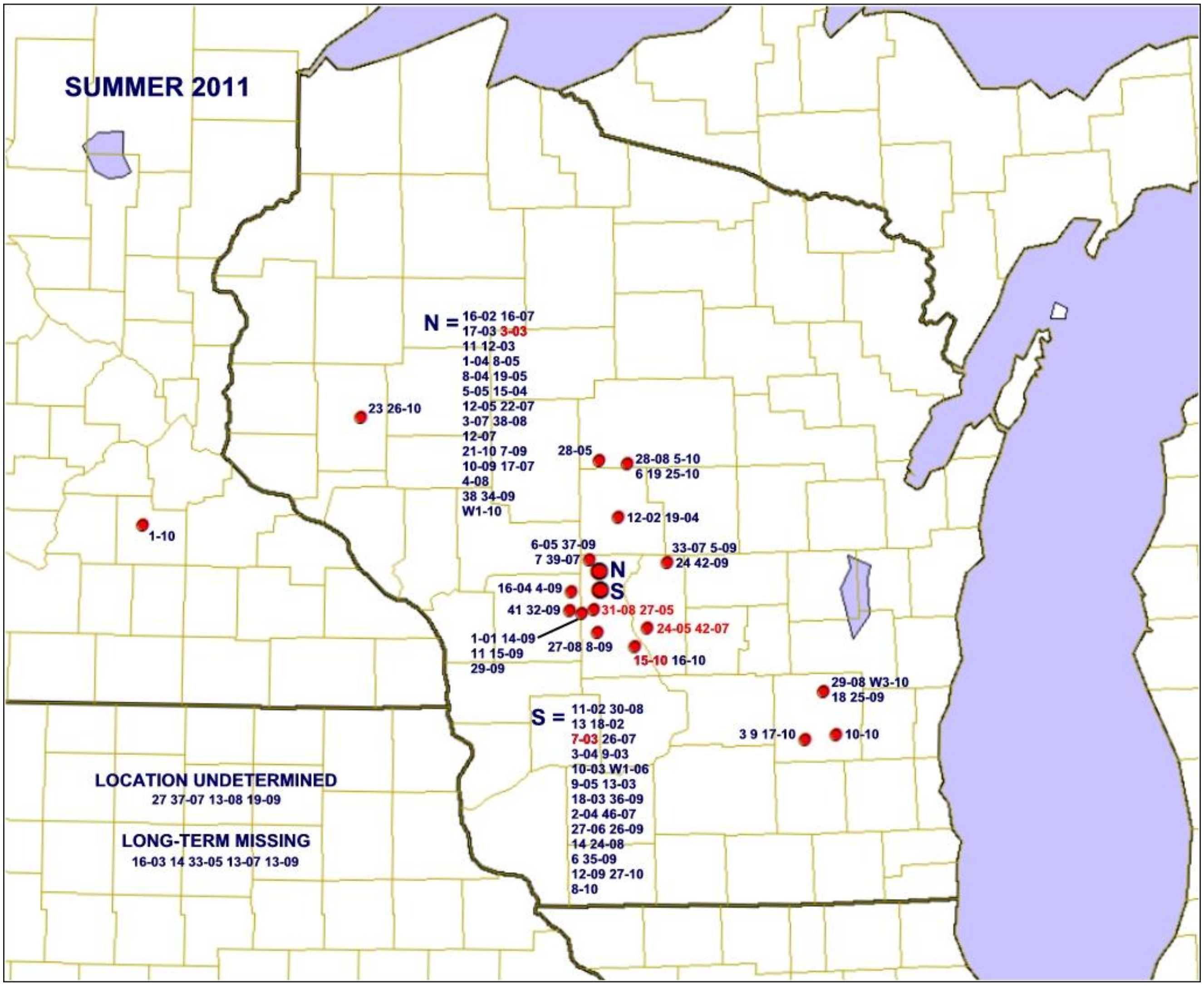


Figure 3: Summer distribution of whooping cranes in the eastern migratory population, 2011. Cranes indicated in red died during the summer period.

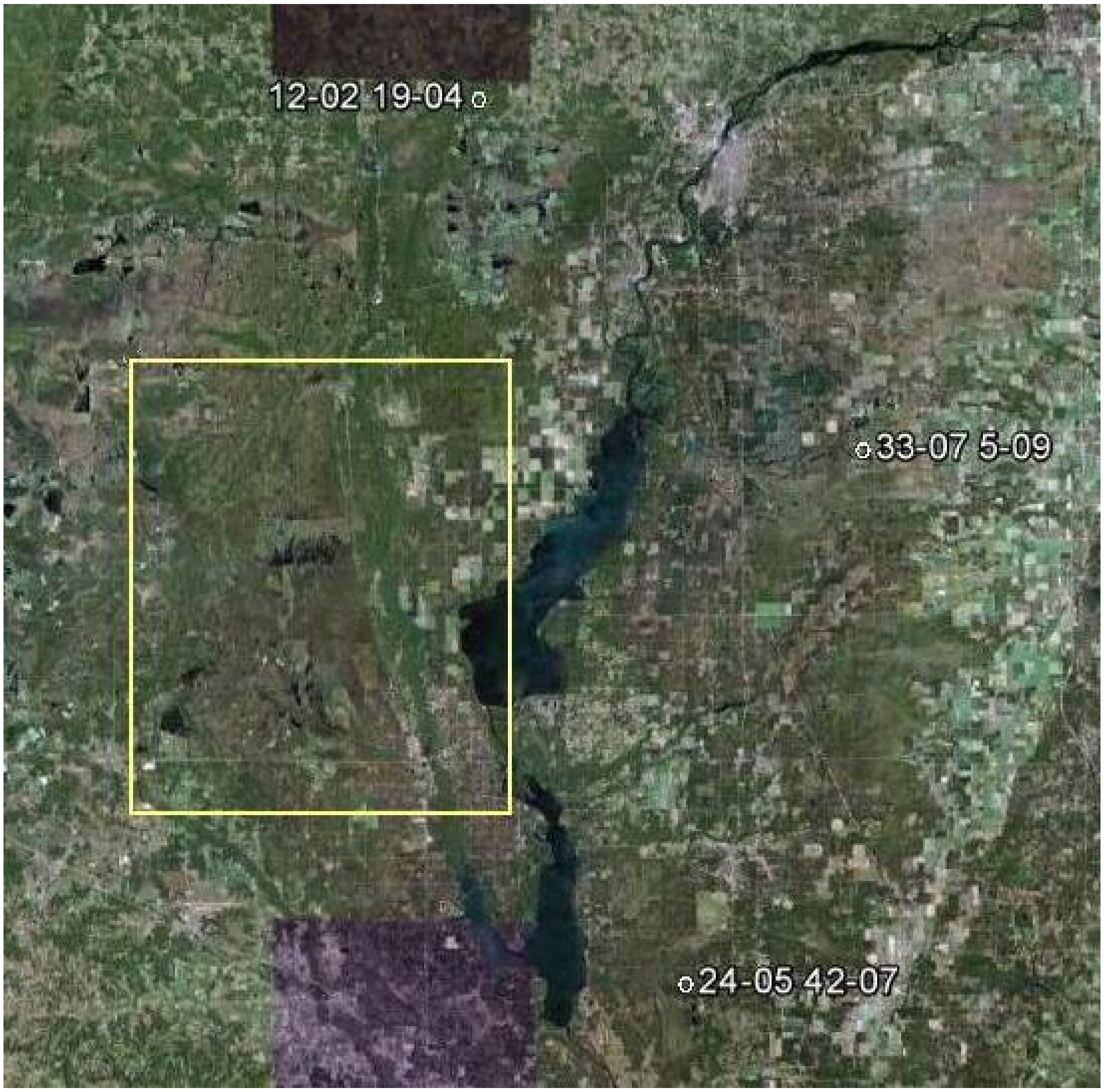


Figure 4a: Nest distribution of whooping cranes in the eastern migratory population outside of the Necedah NWR vicinity, spring 2011. See inset (next page) for remaining nests.

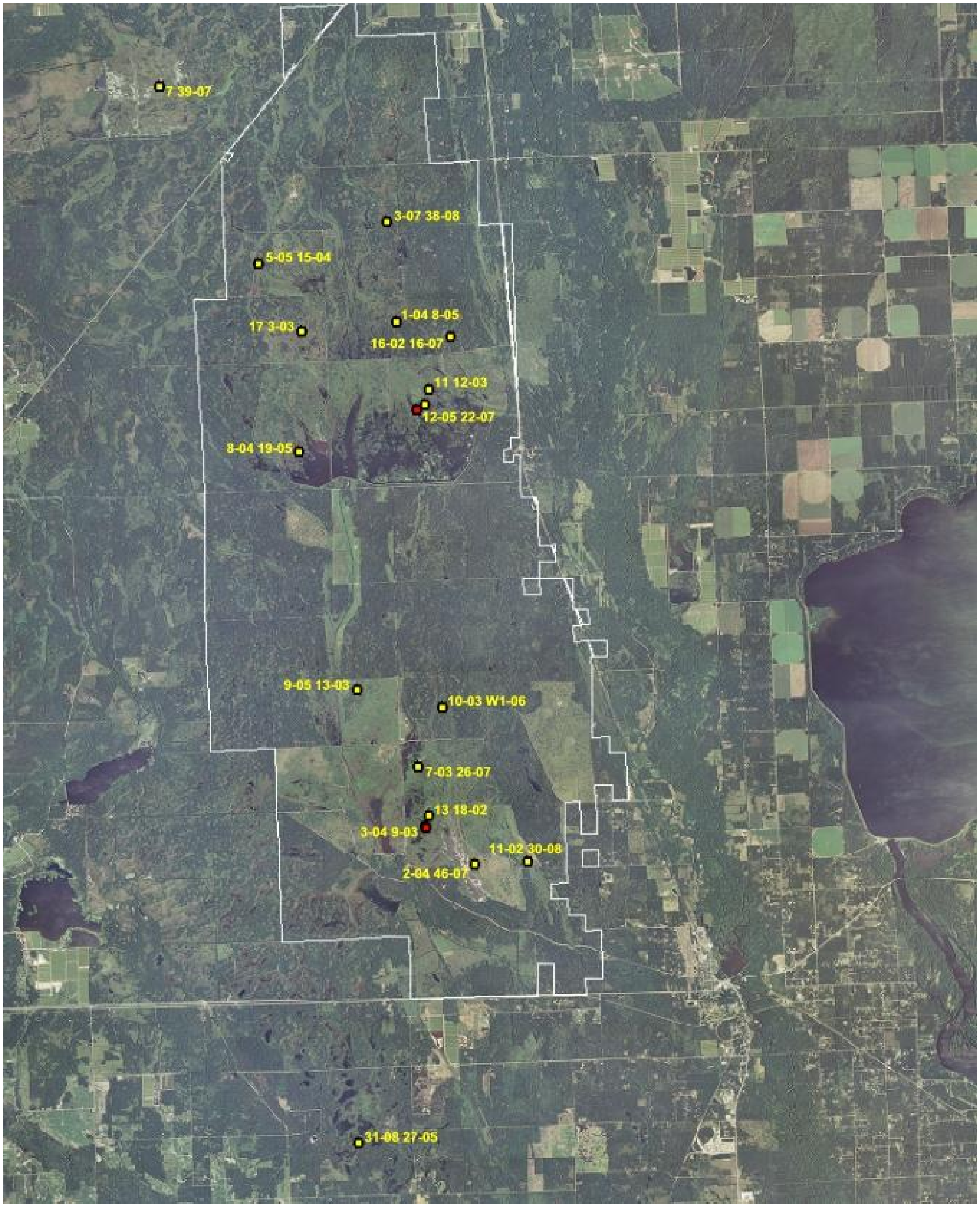


Figure 4b: Nest distribution of whooping cranes in the eastern migratory population in and around the Necedah NWR, spring 2011. Refuge boundary outlined in white. Red=Renest.

Table 1: Wintering areas of whooping cranes in the reintroduced eastern migratory population, winter 2010/11. R = Direct Autumn Release. Winter locations of 12-09, 24-09, 34-09R, 35-09R, 36-09R and 41-09R were not determined.

Crane nos.	Location	County	Spring departure
Florida			
1-01	Shamrock Acres	Citrus	8 Mar
5-01	Stafford Lake (removed from population on 8 January and remanded into captivity on 14 January)	Hernando	--
12-02, 19-04, W3-10	SE of Masaryktown	Pasco	19-23 Feb
7-03, 26-07	Paynes Prairie Preserve State Park	Alachua	2-8 Mar
9-03, 3-04, W1-10	Mallory Swamp WMA (until at least 21 Dec)	Lafayette	--
9-03, 3-04, W1-10	San Pedro Bay (by 13 Jan)	Taylor	<11 Mar
2-04, 46-07R	SW of Mascotte	Lake	8 Mar
8-04, 19-05	Paynes Prairie Preserve State Park	Alachua	8-04: <3 Mar 19-05: 25 Mar-5 Apr
12-05, 22-07	Paynes Prairie Preserve State Park	Alachua	25 Feb-1 Mar
9-05	E of Paisley	Lake	8 Mar
12-07, 17-07	SW of Lake Wales	Polk	7-13 Mar
31-08R	SW of Lake Wales	Polk	4-7 Mar
33-07, 5-09, 7-09, 42-09R	NE of Bartow	Polk	14-19 Mar
4-08, 10-09	Goethe State Forest (until 13 Jan)	Levy	--
4-08, 10-09	St. Markôs NWR (24-26 Jan)	Wakulla	--
4-08, 10-09	SE of Cross City (by 9 Feb)	Dixie	12-13 Mar
14-08, 24-08	Potts Preserve	Citrus	20-23 Feb
27-08	Potts Preserve (until 19 Feb)	Citrus	--
27-08	Chassahowitzka NWR (by 21 Feb)	Citrus	1 Apr
29-08	N of Chumuckla (until 31 Dec)	Santa Rosa	--
29-08	SE of Tallahassee (by 13 Jan)	Leon	>11 Mar
8-09, 11-09, 15-09, 18-09	SE of Tallahassee	Leon	>11 Mar
12-09, 24-09, 41-09R	Unknown	--	18 Mar
25-09, 29-09	St. Markôs NWR	Wakulla	21 Mar
14-09	Tuscawilla Preserve (until at least 3 Feb)	Alachua	--
14-09	Paynes Prairie Preserve State Park	Alachua	29 Mar-5 Apr
19-09	SW of Mascotte	Lake	3 Apr
Georgia			
3-07, 7-07, 39-07R, 38-08R	S of Hahira	Lowndes	8 Mar
23-10, 26-10	N of Leary	Calhoun	8-24 Mar
20-10R, 24-10R, 28-10R (killed ~30 Dec)	N of Leary	Calhoun	--
South Carolina			
10-03, W1-06	Combahee Unit, ACE Basin NWR	Colleton	>19 Feb
11-03, 12-03	Donnelley WMA	Colleton	>4 Mar
Alabama			
12-04, 22-07 (killed ~23 Jan)	Weiss Lake	Cherokee	--
27-05R	Weiss Lake (until 26 Jan)	Cherokee	--
11-02, 30-08, 37-09R, 19-10R, 25-10R, 27-10R	Weiss Lake (until 26 Jan)	Cherokee	--
11-02, 30-08, 37-09R, 19-10R, 25-10R, 27-10R	NE of Meridianville (by 4 Feb)	Madison	18-22 Feb
16-04, 4-09	Grove Oak	DeKalb	>7 Feb
13-02, 18-02	Wheeler NWR	Morgan	>7 Mar
1-04, 8-05	Wheeler NWR (until 27 Jan)	Morgan	unknown
24-05, 42-07R	Wheeler NWR	Morgan	3 Mar
27-06, 26-09	Wheeler NWR	Morgan/Limestone	2-3 Mar
13-08	Wheeler NWR (until 7 Jan)	Morgan	unknown
Tennessee			

16-02, 16-07	N of Ethridge	Lawrence	9-28 Feb
13-03, 18-03	Candies Creek Unit, Chickamauga WMA	Bradley	15-23 Feb
5-05, 15-04, 21-10R	Hiwassee WR/Armstrong Bend	Meigs	14-26 Feb
6-05, 6-09, 38-09	Wolftever Creek	Hamilton	25-27 Feb
27-05R	Hiwassee WR/Armstrong Bend (by 1 Feb)	Meigs	15-19 Feb
28-05R	Hiwassee WR/Armstrong Bend	Meigs	6 Feb-1 Mar
37-07R	Hiwassee WR/Armstrong Bend	Meigs	>8 Mar
28-08	Hiwassee WR/Armstrong Bend	Meigs	>8 Mar
Indiana			
3-03, 17-03	NW of Hazelton	Knox	13-17 Feb
27-07	N of Jasper-Pulaski FWA (summering and wintering areas very close to each other)	Jasper	--
32-09R	Muscatatuck NWR (by 7 Feb)	Jackson	2-3 Mar

Table 2: Primary summering areas of whooping cranes in the reintroduced eastern migratory population, 2011. R = Direct Autumn Release. Summering locations of nos. 27-07, 37-07R, 13-08 and 19-09 were not determined.

Crane nos.	Location	County
Central Wisconsin Core		
1-01, 14-09	Volk Field area/Shumann WRP	Juneau
11-02, 30-08	Site 3, Necedah NWR	Juneau
12-02, 19-04	Elm Lake Cranberry	Wood
13-02, 18-02	Site 2, Rice/Rynearson Pools, Necedah NWR	Juneau
16-02, 16-07	NE Sprague/Turkey Track Pools, Necedah, NWR	Juneau
7-03 (died July), 26-07	Site 4, Necedah NWR	Juneau
9-03, 3-04	West-central East Rynearson Pool, Necedah NWR	Juneau
10-03, W1-06	Upper Rice Pool areas, Necedah NWR	Juneau
11-03, 12-03	ENE Sprague Pool, Necedah NWR	Juneau
13-03, 9-05	Site 5/Canfield/Bee Cut areas, Necedah NWR	Juneau
17-03, 3-03 (died 16 Aug)	Pool 9, Necedah NWR	Juneau
18-03, 36-09R	Carter Woggan Pool, Necedah NWR	Juneau
1-04, 8-05	Pool 13/Danielson Wetland Restoration, Necedah NWR	Juneau
2-04, 46-07R	Site 1/East Rynearson Pool, Necedah NWR	Juneau
8-04, 19-05	Goose Pools/W Sprague, Necedah NWR	Juneau
15-04, 5-05	Pool 19/W Pool 19, Necedah NWR	Juneau
16-04, 4-09	Monroe County Flowage, Meadow Valley SWA	Monroe
6-05, 37-09R	Meadow Valley Flowage, Meadow Valley SWA	Juneau
12-05, 22-07	Sprague Pool, Necedah NWR	Juneau
24-05, 42-07R (both died June)	Quincy Bluff	Adams
27-05R, 31-08R (both died July)	Juneau County Forest	Juneau
27-06R, 26-09	Rice & W Rice Pools, Necedah NWR	Juneau
3-07, 38-08R	Rogers Pool, Necedah NWR	Juneau
7-07, 39-07R	Meadow Valley Flowage, Meadow Valley SWA	Juneau
12-07	NE of Sprague Pool, Necedah NWR	Juneau
17-07, 10-09	Sprague Pool, Necedah NWR	Juneau
33-07, 5-09	Leola Marsh area	Adams
4-08	Sprague Pool, Necedah NWR	Juneau
14-08, 24-08	Suk Cerney/EDU/West Rynearson Pools, Necedah NWR	Juneau
27-08, 8-09	W of New Lisbon	Juneau
6-09, 35-09R	Meadow Valley SWA/southern pools, Necedah NWR	Juneau
7-09, 21-10R	Leola Marsh area (through 22 July)	Adams
	Pools 9/13, Necedah NWR (by 6 August)	Juneau
11-09, 15-09	SW of Cutler/Lemonwier River	Juneau
12-09	West Rynearson Pool & vicinity, Necedah NWR	Juneau
24-09, 42-09R	Leola Marsh area	Adams
29-09	Mill Bluff SP	Juneau/Monroe
32-09R, 41-09R	Near Oakdale	Monroe
34-09R	Sprague Pool, Necedah NWR	Juneau
38-09R	Sprague Pool, Necedah NWR	Juneau
W1-10	Sprague Pool, Necedah NWR	Juneau
8-10	East Rynearson Pool & vicinity, Necedah NWR	Juneau
15-10 (died Aug), 16-10	E of Mauston (by late July/early August)	Juneau
27-10R	Southern pools, Necedah NWR	Juneau
Wisconsin Outside of Core		
28-05R	McMillan Marsh SWA & vicinity	Marathon
28-08, 5-10	George W Mead SWA	Marathon
29-08, 18-09, 25-09, W3-10	Horicon NWR	Dodge
HY2010 3, 9, 17	W of Bancroft (though 15 July)	Portage
	Mud Lake SWA (by 4 August)	Dodge
HY2010 6, 19R, 25R	George W Mead SWA	Marathon
10-10	S of Hustisford	Dodge
23-10R, 26-10R	Tainter Lake	Dunn
Minnesota		
1-10	W of Dennison	Rice

Table 3: Current number/numbers of whooping cranes released[a] per hatch year, reintroduced eastern migratory population, 31 December 2011[b].

	HY2001	HY2002	HY2003	HY2004	HY2005	HY2006	HY2007	HY2008	HY2009	HY2010	HY2011	Total
UL												
males	1[c]/4	4/6	5/11	5/10	4/11	0/1	5[c]/9	5/10	9/11	3/4	--	41/77
females	0/3	1[d]/10	3/5	2/3	2/8	--	5/7	3/4	8/9	6/6	--	30/55
Total	1/7	5/16	8/16	7/13	6/19	0/1	10/16	8/14	17/20	9/10	--	71/132
DAR												
males				0/1[d]	0/1	1/3	1/3	0/3[d]	2/2	4/7	4/4	12/24
females				--	1/3	0/1	2/7	1/4	6[e]/7	2/4	5/5[e]	17/31
Total				0/1	1/4	1/4	3/10	1/7	8/9	6/11	9/9	29/55
Wild-hatched and reared												
Total					--	1/1	--	--	--	2/2	--	3/3
Grand total	1/7	5/16	8/16	7/14	7/23	2/6	13/26	9/21	25/29	17/23	9/9	103/190

[a] Number fledged in recruitment from natural reproduction.

[b] Not included are 17 HY2006 birds that died while confined in a top-netted pen during a winter storm and 1 HY2007 female that could not fly and was remanded to permanent captivity.

[c] 1 HY2001 and 1 HY2007 male were transferred to permanent captivity in 2011 and 2009, respectively, after repeated problems related to habituation to humans. Total number released includes those individuals.

[d] Includes 1 male in 2004 and 1 male in 2008 originally reared in an ultralight cohort but later released in autumn on Necedah NWR.

[e] Includes 1 female in 2011 that was reared in an ultralight cohort but escaped during the first day of attempted ultralight-led migration and was considered released in Wisconsin.

Table 4: Mortalities (*n* =85) of reintroduced eastern migratory whooping cranes by confirmed or probable causal factor, 2001 through 31 December 2011[a,b]. Location during annual cycle: summer (44), autumn migration (8), winter (20), spring migration (5), unknown (7), capture myopathy (1).

Cause of mortality	Males	Females	Total
Ultralight-led (UL)			
Predation (unidentified predator)[c]	5	6	11
Bobcat predation	5	4	9
Alligator predation	1		1
Eagle predation		2	2
Powerline collision[d]	1		1
Gunshot	3	2	5
Trauma (source unknown)	1		1
Epicardial hemorrhage		1	1
Predation of injured bird	1		1
Euthanized (capture myopathy)		1	1
Vehicle collision	1		1
Chronic aspergillosis		1	1
Leg infection		1	1
Undetermined[e]	8	2	10
Presumed dead (no carcass recovered)	8	5	13
Total	34	25	59
Direct autumn release (DAR)			
Coyote predation		2	2
Predation (suspected canid)	2	1	3
Bobcat predation	1		1
Alligator predation		2	2
Predation (unidentified predator)	1		1
Powerline collision	2	2	4
Aircraft collision	1		1
Gunshot	2	2	4
Leg trauma (euthanized)		1	1
Intestinal helminth-related septicemia		1	1
Undetermined[e]		1	1
Presumed dead (no carcass recovered)	3	2	5
Total	12	14	26
All birds	46	39	85

[a] Does not include 17 HY2007 juveniles that died in winter pen mortality event.

[b] Does not include female remanded to captivity because of loss of flight ability.

[c] Includes suspected canid (3).

[d] Includes male found alive but immobile under power line; later died from unrelated cause in captivity.

[e] Carcass recovered, but cause of mortality could not be determined.

Table 5: Number of chicks hatched by whooping crane pairs that produced eggs, reintroduced eastern migratory population, 2005-11. First entry = first nest of season. Second entry = second nest. Third entry = third nest. N, S = northern or southern Necedah NWR

[a] One chick (W1-06) fledged.
[b] Chick hatched from captive-produced egg substituted for infertile eggs at 22 days of incubation of renest.
[c] Chick hatched from captive-produced egg substituted for infertile eggs at 27-29 days of incubation of renest. Chick (W3-10) fledged.
[d] One check (W1-10) fledged.

Pair		General location	Year						
Male	Female		2005	2006	2007	2008	2009	2010	2011
1-01	2-02	Necedah NWR-S	0	0					
5-01	1-05	Necedah NWR-N					0		
17-03	3-02	Necedah NWR-N		0					
2-03	9-02	Meadow Valley SWA		0					
16-04	9-02	Meadow Valley SWA			0	0			
11-02	17-02	Necedah NWR-S	0	0,2[a]	0	0	0,1		
12-02	19-04	Wood County				0	0,1[b]	0,1[c]	0
13-02	18-02	Necedah NWR-S		0	0	0	0	0,0	0
17-03	3-03	Necedah NWR-N			0,0	0	0,0	0,0,2	1
3-04	9-03	Necedah NWR-S				0	0,0	0,2[d]	0,0
10-03	W1-06	Necedah NWR-S					0	0	1
11-03	12-03	Necedah NWR-N				0	0	1	0
18-03	13-03	Necedah NWR-S				0	0,0	0	
1-04	8-05	Necedah NWR-N				0	0	0	0
2-04	46-07	Necedah NWR-S						0	1
8-04	19-05	Necedah NWR-N				0	0	0	0
5-05	15-04	Necedah NWR-N				0	0	0	0
12-04	27-05	Juneau County Forest						1	
11-02	30-08	Necedah NWR-S							0
16-02	16-07	Necedah NWR-N							0
7-03	26-07	Necedah NWR-S							0
9-05	13-03	Necedah NWR-S							1
12-05	22-07	Necedah NWR-N							0,0
24-05	42-07	Adams County							0
31-08	27-05	Juneau County Forest							0
3-07	38-08	Necedah NWR-N							0
7-07	39-07	Meadow Valley SWA							0
33-07	5-09	Adams County							0
Total nests			2	5,1	4,1	11	12,5	12,4,1	20,2
Total chicks			0	0,2	0,0	0	0,2	2,3,2	4

Appendix A: Whooping cranes in eastern migratory flock, 31 December 2011.

Hatch year	Crane no.	Sex	BBL Band no.	Frequency (MHz)	Color code (left:right) L=long bands with transmitter	PTT ID	Studbook no.			Mate
							Own	Sire	Dam	
2001	1	M	659-00215	164.334	L **G/W:G/R/G**		1629	1114	1119	
2002	11	M	599-32114	165.133	L **R/W:R/G**		1672	1147	1142	30-08
2002	12	M	599-32121	164.205	L **R/W:W/R/G**		1673	1114	1119	19-04
2002	13	M	599-32122	165.233	L **R/W:G/R/G**		1674	1127	1154	18-02
2002	16	M	599-32125	165.060	L **R/W:R/G/R**		1677	1147	1142	16-07
2002	18	F	599-34059	164.403	**G/W/G**:L **R/W**		1679	1128	1101	13-02
2003	9	F	599-34042	165.182	**W/R/W**:L **G/R**		1704	1144	1136	3-04
2003	10	M	599-34049	164.395	**W/G/R**:L **G/R**		1705	1175	1188	W1-06
2003	11	M	599-34050	--	**G/W/R**:L **G/R**		1706	1127	1154	12-03
2003	12	F	599-34043	165.646	**W/R/G**:L **G/R**		1707	1133	1135	11-03
2003	13	F	599-34051	164.433	**R/W/R**:L **G/R**		1708	1133	1135	9-05
2003	16	M	599-34052	--	**R/G/W**:L **G/R**		1711	1144	1136	
2003	17	M	599-34053	--	**W/G/W**:L **G/R**		1712	1144	1136	
2003	18	M	599-34054	164.164	**G/R/W**:L **G/R**		1713	1147	1142	
2004	1	M	599-37449	164.365	**R/G/W**:L **W/G**		1744	1133	1135	8-05
2004	2	M	599-37450	164.173	**W/R/W**:L **W/G**		1745	1127	1154	46-07
2004	3	M	599-37451	164.414	**G/R/W**:L **W/G**		1746	1133	1135	9-03
2004	8	M	599-37454	--	**G/G**:L **W/G**		1751	1133	1135	19-05
2004	15	F	599-37446	--	L **R/G**(PTT):L **W/G**	--	1758	1144	1136	5-05
2004	16	M	599-37457	164.754	**W/G/R**:L **W/G**		1759	1144	1136	4-09
2004	19	F	599-37447	164.065	**R/W/G**:L **W/G**		1762	1100	1263	12-02
2005	5	M	599-37233	--	L **G/W:G/R/W**		1786	1133	1135	15-04
2005	8	F	599-37239	164.664	**G/W/R**:L **G/W**		1790	1127	1154	1-04
2005	9	M	599-37236	164.284	L **G/W:R/W/R**		1791	1162	1167	13-03
2005	12	M	599-37242	165.223	**G/R/W**:L **G/W**		1794	1560	1135	22-07
2005	14	M	599-37243	--	**R/W/G**:L **G/W**		1796	1182	1098	
2005	19	F	599-24696	165.323	**G/R/G**:L **G/W**		1802	1560	1135	8-04
2005	28	F	599-32129	--	L **G/W**:L **G/R**(PTT)	--	1812	1128	1140	
2006	W1	F	599-34058	164.444	L **R/G:W/G/W**		1874	1672	1678	10-03
2006	27	M	599-55902	164.263	L **R/G:W/G/R**		1864	1439	1219	26-09
2007	3	M	599-55936	--	L **R/G:R/G/W**		1881	1216	1202	38-08
2007	7	M	599-55938	164.514	L **R/G:G/R/W**		1885	1165	1164	39-07
2007	12	M	599-55941	164.726	L **R/G:W/R/G**		1890	1267	1261	
2007	13	M	599-55942	--	L **R/G:G/W/R**		1891	1386	1261	
2007	16	F	599-55933	--	L **R/G**:L **W**(PTT)	--	1894	1420	1168	16-02
2007	17	F	599-55944	--	-- : --		1895	1674	1679	
2007	22	F	599-55934	165.142	L **R/G**:L **G/W**(PTT)	--	1900	1216	1202	12-05
2007	26	F	599-55947	--	**G/W/G**:L **R/G**		1904	1147	1119	
2007	27	F	599-55948	164.742	**R/W/G**:L **R/G**		1905	1254	1156	
2007	33	M	599-55951	164.054	**W/R/G**:L **R/G**		1909	1127	1154	5-09
2007	37	M	599-55929	164.234	**R/G/W**:L **R/G**		1914	1182	1098	
2007	39	F	599-55923	164.646	**W/G/W**:L **R/G**		1917	1216	1202	7-07
2007	46	F	599-55927	--	L **W/R**(PTT):L **R/G**	--	1927	1128	1263	2-04
2008	4	M	599-55961	165.347	L **R/W:W/G/R**		1933	1165	1292	
2008	13	F	599-55962	164.593	L **W/G**(PTT):L **R/W**	--	1942	1216	1202	
2008	14	M	599-55967	164.764	**G/R/W**:L **R/W**		1943	1254	1156	24-08
2008	24	F	599-55964	165.583	**R/G/R**:L **R/W**		1950	1127	1154	14-08
2008	27	M	599-55970	164.463	**W/R/G**:L **R/W**		1953	1216	1202	8-09
2008	28	M	599-55971	165.592	**G/R/G**:L **R/W**		1954	1216	1202	
2008	29	M	599-55972	165.210	**G/W/R**:L **R/W**		1955	1267/1386	1261	
2008	30	F	599-55973	164.903	**W/G/R**:L **R/W**		1956	1267/1386	1261	11-02
2008	38	F	599-55959	165.747	L **R/W:R/W/G**		1963	1422	1366	3-07

Appendix A: Whooping cranes in eastern migratory flock, 30 December 2011. Continued.

Hatch year	Crane no.	Sex	BBL Band no.	Frequency (MHz)	Color code (left:right) L=long bands with transmitter	PTT ID	Studbook no.			Mate
							Own	Sire	Dam	
2009	4	F	599-55993	164.494	L **W/R**:L **W/G**(PTT)	--	1971	1213/1717	1164	16-04
2009	5	F	599-55997	164.615	**W/R/G**:L **W/R**		1972	1133	1135	33-07
2009	6	M	599-55985	164.255	L **W/R**:**W/R/G**		1973	1746	1704	
2009	7	F	599-55994	164.525	L **W/R**:L **G/R**(PTT)	--	1974	1165/1130	1292	
2009	8	F	599-55983	164.143	L **W/R**:L **G**(PTT)	--	1975	1746	1704	27-08
2009	10	M	599-55986	164.374	L **W/R**:**G/R/G**		1977	1216	1202	
2009	11	M	599-55987	164.385	L **W/R**:**G/W/R**		1978	1248/1256	1241	
2009	12	M	599-55988	164.195	**W/G/W**:L **W/R**		1979	1267/1386	1261	
2009	13	M	599-55998	164.324	**G/R/G**:L **W/R**		1980	1267/1386	1261	
2009	14	F	599-55989	164.295	**R/G/W**:L **W/R**		1981	1041/1100	1197	
2009	15	F	599-55984	164.425	L **W/R**:L **G/W**(PTT)	--	1982	1581	1366	
2009	18	M	599-55990	164.314	**G/R/W**:L **W/R**		1985	1147	1119	
2009	19	M	599-55999	164.554	**G/W/R**:L **W/R**		1986	1581	1292	
2009	24	M	599-56000	164.633	**W/G/R**:L **W/R**		1991	1267/1386	1261	
2009	25	F	599-55991	--	**G/W/G**:L **W/R**		1992	1267/1386	1261	
2009	26	F	599-55992	164.585	**R/W/G**:L **W/R**		1993	1041/1182	1101	27-06
2009	29	M	599-56302	164.795	L **W**:**R/G/W**		1996	1581	1366	
2009	32	F	599-55974	165.271	L **G**(PTT):L **W/R**	--	1999	1041/1100	1197	
2009	34	F	599-55978	165.608	L **W/R**:**W/G/W**		2002	1717/1213	1164	
2009	35	F	599-55975	165.106	L **G/W**(PTT):L **W/R**	--	2003	1128	1263	
2009	36	F	599-55976	164.274	L **W/G**(PTT):L **W/R**	--	2005	1128	1140	
2009	37	F	599-55979	164.873	L **W/R**:**R/G/W**		2006	1147/1560	1119	
2009	38	M	599-55980	165.506	L **W/R**:**G/R/W**		2007	1717/1213	1164	
2009	41	M	599-55981	165.570	L **W/R**:**G/W/G**		2010	1128	1140	
2009	42	F	599-55982	165.359	L **W/R**:**R/W/G**		2011	1128	1263	
2010	W1	F	599-56303	164.457	L **B**:**R/G/W**		2062	1746	1704	
2010	W3	F	599-56304	164.683	**W/G/R**:L **B**		2064	1127	1154	
2010	1	M	599-56326	164.563	L **W**:L **R/G**(PTT)	100211	2014	UNK	1167	
2010	3	F	599-56318	165.634	L **R/G**(PTT):L **B/W**	--	2016	1786	1758	
2010	5	F	599-56316	164.893	L **W/B**:L **R/G**(PTT)	--	2018	1717	1164	
2010	6	F	599-56317	164.153	L **W/B**:L **G/R**(PTT)	103538	2019	1147	1119	
2010	8	M	599-56321	164.643	L **B/W**:**W/R/G**		2021	1581	1637	
2010	9	F	599-56319	165.522	L **G/R**(PTT):L **B/W**	103539	2022	1581	1637	
2010	10	F	599-56322	164.775	L **B/W**:**G/R/G**		2023	UNK	1261	
2010	16	F	599-56324	165.256	**R/G/W**:L **B/W**		2029	1717	1164	
2010	17	M	599-56325	165.194	**G/R/W**:L **B/W**		2030	1144	1136	
2010	19	M	599-56310	164.353	L **B/W**:**G/R/W**		2048	1128	1263	
2010	21	M	599-56305	164.044	L **B/W**:L **R/G**(PTT)	--	2051	1189	1195	
2010	23	F	599-56306	164.914	L **B/W**:L **G/R**(PTT)	--	2053	1189	1195	
2010	25	M	599-56313	164.994	**G/R/G**:L **B/W**		2055	1717	1164	
2010	26	M	599-56314	165.071	**G/W/R**:L **B/W**		2057	1189	1195	
2010	27	F	599-56308	165.370	L **G/R**(PTT):L **W/B**	--	2058	1041	1197	
2011	2	F	--	--	--: L **B**		2097	1147	1119	
2011	13	M	599-56330	164.970	**G/W/G**: L **G/R**		2129	1182	1197	
2011	14	F	599-56327	164.982	L **W**(PTT):L **G/R**	038634	2130	1128	1140	
2011	15	F	599-56328	165.033	L **R/W**(PTT):L **G/R**	062170	2131	1128	1263	
2011	16	M	599-56331	165.093	**R/W/G**:L **G/R**		2132	1128	1140	
2011	17	F	599-56332	164.486	L **G/R**:**W/G/W**		2133	UNK	1197	
2011	18	M	599-56333	164.123	L **G/R**:**R/G/W**		2134	1189	1195	
2011	19	M	599-56334	164.933	L **G/R**:**W/R/W**		2137	UNK	1140	
2011	20	F	599-56329	165.433	L **W/G**(PTT):L **G/R**	070398	2139	1189	1195	

RESEARCH AND SCIENCE TEAM

Team members: Jeb Barzen, Chair, International Crane Foundation; Peter Adler, Clemson University; Mark Berres, University of Wisconsin-Madison; Sarah Converse, USGS Patuxent Wildlife Research Center; Mike Engels, International Crane Foundation; Megan Fitzpatrick, University of Wisconsin-Madison; John French, USGS Patuxent Wildlife Research Center; Elmer Gray, University of Georgia; Scott Hull, Wisconsin Department of Natural Resources; Anne Lacy, International Crane Foundation; Glenn Olsen, USGS Patuxent Wildlife Research Center; Doug Staller, Necedah NWR; and Sarah Warner, U.S. Fish & Wildlife Service.

Five research themes currently being pursued by WCEP are presented below. In Theme 1 we experiment with one factor currently thought to limit nesting success, black flies, to learn not only about how black flies might harass incubating birds to the point of abandoning their nests, but to examine what happens to nest success when the population is released from this environmental perturbation. Theme 2 builds a population model that we can then use to compare the impact of other environmental factors that may influence nest success such as predation, maturation of the population, and energetics, should they present themselves as problems once initial efforts to manage black flies has solidified. Theme 3 examines the habitat-related aspects of breeding and wintering whooping cranes, whereas Theme 4 evaluates the potential for improper energy balances to effect reproduction and how that might occur. Finally, in Theme 5 we begin to explore what questions might be next.

THEME 1: *Bti* Experiment to Assess the Impact of Black Fly Infestation on Whooping Crane Nesting

John French, U.S. Geological Service

Introduction

The eastern migratory flock (EMP) of Whooping Cranes is in the 10th year of existence, and numbers about 100 birds. All of these birds are the offspring of captive parents and were released into the wild starting in 2001; only one bird in this population is the offspring of reintroduced birds producing chicks in the wild. The reintroduced birds of the EMP seem to be very successful in almost every way (survival, molt to adult plumage, pairing, migration, etc.) except in the ability to hatch and fledge chicks. EMP Whooping Cranes form pairs, defend territories, build nests, lay eggs and incubate them, but rarely incubate the eggs to hatching. Nests with eggs were first established in 2005. From 2005-2011, only 15 wild-hatched chicks have successfully hatched from 80 nests containing at least one egg (most nests hold 2-egg clutches); only one chick hatched in the wild without human assistance, has fledged and is still alive. Two other eggs near hatch were inserted into nests. Both of these eggs hatched chicks and these chicks fledged and are still alive. Most nests were abandoned part way through incubation and the eggs were subsequently taken by predators or salvaged by biologists.

One hypothesis explaining the cause of nesting failure is that infestation of cranes by biting black flies (*Simulium* spp.) feeding on bird blood is bothersome enough that the cranes abandon their clutches. An overlap of the incubation period for crane eggs and the emergence of at least two species of *Simulium* spp., observations of heavy *Simulium* infestation on cranes nesting at the

Necedah NWR (NNWR) and observations of (dis)comfort behavior of some nesting cranes, together provide initial credibility for this hypothesis. To test this hypothesis directly, WCEP undertook a field experiment to determine the relationship between black fly abundance and incubation behavior, specifically crane incubation long and steady enough to hatch their eggs. Experimental treatment of the Yellow River, the major *Simulium* larval habitat adjacent to the NNWR, with *Bacillus thuringiensis* var. *israeliensis* (*Bti*) a biological control agent specific to larval black flies (and mosquitoes), was intended to significantly reduce the population of black flies. Under this hypothesis, the effective *Bti* treatment should result in lower black fly populations at nests and improved crane incubation behavior sufficient to have nests hatch.

This conference report summarizes research activity around this hypothesis and results of the Bti experiment for 2011; some sections have more detailed reports attached and include:

1. **Application of Bti and effectiveness of larvicide treatments (by Elmer Gray);**
2. **Identification and quantification of biting fly abundance (by Peter Adler)**
3. **Crane incubation and black fly abundance; determination of crane incubation behavior (by Rich King)**
4. **Analysis of factors (including insect abundance) potentially influencing daily nest survival (by Sarah Converse).**

1. Application of *Bti* and effectiveness of larvicide treatments

Dr. Elmer Gray, University of Georgia

At the request of the Ecological Services Office (Green Bay, WI) of the U.S. Fish and Wildlife Service and the Whooping Crane Eastern Partnership, larval black fly surveillance and suppression was conducted in the Yellow River between Babcock and Necedah, WI during the springs of 2010 and 2011 (Fig 1.). Larval surveillance identified this river as the primary larval habitat of the pest black fly species, *Simulium annulus* and *S. johannseni*, located within 10 km of NNWR, which includes the majority of nesting sites for the Critically Endangered Whooping Crane, *Grus americana*. Larval surveillance also identified secondary populations of the pest species in the Lemonweir River, the South Branch of the Yellow River and Cranberry Creek. A pilot larvicide application was conducted in 2010 at one site on the Yellow River using the biological larvicide, *Bacillus thuringiensis* var. *israelensis*. This application was conducted under unusually warm and dry conditions. Effective larval mortality was produced up to 2.5 miles downstream of the treatment site in 2010, illustrating that a landscape-scale application of *Bti* was possible.

In 2011, larval surveillance confirmed all 2010 larval assessments. A black fly suppression program was conducted over approximately 32 miles of the Yellow River. River flows were approximately four times greater than in 2010 and the water temperature was <1-2°C. Eleven larvicide applications were conducted based on our operational experience, the 2010 pilot study, maps and river flow readings. Initially, applications were conducted from bridges and immediately accessible sites along the river. After evaluating the initial series of larvicide applications, additional access points were located and another series of larvicide applications were conducted. Mortality evaluations were conducted where access was possible downstream of treatment sites (Fig. 2). Complete larval mortality was observed up to 3.4 miles below the application sites. The next closest downstream evaluation site was 4.9 miles below its application site and 66% larval mortality was observed during 24-hour mortality evaluations. At 5.3 miles below an application site, 46% larval mortality was observed.

Using the results of these known distances and larval mortalities, I estimated that we eliminated approximately 85% of the pest species from the Yellow River between Babcock and the outflow of Lake Necedah. Building upon the experience gained in 2011, we are confident that an even more effective black fly suppression program could be developed for 2012.

2. Summary of Identification and quantification of biting fly abundance

Dr. Peter Adler, Clemson University

Adult black fly population numbers were assessed in two primary ways on the NNWR in 2011: a) by means of seven CO2 traps set throughout the Refuge; captures were collected 11 April through 17 June, covering the period of crane egg-laying and incubation, and b) collections or observations at crane nests by means of glue boards, and of broken egg contents as available; black files seem to be highly attracted to the contents of crane eggs. Estimates of numbers of black flies from photographs at active crane nests were also made by Rich King (NNWR, see section 3 below.).

<u>Carbon-dioxide traps</u> - Sampling of adult black flies was conducted with carbon-dioxide traps, designed to attract female biting flies using carbon-dioxide as bait. Trap placement and number at NNWR replicated 2009 sampling and were comparable to more limited sampling in 2010. The traps were baited with dry ice and run once every 3 to 4 days (i.e. twice per week), weather permitting (minimal wind and no precipitation), to encompass the nesting period of whooping cranes, April 1 to June 15. The blocks of dry ice last about 12 hours, and would be deployed immediately above the traps at dawn. Trapped adults would be removed from the traps after dark that day, and placed in labeled vials of 80% ethanol.

<u>Glue-board sampling of flies at nests</u> - Glue boards were deployed with decoy cranes, for 5 minutes, at recently abandoned nests, as per previous years. Flies were removed from glue boards, using a solvent, and placed in 80% ethanol.

<u>*Ad hoc* collection of flies from broken eggs</u> - *Ad hoc* collections of broken eggs were made from abandoned nests and black flies entrapped in the contents of the eggs were placed in vials of 80% ethanol.

<u>High resolution images</u> - To test the measurement of black fly abundance at nests while incubation is still occurring, high resolution cameras were used to take still pictures at 4 active nests. Choice of sample nests was guided by using only pairs with previous nesting experience and waiting to approach nests until after 10 days of incubation had been initiated (to minimize the chance that the disturbance of acquiring the image would cause abandonment). Timing of the nest visit was to also occur before peak black fly emergence as predicted but during the period when black fly presence was likely. The purpose of this sampling was to estimate black fly abundance that birds would tolerate and to measure black fly abundance at the nest in comparison to black fly abundance with CO2 traps (which were not placed very close to nests).

The following preliminary report presented by Dr. Peter Adler at the WCEP Science Workshop is a summary of biting-fly surveillance following a *Bti* treatment conducted in the Yellow River in early April 2011. The year 2009 is used as a baseline for comparison. Adult black fly monitoring was intensive in 2009, and flow conditions and temperatures in 2011 were more similar to those in 2009 than to those in 2010. Water temperature and flow in the Yellow River during the sampling period (30 March-5 April) was <2 ºC and bankfull, respectively, in 2009 and 2011, but 6-12 ºC and easily waded in 2010. All specimens collected from 11 April through 17 June 2011 have been processed, counted, and identified; this timeframe corresponds with that available from the baseline year.

As a result of seasonal timing and the locations where *Bti* was applied, only two species of black flies (*Simulium annulus* and *Simulium johannseni*) were affected by the treatment.

Monitoring of Adult Biting Flies: Carbon-Dioxide Trapping

More than 90,000 females of more than 43 species of blood-feeding insects were collected in carbon-dioxide traps (7 traps on each of 17 days, Table 1).

Table 1. Blood-feeding flies collected in carbon-dioxide traps on NNWR, 11 Aprilð 17 June 2011

Family	Number of species	Number of females
Black flies	18**	32,669
Mosquitoes*	>10	56,703
Horse flies	9	597
Biting midges	6	562
Total	>43	90,531

*Mosquitoes collected in carbon-dioxide traps and placed in ethanol are difficult to identify. However, more than 80% of all mosquitoes trapped were of two species, *Culiseta minnesotae* in April-May and *Coquillettidia perturbans* in May-June. Both species feed on birds and mammals.
**Includes 10 bird feeding species (20,868 females) and 8 mammal feeding species (11,801 females).

a) In agreement with findings in the baseline year (2009):

(1) The seasonal succession of the 3 species of black flies attracted to whooping cranes was repeated: *Simulium annulus* (22 Aprilð 27 May 2011), *Simulium johannseni* (4 Mayð 27 May 2011), and *Simulium meridionale* (3 Juneð 17 June 2011, Figure 3).

(2) Carbon-dioxide traps collected 18 species of black flies in 2011 and 15 species in 2009.

b) In contrast to the baseline year (2009):

(1) *Simulium meridionale* was the most abundant black fly, representing 46.7% (15,272 females) of all black flies collected in carbon-dioxide traps, compared with 0.1% in 2009.

(2) *Simulium annulus* represented 2.7% (868 females) of all CO_2-collected black flies in 2011, compared with 15.8% in 2009.

(3) *Simulium johannseni* represented 14.2% (4,650 females) of all CO_2-collected black flies in 2011 compared with 79.7% in 2009. Of the 4,650 females of *S. johannseni* trapped in 2011, 78.9% were taken in one trap (#2) on one day (26 May).

(4) The ratio of bird feeders to mammal feeders was 1.8 to 1.0 in 2011 compared with 22.6 to 1.0 in 2009.

(5) Despite fewer trapping days in 2011 (17 trapping days), compared with 2009 (55 trapping days), the total numbers of biting midges, horse flies, and mosquitoes were all greater in 2011.

Ad hoc Collections of Adults at Broken Eggs of Whooping Cranes

An average of 585 black flies was collected from 3 whooping crane nests (one nest with 2 eggs) in 2011 (Table 2), compared with an average of 1,514 from 2 nests in 2009. Broken eggs continue to serve as a potent attractant to *Simulium annulus* and *Simulium johannseni*.

Table 2. Black flies collected from broken whooping crane eggs on Necedah NWR, 2011

Date	Pair	Number of *S. annulus*	Number of *S. johannseni*
8 May*	11-03/12-03	885	442
11 May	17-03/3-03	10	0
11 May	9-05/13-03	241	177

*This sample represents a collection of black flies from 2 eggs.

Monitoring of Adult Black Flies at Whooping Crane Nests: Glue Boards

Two species of biting flies, *Simulium annulus* and *Simulium johannseni*, were collected by glue boards at nests (Table 3). Glue boards were also set at nests in 2009 from 25 April to 12 June and included various modifications, such as on nest, off nest, and mounted on a crane dummy with a wing or without a wing. A comparative analysis of 2009 and 2011 data, therefore, will need to take into account these dates and modifications.

Table 3. Glue-board collections from whooping crane nests on Necedah NWR*, 2011

Date	Pair	Number of *S. annulus*	Number of *S. johannseni*
25 April	16-02/16-07	21	0
29 April	5-05/15-04	133	0
29 April	27-05/31-08	25	0
29 April	12-05/22-07	40	0
4 May	7-03/26-07	173	0
7 May	1-04/8-05	69	4
8 May	11-03/12-03	97	4
9 May	8-04/19-05	0	1
10 May	10-03/WI-06	1	0
11 May	9-05/13-03	53	2
11 May	17-03/3-03	56	0
25 May	12-05/22-07	1	0
28 May	3-04/9-03	0	1
Mean ± SE		51.4 ± 15.20	0.9 ± 0.42

*4 females of *Simulium annulus* were collected from Quincy Bluff, 4 May.

Monitoring Adult Black Flies at Nests of Other Birds: Glue Boards

Glue boards set at 6 nests of trumpeter swans, 3 of Canada geese, and 3 of sandhill cranes also collected *Simulium annulus*; glue boards at 2 mallard nests, however, collected no flies.

Surveys of Larval Black Flies in the Necedah Area

Sampling of breeding sites in early April again demonstrated that the Yellow River supported the primary populations of *Simulium annulus* and *Simulium johannseni*. Secondary populations of both species again were found in Cranberry Creek, South Branch of the Yellow River, and the Lemonweir River. A second cohort of *Simulium johannseni* developed in the Yellow River, as evidenced by a larval population on 6 May.

Larval sampling on the NNWR included 4.8 km (3 miles) of Spencer-Robinson Ditch. A random collection of 144 larvae in this ditch revealed 1 larva of *Simulium annulus*. A subsequent focused search for *Simulium annulus* and *Simulium johannseni* produced no larvae or pupae. Over 120 miles of ditch occur on the refuge but a focus on the Spencer-Robinson Ditch was based on results from intensive sampling of flowing water on the NNWR in 2009, which identified the Spencer-Robinson Ditch as the flow supporting *Simulium annulus* and *Simulium johannseni*. The known biology of both species also directs sampling; these species breed in large streams and rivers. Spot checks in 2010 to test the model upon which the sampling occurred predicted accurately the presence/absence of the larvae of these species of black flies.

Black Fly Marking Experiments

Black flies (ca. 125) were collected with carbon-dioxide traps along the Yellow River, successfully marked with different colors of fluorescent dusts, and released at the capture sites. Traps set on the NNWR revealed no trace of dusted flies.

Monitoring of Adult Biting Flies at Other Wisconsin Sites: Carbon-Dioxide Trapping

To survey the range of ornithophilic black files in the state, adult black flies were monitored at several sites in central and northwest WI, outside of the NNWR (Fig. 4). All insects captured and submitted from Crex, ICF, Mead, and Powell were processed, identified, and tallied. *Simulium annulus* (15 females) and *Simulium meridionale* (18) were identified from Crex; *Simulium johannseni* (1) from ICF; *Simulium annulus* (5), *Simulium johannseni* (11), and *Simulium meridionale* (2) from Mead; and *Simulium annulus* (129) and *Simulium meridionale* (10) from Powell. Coupled with a relative absence of ornithophillic black flies sampled in southern Wisconsin during 2010, the Necedah area appears to harbor an isolated high density of black flies.

Summary

(1) Populations of *Simulium annulus* and *Simulium johannseni*, which were the only species of black flies exposed to *Bti*, were markedly lower on the NNWR landscape in 2011 than in the baseline year of 2009, based on carbon-dioxide trap catches, relative to other species of black flies that would not have been exposed to *Bti* treatments. Further understanding the difference in measurement for black fly abundance provided by CO2 traps and various measures at the nest directly is needed. A separate paper by King and Adler, which evaluates different assessment techniques (e.g., CO2 traps) for determining population levels of black flies, is currently being developed. A replicate experiment in spring, 2012 will also help to rule out other variables that may have confounded the first year of *Bti* study.

(2) Broken eggs and whooping cranes continued to be highly attractive to *Simulium annulus* and *Simulium johannseni*, and despite lower numbers of these species on the refuge, they concentrated at nests.

(3) Larval populations of *Simulium annulus* and *Simulium johannseni* were virtually absent on NNWR, based on sampling of 4.8 km of the Spencer-Robinson Ditch, the only site on NNWR identified in 2009 as supporting these species.

(4) Based on glue-board collections at nests of other avian species, *Simulium annulus* is attracted to trumpeter swans, Canada geese, and sandhill cranes (but not mallards), potentially diluting the number of flies attracted to whooping cranes.

(5) A marking technique for black flies was technically successful, but the ability to mark large numbers of flies will be necessary before a mark-recapture program can be effective.

3. Monitoring crane incubation and black fly abundance on NNWR; determination of crane incubation behavior

Rich King, Necedah National Wildlife Refuge

Whooping Crane nests were monitored to detect abandonment or success using three different techniques: aerial over-flights, ground observation, and nest cameras. Aerial over-flights were useful to monitor attendance for remote nests both on and off NNWR. Monitoring via ground observation and radio telemetry was used to examine incubation success for nests with relatively easy accessibility. Nest cameras, supplied by NNWR, were used to better estimate time of failure or hatch and to better infer cause of failure. Cameras were located far enough away so that the camera could be approached by an observer without flushing the bird on the nest. The minimum distance that a camera was placed near a nest was 50 m with a blind erected or for a nest with a completely obscured approach. Erection of a blind to facilitate the approach was designed to allow subsequent visits to the camera without flushing the bird from the nest even if erecting the blind did flush the bird from the nest. Camera distances of 150m from the nest were the minimum for situations where covered approaches were not possible.

In addition, on-nest behavior and off-nest comfort behavior were assessed from blinds to detect cues of increasing nest disturbance due to black flies. These data were derived from focal animal samples of birds where head flicks and other comfort behaviors were counted for a 5-minute period each hour. Sampling periods were stratified throughout the daylight hours. NNWR nest cameras were also deployed to measure nest behavior but, to avoid compounding *Bti* experiment results, cameras were placed so as to avoid nest disturbance.

The following summary of results was provided by Rich King: Wisconsinós Whooping Crane nest survival is generally increasing regardless of the metric used to measure it including apparent nest success (Fig 5), daily nest survival following the Mayfield method, and daily nest survival estimates derived from nonlinear mixed models (NLMIXED SAS). Although each of these techniques has advantages and disadvantages, they have all produced similar results regarding Whooping Crane nest performance in Wisconsin. An examination of variables that could possibly explain this trend produced mixed results with factors related to nest phenology generally best supported by daily nest survival modeling (NLMIXED SAS) (2005 to 2010). A noteworthy exception to this was biting midge abundance in 2009. Abundance of other biting insects at Whooping Crane nests (Figs 6-9), as well as other variables including Whooping Crane age, captive history, and weather are generally poorly supported by daily nest survival modeling. Biting insect samples collected at Wisconsin Whooping Crane nests using three different methods produced mixed results with counts at successful and unsuccessful nests ranging from none to several hundred, which explains why these variables have limited value for describing Wisconsin Whooping Crane nest survival which is generally increasing. Wisconsinós Whooping Crane population does show two trends of increasing comfort behaviors (bill flick and head rub; Figs 10, 11) and the amount of time Whooping Cranes are leaving their eggs unattended (Fig 12). It remains to be seen if these behaviors will alter overall nest success.

4. Analysis of relationship between black fly abundance and crane incubation

Dr. Sarah Converse, U.S. Geological Service

[This section is extracted from a more complete report of the analysis attached as Appendix 1.]

The purpose of this analysis is to evaluate the hypothesis that blood-feeding insect populations contribute to nest abandonment and failure of whooping crane nests in the EMP, along with several additional hypotheses, including (1) whooping crane pairs are too young to evince successful incubation behavior; (2) whooping crane pairs are too inexperienced to evince successful incubation behavior; (3) whooping crane pairs suffer from captive breeding effects, leading to poor incubation behavior, and (4) rearing method of captive-reared birds has an influence on future incubation behavior.

To complete this analysis, we developed a novel daily nest survival model which accounts for missing data in temporally-varying covariates (namely, insect population indices) and implemented the model in a Bayesian inferential framework.

Of 56 nests included in this analysis, 11 were successful, including 2 in 2009, 5 in 2010, and 4 in 2011. Apparent nest success, therefore, from 2009-2011 was 0.20 (95% CI = 0.13, 0.28).

None of the crane-specific factors that we considered appeared to be important predictors of nest survival at the 95% CI level. However, at the 80% level, 2 factors had CIs that did not contain 0. These were male generations to any wild ancestor, and cumulative generations to any wild ancestor (Table 1; Figure 1); these effects had negative estimates, such that as the number of generations removed from any wild ancestor increases, nest survival is predicted to decrease. These results suggest that the hypothesis that whooping crane pairs suffer from captive breeding effects deserves some further exploration.

Two of the 5 insect taxa proved to be good predictors of daily nest survival. First, the index of abundance of *S. annulus* had a consistently negative effect on daily nest survival, with a 95% CI that excluded 0 (Table 2; Figure 2). Second, the index of abundance of *Tabanidae* (horseflies) had a consistently positive effect on daily nest survival, with a 95% CI that excluded 0 (Table 2; Figure 3).

A third insect taxon, *S. meridionale*, showed some evidence of a positive effect on nest survival. At the 80% level, the CI for this taxon did not contain 0 (Table 2; Figure 4). For the analyses of *S. meridionale* that eliminated the 3 nests >10K from the traps, numerical problems with the MCMC routine prevented estimation of the effects ï the MCMC routines for these 2 analyses did not run successfully (Table 2). However, because, for the other taxa, elimination of these far distant nests had no impact on inference, we felt that this problem with the MCMC routine did not cause challenges in interpreting the results for *S. meridionale.*

Finally, there was also some evidence for an effect of *Bti* on nest survival (Table 2; Figure 5). Nest survival was higher in 2011, when *Bti* was used, than in the other 2 years. The CI for this variable excluded 0 only at the 80% level, however. These results were consistent regardless of whether the 3 nests further distant from NNWR were or were not included in the analysis.

Discussion – Uncertainties in the *Bti* experiment

The underlying logic of the *Bti* field experiment is that if black flies infesting whooping cranes on nests at Necedah prevent cranes from fully incubating their eggs, hence hatching and raising chicks, then removal or lowering of the black flies should result in full term incubation, greater hatching of eggs, and production of chicks. In our first year of the experiment we found intermediate results. Black fly populations were lowered but not eliminated at NNWR in general or at nests specifically. As in any experiment, different uncertainties from each year can temper a straightforward interpretation of experimental results. Before any firm conclusion can be made we should replicate the experiment to attempt clearing up affects due to other variables that were not possible to control. The overall purpose of conducting this experiment is to identify whether or not black fly populations are an important cause of nest abandonment as opposed to other contributing factors such as energetics (Theme 2) or other insects (Theme 1), experience in the population (treated here), genomic change through captive management of populations (treated here), and negative impacts of rearing techniques (not treated in the overall research report). Understanding the relative role of black flies versus other factors concomitant in this environ is critical in guiding future management actions facing reintroduction of the EMP.

Below are the relevant issues that the Research and Science Team addressed in consideration of conducting a *Bti* treatment again in 2012:

1. Was the *Bti* treatment effective?

   Bti is a larvicide applied to habitats where black fly eggs hatch and larvae develop (i.e. running water). Pupae do not feed and are therefore not susceptible to *Bti*. Application of *Bti* may not have been as effective as desired because:

   a) Treatment was possible in the main area of black fly production (Yellow River) but not possible in areas of secondary importance (East Fork Lemonwier River, Beaver Creek, Cranberry Creek, South Branch of the Yellow River) for the production of adult black flies that utilize NNWR;
   b) Spring 2011 flow rates in the Yellow River were much higher than anticipated, and the amount of *Bti* larvicide on hand for use in secondary sites was not sufficient. Despite this, larval mortality in the Yellow River was quite high overall, estimated at 85%. Preparations for the second year of treatment will, pending permits, include sufficient larvicide to treat the Yellow River at 2011 flow rates as well as other secondary sites containing target black fly larvae.

2. Were numbers of black fly adults reduced by the treatment?

Adult black flies were monitored in several ways, none of which yield the information directly pertinent to the hypothesis, that is, the number of black flies infesting nesting whooping cranes during incubation. CO2 traps were deployed during incubation, but are variously distant from nests and collections from traps are made at intervals of several days; even so, Converse used these data to model daily levels of black flies during nesting and found that *S. annulus* negatively affected daily nest survival and *Bti* treatment may have increased daily nest survival rate. The other methods of collection (glue boards, photographs, collections from broken eggs) were made at nests, usually on the day or day after abandonment by nesting cranes; King relied on these data at the nest for his analysis as well as general adult black fly monitoring but his analysis was simpler than the models used by Converse (Kingộs analysis is not described in detail herein). All collection methods resulted in high variability among counts, variability that needs to be accounted for in some way in the analysis. Adler demonstrated that target black fly species at NNWR were significantly lower in 2011 than in 2009, based on the numbers collected in carbon-dioxide traps (*cf.* Fig. 3 below, vs. 2009 and 2010 reports). Figs. 6 and 8 below, using other assessment techniques, also indicated lower numbers of black flies in 2011 than in 2009, although cause and effect cannot be concluded, further treatment with *Bti* appears warranted. The *Bti* experiment, to run fully, will need to include monitoring after *Bti* has ceased so that nest success can be evaluated again. If *Bti* treatment did cause greater nest success then that advantage would disappear as black flies re-colonize areas from which they were removed. If bird age or experience were more important factors, then nest success would continue to increase following cessation of *Bti* treatment.

Intensive sampling of breeding habitats for *S. annulus* and *S. johannseni* in 2009, 2010, and 2011 identified the breeding sites on, and within 10 km of, the NNWR. The justification for sampling streams and rivers to a distance of 10 km from the NNWR was based on the maximum dispersal distance of 5 miles (= 8 km) recorded in the only study of dispersal by *S. annulus* (as *S. euryadminiculum*) (Bennett and Fallis 1971). The intensive sampling of streams, drainage ditches and rivers on the NNWR and to a distance of 10 km out from the NNWR clearly defined the major breeding populations of *S. annulus* and *S. johannseni*. Based on the known biology of *S. annulus* and *S. johannseni* (e.g., breeding in large streams and rivers) and larval sampling, confidence can be expressed that the location of all breeding populations within the 10-km boundary have been discovered. Further, within the 10-km boundary, the Yellow River has consistently been the greatest producer of *S. annulus* and *S. johannseni*. However, in previous reports and meetings, it has been stressed that large populations might exist beyond the 10-km boundary; no sampling has been conducted beyond that distance. A number of studies have examined dispersal distances of other species of black flies, and the conclusion from those papers is that dispersal distances vary greatly among species and environmental conditions. Whether dispersal distances in the study by Bennett & Fallis (1971), which was conducted in the forested region of Canada, are comparable to those in the NNWR area is not known. Limitations of the Bennett and Fallis (1971) study design (e.g., failure to randomize trapping sites) also call into question the conclusions regarding dispersal distances in that study.

3. <u>What constitutes nest abandonment?</u>

Each method for assessing daily nest attendance by cranes can itself affect attendance and produce abandonment, the very datum we want to collect. In addition, there was a desire in 2011 to collect eggs from truly abandoned nests while the eggs remained viable, so that they could be incubated, hatched and reared at captive facilities for reintroduction later that spring. The constraints of field work along with the variation in nest attentiveness among pairs resulted in different intervals between observations of nesting birds hence there was some inconsistency in when a nest was considered abandoned. Two consequences of importance:

- a) it is possible that a nest was considered abandoned and eggs were collected when in fact that pair had not abandoned and would have returned to continue incubation if the eggs were left in the nest, and
- b) for analytical purposes, an explicit operational definition abandonment, applied uniformly, is needed for consistent categorization of a nest as abandoned or not. Further, it may not be possible, within one year, to accommodate the conflicting goals of maximizing egg salvage and evaluating nest success.

4. Which nests should be included in an analysis of *Bti* treatment/black fly infestation?

More thought may be needed to consider if nests with fertile and/or infertile eggs should be included (if known), and if nests need to be excluded because the nest is located too far away. Converseô's analysis was done with and without nests > 10 km from a trap, and her conclusions did not change. Only one paper provides any measure of distances that *Simulium annulus* (as *S. euryadminiculum*) can travel (Bennett and Fallis 1971) and it is not clear how much results from that paper would apply on the Necedah landscape. In that study most marked black flies were captured 3 km from the initial capture site even though some individuals were recaptured as far as 10 km from the initial capture site. Infertile nests were included but only as failed nests. King only included nests in NNWR in his analysis. Adler has been clear that it is not possible to clearly define, on an *a priori* basis, the distance from the Yellow River, or any treatment area, that *Bti* would be effective in reducing adult populations. Predicting such a zone of effectiveness depends not only on distances that adult black flies might travel (which is poorly known) but also upon where other black fly populations might exist that have not been sampled.

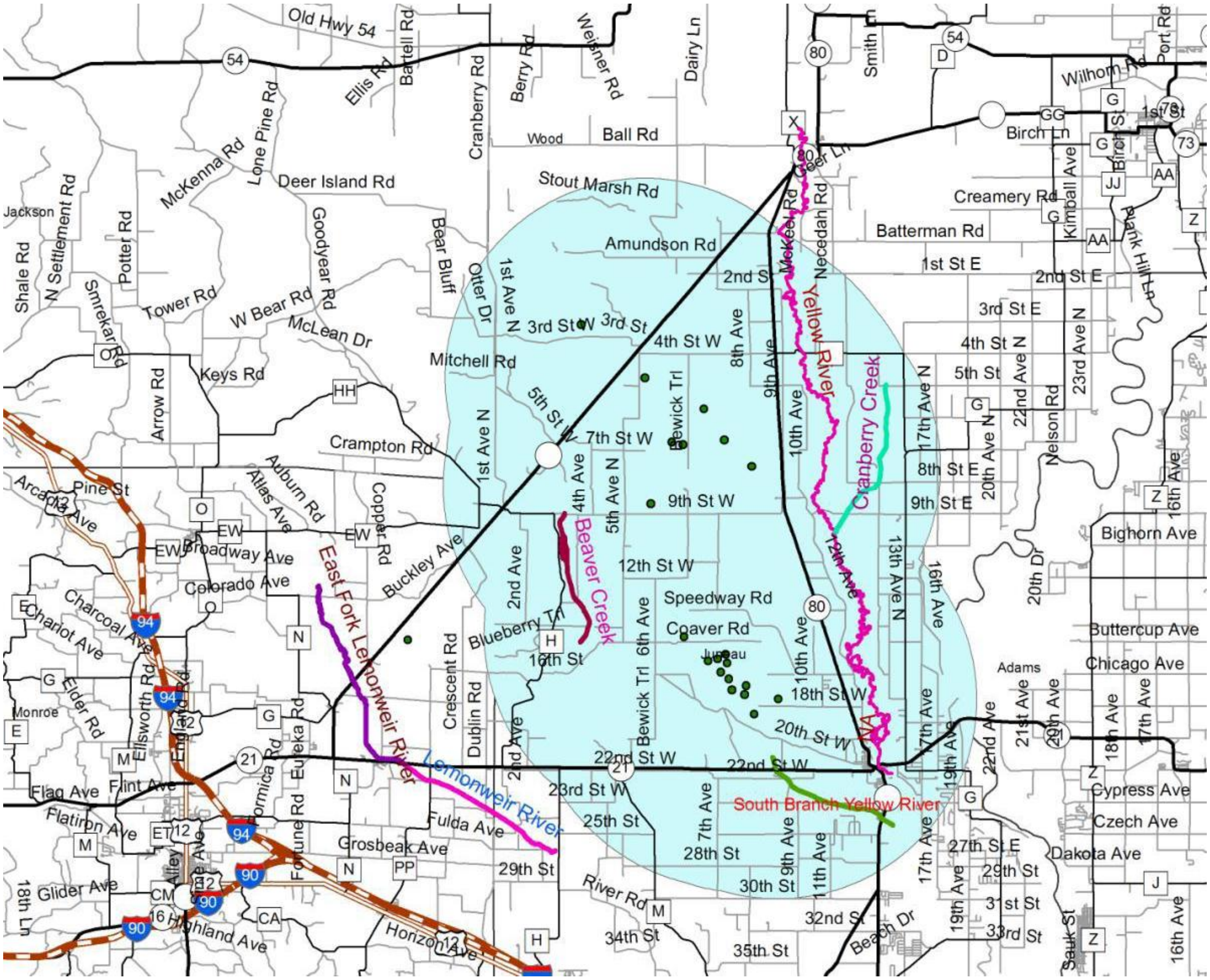
5. What distinguishes the analysis used by King from that used by Converse?

Differing advantages or disadvantages for two different methods of analysis are likely for our hypothesis; should we prefer one over the other? At a minimum, we should ensure that each analysis is using the same dataset and that a consensus is developed before publishing these results.

Literature Cited

Bennett, G.F. and A.M. Fallis. 1971. Flight range, longevity and habitat preference of female *Simulium euryadminiculum* Davies (Diptera: simuliidae). Can. J. Zool. 49:1203-1207.

Fig 1. Map of *S. annulus* and *S. johannseni* breeding sites and potential areas of treatment



Map shows potential treatment locations based on *S. annulus* and *S. johannseni* larval surveys and breeding sites.

Primary breeding site

- Yellow River, essentially from Babcock (and above) to slightly below the dam in Necedah

Secondary breeding sites (smaller populations)

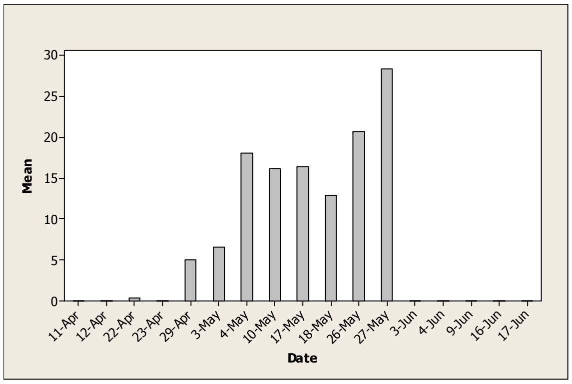
- South Branch of the Yellow River from south of 22nd Street to about Hwy 80
- Lemonweir River from 25th Street to 14th Street
- Cranberry Creek from about 5th Street to the confluence with the Yellow River
- Beaver Creek from about 9th Street to 15th Street

Figure 2. Mortality of black fly (*Simulium)* larvae after treatment with Bti in the Yellow River, WI.

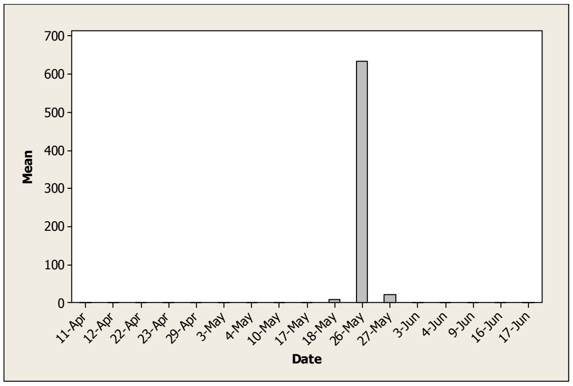
Yellow River, Babcock to Necedah, WI
March 31- April 3, 2011

Miles Downstream	# Alive	# Dead	% Mortality
UTC	232	2	0.9
UTC	98	4	3.9
0.25	0	249	100.0
2.7	6	195	97.0
2.8	1	235	99.6
3.4	100's dead		99.0
4.9	67	321	66.0
5.3	60	371	46.0

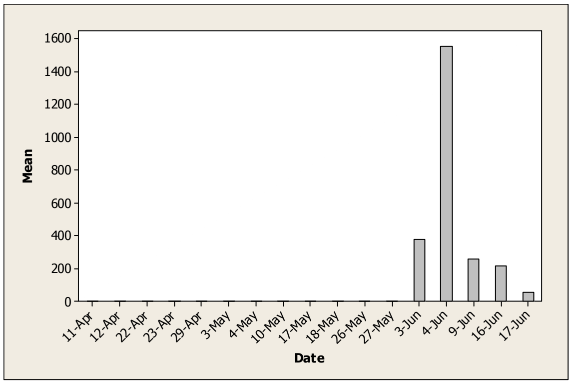
Figure 3**.** Average numbers of 3 species of black flies collected in carbon-dioxide traps on Necedah NWR, 2011.



Simulium annulus



Simulium johannseni



Simulium meridionale

Figure 4. Locations of CO2 traps to survey black fly populations in central and northwest Wisconsin, spring 2010 and 2011.

Figure 5. Whooping crane nesting at Necedah NWR, 2011 (Apparent nest success: the number of successful (full-term nests) divided by the number of nest attempts)

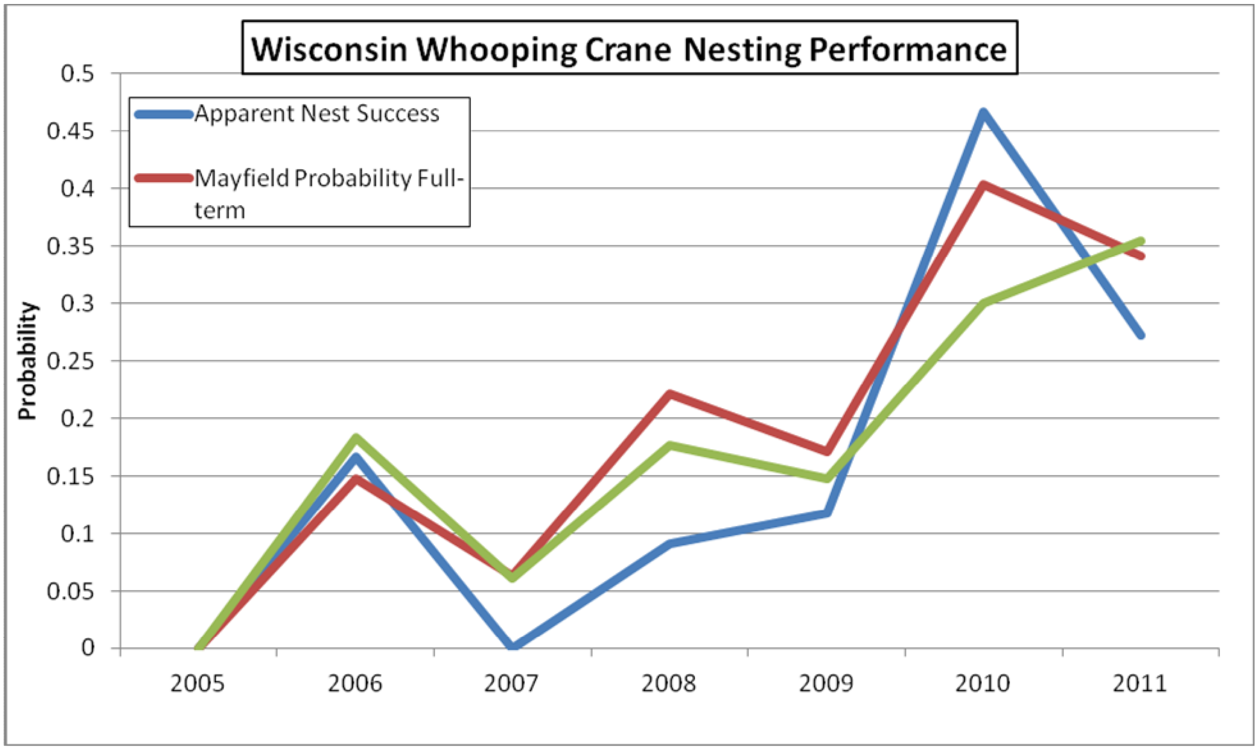


Figure 6. Numbers of black flies at selected whooping cranes nests, estimated from counts in photographs.

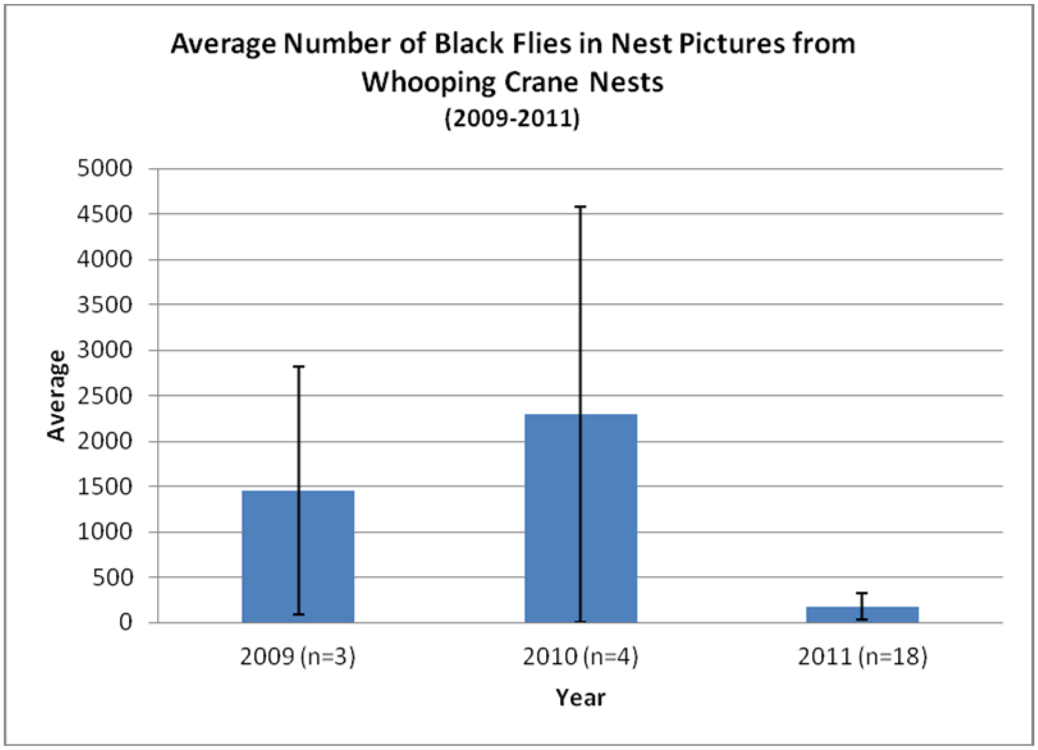


Figure 7. Whooping crane nests and black fly assessments using photographs.

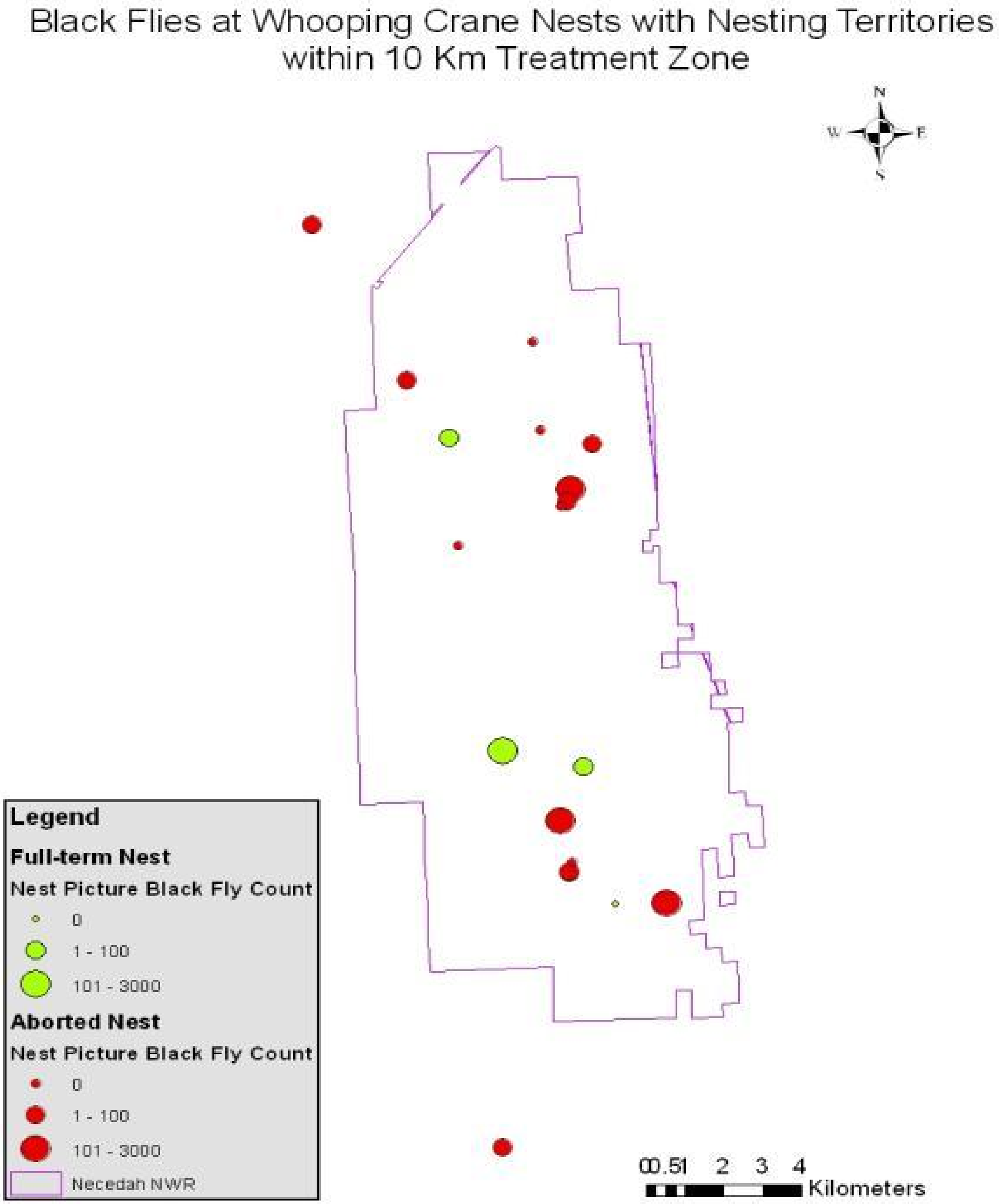


Figure 8. Black flies collected on glue boards deployed at selected whooping crane nests.

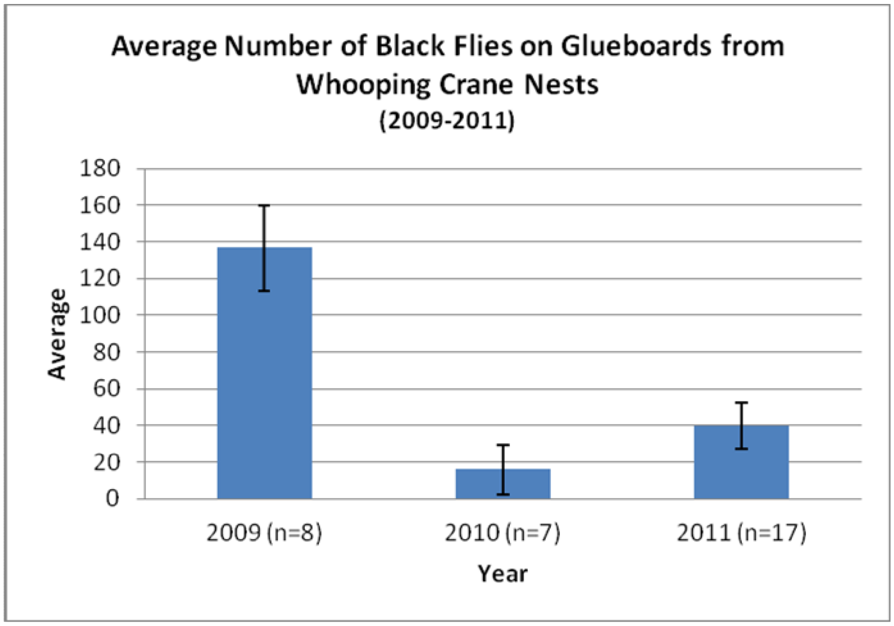


Figure 9. Whooping crane nests and black fly assessment using glueboards.

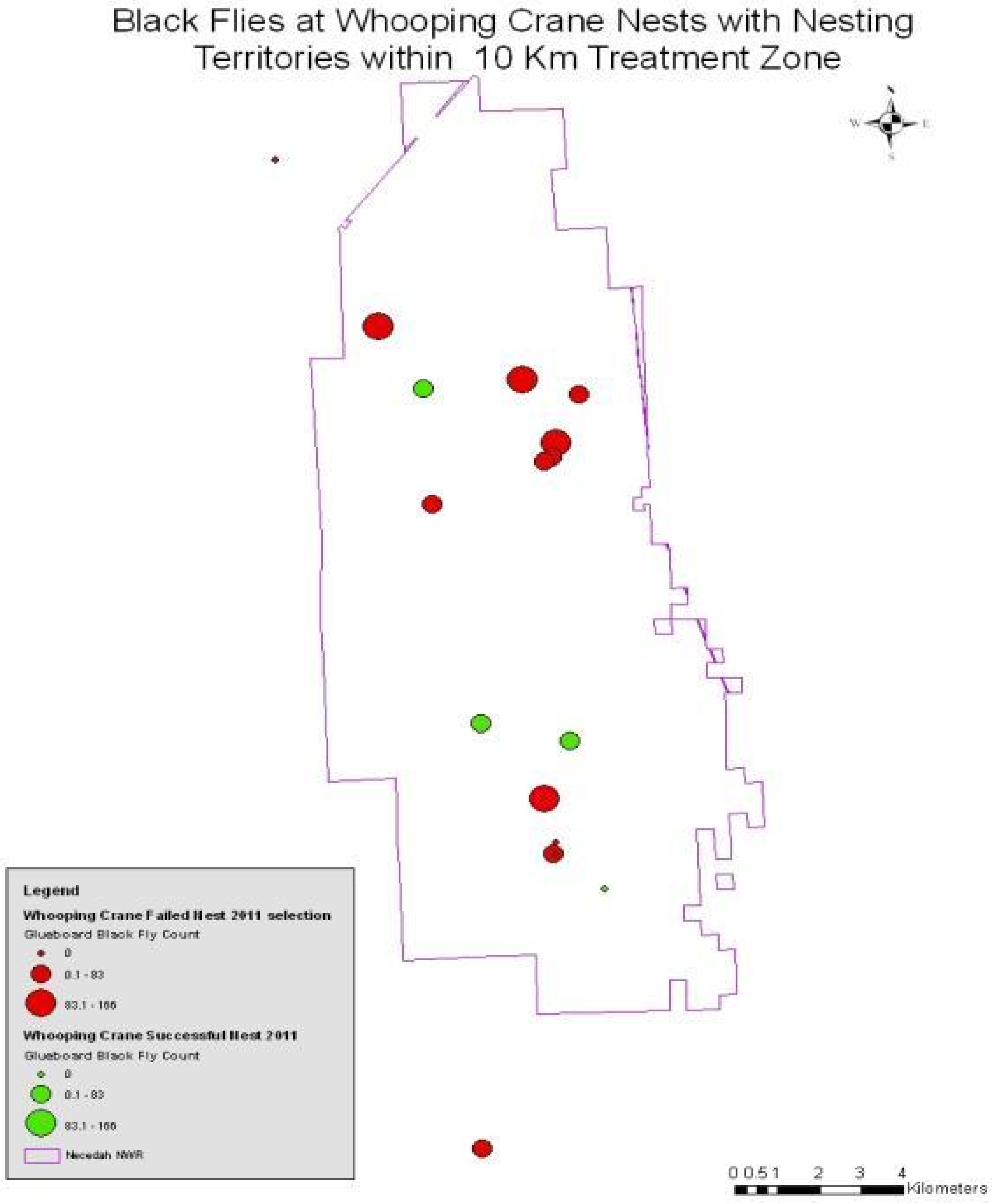


Figure 10. Whooping Crane Comfort Behaviors: bill-flicks.

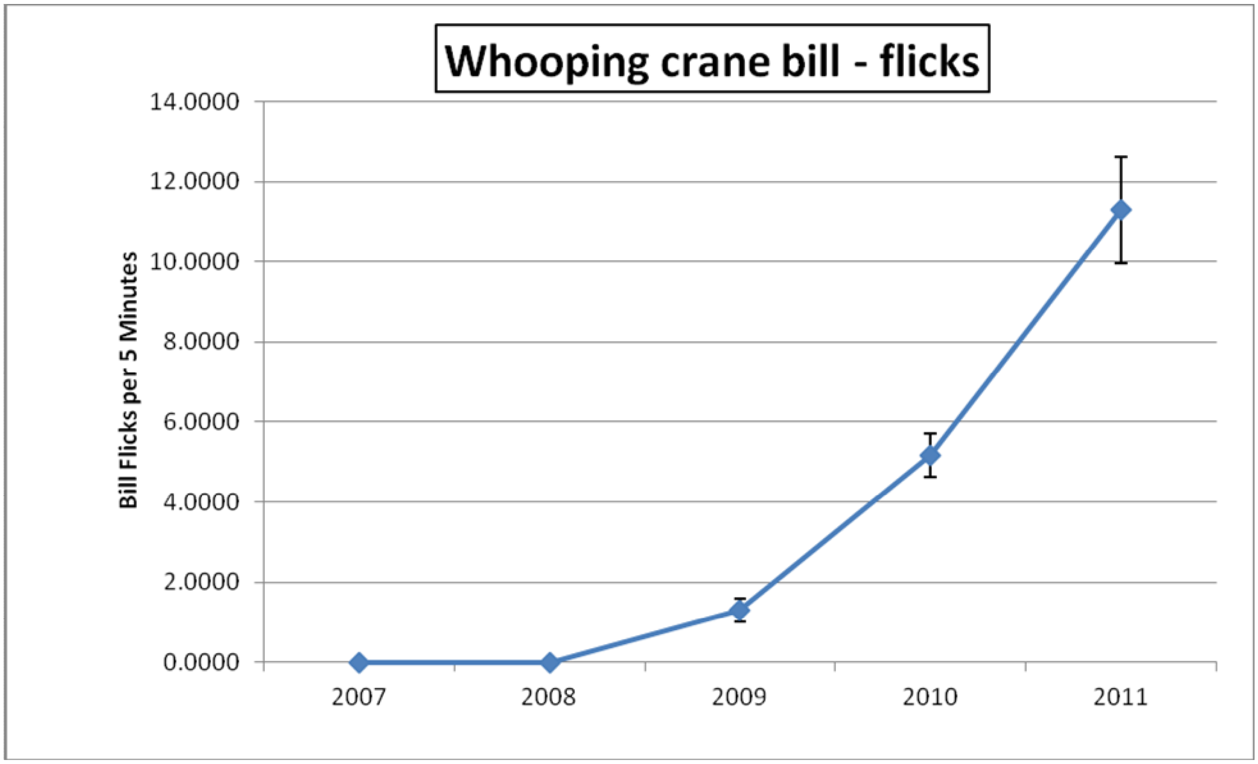


Figure 11. Whooping Crane Comfort Behaviors: Head-rubs.

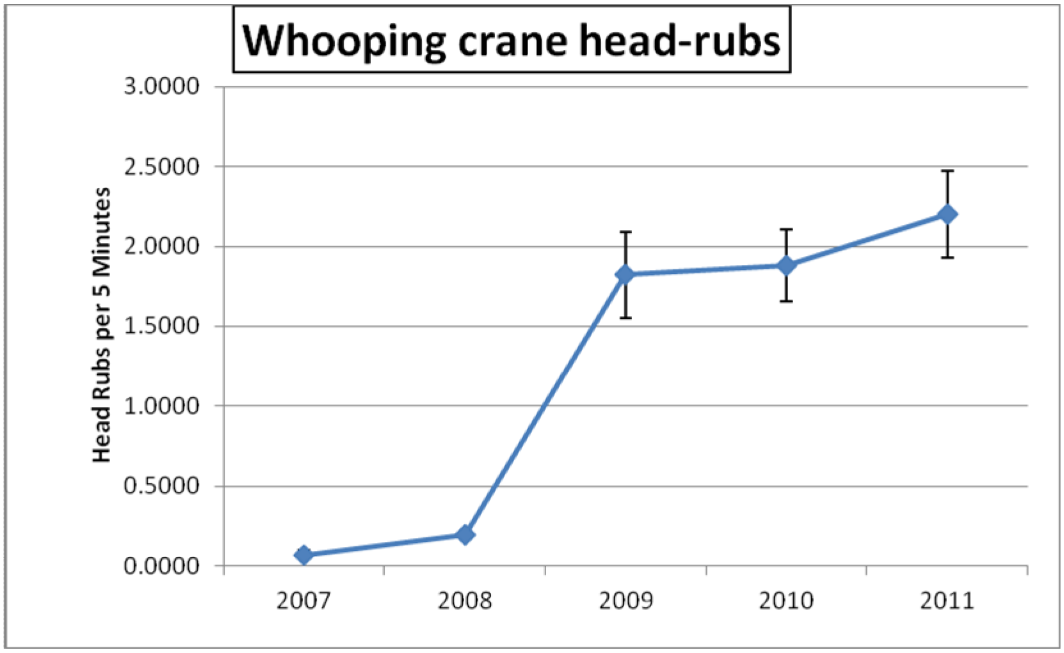
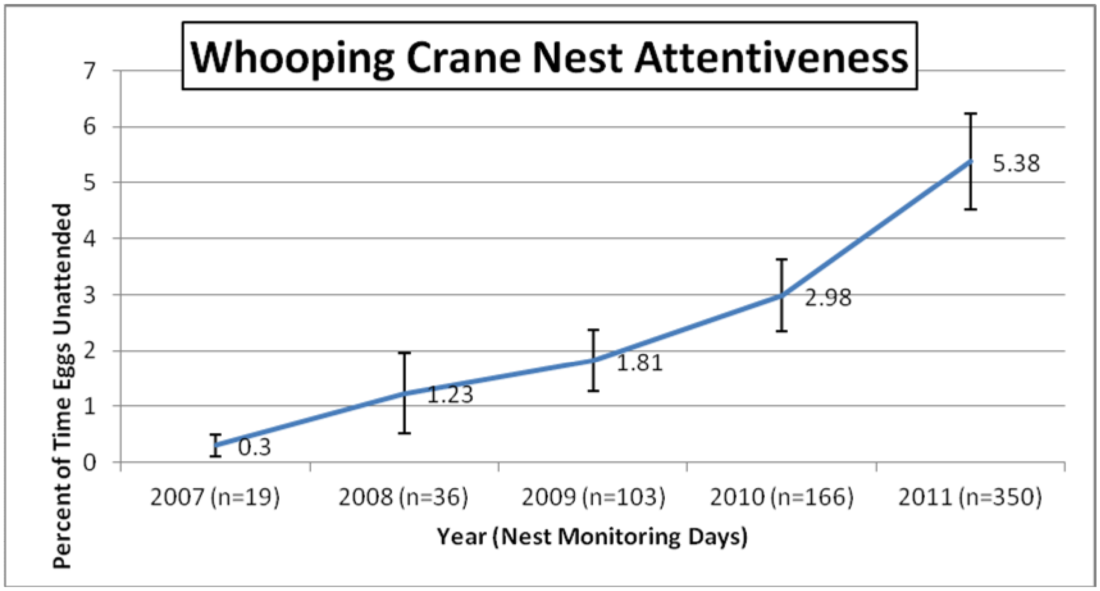


Figure 12. Nest attentiveness for whooping cranes at Necedah NWR.



APPENDIX

Daily Nest Survival in the Whooping Crane Eastern Migratory Population

Sarah J. Converse[1,2], Peter H. Adler[3], and J. Andrew Royle[1]

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Introduction

The reintroduction of the Eastern Migratory Population to central Wisconsin (to date, on Necedah National Wildlife Refuge; NNWR) is a cornerstone effort in whooping crane conservation. If successful, this reintroduction would add one additional population to the only self-sustaining population of whooping cranes, the Aransas-Wood Buffalo Population. Adding an additional 1 or 2 whooping crane populations is a goal of the Whooping Crane International Recovery Plan (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005).

Many indicators of success for this reintroduced population, established with releases of captive-reared birds beginning in 2001, are good. The birds have learned migratory behavior (Urbanek et al. 2009), survival is relatively high (Converse et al. 2011; Servanty and Converse this report) and birds are pairing and have been nesting since 2005 (Converse et al. 2011; Servanty and Converse this report). However, reproductive success has been poor, largely due to a high rate of nest abandonment (R. S. King and R.P. Urbanek, US Fish and Wildlife Service, unpublished).

In 2008, USFWS biologist R.P. Urbanek posed the hypothesis that nest abandonment is caused by harassment of cranes by blood-feeding black flies of the genus *Simulium* (Urbanek et al. 2010). Since that time, data have been collected to facilitate the evaluation of this hypothesis. These data are of 2 primary types: (1) Insect Survey Data: beginning in 2009, regular collection of insect index data from carbon dioxide traps at 7 locations on NNWR; and (2) Experimental Treatment: in 2011, an experimental treatment of black fly breeding habitat in the Yellow River with *Bacillus thuringiensis* var. *israelensis* (*Bti*), a larvicide.

The purpose of this analysis is to evaluate the hypothesis that black fly populations contribute to abandonment and failure of whooping crane nests in the Eastern Migratory Population, along with several additional hypotheses, including (1) whooping crane pairs are too young to evince successful incubation behavior; (2) whooping crane pairs are too inexperienced to evince successful incubation behavior; (3) whooping crane pairs suffer from captive breeding effects, leading to poor incubation behavior, and (4) rearing method of captive-reared birds has an influence on future incubation behavior.

In order to complete this analysis, we developed a novel daily nest survival model which accounts for missing data in temporally-varying covariates (namely, insect population indices) and implemented the model in a Bayesian inferential framework. Daily nest survival methods were first developed by Mayfield (Mayfield 1961;1975) as an improvement to apparent nest success for use in avian nesting studies. Mayfield recognized that apparent nest success (number of successful nests/total nests surveyed) would be in most cases a positively biased measure of nest success, because successful nests are more likely to be located due to their longer lifespans. Mayfield's solution was to analyze daily nest survival intervals, rather than overall nest success.

Johnson (1979) described a related model that formally accounted for uncertain date of nest failure and also provided a likelihood function for that model. Dinsmore et al. (2002) and Shaffer (2004) each developed likelihood-based approaches that allow greater flexibility in accounting for variation in daily nest survival over time. One major benefit of these methods is the ability to examine hypotheses about time-varying factors that may influence nest outcomes.

We developed a variant of the Dinsmore et al. (2002) and Shaffer (2004) methods in a Bayesian inferential framework. Our method accommodates missing temporally-variable predictor data (in this case, indices of insect abundance) via a simple autoregressive model of insect abundance.

Methods

Daily nest survival analysis can be described as follows. Imagine a nest that was found on the first day of the nesting season, was subsequently observed to be active on day 4, but was then observed to be failed on day 6. The probability of this sequence of events occurring can be expressed as:

$$P(\text{encounter history}_i) = S_{i,1}*S_{i,2}*S_{i,3}*(1-S_{i,4}*S_{i,5})$$

where the encounter history of nest *i* is a function of survival (*S*) on days 1, 2, and 3, and mortality (1-*S*) somewhere during the interval between days 4 and 6. Once we have specified this probability structure for each nests' encounter history, we can then specify models for each of these daily survival rates, and can include in these models various factors that are hypothesized to influence survival rates. Some of these factors may be independent of time, such as the age of the male member of the nesting pair, with a model such as:

$$\text{logit}(S_{i,t}) = \beta_0 + \beta_1*\text{male.age}_i \tag{1}$$

where β_0 is the intercept (on the logit) scale, of daily nest survival, and β_1 describes the relationship between daily nest survival and male age.

We built models of daily nest survival using several predictors that were crane-specific, including: (1) male age (years) – the age of the male member of the nesting pair; (2) female age; (3) minimum age – the minimum of (1) and (2); (4) average age – the average of (1) and (2); (5) male experience – whether the male member of the pair had previously produced a nest; (6) female experience; (7) minimum experience; (8) average experience; (9) male cumulative attempts – the cumulative number of previous nesting attempts by the male member of the nesting pair; (10) female cumulative attempts; (11) minimum cumulative attempts; (12) average cumulative attempts; (13) male generations to any wild ancestor – the number of generations that the male member of the nesting pair is removed from any wild-hatched ancestor (i.e., excluding generations that were hatched in captive breeding centers); (14) female generations to any wild ancestor; (15) cumulative generations to any wild ancestor – the number of generations that both members of the nesting pair are removed from any wild-hatched ancestor; (16) male generations to all wild ancestors – the number of generations that the male member of the nesting pair is removed from entirely wild ancestors (i.e., the number of generations back to the point where none of the ancestors were captive bred); (17) females generations to all wild ancestors; (18) cumulative generations to all wild ancestors; and (19) release type of pair, where either both members of the pair were members of ultralight-led (UL) release cohorts (pair type 1) or where one or both members of the pair are either direct autumn release (DAR) birds or wild-hatched (WH) birds (i.e., ≥ 1 member of the pair is a UL bird; pair type 2).

These 19 crane-specific factors corresponded with hypotheses for poor incubation behavior mentioned above; in particular, factors (1) through (4) correspond with the hypothesis that whooping crane pairs are too young to evince successful incubation behavior; factors (5) through (12) correspond with the hypothesis that whooping crane pairs are too inexperienced to evince successful incubation behavior; factors (13) through (18) correspond with the hypothesis that whooping crane pairs suffer from captive breeding effects, leading to poor incubation behavior, and finally, factor (19) corresponds with the hypothesis that rearing method of captive-reared birds has an influence on future incubation behavior ï although we recognize that our ability to test this hypothesis is seriously compromised by the fact that both UL and DAR rearing and training methods may have a similar influences on future incubation behavior, especially as there are many similarities in the rearing and training of UL and DAR birds. The value of examining pair type as a factor is based more on the important management implications that would arise if one rearing type was found to produce more successful reproductive behaviors than the other. However, it is also important to recognize that our ability to understand the difference in nesting behavior of UL and DAR birds is also somewhat compromised by the fact that UL birds are, on average, older than DAR birds because the UL releases began 4 years earlier.

It is also possible to specify models using predictors that are time-varying, such as an index of insect abundance on each day of the nesting season:

$$\text{logit}(S_{i,t}) = ɓ_0 + ɓ_1 * \text{insect}_{i,t}. \qquad (2)$$

In order to build models of this type, we used data from 7 carbon dioxide traps that were located around NNWR in 2009. The traps were operated each year from 2009-2011 (except in 2010 only 3 of the traps were operated). In addition, it was possible to fill in 0ôs for missing insect data from before and after trapping commenced each year in some cases, if it was known for certain that adults of a particular insect species had not yet emerged (based on monitoring of the insect breeding sites by PHA). However, there was still missing information in the daily indices of insect abundance from the traps. In 2009, trapping was conducted on 50 days between 4 April and 15 June, when nests were active. In 2010 and 2011, trapping was less frequent than in 2009 (2010: 5 days of trapping between 1 April and 14 June; 2011: 15 days of trapping between 6 April and 12 June). In addition, on many days, particularly in 2009, certain traps were not operational due to the effects of wind, rain, etc. Therefore, to account for missing temporally-varying covariates, we built a simple autoregressive model for the insect populations:

$$\log(\text{black.fly}_{i,t}) \sim \text{Normal}(ɛ_{\text{year}[i]}+Ɉ_{\text{year}[i]}*(\log(\text{black.fly}_{i,t\text{-}1})-ɛ_{\text{year}[i]}),ů_{\text{year}[i]}). \qquad (3)$$

This model imposes a year-specific normal distribution for each daily index of insect abundance, with a year-specific variance ($ů_{\text{year}[i]}$) and a year-specific mean $ɛ_{\text{year}[i]}$ plus an autoregressive term ($Ɉ_{\text{year}[i]}$) that predicts insect abundance as a function of the divergence of the previous dayôs insect abundance from the year-specific mean. In this way, the insect population model is independent across years, but the effect of insects on nest success is constant across years (as in equation 2).

We analyzed 5 different insect data sets, including: *Simulium annulus*, *S. johannseni*, and *S. meridionale*. These 3 species are the major avian-feeding species found in surveys on and around NNWR. We also included 2 additional taxa of blood-feeding flies that were common and widespread in the insect survey data, including mosquitoes (family Culicidae) and horseflies (family Tabanidae).

Each insect data set was compiled in 2 different ways for use in the nest survival models including (1) Nearest: the daily survival at each nest was based on the insect indices for the insect trap nearest the nest, and (2) Weighted: the daily survival at each nest was based on a weighted mean across all traps for the appropriate year, where the weighting factor was the inverse distance between the nest and the various traps. When calculating weighted means across traps, as in (2), we ignored missing data for a given trap on a given day, and a mean was calculated for any day in which Ó1 trap was operating. Missing data occurred, then, only on days when no trap was operating.

The distance between nests and the nearest trap, for 53 nests in the sample, was <10 kilometers. For the remaining 3 nests, it was 28K, 31K, and 36K, respectively (each of these nests was located off NNWR). Each of these nests occurred in 2011. We conducted a secondary analysis where we eliminated these 3 far-distant nests.

Finally, we conducted an additional analysis to examine the effect of treatment with *Bti* on nest survival. *Bti* treatment of the Yellow River, which runs near the eastern edge of NNWR, was conducted in 2011. We examined whether nests in 2011 had higher nest survival than nests in the previous 2 years. We conducted this analysis based on all nests, and again on the 53 nests that were within 10K of a trap (as these nests were also substantially closer to the area that was treated by *Bti*).

Except where noted, we used data from all known whooping crane nests 2009-2011 (*n*=56), where a nest is defined as containing Ó1 egg, to fit these models. We terminated the analysis at hatching, such that nests that produced live hatchlings were fully successful. Because of the intensity of monitoring, there is little chance that any whooping crane nests went undetected, so this dataset of 56 nests represents a census of nests produced by whooping cranes in the population over this 3-year period. Data were available on an additional 24 nests produced from 2005-2008, but because our focus was on analysis of the relationship between biting insects and nest success, we focused on the period when biting insect surveys were conducted.

We fit the models using Markov chain Monte Carlo (MCMC) methods implemented in WinBUGS (Gilks et al. 1996, Lunn et al. 2009) via R (R Development Core Team 2004) and the R library R2WinBUGS (Sturtz et al. 2005). We used standard flat priors for all terms in the model, with flat gamma distributions on variance parameters and flat normal distributions on all other parameters. We sampled from 3 independent Markov Chains, a total of 4000 samples (4500 for insect taxa analyses; these more complex models mixed slightly more slowly) each, and discarded the first 2500 samples, for a total of 4500 (6000 for insect taxa analyses) samples from which we made inference. We evaluated the behavior of the MCMC routines based on visual inspection of chains and on $\widehat{R}$ generally < 1.2 as recommended by Gelman et al. (2004). We made inference on the importance of a given factor based on whether the Bayesian credible interval (CI) for parameter β_1, which models the effect of a given variable on nest survival (see Equation 2), did not contain 0 for a given variable. Because of the small sample size involved, we considered both the 95% CI and the 80% CI.

Results

Of 56 nests included in this analysis, 11 were successful, i.e., produced live hatchlings, including 2 in 2009, 5 in 2010, and 4 in 2011. Apparent nest success, therefore, from 2009-2011 was 0.20 (95% CI = 0.13, 0.28).

None of the crane-specific factors that we considered appeared to be important predictors of nest survival at the 95% CI level. However, at the 80% level, 2 factors had CIs that did not contain 0. These were male generations to any wild ancestor, and cumulative generations to any wild ancestor (Table 1; Figure 1); these effects had negative estimates, such that as the number of generations removed from any wild ancestor increases, nest survival is predicted to decrease. These results suggest that the hypothesis that whooping crane pairs suffer from captive breeding effects deserves some further exploration.

Amongst the insect analyses, there was no difference in the inference based on the 4 different analyses that were run for a given taxon (i.e., nearest trap, including all nests; nearest trap, excluding nests >10K from nearest trap; weighted mean across traps, including all nests; and weighted mean across traps, excluding nests >10K from nearest trap).

Two of the 5 insect taxa proved to be good predictors of daily nest survival. First, the index of abundance of *S. annulus* had a consistently negative effect on daily nest survival, with a 95% CI that excluded 0 (Table 2; Figure 2). Second, the index of abundance of Tabanidae (horseflies) had a consistently positive effect on daily nest survival, with a 95% CI that excluded 0 (Table 2; Figure 3).

A third insect taxon, *S. meridionale*, showed some evidence of a positive effect on nest survival. At the 80% level, the CI for this taxon did not contain 0 (Table 2; Figure 4). For the analyses of *S. meridionale* that eliminated the 3 nests >10K from the traps, numerical problems with the MCMC routine prevented estimation of the effects ï the MCMC routines for these 2 analyses did not run successfully (Table 2). However, because, for the other taxa, elimination of these far distant nests had no impact on inference, we believe that this problem with the MCMC routine did not cause challenges in interpreting the results for *S. meridionale.*

Finally, there was also some evidence for an effect of *Bti* on nest survival (Table 2; Figure 5). Daily nest survival was higher in 2011, when *Bti* was used, than in the other 2 years. The CI for this variable excluded 0 only at the 80% level, however. These results were consistent regardless of whether the 3 nests further distant from NNWR were or were not included in the analysis.

Discussion

The apparent nest success estimate of 0.2 is a sobering number. In contrast, the recruitment parameter estimated for the wild Aransas-Wood Buffalo population (AWBP), based on counts of adult and juvenile birds wintering at Aransas National Wildlife Refuge, averaged approximately 0.35 (Link et al. 2003) and this estimate integrates all mortality that occurs between hatching and arriving on the wintering ground, and also is based on all adult birds in the population, rather than just the nesting birds, as is our estimate. In short, the apparent nest success estimate indicates that this population is producing at an extremely low rate compared to the AWBP.

Of all the variables considered herein, the analysis results provided strongest evidence for an effect of *Simulium annulus* on daily nest survival of whooping cranes in the Eastern Migratory Population. While both *S. annulus* and Tabanidae had 95% CIs that excluded 0, a plot of the posterior probability distributions (Figures 2 and 3) indicate a much more precise estimate of the posterior for the *S. annulus* effect, with the entire distribution located away from 0 (based on 6000 samples from that distribution), while the Tabanidae effect was much more diffuse and did not exclude 0 entirely. In addition, there is a plausible mechanistic *a priori* hypothesis for the negative effect of *S. annulus* on daily nest survival ï in particular, that harassment by biting black flies causes whooping cranes to abandon nests. However, no mechanistic hypothesis has been advanced that predicts a positive effect of Tabanidae on daily nest survival. One possibility is that the positive effect of Tabanidae is simply correlative, due to higher numbers of Tabanidae later in the spring, when nests are more successful. For example, in 2009, when insect sampling was most intensive, Tabanidae did not appear in the traps until 22 May.

There were 4 other variables that, at the 80% level, showed some evidence of an effect on daily nest survival: male generations to any wild ancestor, and cumulative generations to any wild ancestor (we note that the correlation between these 2 factors is 0.54, only male generations is shown in Figure 1); *S. meridionale*, and *Bti*. The effect estimates associated with generations to any wild ancestor were both negative, as would be predicted if this was an indication of captive selection negatively influencing the demographic performance of released birds. The estimated positive effect of *S. meridionale*, like the positive effect estimate for Tabanidae, does not have a ready mechanistic explanation ï although again, we note the late emergence of *S. meridionale*, not observed in 2009 until 20 May, and the possibility of a spurious effect due to correlation. Additional data should be collected to further test the effects of these 2 taxa. Last, the *Bti* treatment had an estimated positive effect on daily nest survival ï this accords well with the evidence suggesting a negative effect of *S. annulus* on daily nest survival, as the *Bti* treatment was associated with reduced abundance of this species in the traps.

The ability to accurately sample the insect populations that whooping cranes experience at the nests is a major challenge in understanding the potential influence of these populations. Different methods for sampling these populations (e.g., carbon dioxide traps versus glueboards) have highly differential results (R. King, US Fish and Wildlife Service, personal communication). Considerations in choosing a sampling method include (1) whether the sampling method allows for collection of time-specific data, (2) the ability to sample in a way that would best represent what whooping cranes experience, and (3) the ability to sample near the nests. One benefit of carbon dioxide traps is that they allow for day-specific indices of abundance. Another is that the sampling method at least partially replicates an important cue that draws the flies to whooping cranes; blood-feeding flies are attracted to the carbon dioxide produced by respiring vertebrates (Sutcliffe 1986). However, it is important to recognize that this sampling method cannot be used close to the nests, for fear of disturbing the birds, and in fact, the majority of nests were between 1000 and 3000 m from the nearest trap (Figure 6).

It is important to recognize that evaluation of nest success in this population is complicated by management of the population: eggs in nests that appear to be abandoned (based on absence of the pair for >2 hours) are sometimes collected in order to salvage some value from the nest ï however, collections of eggs in apparently abandoned nests are not consistent, and in fact in some cases apparently ñabandonedò nests (by the 2 hour standard) have gone on to hatch chicks when parents returned from multiple hour absences. The need to salvage precious whooping crane eggs may supersede, in this case, the value of information to be gained by a more carefully-designed study of nesting behavior, and this must be recognized in interpreting results.

Finally 4 of 56 nests, though they did not hatch, were incubated for 30 days or more, i.e., did not fail due to abandonment by the adults. Two of these nests occurred in 2010, and 2 in 2011. It would be potentially of interest to examine nest survival while treating these nests as successful rather than failed. However, a complication in doing so is that the failure of a nest to hatch may be caused by poor incubation behavior by parents, i.e., nests may fail to hatch because poor incubation behavior caused embryo death. Because of this, we chose to take the more conservative approach of treating nests as successful only if they produced a live chick.

Acknowledgments

Richard P. Urbanek, Richard S. King, and staff at NNWR provided much of the data for these analyses. We also acknowledge the assistance of the International Crane Foundation for data collection and processing, especially M. Engels and J. Barzen. Finally, thanks to J. French Jr. at USGS Patuxent Wildlife Research Center for support of this work by SJC.

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Table 1. Estimates of logit-scale parameters, and associated 95% Bayesian Credible Intervals (CI) describing the influence of individual-specific predictors on daily nest survival for whooping cranes in the Eastern Migratory Population, 2009-2011. Variables are described in detail in the text.

Predictor	Estimate	95% CI	80% CI
Age Male	0.13	-0.15,0.41	-0.05,0.31
Age Female	0.04	-0.25,0.32	-0.15,0.22
Minimum Age	0.03	-0.26,0.33	-0.16,0.22
Average Age	0.09	-0.19,0.37	-0.09,0.27
Experience Male	-0.09	-0.42,0.22	-0.29,0.11
Experience Female	-0.05	-0.36,0.25	-0.25,0.15
Minimum Experience	-0.10	-0.43,0.20	-0.31,0.10
Average Experience	-0.07	-0.40,0.23	-0.28,0.13
Attempts Male	0.11	-0.18,0.44	-0.09,0.32
Attempts Female	0.17	-0.14,0.51	-0.04,0.38
Minimum Attempts	0.10	-0.21,0.43	-0.11,0.31
Average Attempts	0.15	-0.16,0.49	-0.06,0.36
Male Generations Any	-0.25[a]	-0.55,0.05	**-0.45,-0.05**
Female Generations Any	0.03	-0.27,0.35	-0.17,0.24
Cumulative Generations Any	-0.28[a]	-0.57,0.05	**-0.48,-0.08**
Male Generations All	-0.16	-0.41,0.11	-0.32,0.01
Female Generations All	-0.10	-0.43,0.26	-0.32,0.12
Cumulative Generations All	-0.13	-0.42,0.22	-0.33,0.08
Pair Type[b]	0.18	-0.13,0.55	-0.03,0.40

[a] Effect for which the 95% CI does contain 0, but for which the 80% CI does not contain 0. The relevant credible intervals are shown in bold.

[b] The increase in daily nest survival, on the logit scale, for nests produced by pair type 2 (one ultralight parent/one direct autumn release parent, two direct autumn release parents, or one ultralight/one wild-hatched parent) over those produced by pair type 1 (two ultralight parents).

Table 2. Estimates of parameters describing the influence of various insect taxa, sampled in carbon dioxide traps, and treatment with *Bti*, on daily nest survival for whooping cranes in the Eastern Migratory Population, 2009-2011. Data for each insect taxa were based on either the index of abundance from the nearest trap or were a weighted mean across all traps. Analyses were completed once for all nests, and once excluding 3 nests that were >10K from the nearest trap.

Taxa	Dataset	All Nests			Nests <10K from Trap		
		Est	95% CI	80% CI	Est	95%CI	80% CI
S. annulus	Nearest	-0.50[a]	**-0.76,-0.25**	**-0.66,-0.34**	-0.51[a]	**-0.78,-0.26**	**-0.68,-0.35**
	Weighted[b]	-0.49[a]	**-0.75,-0.23**	**-0.66,-0.32**	-0.54[a]	**-0.79,-0.29**	**-0.70,-0.38**
S. johannseni	Nearest	0.04	-0.24,0.46	-0.16,0.29	0.06	-0.24,0.45	-0.16,0.30
	Weighted	0.07	-0.18,0.39	-0.11,0.27	0.03	-0.21,0.36	-0.14,0.23
S. meridionale	Nearest	0.61[c]	-0.31,1.75	**0.05,1.27**		NA[d]	
	Weighted	0.56[c]	-0.09,1.52	**0.07,1.12**		NA[d]	
Culicidae	Nearest	0.06	-0.12,0.26	-0.06,0.19	0.08	-0.11,0.27	-0.04,0.20
	Weighted	0.08	-0.13,0.30	-0.06,0.22	0.09	-0.11,0.31	-0.05,0.23
Tabanidae	Nearest	1.05[a]	**0.21,2.49**	**0.43,1.80**	0.98[a]	**0.16,2.44**	**0.37,1.71**
	Weighted	0.77[a]	**0.13,1.66**	**0.31,1.29**	0.81[a]	**0.11,1.85**	**0.31,1.38**
Bti Treatment	-	0.53[c]	-0.11,1.18	**0.10,0.95**	0.51[c]	-0.17,1.20	**0.06,0.97**

[a] Effect for which the 95% CI does not contain 0. The relevant credible intervals are shown in bold.

[b] The weighted mean was taken across all operational traps on a given day, in a given year, with weighting based on the inverse of linear distance from the trap.

[c] Effect for which the 95% CI does contain 0, but for which the 80% CI does not contain 0. The relevant credible intervals are shown in bold.

[d] Numerical problems prevented estimation of these 2 effects.

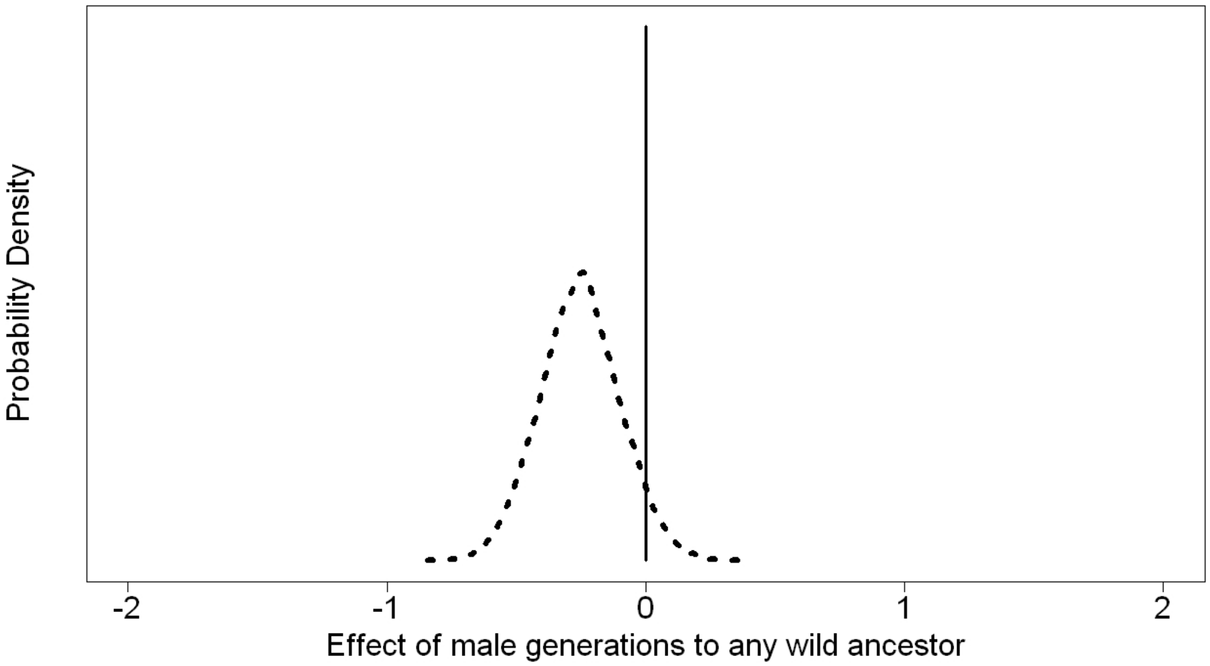

Figure 1. The posterior probability density for the effect of the number of generations to any wild ancestor, for the male member of the nesting pair, on nest survival of whooping cranes in the Eastern Migratory Population.

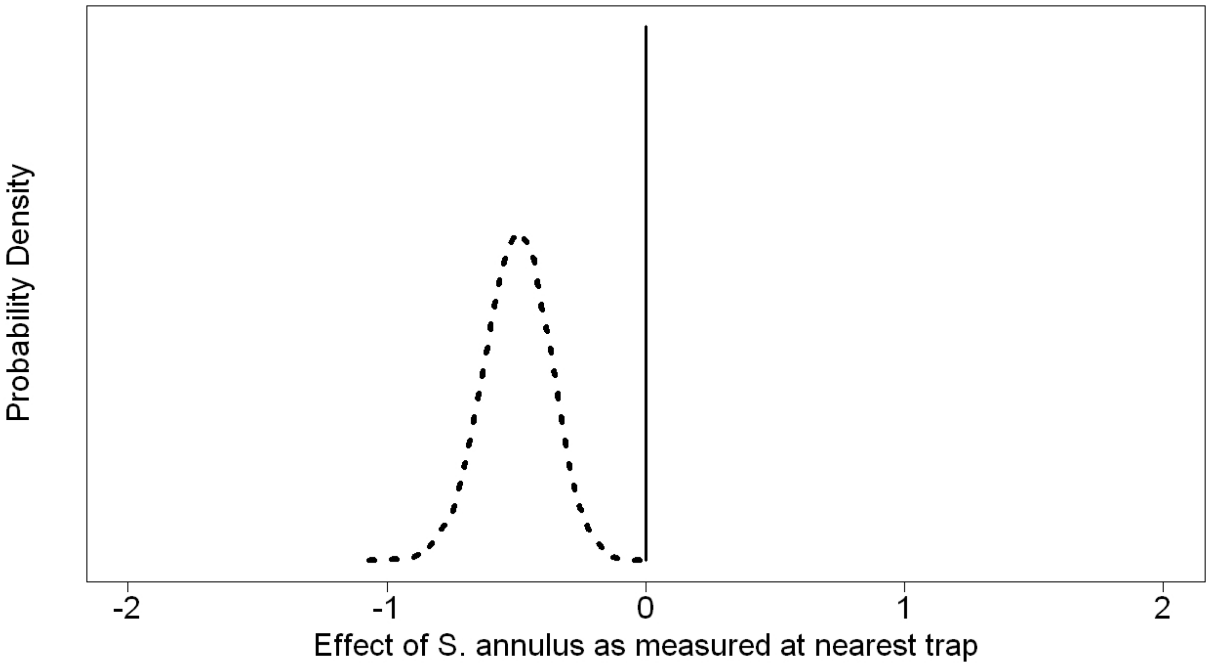

Figure 2. The posterior probability density for the effect of *S. annulus*, as measured at the carbon dioxide trap nearest the nest, on nest survival of whooping cranes in the Eastern Migratory Population.

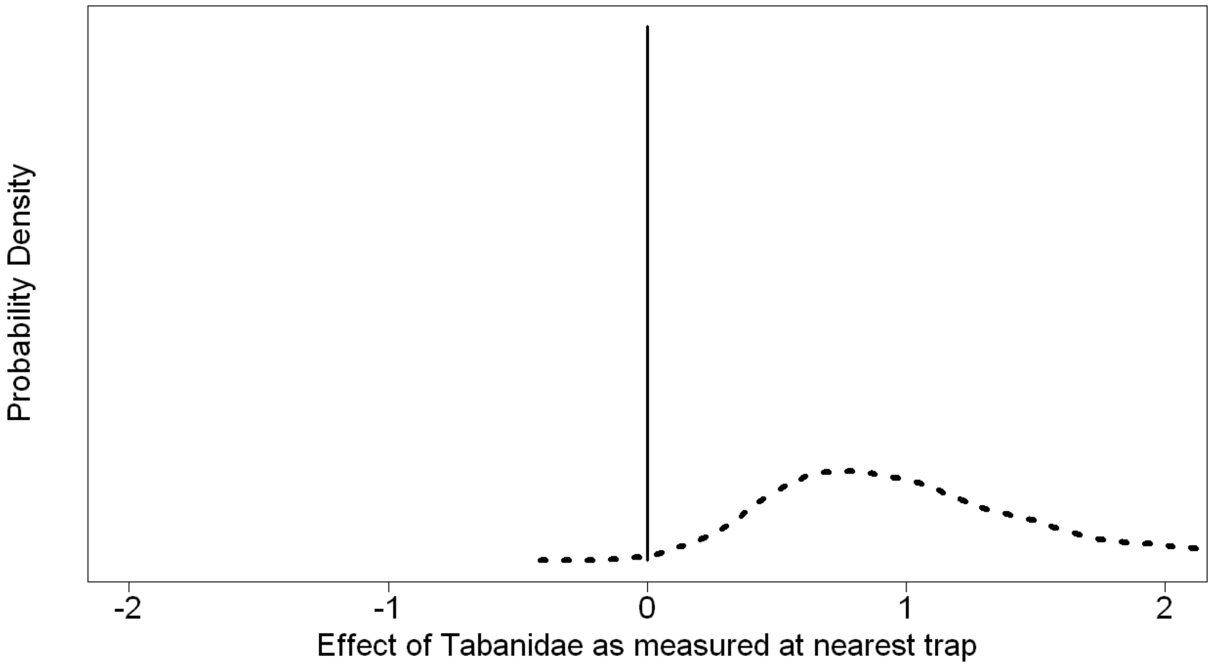

Figure 3. The posterior probability density for the effect of Tabanidae (horseflies), as measured at the carbon dioxide trap nearest the nest, on nest survival of whooping cranes in the Eastern Migratory Population.

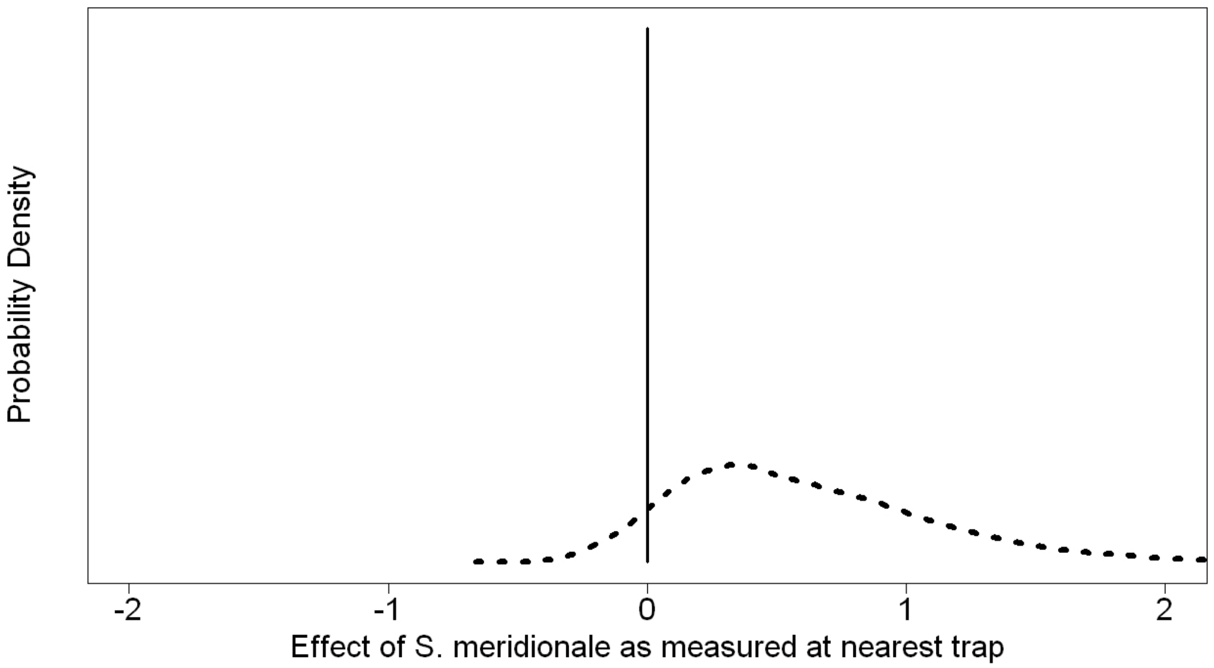

Figure 4. The posterior probability density for the effect of *S. meridionale*, as measured at the carbon dioxide trap nearest the nest, on nest survival of whooping cranes in the Eastern Migratory Population.

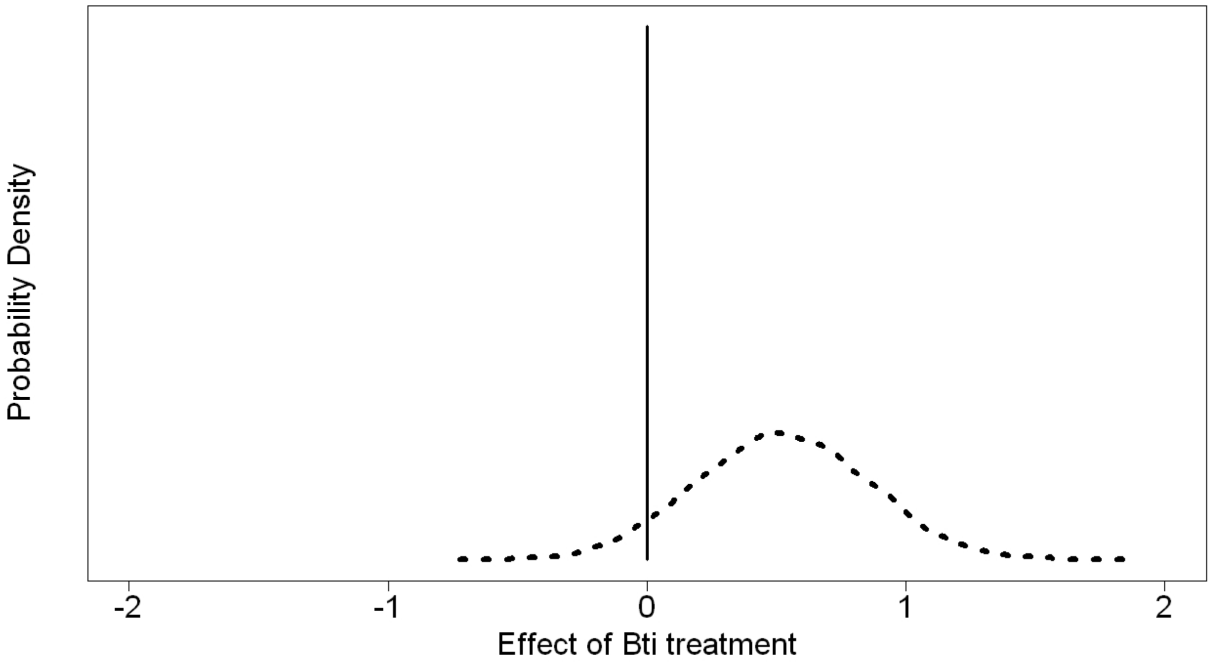

Figure 5. The posterior probability density for the effect of treatment with *Bacillus thuringiensis* subspecies *israelensis* larvicide on nest survival of whooping cranes in the Eastern Migratory Population.

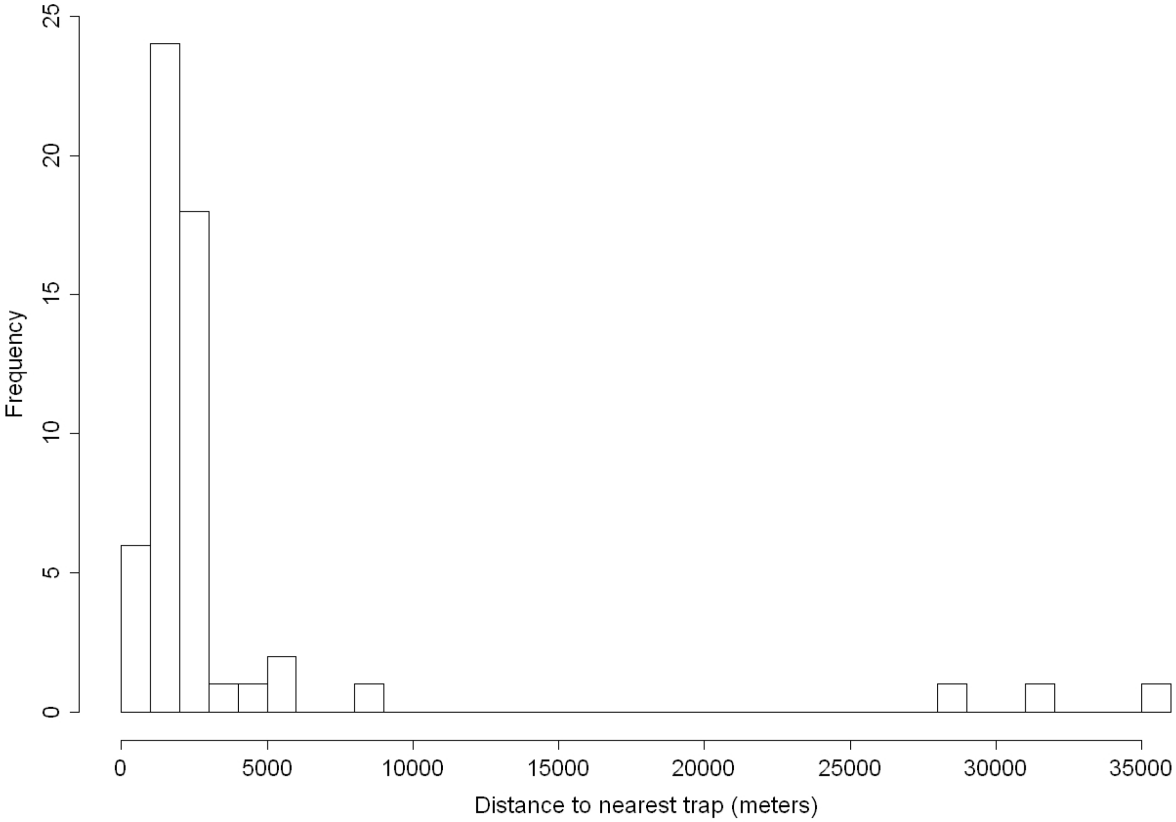

Figure 6. Histogram of distance to the nearest carbon dioxide trap, for 56 whooping crane nests on and around Necedah National Wildlife Refuge, 2009-2011.

THEME 2: Population Modeling

Modeling the Eastern Migratory Population of Whooping Cranes: Demographic Estimation and Projection under Future Release and Reproductive Success Scenarios

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Introduction

The whooping crane is listed under the US Endangered Species Act and the Canadian Species At Risk Act, and its recovery is informed in both countries by an International Recovery Plan (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005). A focus of the whooping crane Recovery Plan is the establishment of additional populations to supplement the single natural population, the Aransas-Wood Buffalo Population, which migrates between the Texas Gulf Coast and Wood Buffalo National Park in central Canada. In fact, established downlisting criteria for the species are heavily dependent on the successful establishment of 1-2 additional populations. Unfortunately, 2 attempts to establish populations have failed to date.

In 2001, a restoration program was undertaken to establish a migratory population in the eastern US (Urbanek et al. 2005). This effort is led by the Whooping Crane Eastern Partnership (WCEP), a partnership of public and private organizations that includes the US Fish and Wildlife Service as a founding member. WCEP initiated releases of cranes taught to migrate behind ultralight (UL) aircraft from Necedah National Wildlife Refuge (NNWR), in central Wisconsin, to the Gulf Coast of Florida. These birds are reared and trained at USGS Patuxent Wildlife Research Center. In addition, since 2005, a second release technique has been used, involving releases at NNWR in the vicinity of other cranes in the fall (Direct Autumn Release; DAR). These birds are reared and trained at the International Crane Foundation in Baraboo, Wisconsin.

In August 2011, there were approximately 100 wild whooping cranes in the Eastern Migratory Population (EMP), and by several measures, this effort appears to have met with the greatest success of any whooping crane population restoration attempt to date (e.g., Converse et al. 2011). However, the ultimate objective, not yet achieved, is to establish a population that is self-sustaining. A population model can be used to answer questions about the conditions under which the population can be expected to meet this objective and for selection of optimal management actions in a decision making process. In both cases, population outcomes need to be projected under different scenarios while taking into account temporal variation in demographic rates, and demographic variation which is magnified by the small size of the population. To build such a model, we need first to estimate the demographic parameters with which the model will be parameterized. Potential outcomes for the population can then be simulated and an initial understanding can be developed of when and under what conditions the population could become self-sustaining.

Methods

Estimation of demographic parameters

We used a state-space modeling approach to separate the demographic process (i.e., survival and probabilities of transition from pre-defined life history states) from the observation process, describing probabilities of resighting or dead recovery. We considered a seasonal time-step from spring 2001 to winter 2009, including: (1) January 1 to March 31, which represents winter/spring migration, (2) April 1 to June 30, which represents the breeding season, (3) July 1 to September 30, which constitutes the post-breeding season and (4) October 1 to December 31, which represents fall migration/winter.

Several life history states that a bird would encounter during its life were considered (Fig. 1a). We included a captive state (C) when birds are receiving direct care. Birds then enter the unpaired state (U) when they are released into the EMP (at commencement of northward migration for UL birds or at release for DAR birds). Then, birds can become paired for the first time (P1). Once a bird has become paired for the first time (P1), it transitions automatically into an established paired (P2) state starting the following season. The distinction between P1 and P2 states allows for the modeling of factors that influence the initial pairing of birds. During the spring (Fig. 1b), birds can become first-time nesters (N1). Birds must remain in this nesting state for 1 year, but at the outset of the next spring time period, birds that were previously nesters can either nest again (N2) or not nest (NN). For each stage, it is then possible to estimate the survival and the probability of transitioning among states.

To be considered a paired bird (states P1 and P2), an individual had to associate continuously for at least 3 months with the same opposite-sex individual. This 3-month period was chosen according to the observed distribution of longevity of pairs in the population (Fig.2). From this distribution, we were able to distinguish short-term associations from mid- or long-term pairs.

Effects in estimation models included, where possible, sex effects, fixed or random temporal effects, age effects (including 6 age-classes), and release-type effects (UL vs DAR; see Table 1 for details on where effects were included). Fixed, rather than random, temporal effects were included on transitions into the various nester states because these were only observed during 4 springs (i.e., beginning in spring 2005 for N1) or 3 springs (i.e., beginning in spring 2006 for N2 and NN).

To fit state-space models incorporating random effects, we used Markov chain Monte Carlo simulations in a Bayesian context, to estimate model parameters. Non-informative priors were used for all the parameters. To summarize posterior distributions, we used empirical means and 95% Bayesian credible intervals (95% BCI).

Simulation of potential outcomes for the population

The parameter estimates were then used to build a model for simulating potential outcomes so as to develop an initial understanding of the conditions necessary for the population to become self-sustaining. To do so, we used a projection matrix at an annual time-step. We considered a female-only population model and assumed a balanced sex ratio. Three different compartments were considered: one for DAR birds, one for UL birds, and one for wild-hatched (WH) birds. Every spring, new birds enter the population either in the captive state via releases of DAR or UL birds, or in the unpaired state via wild reproduction. Survival and transition probabilities were equal between the DAR compartment and the UL compartment, in states P1, P2, N1, N2, and NN; in the C and U states, we used parameter estimates specific to the 2 release types. We assumed that WH individuals had demographic rates equal to the DAR compartment for state U and the UL compartment for states P1, P2, N1, N2, and NN (because UL birds are in direct human care much later than are DAR birds) although this could be varied in future simulation scenarios to account for the possibility of different demographic performance by WH cranes. To initialize the model, we used the number of females observed in each state in the spring of 2009.

As an initial set of simulations, in order to demonstrate the basic ways in which this population model can be used, we simulated the fate of the population over a 50-year time-period after the end of the releases. We considered 12 different scenarios (Table 2), each one composed of a future release scenario, a future hatching success (probability of a nest producing a chick) and a future fledging success (probability of a chick surviving two seasons until fledging). We tested three different release scenarios: (1) releases are done for 10 more years at current levels (scenarios 1 to 4) by randomly sampling from historic release numbers in each release type and then applying a binomial trial to get the number of reintroduced females given the total birds (p=0.5); (2) releases are done for 10 years at current levels, then the release effort is halved during the next 10 years (scenarios 5 to 8); (3) releases are done for 20 years at current levels (scenarios 9 to 12). We simulated four different hatching success and fledging success scenarios: (1) the current observed hatching success of 0.15 (12 nests out of 80 produced a chick between 2005 and 2011) and the current observed fledging success of 0.20 (3 chicks out of 15 were fledged between 2005 and 2011; scenarios 1, 5, 9) applies; (2) both hatching and fledging success are increased by 10% over current levels (i.e., 0.25 and 0.3, respectively; scenarios 2, 6, 10); (3) both hatching and fledging success are increased by 20% (scenarios 3, 7, 11) over current levels, and (4) both hatching and fledging success are increased by 30% (scenarios 4, 8, 12) over current levels.

We ran 10,000 replicate iterations for each scenario to account properly for uncertainty. To describe population outcomes, we used three different metrics, including realized population growth rate (the total number of birds at time *t+1* divided by the total number of birds at time *t*), the total number of females in the simulated population as a function of time, and the probability of extinction as a function of time (the ratio of the number of iterations with extinction to the total number of iterations).

Results

Probabilities of observing a bird in a given state were high (i.e., above 95%) in a given season, the lowest being the dead recovery of a bird (Table 3). Survival was also high whatever the state (>0.9 per season; Table 4a). However, one should note the difference in survival between the DAR and UL birds; DAR birds in both the captive state and the unpaired state had lower mean survival estimates (Table 4a). Specific survival and transitions estimated during spring were also more variable. This is mainly due to the fact that the first spring considered (first time the transition to the nester state appeared) is spring 2005. These estimates thus relied on only 4 years of data. It was not possible to examine differences in survival by release-type for other states as DAR birds did not occupy these states by the end of winter 2009. Also of interest is that transition to the P1 state increased with age, and females tended to have higher probabilities of transition into this state than did males (Table 4b). N1 birds were more likely to enter the N2 state the next year and N2 were also more likely to remain in the N2 state the next year. NN birds were, on the contrary, more likely to stay in the NN state than to transition to N2 (Table 4b).

Preliminary analyses of the future of the WCEP population indicate, unsurprisingly, that if there is no improvement in the hatching and fledging success, regardless of future releases, the population will not be self-sustaining (scenarios 1, 5, 9; Figure 3a). Fifty years after the last year of releases, the probability of extinction is around 80% regardless of the release level. By contrast, an increase of 30% in hatching success and fledging success (to 0.45 and 0.5, respectively) along with additional releases would likely result in a self-sustaining population (scenarios 4, 8, 12; Figure 3b). Under these reproductive success parameters, probability of extinction is not equal to zero, is just 18% when releases are done for 10 more years at the current level and 8% when releases are done for 20 more years at the current level.

Discussion

There are several results from the demographic analysis that are encouraging vis-à-vis the future of this population. First, survival is relatively high in every life history state and is even slightly higher than estimates coming from the Aransas-Wood Buffalo population (0.91± 0.01 SD on average; Link et al. 2003). Also, the probability of becoming paired for the first time is high and increasing from two years of age to five years of age, such that individuals older than 5 years of age are very likely to have paired (in winter 2009 only 3 of 30 birds greater than 5 years had never been paired). It thus seems that birds in the EMP are able to reproduce at an early age. One other encouraging result is that, once a bird has nested, the probability that the bird will nest in subsequent years is high (between 82 and 90% on average).

Unsurprisingly, preliminary analyses showed that the population will not become self-sustaining with currently-observed levels of hatching and nesting success. An increase of 30% (to 45% hatching success and 50% fledging success) would greatly reduce the probability of extinction.

In the coming months, our aim is to update the state-space model integrating data through winter 2011 (i.e., adding two more years). This should enable us to reduce uncertainty in the estimates of survival and transition probabilities for the N2 and NN states. However, it will probably not be possible to examine release-type effects for those states because the number of DAR birds that are reproducing in the population is still very low. We also plan to further develop methods and scenarios for simulating the population at various levels of nesting success. Finally, we will work with the Whooping Crane Eastern Partnership to further develop future release scenarios of interest. Once the different scenarios have been decided upon, this population model will help us to identify future probabilities of success under different management (i.e., release) scenarios and also to explore whether the population could be sustainable under realistically attainable levels of reproduction. In future, this tool will also be useful for examining the effects of a variety of management actions on particular demographic processes, and thus, ultimately, on the probability of attaining a self-sustaining EMP.

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Figure 1: Sketch of the life cycle of the whooping crane during summer-fall-winter (a) and during spring (b). The different stages considered were: captive (C), unpaired (U), first time paired (P1), established paired (P2), first time nester (N1), previously nester but not nesting again (NN), previously nester and nesting again (N2), newly dead (Nd; this state allows birds to be recovered dead) and dead (D). The survival in each state is noted as ű with the subscript corresponding to the stage. The possible transitions from one state to another are noted as P with the subscript also corresponding to the different stages. Some transitions are only possible during the spring season, which is the breeding season (Dashed lines in Fig. 1b).

Fig. 1a: Summer-winter-fall seasons

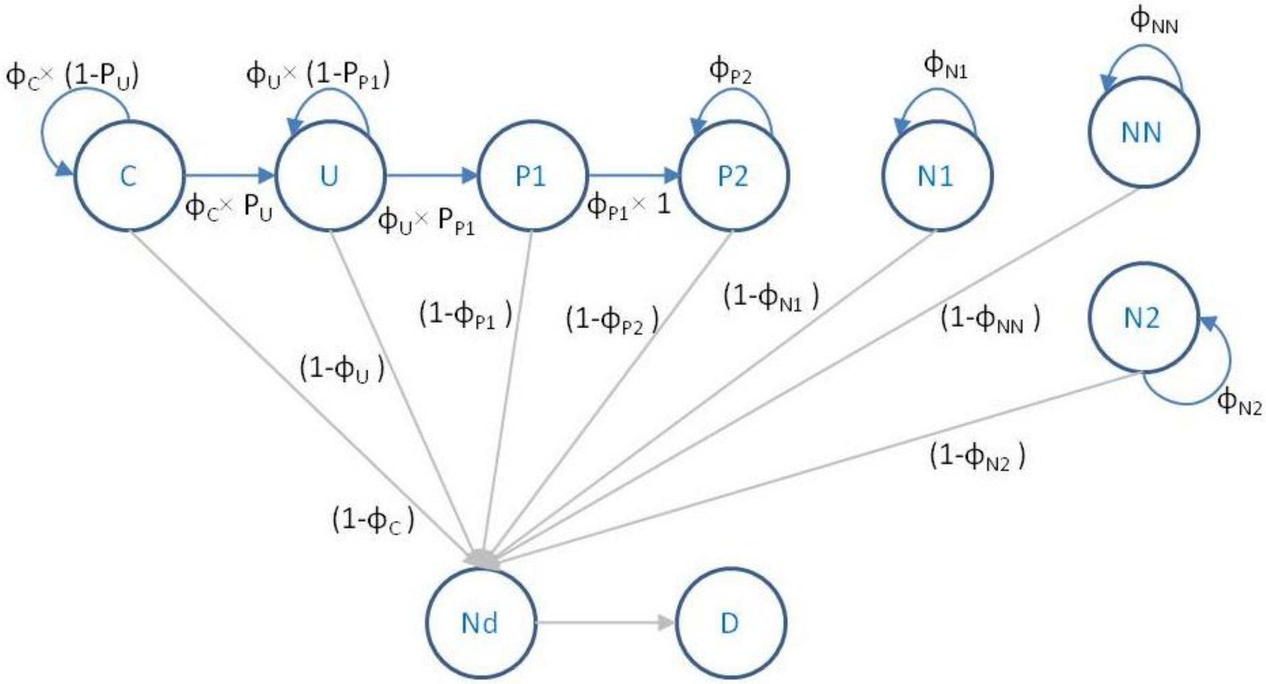

Fig. 1b: Spring season

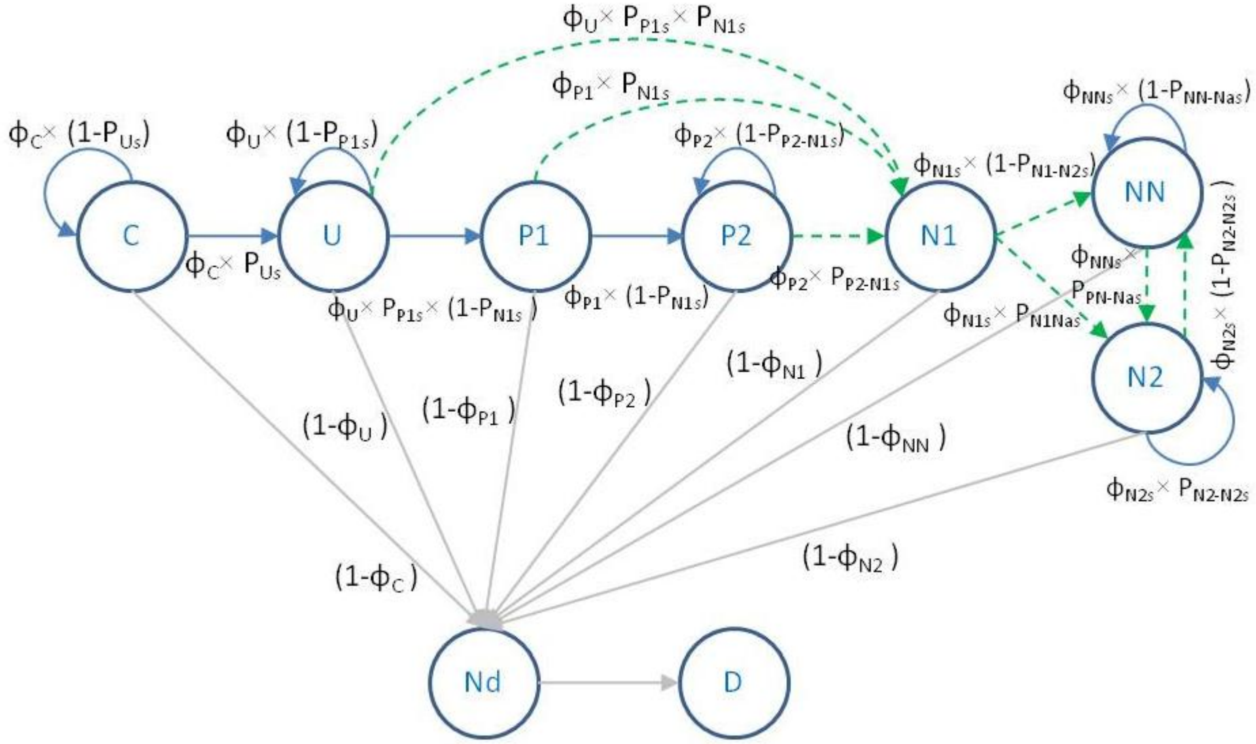

Figure 2: Distribution of the observed social pairs; 12 weeks was determined to be an appropriate time interval for determining when an association constituted a breeding pair.

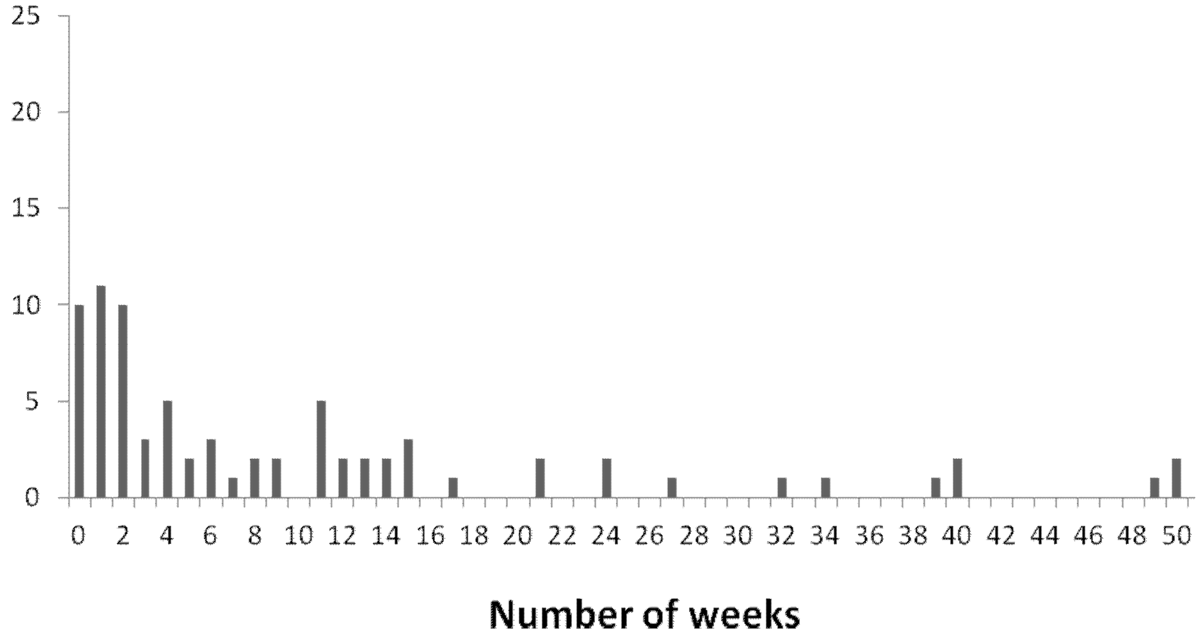

Figure 3: Realized population growth rate, total number of females in the population, and probability of extinction as a function of time, for 50 years after the last year of releases.
Figure 3a: Under these 3 scenarios, the hatching success and the fledging success are set to the current levels while the number of released birds and the number of years during which releases occurred are varying (see also Table 2).
Figure 3b: Under these 3 scenarios, the hatching success and the fledging success are increased by 30% compared to the current levels while the number of released birds and the number of years during which releases occurred are varying (see also Table 2).

Figure 3a:

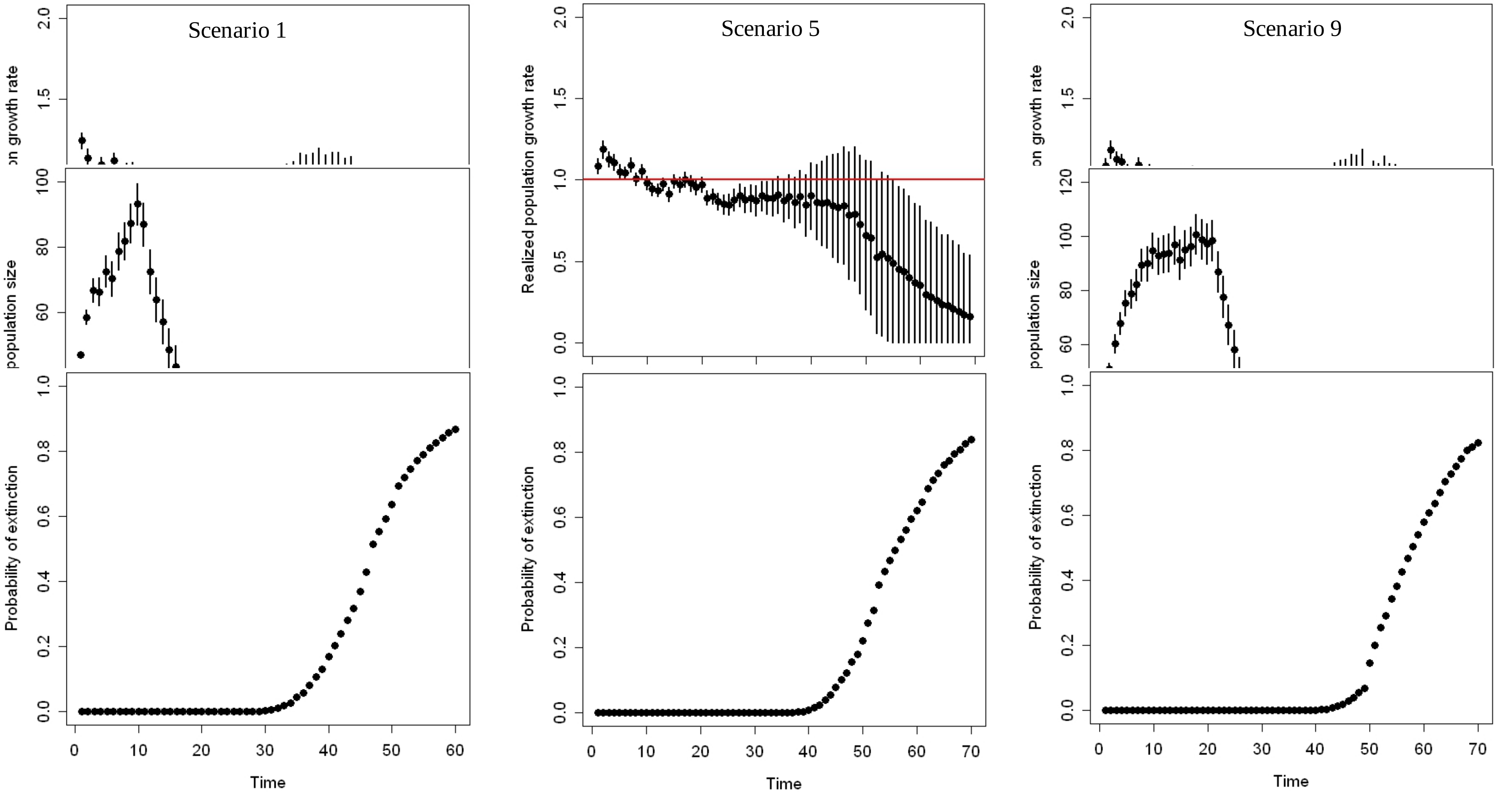
Scenario 1
Scenario 5
Scenario 9
Realized population growth rate
population size
Probability of extinction
Time
0.0
0.5
1.0
1.5
2.0
60
80
100
120
0.2
0.4
0.6
0.8
0
10
20
30
40
50
60
70

Figure 3b:

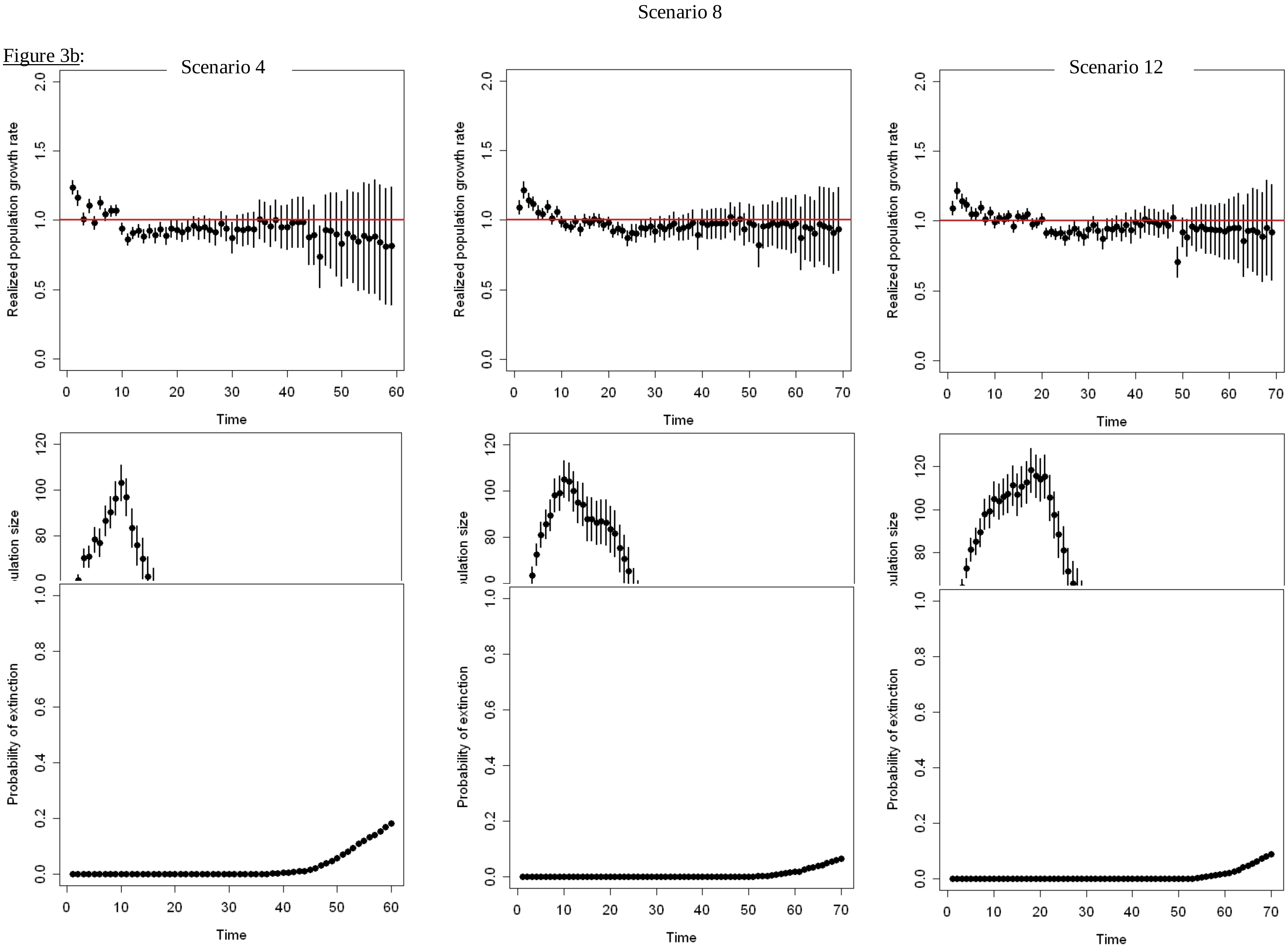
Scenario 4
Scenario 8
Scenario 12
Realized population growth rate
0.0
0.5
1.0
1.5
2.0
Time
0
10
20
30
40
50
60
70
ulation size
0
80
100
120
Probability of extinction
0.0
0.2
0.4
0.6
0.8
1.0

Table 1: Effects included in estimation model for survival and transition probabilities. The column Notation corresponds to the notation used in Figure 1.

a) Survival	Notation	Tested effects
C	ű$_{c}$	Intercept + Release-type + Random time
U	ű$_{U}$	Intercept + Release-type + Sex + Random time
P1	ű$_{P1}$	Intercept + Sex + Random time
P2	ű$_{P2}$	Intercept + Sex + Random time
N1	ű$_{N1}$	Intercept + Sex + Random time
N1 (spring)	ű$_{N1s}$	Intercept + Sex + Fixed time
NN	ű$_{NN}$	Intercept + Random time
NN (spring)	ű$_{NNs}$	Intercept + Fixed time
N2	ű$_{N2}$	Intercept + Sex + Random time
N2 (spring)	ű$_{N2s}$	Intercept + Sex + Fixed time

b) Transition	Notation	Tested effects
C to U	P_{u}	Intercept + Release-type + Random time
U to P1	P_{P1}	Intercept + Sex + Age + Random time
U to N1	P_{P1s}	Intercept + Fixed time
P1 to N1	P_{N1s}	Intercept + Fixed time
P2 to N1	$P_{P2\text{-}N1s}$	Intercept + Sex + Fixed time
N1 to N2	$P_{N1\text{-}N2s}$	Intercept + Sex + Fixed time
NN to N2	$P_{NN\text{-}N2s}$	Intercept + Fixed time
N2 to N2	$P_{N2\text{-}N2s}$	Intercept + Sex + Fixed time

Table 2: Simulated scenarios for the future of the population

Scenario	Release scenario	Hatching success	Fledging success
1	Sample from historic release numbers for 10 years	Current: p=0.15	Current: p=0.2
2	Same as scenario 1	p=0.25	p=0.3
3	Same as scenario 1	p=0.35	p=0.4
4	Same as scenario 1	p=0.45	p=0.5
5	Sample from historic release numbers for 10 years then sample from historic release numbers divided by 2 for 10 more years (release effort is decreased by half)	Current: p=0.15	Current: p=0.2
6	Same as scenario 5	p=0.25	p=0.3
7	Same as scenario 5	p=0.35	p=0.4
8	Same as scenario 5	p=0.45	p=0.5
9	Sample from historic release numbers for 20 years	Current: p=0.15	Current: p=0.2
10	Same as scenario 9	p=0.25	p=0.3
11	Same as scenario 9	p=0.35	p=0.4
12	Same as scenario 9	p=0.45	p=0.5

Table 3: Mean probabilities (with 95% Bayesian credible interval, 95% BCI) of resighting a bird in a given state or of recovering a dead bird in a season.

States	Mean value	95% BCI
Unpaired	0.972	0.928 - 0.993
First time paired	0.972	0.905 - 0.993
Breeder	0.969	0.926 - 0.993
First time nester	0.987	0.970 - 0.993
Previously nester but not nesting again	0.977	0.928 - 0.993
Previously nester and nesting again	0.972	0.930 - 0.993
Dead	0.952	0.841 - 0.993

Table 4: Estimates of mean annual survival probabilities with 95% Bayesian credible intervals (Table 4a) and mean transition probabilities with 95% Bayesian credible intervals (Table 4b) from Spring 2001 to Winter 2009. The column Notation corresponds to the notation used in Figure 1.

Table 4a:

Survival	Notation	Mean (95% BCI)	Release type effect	Sex and release type effect	Sex effect
C	ű$_{c}$	0.934 (0.887 - 0.969)	DAR: 0.888 (0.775 - 0.956)		
			ULM: 0.960 (0.925 - 0.985)		
U	ű$_{U}$	0.966 (0.948 - 0.982)		ǀ $_{DAR}$: 0.944 (0.893 - 0.978)	
				ǀ $_{ULM}$: 0.976 (0.951 - 0.991)	
				ǁ $_{DAR}$: 0.945 (0.883 - 0.981)	
				ǁ $_{ULM}$: 0.977 (0.959 - 0.991)	
P1	ű$_{P1}$	0.983 (0.951 - 0.993)			ǀ : 0.952 (0.826 - 0.995)
					ǁ : 0.988 (0.941 - 0.999)
P2	ű$_{P2}$	0.976 (0.951 - 0.993)			ǀ : 0.972 (0.933 - 0.993)
					ǁ : 0.978 (0.944 - 0.995)
N1	ű$_{N1}$	0.984 (0.957 - 0.993)			ǀ : 0.981 (0.939 - 0.996)
					ǁ : 0.982 (0.943 - 0.997)
N1 (spring)	ű$_{N1s}$	0.909 (0.339 - 0.993)			ǀ : 0.900 (0.306 - 0.995)
					ǁ : 0.908 (0.343 - 0.996)
NN	ű$_{NN}$	0.980 (0.928 - 0.993)			
NN (spring)	ű$_{NNs}$	0.891 (0.439 - 0.993)			
N2	ű$_{N2}$	0.970 (0.927 - 0.993)			ǀ : 0.935 (0.840 - 0.988)
					ǁ : 0.984 (0.944 - 0.998)
N2 (spring)	ű$_{N2s}$	0.933 (0.641 - 0.993)			ǀ : 0.873 (0.414 - 0.989)
					ǁ : 0.962 (0.768 - 0.998)

Table 4b:

Transition	Notation	Mean (95% BCI)	Release type effect	Age effect	Sex and age effect	Sex effect
C to U	P_u	0.086 (0.007 - 0.484)	DAR: 0.739 (0.424 - 0.997)			
			ULM: 0.002 (0.000 - 0.009)			
U to P1	P_{P1}			A_1: 0.005 (0.000 - 0.034)	ǀ $_{A1}$: 0.007 (0.000 - 0.044)	
					ǁ $_{A1}$: 0.004 (0.000 - 0.031)	
				A_2: 0.073 (0.037 - 0.119)	ǀ $_{A2}$: 0.089 (0.042 - 0.143)	
					ǁ $_{A2}$: 0.061 (0.029 - 0.106)	
				A_3: 0.086 (0.039 - 0.153)	ǀ $_{A3}$: 0.105 (0.045 - 0.194)	
					ǁ $_{A3}$: 0.072 (0.031 - 0.131)	
				A_4: 0.082 (0.028 - 0.170)	ǀ $_{A4}$: 0.099 (0.034 - 0.203)	
					ǁ $_{A4}$: 0.068 (0.022 - 0.144)	
				A_5: 0.096 (0.022 - 0.233)	ǀ $_{A5}$: 0.115 (0.025 - 0.290)	
					ǁ $_{A5}$: 0.080 (0.018 - 0.204)	
				A_6: 0.004 (0.000 - 0.037)	ǀ $_{A6}$: 0.005 (0.000 - 0.044)	
					ǁ $_{A6}$: 0.003 (0.000 - 0.032)	
U to N1	P_{P1s}	0.245 (0.153 - 0.298)				
P1 to N1	P_{N1s}	0.065 (0.017 - 0.099)				
P2 to N1	$P_{P2\text{-}N1s}$	0.413 (0.015 - 0.861)				ǀ : 0.433 (0.015- 0.892)
						ǁ : 0.394 (0.013 - 0.861)
N1 to N2	$P_{N1\text{-}N2s}$	0.820 (0.280 - 0.993)				ǀ : 0.807 (0.210 - 0.995)
						ǁ : 0.821 (0.240 -0.996)
NN to N2	$P_{NN\text{-}N2s}$	0.328 (0.008 - 0.963)				
N2 to N2	$P_{N2\text{-}N2s}$	0.908 (0.573 - 0.993)				ǀ : 0.950 (0.654 -1.000)
						ǁ : 0.764 (0.272- 0.986)

THEME 3: Summary of 2011 Whooping Crane Habitat Use Research

Anne Lacy, International Crane Foundation

Introduction

Investigating a potential cause and effect relationship between black fly abundance and Whooping Crane nest success was not the only relevant research priority proposed for 2011. We completed the second year studying the habitat use of paired or breeding whooping cranes. A very basic objective is to identify wetland types that WHCR prefer and the wetland size needed to accommodate cranes during the summer phase of their life cycle. Though other factors such as social interactions and population density might influence habitat use, we have focused on territory size because it creates a basis for evaluating alternative release sites. A standing question regarding this newly reintroduced population is the composition of habitats within Whooping Crane nesting territories.

Habitat use data for wintering birds has been collected since reintroductions began in 2001 but our effort at analyzing these data has lagged. In addition to analysis presented in the energetics theme, we describe here major staging and winter use areas, migration routes, and bird associations via monitoring data. Our priority over the next two years is to focus first on completing the analysis of data that we already have collected before addressing new questions related to staging or wintering birds.

A subset of summer habitat is the habitat used by cranes during molt, which occurs once every two or three years. This is a critical time for the birds, as they are flightless for approximately 6 weeks. They must find not only safe roosting areas during this time, but find enough food items to satisfy their energetic needs. We undertook a project during the summer of 2011 to describe the use areas of several paired and nesting cranes before, during, and after their molt. It is hoped that weǒll also gain insight into molt patterns between birds in a molting pair and within years.

1. Habitat use during spring and summer

Andrew Gossens, Mike Engels; International Crane Foundation

Currently, six territorial pairs of whooping cranes are being tracked by the International Crane Foundationôs Field Ecology Department (Table 1). Individuals in these pairs are followed once per week from AM roost to PM roost, with locations recorded every 1-1.5 hours throughout the day using radio telemetry techniques. Habitat use field work for the 2011 breeding season began April 1st and continued through the end of October. This summary utilizes data collected between April 1 and July 30, 2011. The objectives of this research are to understand more about territory size and composition, habitat use, and daily movements of breeding whooping cranes in Wisconsin.

Three focal pairs (14-08/24-08, 12-05/22-07, and 3-04/9-03) have territories in or near the Necedah National Wildlife Refuge (NNWR) in Juneau County. The remaining pairs (33-07/5-09, 24-05/42-07, and 12-02/19-04) are located outside of NNWR and have territories located in Wood and Adams Counties. One monitored pair, 24-05/42-07, was found dead 6/13/2011. Habitat classification will follow National Land Cover classifications (Homer et al. 2004). Wherever possible observers also acquired water depth data for each location to improve habitat structure information. Time periods and sampling rates for each pair were constant through the season.

Territory Landcover

The National Landcover Dataset (NLCD) was used to determine the percent landcover for the focal territories based on locations of individuals within a pair during 2011 Habitat Use Research. Where appropriate, landcover data from the NLCD were grouped into more general landcover types (Table 2); these include ñwetlandò (open water + emergent herbaceous wetland), ñdeveloped lowò (developed open space + developed low intensity), ñforestò (deciduous forest + evergreen forest + mixed forest), and ñupland openò (cultivated crop + herbaceous). The total area of each territory varied by an order of magnitude (Table 2). Two pairs with territories of approximately 10 km^2 either did not incubate at all or incubated for less than a week whereas the four pairs with territories less than 2 km^2 had confirmed nests and incubated for at least several weeks. Habitat composition for six territories examined in 2011 was comparable to the composition of habitats in previous years (Schmidt et al. 2011).

Individual Movements

óDaily movementsô are the total distance individuals within each pair traveled on days tracked from AM roost to PM roost. Minimum and maximum distances refer to the least and greatest distances one individual traveled throughout one day during the breeding season. The mean daily movement is the average distance the individual traveled daily during the season. Total mean daily movements among long-term incubating pairs averaged two times greater than the diameter of their territory, but were less than half the length traveled by the pairs that did not incubate for a significant period of time (Table 3). Future analysis will attempt to relate movement patterns and habitat composition to stages of the summer activity cycle (i.e. arrival, egg-laying, incubation, chick-rearing, molting).

The daily straight-line distance traveled from roost is the furthest each individual moved from AM roost on days when tracking included AM and PM roost locations. Minimum and maximum distances refer to the least and greatest distances traveled from roost in one day during the season, while mean distance is the average distance traveled from roost during the entire breeding season. On average, long-term incubating pairs traveled 0.62 km from AM roost during the day while individuals from the other pairs averaged 1.51 km from AM roost per tracking day (Table 4).

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Schmidt, N., J. Barzen, A. Lacy, and J.M. Engels. 2011. Habitat suitability analysis of east central Wisconsin for breeding Whooping Cranes (Grus Americana). Unpublished report to the Whooping Crane Eastern Partnership. International Crane Foundation, Baraboo, Wisconsin. 19 pp.

Table 1. Whooping Crane pairs being tracked through radio-telemetry in 2011, April-July. Bird i.d. is the number within a year-the year of release. Territory location is the center point coordinate, averaged over the entire tracking season.

Pair (male / female)	**Territory Location** (latitude / longitude)
14-08 / 24-08	44.046664 / -90.177016
12-05 / 22-07	44.146860 / -90.154598
3-04 / 9-03	44.062728 / -90.167797
33-07 / 5-09	44.209349 / -89.705082
24-05 / 42-07	43.883639 / -89.849365
12-02 / 19-04	44.421217 / -90.023929

Table 2. Percent Landcover found in each pairsôterritory as defined by roost-to-roost tracking in the spring and summer 2011.

Territory	Area (km^2)	Wetland	Dev. Low	Barren Land	Forest	Shrub/Scrub	Upland Open	Woody Wetland
14-08/24-08	10.99	32.80	2.60	0.00	20.69	17.15	12.88	13.87
12-05/22-07	9.89	68.26	2.03	0.00	8.84	0.19	2.24	18.44
3-04/9-03	1.92	80.45	3.72	0.00	0.80	0.00	7.54	7.49
33-07/5-09	0.67	34.24	0.00	0.82	1.22	0.00	63.04	0.68
24-05/42-07	1.25	61.96	0.94	0.00	16.88	0.00	9.28	10.94
12-02/19-04	1.07	0.94	3.00	0.00	46.66	0.00	49.40	0.00
Mean	4.30	46.44	2.05	0.14	15.85	2.89	24.06	8.57
StDev	4.79	29.25	1.37	0.33	17.11	6.99	25.51	7.32

Table 3. Total Daily Movement by individual of WHCR tracked spring and summer 2011. Pairs are grouped together with males listed on the left, females on the right. (* indicates extreme outlier removed from dataset)

	Territorial Pairs					
	14-08	**24-08**	**12-05**	**22-07**	**3-04**	**9-03**
Min. Daily Movement (km)	2.91	2.60	1.87	1.89	1.99	1.25
Max Daily Movement (km)	6.72	9.98	74.41*	9.04	5.82	5.66
Mean Daily Movement (km)	4.73	5.77	12.36	4.88	3.05	2.88
StDev	1.35	2.73	25.09	2.24	1.14	1.07

	33-07	**5-09**	**24-05**	**42-07**	**12-02**	**19-04**
Min. Daily Movement (km)	0.88	0.86	1.35	1.47	0.34	0.51
Max Daily Movement (km)	3.58	4.07	4.10	1.84	10.06	10.06
Mean Daily Movement (km)	2.19	2.23	2.58	1.65	3.68	2.88
StDev	0.88	1.16	1.05	0.27	3.13	3.31

Total Mean Daily Movement (km)	4.05
StDev	7.59

***Total Mean Daily Movement (km)**	3.30
StDev	2.10

(* excluding daily max from 12-05)

Table 4. Daily straight-line distance traveled from roost by each individual tracked spring and summer, 2011. (* indicates extreme outlier removed from dataset)

	Territorial Pairs					
	14-08	**24-08**	**12-05**	**22-07**	**3-04**	**9-03**
Min. Daily Distance from Roost (km)	0.64	0.64	0.43	0.43	0.40	0.42
Max. Daily Distance from Roost (km)	3.41	2.95	33.04*	3.65	1.80	2.05
Mean Daily Distance from Roost (km)	2.08	1.78	4.90	1.28	0.81	0.93
StDev	1.16	1.08	11.37	1.06	0.42	0.55

	33-07	**5-09**	**24-05**	**42-07**	**12-02**	**19-04**
Min. Daily Distance from Roost (km)	0.22	0.16	0.17	0.32	0.10	0.10
Max. Daily Distance from Roost (km)	1.08	1.09	0.92	0.33	0.87	0.87
Mean Daily Distance from Roost (km)	0.64	0.61	0.69	0.33	0.53	0.43
StDev	0.24	0.28	0.30	0.01	0.33	0.29

Total Mean Distance (km)	1.23
StDev	3.38
***Total Mean Distance (km)**	0.89
StDev*	0.73

(* excluding distance from 12-05)

2. Wintering of the Eastern Migratory Whooping Crane Population

Richard Urbanek, U.S. Fish and Wildlife Service, Necedah National Wildlife Refuge

Juvenile Whooping Cranes (*Grus americana*) were led by ultralight aircraft to winter release sites in saltmarsh on Chassahowitzka and St. Marks National Wildlife Refuges (NWRs) on the Florida Gulf Coast. With few exceptions, most of these cranes wintered in inland freshwater habitats in subsequent winters. Juveniles were also reintroduced by direct autumn release (DAR) on Necedah NWR, Wisconsin, in October. Wintering areas of the population occurred in 4 general regions: Florida/southern Georgia, Carolinas, mid-South (i.e. Tennessee, northern Alabama), and Indiana/northern Kentucky (Fig. 1). Primary habitats used by reintroduced cranes consisted of open shallow water and marsh, improved pasture (Florida only), and harvested cornfields. In addition to habitat conditions, tradition and associations with other cranes were major factors influencing whooping crane winter distribution.

Of 89 yearlings remaining from juveniles released at Chassahowitzka NWR during 9 winters, wintering during the second winter occurred in the release area (n=9 [4 of these at the pensite]), inland in the local Florida wintering area (n=38), at the release site on St. Marks NWR (n=1), inland at remote sites in Florida/Georgia (n=26), Carolinas (n=10), other states (n=3), and undetermined (n=2). Mean group size of yearlings wintering with whooping cranes was 3.1 Whooping Cranes. Six yearlings wintered alone or with sandhill cranes.

Of 14 yearlings remaining from juveniles released at St. Marks NWR during 2 winters, wintering during the second winter occurred at the pensite (n=1), locally inland (n=4), at Chassahowitzka NWR (n=1), inland at remote sites in Florida/Georgia (n=3), other states (n=5), and undetermined (n=1). Four yearlings wintered with sandhill cranes.

The DAR method of release allows juveniles to learn migration routes to winter areas by following other Whooping or Sandhill Cranes from Wisconsin. Because DAR juveniles are not led to winter areas, the first winter of selection by DAR individuals is somewhat comparable to the second winter of selection for birds taught to follow ultralight aircraft. Of 21 yearlings resulting from DAR juvenile releases during 5 years, wintering during the first and second winters, respectively, occurred in Tennessee (n=9, n=9), Florida/southern Georgia (n=5, n=6), Alabama (n=0, n=2), Kentucky (n=6, n=1), Indiana (n=1, n=1), and undetermined (n=0, n=3; note, one bird is tallied in the second year in both Tennessee and Kentucky). Eight yearlings returned to the previous wintering area in the second winter. During the second winter, mean group size of located yearlings wintering with whooping cranes was 3.4 whooping cranes, and 7 yearlings wintered alone or with sandhill cranes.

The following summary is based on 90 pair-winters (0-7 winters/pair) of 35 different whooping crane breeding pairs. For the first winter after pairing, the member that changed wintering area was the female (n=20), male (n=1), female in first but male in subsequent winters (n=1), and where both or neither individuals changed locations (n=13). Location of winter territory remained the same for 11 of 24 pairs that had wintered together for 2 or more winters. Changes in wintering areas of pairs were associated with drought, habitat degradation, shortstopping, or unidentified factors but a quantitative assessment has not been completed.

The only naturally occurring population of Whooping Cranes winters at Aransas NWR on the Texas Gulf Coast. This area is unique in its quality and juxtaposition of different winter habitat types (e.g. fresh water sources, food sources in brackish water, and upland food sources) for whooping cranes. A barrier island protects the coastal marsh from tides and results in generally less than 3 cm change in overnight water level. The substrate is sand. Dominant marsh vegetation consists mainly of low-growing species less than 30 cm in height. Salinity is highly variable, but freshwater sources are available within 1 km of the saltmarsh. There is no area with similar habitat conditions within the winter range of the reintroduced eastern migratory population. The release site on Chassahowitzka NWR, for example, typically has variable wind-driven winter tides averaging 30 cm overnight. The two substrates are oyster rock and soft muck. The dominant saltmarsh species is black needlerush (*Juncus roemerianus*), which forms dense stands greater than 1 m in height. In most winters, water is likely near or beyond the salinity tolerance of whooping cranes, and there are no nearby sources of freshwater. This area provides an excellent release site, but preferred habitats for long-term use appear to occur inland.

Historical winter ranges of Whooping Cranes did, however, include areas other than Aransas NWR. The coastal prairies of Louisiana, high plateau wetlands of Mexico, and tidal marshes in South Carolina once supported wintering Whooping Cranes (Allen 1952). This discrete historical winter distribution contrasts with the scattered distribution of current Whooping Cranes in the Eastern Migratory Population (EMP, Fig. 1). Winter habitat quality is important to reproductive success in the AWB flock (Gil de Weir 2006), therefore the winter distribution of Whooping Cranes in the EMP, as it relates to habitat quality, is of concern. Further, distribution of wintering Sandhill Cranes in the Eastern Population of Greater Sandhill Cranes (*Grus canadensis tabida*) is similar to that of Whooping Cranes in the EMP (Norris et al. in prep.).

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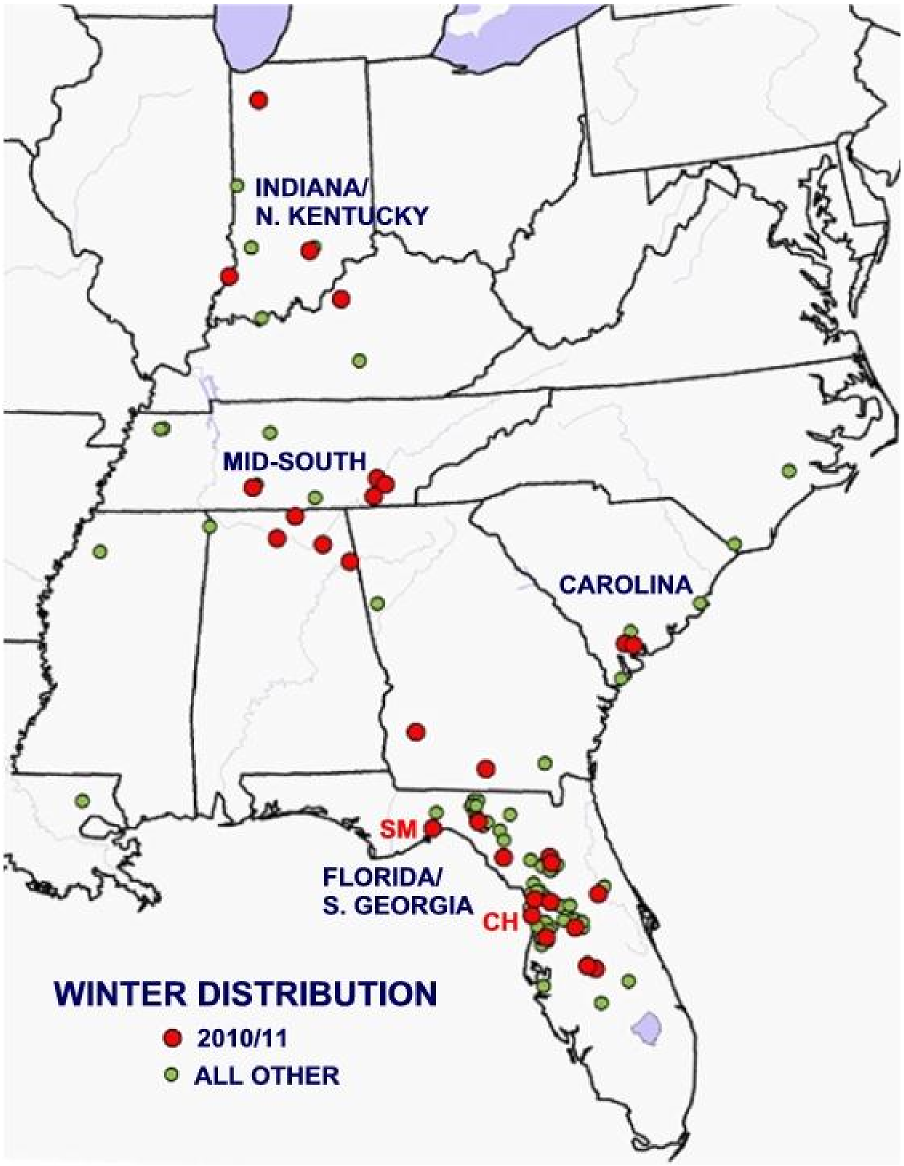

Fig. 1. Winter distribution of the reintroduced eastern migratory whooping crane population, 2001-2011 (CH = Chassahowitzka NWR and SM = St. Marks NWR).

3. Habitat Use of Whooping Cranes (*Grus americana*) During Primary Feather Molt in Wisconsin

Dan McElwee and Anne Lacy; International Crane Foundation

Abstract

Whooping cranes (WHCR) complete a full and synchronous ecdisis or molt of primary flight feathers every 2-3 years, resulting in temporary flightlessness. Though the flightless molt presumably represents an important component of the annual cycle (when it occurs) the phenomenon of molt in wild cranes is poorly understood. The goals of this study were to identify molting WHCR on or near Necedah National Wildlife Refuge and identify the habitat used during molt. Six individual WHCR within the eastern migratory flock were confirmed in late June and early July of 2011 to be molting.

Radio tracking data before, during, and after these birds molted illustrated that the range of a whooping crane is significantly smaller ($p = 0.05$) while they are in molt [mean=0.47 km^2 (territorial pairs), mean= 0.44 km^2 (non-territorial pairs)] compared to pre-molt [mean=9.5 km^2 (territorial pairs), mean=135.9 km^2(non-territorial pairs)] and post-molt [mean=21.1 km^2 (territorial pairs), mean=206.7 km^2 (non-territorial pairs)].

During molt, cranes favored areas with open water/emergent vegetation (52.4%), emergent/wet meadow (39.5%), upland (7.5%) and wetland lake (0.6%). Though territory sizes during molt are smaller than are territory sizes during other times in summer, habitat composition during molt may uniquely constrain the overall make-up of crane territories even in years when remiges (i.e. primary, secondary and tail feathers) are retained.

Introduction

Every 2-3 years near the time of incubation, Whooping Crane flight feathers are forced out and replaced by new flight feathers; this physiological process is known as remigial molt and renders the birds flightless for about 6 weeks starting in early June (Ellis 1996). As WHCR begin to spread across the Wisconsin landscape they must find appropriate habitat to suit the needs of all phases of their life cycle including molt. As they are flightless, the molting phase for a Whooping Crane might demand specific habitats which are critical to their survival. Four deaths of adult breeding-age birds have been confirmed to have occurred while birds were undergoing remigial molt since 2001. The goals of this study were to delineate areas used by molting WHCR and identify the specific habitat types within those areas.

Methods

During monitoring of the Eastern Migratory Population (EMP) of WHCR in 2011, six molting birds were identified as molting initially by observing secretive behavior and or by observing limited movement. These observations were followed by visual confirmation through observing a wing flap so that presence/absence of remiges could be noted. The birds confirmed to be molting included WCEP ID: 29-09, 4-08, 13-02, 18-02, 12-02, and 19-04. One pair (12-02 and 19-04) was not confirmed by seeing wing flaps but confirmed to be molting with the collection of thirty-four (out of a maximum of 40) primary feathers on the pairôs territory. No other WHCR that could account for additional primaries were located near the territory. All birds were confirmed to be molting within 6 day of each other during the first week of July. Each birdôs primaries were observed to be approximately ¼ emerged or less, placing the start date of molt around the 2nd week of June. The birds remained flightless for 6 weeks.

Location data from April 1st through September 31st 2011 was compiled on all six birds to create four (one for each breeding pair, one for each non-breeding bird) minimum convex polygons (MCP) within ArcGIS. Three distinct phases were analyzed including pre-molt, molt, and post-molt. These three phases were separated under the assumption that each phase involves behavioral differences such as territorial establishment (pre-molt, April-May), nesting and flightlessness (molt, June-July), and the regaining of flight/pre-migration (post-molt, August-September) and these different behaviors likely play a role in the choice of habitat use and movement. Using the Wilcoxon Rank-Sum Test the molt area for each individual/pair was compared to both pre-molt areas and post-molt area. The areas used by the two members of breeding pairs were assumed not be independent and thus one randomly selected bird was removed from each pair and the other retained for analysis. The sum of rank molt is (N1=10) and the sum of rank pre and post molt is (N2=26) with an upper and lower boundary of 11<=N<=25.

The Wisconsin Wetland Inventory (WWI) was used to describe the wetland types that were used by each bird during molt. The four types of habitat found in the use areas of molting WHCR included upland (a mix of broad-leaved deciduous, needle-leaved coniferous, and dry soil), open water/emergent (persistent narrowï leaved emergent vegetation, standing water), emergent/wet meadow (wet soil, persistent narrow-leaved vegetation), and wetland lake (open water; deep water lake with a depth of 6 feet or more). The number of occurrences within each habitat type was counted for each bird to give the percent that each habitat type was used by a given bird in molt. Few locations of molting WHCR are in areas that are not described by WWI.

Results

Area of Use

The territory size used by WHCR in pre- versus post-molt did not differ (Fig. 1).However, the area used during molt versus pre- and post-molt was smaller (*p*=0.05, Table 2, Fig. 2).

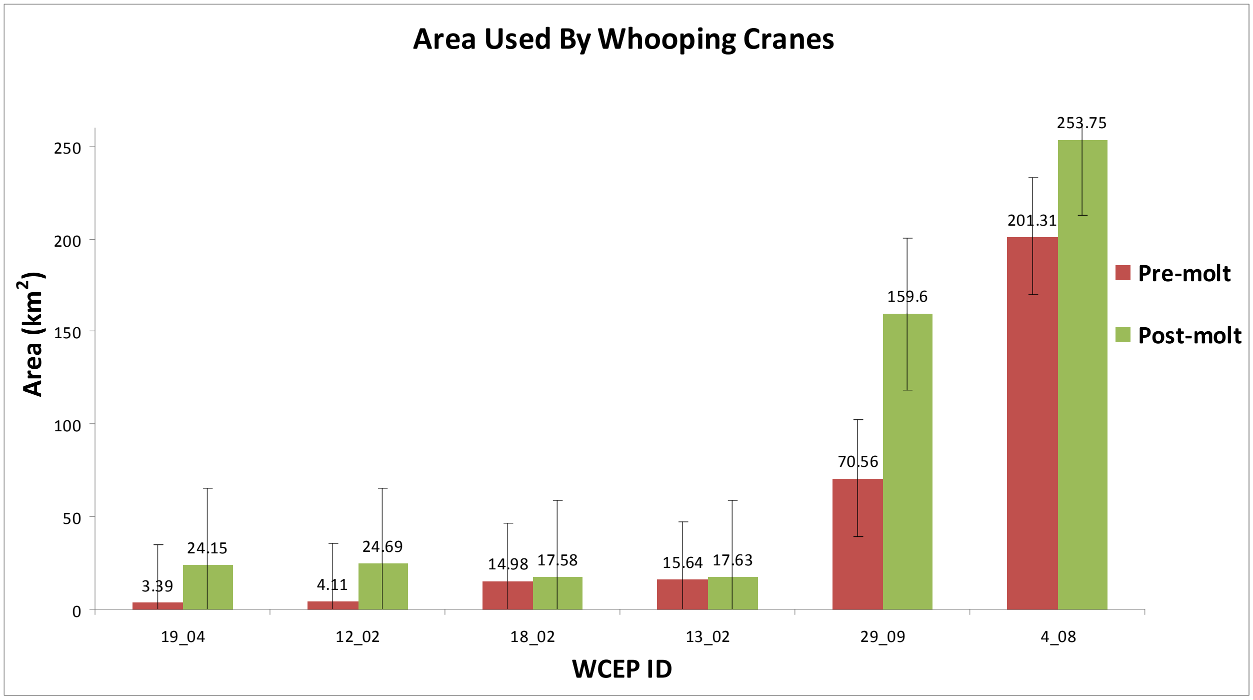

Fig. 1. Area used by WCEP WHCR during Pre-molt (April-May) and Post-molt (August-September) in central Wisconsin, 2011. Standard Error bars are depicted for each histogram along with the actual area used by each bird.

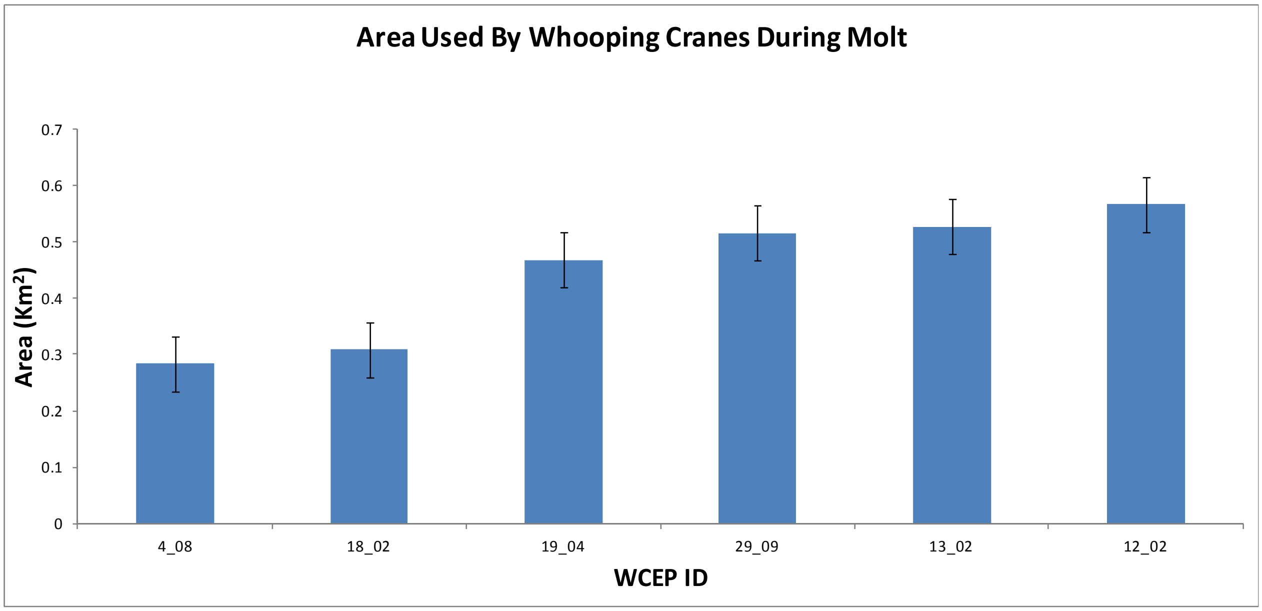

Fig. 2. Area used by molting WCEP WHCR (June-July) in central Wisconsin, 2011. Standard error bars are depicted for each.

Habitat Use

Locations of birds during molt were plotted in relation to habitat type (Fig. 3a-d). The area of all land cover types that molting WHCR used was averaged and separated by type. The number of occurrences in each of those four habitat types was also counted to give an indication of preference. The most used cover type was emergent/ wet meadow followed by open water/ emergent, upland, and wetland lake (fig. 4).

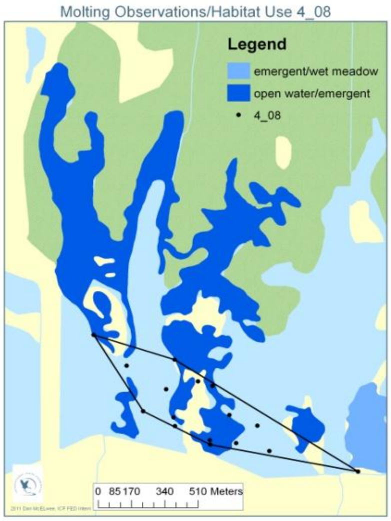

Fig. 3a. MCP for 4_08 on Necedah National Wildlife Refuge in Wisconsin in June and July of 2011.

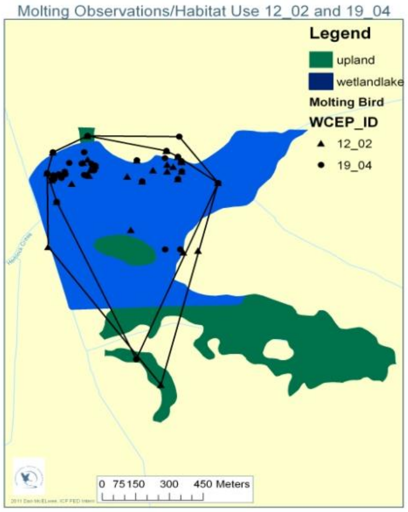

Fig. 3b. MCP for 12_02 and 19_04 in Wood County, Wisconsin in June and July of 2011.

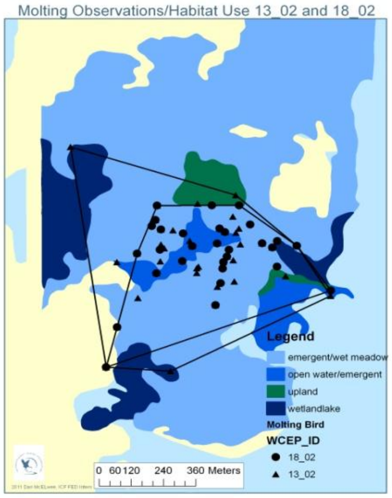

Fig. 3c. MCP for 18_02 and 13_02 on Necedah National Wildlife Refuge in Wisconsin in June and July of 2011.

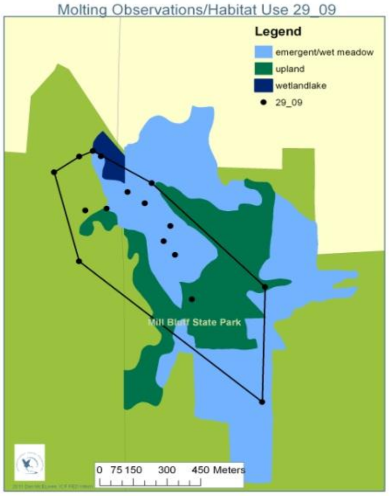

Fig. 3d. MCP for 29_09 in Mill Bluff State Park in Wisconsin in June and July of 2011.

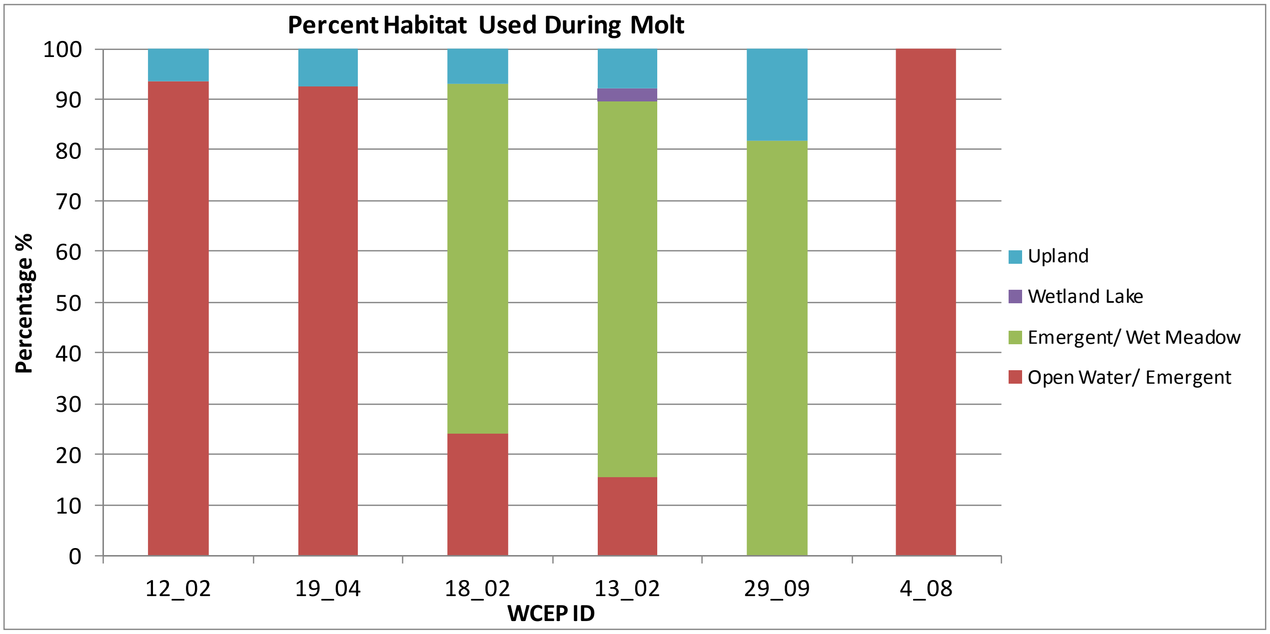

Figure 4. The percent used of four wetland types used by six molting WHCR during molt in central Wisconsin, 2011.

Discussion

In addition to the differences in the area used during pre-molt and post-molt, the relationship between paired and unpaired birds and area used are interesting. While in molt there is very little difference in the size of the area used by territorial or non-territorial birds. During pre-molt and post-molt, however, the areas used by non-territorial birds are significantly larger than the area used by territorial birds. This indicates that regardless of breeding status, the birds seek out similar habitats to fulfill their habitat needs during molt.

While in molt, WHCR overwhelmingly chose to use open water/emergent and emergent/ wet meadow habitat over wetland, lake, and upland. Presumably, when molting they have found safety in water but were more likely to stay away from both deep water and dry areas. In all probability this allows birds to forage while also remaining safe from predators. A molting WHCRôs selection of open water/emergent and emergent/ wet meadow wetland types gives great insight into the types and sizes of wetlands that a whooping crane will need during its time in molt. Schmidt (2010), using the National Landcover Data Set to describe habitat use by territorial WHCR in Wisconsin, found that birds most favored a mix of open water and emergent herbaceous wetlands. These similarities, found using different datasets, supports our hypothesis that these types of wetlands are essential to molting WHCR. Although the amount of habitat used has not yet been compared to the habitat available to the cranes, the fact that the birds are flightless further supports the importance of emergent vegetation and open water for Whooping Cranes.

In order to gain a more complete understanding of WHCR molt, additional location information is needed throughout the breeding season on a greater number of birds, for both territorial and non-territorial pairs. It would also be important to make these measurements for birds in different landscapes of Wisconsin once birds released at White River and Horicon Marshes initiate their first molt. Having a larger dataset will illustrate habitat use of WHCR across the Wisconsin landscape on both public and privately owned lands.

Conclusion

For this endangered species, the molting phase of a WHCR can be a vulnerable time. As efforts to reintroduce this species continue, understanding the molting period for WHCR is vital to a successful reintroduction. Though all six molting WHCR studied in 2011 survived their molt, two cranes that were found dead in 2011 were in molt. The molting period for a whooping crane presents it with unique behavioral and environmental constraints. These constraints play an obvious role in the amount and type of habitat used during molt and should be considered when people select and manage habitat for WHCR reintroduction efforts. The next steps of this study are to identify other aspects of whooping crane molt such as molt patterns between breeding pairs and more specific habitat requirements during molt such as water depth.

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Summary

Generally we can show that off refuge pair territories were smaller than territories on the refuge (see section 1: habitat use during spring and summer). One important caveat is the use of National Landcover Data Set; there are several examples of landcover data that were interpreted incorrectly in the NLCD (e.g. open water in reservoirs were classified as agriculture). To ensure an accurate calculation of habitat use, we need to know that all landcover is correctly classified.

In the winter, the cranesô use of the landscape is more poorly understood. There are, however, broader trends emerging; Florida habitat is generally declining in quality due to development. Though Paines Prairie (north central FL) is protected and is the biggest current area of use for wintering Whooping Cranes, the surrounding areas are being developed rapidly. Most winter areas of birds are known and Hiwassee NWR in Tennessee has the second largest concentration of WCEP birds. Either area of concentration (Tennessee or Florida) may be a place to concentrate future research, combining work on winter habitat use with energetics studies, and banding birds that need replacement of transmitters. The UL route shifted west (in 2007) and it appears that winter site use has shifted as well. Further discussions with staff at Chassahowitzka and St Marks NWRôs are needed to discuss how to continue making these refuges attractive for wintering birds but some barriers to making these coastal sites better for wintering Whooping Cranes might prove insurmountable. Currently few birds use coastal sites after their first assisted migration.

Regarding the molt of Whooping Cranes, little work has been done to describe the timing of the molt and how the birds use the landscape when in molt. Several WCEP birds have been found dead with evidence that they were in molt, indicating that it might be a vulnerable time for this population. From this preliminary work, it appears that the area of use when in molt is significantly smaller compared to total territory size, which is expected because the birds cannot fly during molt. However, we still do not fully understand the specific habitat needs of birds at this time, if current territory choices fulfill those needs, and at what frequency molt occurs (i.e. is molt synchronous among pairs within a year and between years). Clearly further analysis on overall mortality rates, as compared to this specific period of the life cycle, is needed to evaluate if mortality during molt is more frequent than expected. This pilot study highlighted several directions for future research; the need for comparison of habitat use of molting to non-molting birds during the same time period, the depth of water within the use area during the molt, and better defining the timing of molt within pairs. Concurrently, we can compare habitat conditions of molting birds that died with habitat conditions of molting birds that have survived as the birds in this study all survived their molting season. Also of interest is learning more about how management activities like pool drawdown at NNWR could affect habitat use and survival of cranes, especially during molt.

THEME 4: The Role of Energetics in Whooping Crane Reproduction

The Energy Budget of Breeding Whooping Cranes in Wisconsin

Megan Fitzpatrick, Anne Lacy, Jeb Barzen and Warren Porter

Introduction

The extent to which birds rely on endogenous nutrient reserves during reproduction is fundamental to understanding the relationship between local environmental conditions, energy requirements, and reproductive success. At one end of a continuum of breeding strategies, income breeders (*sensu* Jönsson 1997) depend entirely on food acquired during reproduction to support reproductive efforts. At another extreme, capital breeders (*sensu* Jönsson 1997) rely on stored reserves to form eggs and meet their own energy requirements while nesting. A capital breeding strategy may be advantageous when food availability is low or variable early in the breeding season (Jönsson 1997). This is particularly true given the association between early breeding and increased reproductive success in many species (reviewed in Verhulst and Nilsson 2008), and the increased time available for re-nesting after failure of an early nesting attempt.

In 2011, we examined use of fat reserves during reproduction by Whooping Cranes (*Grus americana*) in Wisconsin. Whooping Cranes are one of the worldôs rarest crane species. The single remaining wild, non-experimental (i.e., not reintroduced) population breeds in Wood Buffalo National Park (WBNP), NT, and winters in and around Aransas National Wildlife Refuge (ANWR), TX. Managers are using reintroduction techniques to establish an additional migratory population (the Eastern Migratory Population, or EMP) in the eastern portion of the historical Whooping Crane breeding range. This population breeds in southern Wisconsin and winters throughout the southeastern United States. An understanding of how reintroduced Whooping Cranes use nutrient reserves in reproduction will help managers evaluate habitat requirements, range limits, and potential reintroduction locations for this species.

No study has directly tested whether wild Whooping Cranes rely on fat reserves during the breeding season. However, it is likely that individuals in the Aransas-Wood Buffalo Population (AWBP) use fat reserves to some extent. Like many capital breeding birds (e.g. Sandhill Cranes nesting in AK; Krapu *et al.* 1985, Reinecke and Krapu 1986; Tacha *et al.* 1987), this population breeds at a high latitude and often arrives at breeding grounds when water is frozen and food availability is low. Further, a study estimating the daily energy expenditure and daily energy intake of wintering AWBP cranes found that birds store significant amounts of fat in winters when food is abundant (Chavez-Ramirez 1996). Circumstantial evidence (fewer nesting attempts and chicks produced following a winter when food availability at ANWR was low and cranes had a lower energy balance) suggests that these fat reserves may be used for reproduction (Chavez-Ramirez 1996). A more formal analysis of historical data showed that some aspects of Whooping Crane reproductive success (percentage of pairs that breed and clutch size) at WBNP are correlated with conditions in ANWR during the prior winter (Gil de Weir 2006). This is also consistent with a capital breeding strategy.

Less is known about the energetics of the EMP. The EMP has a wider wintering range (from TN to FL), a shorter spring migration route, and breeds at a warmer, more southern location than the

AWBP. However, most EMP birds arrive at breeding grounds approximately one month earlier (late March to early April) than AWBP birds arrive at WBNP. Consequently, water is often frozen when they arrive, and availability of potential food items is likely low (J. Barzen, personal communication). Given that birds begin laying eggs shortly after arrival (early April), fat reserves may be necessary for females to form eggs and for birds to meet their energy needs early in the breeding season.

In this study, we addressed the question: Do Whooping Cranes in Wisconsin rely on fat reserves for egg formation and maintaining high nest constancy through incubation and nest guarding? We addressed this question in two ways. One approach was based on the information that the AWBP is likely to rely to some extent on fat reserves during the breeding season, and that the AWBP and EMP often encounter similar conditions of low food availability upon arrival in their breeding grounds. Thus, we asked the question: Does the climate-dependent daily energy expenditure of a breeding Whooping Crane in Wisconsin (Necedah National Wildlife Refuge-NNWR), differ from that of a Whooping Crane in the Northwest Territories? Given that the populations achieve similar (low) daily energy intake upon arrival at the breeding grounds, similar daily energy expenditure between the two populations would suggest that EMP birds also experience a negative energy balance (and thus rely on fat reserves) early in the breeding season.

Second, we compared daily energy expenditure of a focal pair of Whooping Cranes at NNWR to their estimated daily energy intake during different months and stages of the breeding cycle. If these birds burn fat during incubation, the difference between daily energy intake and daily energy expenditure will be negative.

Mechanistic modeling, such as that done by Chavez-Ramirez (1996), is a non-invasive method for examining the energy budget of an organism, and is especially appropriate for endangered species, where non-invasive study methods are especially important for avoiding harm. We used the program Niche Mapper^{TM} to model daily Whooping Crane energy expenditure at both WBNP and NNWR. Niche Mapper^{TM} uses many of the same equations used by Chavez-Ramirez (1996), but it also incorporates energy costs of thermoregulation, has a unique porous media model for feather insulation and a mechanistic microclimate model to estimate the full range of local microclimates available for the birds. Thermoregulatory costs may be substantial in early spring at Whooping Crane breeding grounds and may vary between WBNP and NNWR.

Methods

Model description:

We used the mechanistic modeling program Niche Mapper^{TM} (Porter *et al.* 1994; Porter *et al.* 2000; Porter *et al.* 2002; Porter *et al.* 2006; Natori and Porter 2007; Kearney and Porter 2009) to model the daily energy expenditure and food requirements of Whooping Cranes. Niche Mapper^{TM} consists of two coupled models: a microclimate model and an endotherm model. The microclimate model applies first principles of physics and meteorology to compute local microclimate data for an area of interest. It calculates microclimate conditions at a series of heights for each pixel of a spatial dataset or for a point location. The endotherm model, given behavioral, physiological and morphological properties of an animal and output from the microclimate model, solves coupled heat and mass balance equations to find resting metabolic rates necessary to maintain a given core temperature. To obtain a field metabolic rate, activity multipliers are applied to resting metabolic rate in proportion to the amount of time per hour spent in each activity (such as flying or walking). Mass balance equations for oxygen, food, and water are then applied to determine food and water requirements that meet daily metabolic demands at an hourly time scale throughout the year.

Microclimate model input:

For the between-population comparisons of daily energy expenditure, Whooping Crane energy expenditure was modeled in WBNP and NNWR under two temperature scenarios: a warm scenario and a cold scenario. These scenarios were chosen to model the bounds within which Whooping Crane metabolic rates lie during most years.

For each location and climate scenario, the middle Julian date of each month was modeled using average climate conditions for that month, and output was integrated over the days between mid-points of each month. Average daily minimum and maximum air temperatures were downloaded from the NOAA National Climate Data Center website and Canadaͨs National Climate Data and Information Archive. Data from all available years were downloaded from weather stations in Necedah, WI (1954-2008) and Fort Smith, Northwest Territories (near Wood Buffalo National Park; 1913-2008). A cold year was chosen based on daily minimum temperatures in months when Whooping Cranes are present at breeding grounds (March-November), and a warm year was chosen based on daily maximum temperatures.

For the calculation of daily energy expenditure of a focal pair of cranes in the year 2011, average monthly air temperatures at NNWR were used.

Endotherm model input:

Endotherm model input data and sources are shown in Tables 1 and 2. Most Whooping Crane allometric and feather properties were measured on two adult captive Whooping Cranes (one male and one female) at the International Crane Foundation, Baraboo, WI.

For the between-population comparison of daily energy expenditure, daily energy cost of activity was assumed to be the same between the two populations. Energy expenditure of resting Whooping Cranes was modeled in order to directly compare energy costs of thermoregulation between birds at WBNP and birds at NNWR.

The average daily energy cost of activity for the daily energy expenditure ï daily energy intake comparison was estimated from time-budget data collected in the field for a pair of Whooping Cranes (WCEP ID#ͨs 2-04 and 46-07) breeding at NNWR. Observers took instantaneous scan samples of behavior of each bird in the pair every 30 seconds during 50-minute periods. Observation periods were stratified throughout the day such that each period of the day (morning, mid-day, and afternoon) was covered once per week . To find the proportion of time spent in each behavior during daylight hours, proportion of time spent in a behavior in a given habitat type (corn field or wetland) was multiplied by the proportion of daylight time spent in that habitat type. Proportions were summed across habitat types for each behavior.

Approximate energy costs of behaviors are available in the bird literature. To obtain an average cost of activity, energy cost of each behavior exhibited by Whooping Cranes (Table 3) was multiplied by total proportion of time birds spent in that behavior.

Daily energy intake

Average daily energy intake of the focal pair of Whooping Cranes was estimated from observations of foraging behavior. During 50-minute observation periods, observers focused on one bird and recorded number of food items consumed (LaChance et al, unpublished report), type of food consumed, habitat in which each item was consumed (wetland or corn field), and food capture behavior used to catch food item (probe into substrate, low jab at ground, or high jab at vegetation). Observation periods were carried out in alternate hours between energy budget observations (described in *Endotherm model input*, above) and stratified throughout the day such that each period of the day (morning, mid-day, and afternoon) was covered once per week.

To calculate average number of food items consumed per day, average number of food items consumed/min was multiplied by total minutes of daylight available that month.

Type of food item consumed could rarely be identified, and observers noted that most food items consumed were too small to see from a distance. Consequently, we calculated average proportions of food items consumed per day by habitat and food capture behavior and assumed that each habitat/food capture behavior represented consumption of a particular (small) food type, which did not require extensive food handling (e.g. crayfish), that Whooping Cranes may consume. For example, birds probing in wetlands were probably consuming tubers (e.g. Sago pondweed, *Potamogeton pectinatus*). Jab highs likely represented capture of aerial insects (e.g. dragonflies) from vegetation in any habitat type. Probes and low jabs in corn fields were always assumed to represent consumption of waste corn, based on observer comments that birds primarily consumed waste corn in this habitat type. Jab lows in wetlands could have captured a wide range of food types. Simulations assuming that birds consumed snails (low energy per item), dragonfly larvae (moderate amount of energy per food item), and tadpoles (high energy per item) were run to find minimum and maximum amounts of energy that birds may have been consuming. Composition of each potential food type was taken from the literature (Table 4).

Results

The modeled daily energy expenditures of resting Whooping Cranes at NNWR and WBNP over a range of climate conditions were compared (Figure 1). Metabolic rates at WBNP are higher than those at NNWR during any given month. Due to the earlier arrival time of EMP birds to NNWR, energy costs of thermoregulation at time of arrival at the breeding grounds (Figure 1, gray boxes) are similar between the two populations. Minimum energy expenditure is approximately 20 kJ lower for the EMP than for the AWBP, and the maximum energy expenditure is approximately 75 kJ higher for the AWBP than for the EMP.

The focal pair of Whooping Cranes at NNWR in 2011 laid eggs on April 16. Prior to egg-laying, birds appeared to spend all their time on their territory in wetland habitat. During incubation, parents spent 25-39% of their time off-nest in corn stubble fields approximately 6 miles south of their territory. One egg hatched on May 16. Following hatch, the family remained in wetlands on their territory.

The average daily food requirement (number of food items) for neutral energy balance (calculated from daily energy expenditure) of a Whooping Crane at NNWR at different months/stages of the breeding season in 2011 was developed for three hypothetical prey items (Figure 2). One assumes that the proportion of food items consumed by Whooping Cranes through jab lows in wetlands is snails. Another assumes that this proportion is dragonfly larvae, and a third assumes that this proportion is tadpoles.

During egg-laying and chick-rearing stages, when birds spend all their time in wetland habitat, Whooping Cranes would have to consume far more food items on a diet containing a large proportion of snails than they would on a diet containing a large proportion of dragonfly larvae or tadpoles. This pattern occurs as a result of the relative energy content of each food item (highest in tadpoles, lowest in snails). Due to the large proportion of energy-rich corn in the focal pairôs diet during incubation, items of food required per day is consistently low, regardless of the food type being consumed via jab lows.

At stages of the breeding season when birds spent all their time in wetlands, daily energy intake (number of food items) was higher than daily energy expenditure (number of food items) on a diet incorporating dragonfly larvae or tadpoles (Figure 2, Table 6). Daily energy expenditure is lower than daily energy intake on a diet incorporating snails. During incubation, when corn formed a substantial portion of the diet, birds consumed more energy than they expended under every diet modeled and may have been able to store fat.

Because corn consumption had a considerable impact on the energy balance of incubating Whooping Cranes, we ran an additional simulation to estimate what the energy balance might have been if the pair had not used cornfields during incubation (Figure 3). Daily energy intake was estimated based on observed foraging rates in wetlands, and diet was estimated based on proportions of food items acquired with various capture behaviors in wetlands. Flight between territory and corn fields was removed from the daily time budget when calculating energy expenditure because cranes foraging only in wetlands would not incur energy costs of flight to corn fields.

In simulations where crane habitat use was restricted to wetlands, energy balance was again heavily dependent on food types captured using low jabs. Birds could have maintained positive energy balance during incubation on a diet that included tadpoles, but would have burned fat (i.e. been at a negative energy balance) on a diet incorporating dragonfly larvae or snails (Table 5).

Discussion

The daily energy expenditure of EMP Whooping Cranes at spring arrival to NNWR is similar to the daily energy expenditure of AWBP cranes at arrival to WBNP. If birds in these populations also experience similar conditions of low food availability upon arrival the breeding grounds, they likely use similar strategies of fat reserve use during reproduction.

Our analysis of the energy budget for a focal pair of Whooping Cranes in 2011 suggests that EMP cranes may use fat reserves during egg laying, depending on what types of food cranes are capturing using low jabbing behavior in wetlands. Availability of some food items, such as tadpoles and dragonfly larvae, may allow for neutral to positive energy balance. If birds are capturing very small, low energy food items (e.g. snails), they may be relying on fat reserves.

Cranes are probably consuming a mixture of food types using low jabs. On a diet where all jab lows result in tadpoles, breeding cranes would store more fat per day than wintering Whooping Cranes preparing to migrate (4.3-125.9 g fat/day; Chavez-Ramirez 1996). On a diet of strictly snails, birds that remain in wetland habitat would burn about 600 g of fat during their first month on the breeding grounds. Six hundred grams of fat could well consume a large portion of potential stored fat.

Energy balances may differ between male and female Whooping Cranes during the pre-laying/egg formation period. In addition to energy (fat), female birds must deposit substantial amounts of calcium and protein in eggs during the laying period. Females of some species (e.g. Tufted Ducks) forage for high-calcium, low-energy prey (e.g. small mollusks) during egg formation/laying, and fat reserves may be necessary to meet energy needs on such a low-energy diet (reviewed in Perrins 1996). Female Whooping Cranes in particular may have to rely on fat reserves if many of the food items they consume are snails or other small mollusks.

During incubation, energy balance of focal Whooping Cranes at NNWR was positive for any diet simulated due to the substantial amount of energy-rich corn in the diet. This suggests a positive energy balance existed for the incubating pair. This positive energy balance may indicate that the pair, which successfully hatched a chick, used an income breeding strategy (little to no reliance on fat reserves) during incubation.

Would a positive energy balance have been possible to maintain during incubation if the birds remained in the wetland instead of feeding in corn fields? Our results suggest that the pair could have maintained positive energy balance during incubation on a diet that included a sufficient number of tadpoles but they would have burned fat (i.e. been at a negative energy balance) if they were consuming solely dragonfly larvae or snails. Thus, if a sufficient number of energy-rich food items like tadpoles were unavailable on the pairȇs territory during incubation, they might have been at a negative energy balance (i.e. relied on fat reserves) if they had not foraged in corn fields.

Despite the relationship between corn fields and positive energy balance for the focal pair of Whooping Cranes in this study, not all nesting cranes in the EMP use this habitat. Six additional pairs of Whooping Cranes were radio-tracked regularly in 2011 as part of a study of Whooping Crane habitat use. Of the four pairs that laid eggs, none used corn fields before a first nesting attempt or during incubation.

Variation in use of corn fields may indicate variation in strategies of energy storage and use among Whooping Crane pairs in the Wisconsin population. If the energy expenditure and wetland foraging strategies of pairs that do not use corn fields are similar to those of the focal pair of Whooping Cranes in this study, and if sufficient numbers of energy-rich food items (e.g. tadpoles) are not available in wetland territories, then pairs that do not use corn fields during incubation may be at a negative energy balance (and thus rely on fat reserves) during incubation. Given the overall positive energy balance that can be achieved by using corn fields during incubation, variation in use of corn fields among pairs (assuming equal access by all pairs to corn fields) suggests that there may be costs to use of corn fields by off-nest birds, such as reduced territory defense, cost of flying between territory and field or ingestion of agricultural pesticides.

Given the possible costs of foraging in corn fields during incubation, two factors may influence Whooping Crane foraging strategies (corn field use) during incubation: (1) food available on territory and (2) size of fat reserves remaining after spring migration and egg formation. If sufficient numbers of energy-rich food items (e.g. tadpoles) are available on a territory during incubation, cranes may not need to leave the territory to forage in corn fields. However, if a territory contains insufficient numbers of energy-rich food items available during incubation, cranes face a choice between two energetic strategies: rely on fat reserves to support energy expenditure during incubation or forage in corn fields, which are currently only available outside of known Whooping Crane territories. The amount of fat reserves that cranes have stored may influence this decision. In particular, cranes that do not have sufficient fat reserves to support their energy expenditure on territory may need to use corn fields to avoid starvation during incubation or to avoid abandoning otherwise viable nests.

Consequently, the amount of fat reserves carried by Whooping Cranes to the breeding grounds may influence nest success. If birds arrive on breeding grounds with insufficient stores of fat, and require those fat reserves to maintain nest constancy or vigilance, foods found within wetland territories might limit incubation behavior and ultimately nest success. Birds may abandon nests in order to achieve increased foraging time, or they may incur non-energetic costs of flight to corn fields (e.g. reduced nest vigilance or ingestion of agricultural pesticides).

Of the four pairs of radio-tracked Whooping Cranes that laid eggs in 2011 and did not forage in corn fields before a first nesting attempt or during incubation, three pairs laid viable eggs but abandoned their nests prior to hatch. One pair (12-02 and 19-04) incubated a nest for more than 30 days but their eggs were infertile. It is possible that these nests failed because parents did not have sufficient fat reserves to maintain nest constancy and vigilance.

At a larger geographic scale, variation in strategies of energy storage and use may exist between the EMP and the AWBP. There are no agricultural fields near Whooping Crane territories in WBNP, and the greater food availability near NNWR early in the breeding season may allow EMP birds to use an income breeding strategy, despite the similar energy expenditures by EMP and AWBP cranes upon arrival to the breeding grounds.

In summary, Whooping Cranes may be in negative energy balance prior to egg-laying, depending on what types of food are available in wetlands and whether females must forage for substantial amounts of other nutrients, such as calcium. Different pairs appear to manage their energy balance differently during incubation. Some birds, such as the focal pair in this study, use corn fields to maintain positive energy balance, despite possible costs. Other pairs may be at a negative energy balance, again depending on types of food available in wetlands. Additional research on Whooping Crane diet, including improved sampling of food items available in NNWR wetlands throughout the breeding season and further attempts to identify foods being consumed, would allow for more precise modeling of Whooping Crane energy balance.

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Table 1. Non-allometric endotherm model input parameters for Whooping Cranes.

Variable	Input value	Source
Fat mass as percent body mass	5	Estimate (birds assumed lean)
Decimal percent area contracting substrate	0.01	Estimate
Animal density (kg/m^3)	633.3	Unpublished lab data from newly dead birds
Basal metabolic rate (W)	12.75 (female) 12.91 (male)	From Aschoff and Pohlôs (1970) allometric equation for resting basal metabolic rate of non-passerine birds
Decimal percent variance	0.05	Chosen to trigger thermoregulation without

from metabolic rate to trigger thermoregulation		creating infinite loop
Core temperature (°C)	40.7	(Olsen *et al.* 1996)
Max. core temperature (°C)	43	(Tieleman and Williams 1999)
Min. core temperature (°C)	37	(Porter *et al.* 2006)
Difference between expired air temperature and ambient air temperature	0.1	Estimate
Percent skin wet	2	Estimate
Thermal conductivity of flesh	0.5	(Cheng and Plewes 2002)
Maximum O_2 extraction efficiency (%)	31	(Hainsworth 1981)
Minimum O_2 extraction efficiency (%)	25	(Arens and Cooper 2005)
Fecal water content (decimal percent)	0.1	Estimate
Urea in urine (decimal percent)	0.2	Estimate

Table 2. Allometric endotherm model input parameters for Whooping Cranes. Measured values were measured on two adult captive Whooping Cranes (one male and one female) at the International Crane Foundation, Baraboo, WI, unless noted otherwise. Solar reflectivities of molted Whooping Crane feathers and live captive Whooping Cranes were measured using an ASD portable spectroreflectometer (spectral range = 350-2500 nm). Abbreviations: d = dorsal, v = ventral.

Variable	female	Male	Source
Mass (kg)	5.7	5.8	Measured
Head diameter (cm)	6.1	6.3	Measured
Head length (cm)	24.9	25.6	Measured
Head feather depth, d (mm)	2.5	2.5	Estimate
Head feather depth, v (mm)	2.5	2.5	Estimate
Head feather length, d (mm)	25	25	From Siberian Crane data (Ilyashenko and Chernova 2008)
Head feather length, v (mm)	25	25	From Siberian Crane data (Ilyashenko and Chernova 2008)
Head feather diameter, d (um)	18.75	18.75	Measured on plastic-embedded ostrich feather
Head feather diameter, v (um)	18.75	18.75	Measured on plastic-embedded ostrich feather
Head feather density, d(1/cm2)	14400	14400	Measured on plastic-embedded ostrich feather
Head feather density,	14400	14400	Measured on plastic-embedded ostrich feather

v(1/cm2)			
Neck diameter, front-back (cm)	4.4	3.7	Measured(including feathers)
Neck diameter, left-right (cm)	4.4	3.7	Measured (including feathers)
Neck length (cm)	43.4	46.5	Measured (including feathers)
Neck feather depth, front (mm)	7.5	7.5	Estimate
Neck feather depth, back (mm)	7.5	7.5	Estimate
Neck feather diameter, d (um)	18.75	18.75	Measured on plastic-embedded ostrich feather
Neck feather diameter, v (um)	18.75	18.75	Measured on plastic-embedded ostrich feather
Neck feather density , front (1/cm2)	14400	14400	Measured on plastic-embedded ostrich feather
Neck feather density, back(1/cm2)	14400	14400	Measured on plastic-embedded ostrich feather
Torso diameter, vertical (cm)	22.8	23.3	Measured (including feathers)
Torso diameter, horizontal (cm)	22.8	23.3	Measured (including feathers)
Torso length (cm)	37	41.5	Measured (including feathers)
Torso feather depth, d (mm)	10	7	Measured
Torso feather depth, v (mm)	20	20	Measured
Torso feather length, d(mm)	91	118	Measured
Torso feather length, v (mm)	93	88	Measured
Torso feather diameter, d (um)	18.75	18.75	Measured on plastic-embedded ostrich feather
Torso feather diameter, v (um)	18.75	18.75	Measured on plastic-embedded ostrich feather
Torso feather density (1/cm^2)	14400	14400	Measured on plastic-embedded ostrich feather
Torso feather density (1/cm^2)	14400	14400	Measured on plastic-embedded ostrich feather
Bare leg diameter (cm)	1.66	1.8	Measured
Total leg length (cm)	58.9	58.6	Measured
All leg feather properties	0	0	Whooping Crane legs are not feathered

Table 3. Energy costs assigned to observed Whooping Crane behaviors. Abbreviations: x BMR = multiple of basal metabolic rate.

Behavior	Cost (x BMR)	Source
Foraging (food capture and consumption only)	1.95	(Goldstein 1988; Chavez-Ramirez 1996)
Walking	2	(Bamford and Maloiy 1980; Chavez-Ramirez 1996)
Flight	11	(Goldstein 1988; Chavez-Ramirez 1996)
Resting	1	Estimate
Comfort movements (preening, head shakes, etc.)	1.95	(Goldstein 1988; Chavez-Ramirez 1996)
Unison call	1.15	(Horn *et al.* 1995)
Nest building/egg-rolling	1.95	Estimate (same as comfort)
Brooding chick	1	Estimate (same as resting)
Provisioning for chick	1.95	Estimate (same as foraging)

Table 4. Compositions of food types used in Whooping Crane energy expenditure simulations.

	Wet mass	% Dry mass				
Species	Dry mass	Protein	Lipid	Carbohydrate	MEC	Wet weight (g)
Corn	84.7[1]	10.6[2]	3.6[2]	81.6[2]	0.84[3]	0.35[4]
Aerial insect, e.g. dragonfly	27.5[5]	59.5[5]	15.5[5]	7.2[5]	0.77[6]	0.9[7]
Tuber, e.g. Sago pondweed (*Potamogeton pectinatus*)	30.0[8]	13.1[9]	1.0[10]	74.9[11]	0.56[12]	1[13]
Snail, e.g. Planorbidae spp.	53.8[12]	12.2[13]	1.1[13]	0.9[13]	0.75[14]	0.145[15]
Aquatic insect, e.g. dragonfly larvae	27.5[5]	59.5[5]	15.5[5]	7.2[5]	0.77[6]	0.84[16]
Tadpole, e.g. Green frog (*Rana clamitans*)	17.6[17]	34.4	31.4	14.3	0.75	8

Footnotes:

[1] (Baldassarre *et al.* 1983)

[2] Average value for wild-type corn from (Sidhu *et al.* 2000)

[3] Average value for six non-passerine species (Karasov 1990)

[4] Calculated using percent moisture and an intermediate value of dry mass in (Hashemi *et al.* 2005)

[5] From (Bell 1990)

[6] Value for birds consuming arthropods from (Karasov 1990)

[7] Estimate based on values in (Clarke *et al.* 1996)

[8] (Kantrud 1990)

[9] Average values from (Anderson and Low 1976)

[10] Average value for birds eating bulbs and rhizomes (Karasov 1990)

[11] Intermediate weight from (Kantrud 1990)

[12] Average value for Planorbidae spp. in (Cummins and Wuycheck 1971)

[13] (Reinecke and Owen 1980)

[14] Value for Whooping Cranes consuming Rangia clam (Nelson *et al.* 1996); used as MEC for Periwinkle Snails in (Greer 2010)

[15] From length-weight regression for *Helisoma trivolvis*, for an intermediate size (15-mm) *Helisoma* snail

[16] From length-weight regression in (Benke *et al.* 1999) for 40-mm Odonata larvae

[17] Values for bullfrog tadpole from (Dierenfeld *et al.* 2002). % carbohydrates calculated as 100% dry matter ï (% protein + percent fat + percent ash)

[18] Estimate

[19] Average value for birds consuming vertebrates from (Karasov 1990)

Table 5. Estimated energy balance of Whooping Cranes throughout the 2011 breeding season at Necedah National Wildlife Refuge. Two potential diets based on observations of foraging cranes are shown for each month/stage of the breeding season. One diet assumes that the proportion of food items consumed through low jabs in wetlands are snails (low energy per food item), and the other assumes that this proportion is tadpoles (high energy per food item). All diets assume that probes in wetlands represent consumption of plant tubers, low jabs and probes in corn fields represent waste corn consumption, and high jabs in any habitat represent consumption of aerial insects. Fat storage and use is calculated assuming that production efficiency is 75% and that fat releases 90% of its energy when burned (Krapu *et al.* 1985).

Time of year	Diet	Estimated energy in (kJ/day)	Modeled energy out (kJ/day)	Energy in ï Energy out (kJ/day)	Fat stored (g/day)	Fat burned (g/day)
Before eggs laid (April)	JL = snail	529.9	1387.4	-857.5	0	19.6
	JL = tadpole	9849.6		8462.2	161.4	0
Incubation (April)	JL = snail	2876.5	1593.8	1282.7	24.5	0
	JL = tadpole	26650.1		25056.3	477.8	0
Incubation (May)	JL = snail	3319.0	1612.0	1707.0	32.6	0
	JL = tadpole	30750.2		29138.1	555.6	0
Chick-rearing (May)	JL = snail	909.5	1729.1	-819.6	0	18.8
	JL = tadpole	3690.8		1961.7	37.4	0
Chick-rearing (June)	JL = snail	909.5	1667.6	-758.1	0	17.3
	JL = tadpole	3690.8		2023.2	38.6	0
Incubation, habitat use restricted to wetlands (April)	JL = snail	461.6	1507.2	-1045.6	0	23.9
	JL = tadpole	7741.5		6234.3	118.9	0
Incubation, habitat use restricted to wetlands (May)	JL = snail	532.6	1437.1	-904.5	0	20.7
	JL = tadpole	8932.5		7495.4	142.9	0

Literature Cited for Tables:

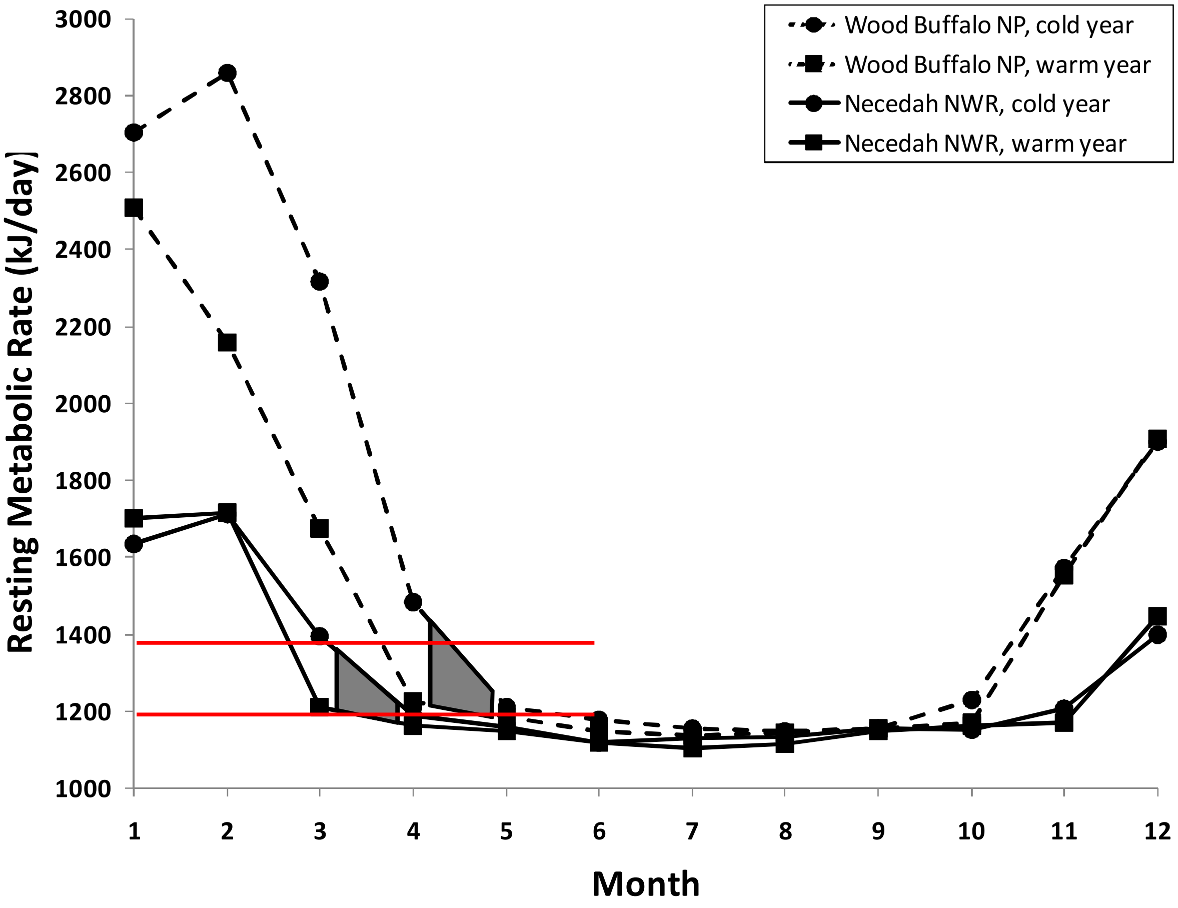

Figure 1. Modeled resting metabolic rate of a Whooping Crane at Wood Buffalo National Park and Necedah National Wildlife Refuge throughout the year under a range of climate conditions experienced at each location. Gray boxes highlight the range of metabolic rates experienced at each location during usual time of spring arrival to the breeding grounds. Red lines show the range of overlap in resting metabolic rates between Whooping Cranes at the two locations.

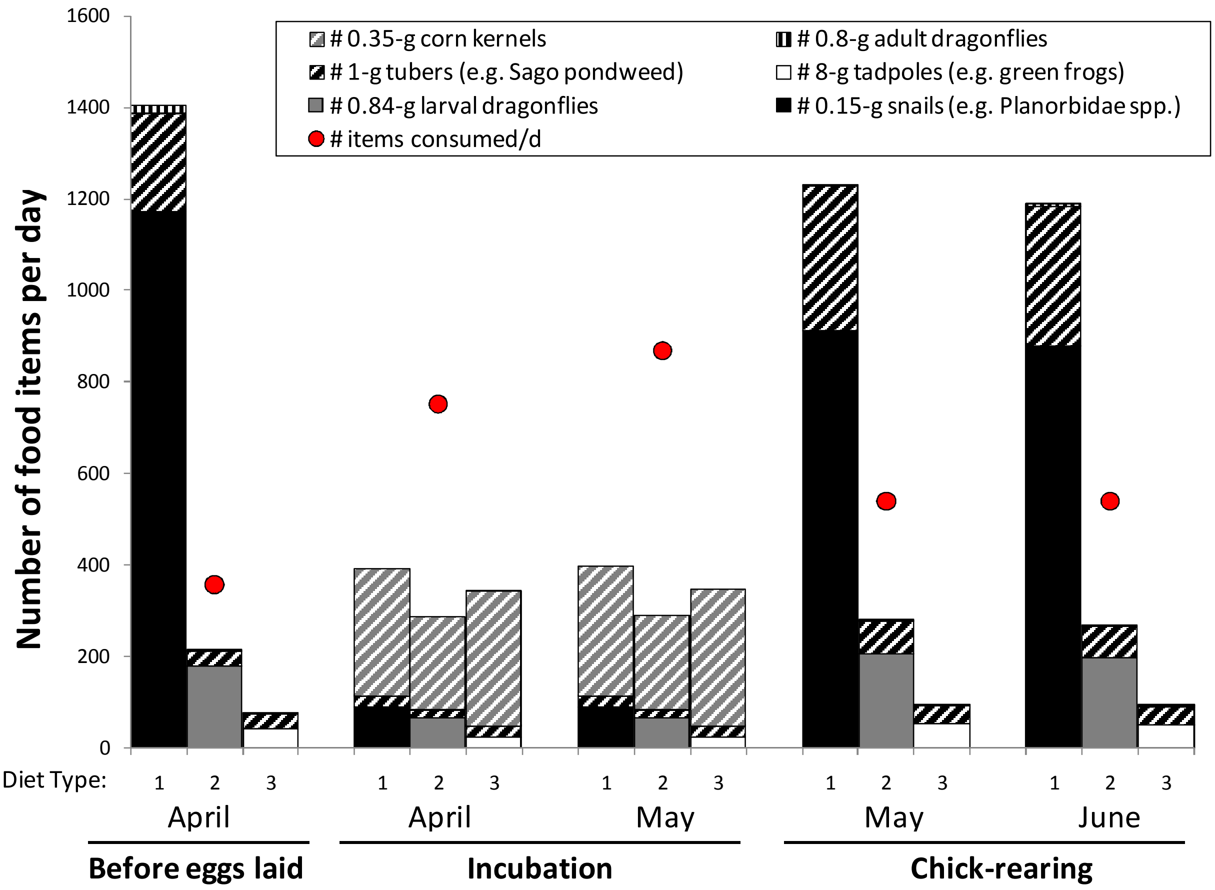

Figure 2. Modeled number of food items required per day to maintain neutral energy balance for a Whooping Crane in Necedah National Wildlife refuge throughout the breeding season. Bars are shaded to show proportions of different food types in three potential diets, based on observed proportions of food items caught in different habitat with various food capture behaviors. Red dots represent estimated number of food items actually consumed per day based on observations.

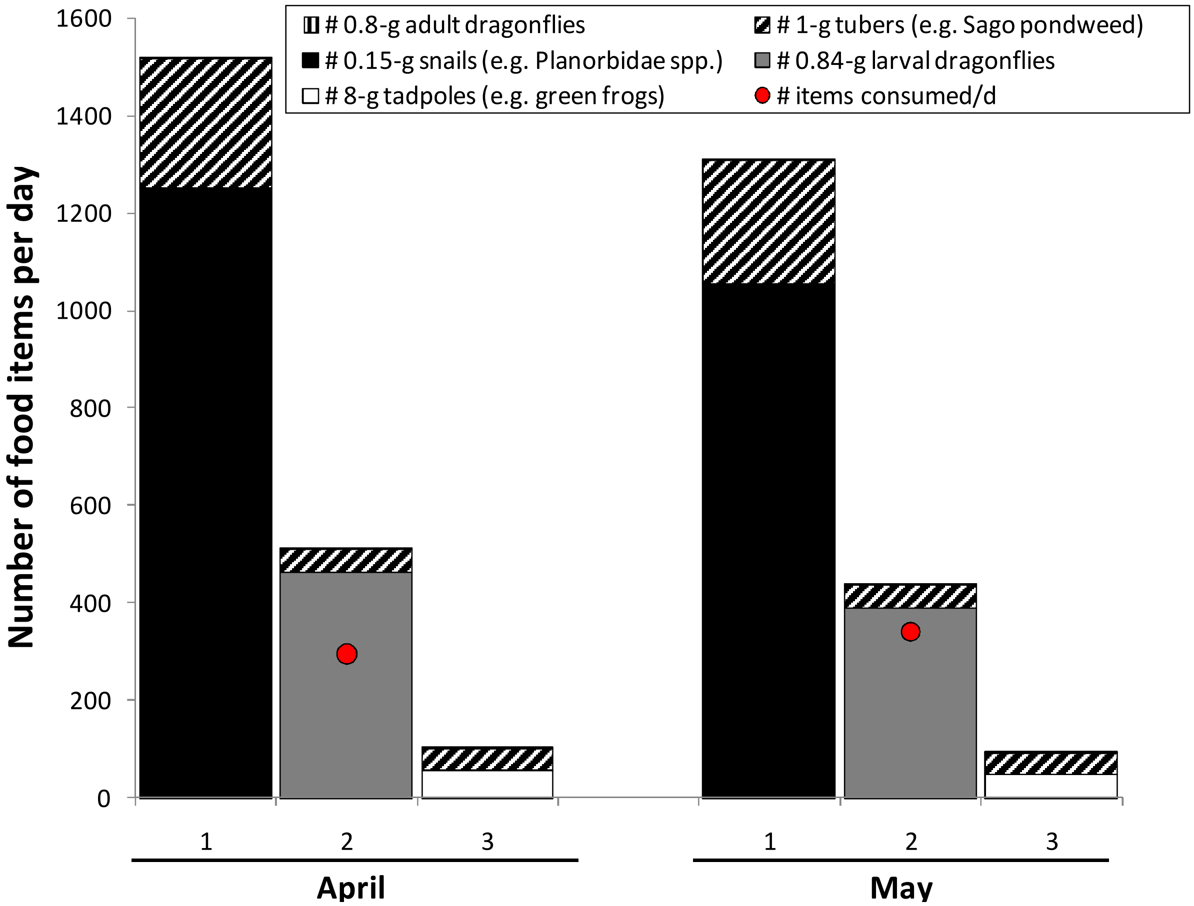

Figure 3. Modeled number of food items required per day to maintain neutral energy balance for a Whooping Crane during an incubation period in which all time is spent in wetland habitat at Necedah National Wildlife Refuge. Bars are shaded to show proportions of different food types in three potential diets, based on observed proportions of food items caught in wetland habitat with various food capture behaviors. Red dots represent estimated number of food items that could actually be consumed per day based on observed foraging rates of Whooping Cranes in wetlands.

Whooping Crane Winter Habitat Use and Incubation Length: Is There A Relationship?

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Introduction

Releases of Whooping Cranes into the Eastern Migratory Population began in 2001 in an effort to create a second self-sustaining population in North America. In 2005, the first nests of the Eastern Migratory Population were established on Necedah National Wildlife Refuge in Wisconsin. Over the years however, a pattern of nest abandonments has developed, and to date, only three wild-hatched chicks survive in the population. An effort to identify and study possible reasons for these nest abandonments has intensified over the last few years.

One hypothesized cause has to do with the energetics of the breeding pairs upon arrival at their breeding grounds in the spring. The following analysis was conducted in an attempt to understand if the types of habitats used by Whooping Crane pairs in winter have an effect on the length of incubation period for initial nesting attempts the following spring. The hypothesis of interest is that lack of good wintering habitats are keeping Whooping Cranes from incubating full term by reducing fat reserves acquired on winter habitats.

Methods

Three analyses were conducted on data covering the winter of 2004/2005 through the winter of 2010/2011. The first nests of Whooping Cranes in the Eastern Migratory Population were established in spring, 2005, with nesting occurring each subsequent spring. The first analysis included all data on habitat use collected from the winters of 2004/2005 through 2008/2009 as well as all incubation lengths for each following spring. Winter data in this dataset consisted of both visual observations and triangulations. The second analysis covered only the winter of 2009/2010 and the incubation lengths during the 2010 nesting season. The third analysis covered the winter of 2010/2011 and the incubation lengths during the 2011 season. Only visual observation data were used to compile the dataset for the last two analyses described above.

Three analyses were conducted due to the increased number of samples in the later years. Additionally, an analysis had previously been completed examining the time period between the winters of 2004/2005 and 2008/2009 where all years were grouped together. This analysis was updated and rerun in the original grouping (all years together) so it could be compared to the previous study covering this time period.

Winter locations were collected for each pair of Whooping Cranes and then applied for birds who nested the following spring. Number of locations per pair was mainly dependent on location of field staff or volunteers in the area but the data collection method was consistent through all years. So while data collection methods (i.e. ad hoc locations of birds in winter) remained equal for all birds, the amount of effort to collect data varied by pair. Each data point of each pair had a corresponding coordinate associated with it. Location points were used to determine habitat types which were derived from the 2001 National Land Cover Dataset. Incubation lengths for each nesting season were also collected for each pair and were based on visual observations or interpretation of telemetry signals.

Nest initiation varied between pairs throughout the years, however variation was more pronounced during the nesting seasons of 2010 and 2011 due to the larger number of nesting pairs in the population. Because some pairs did not initiate a nest until after being back on their summering territory for an extended length of time (over a month), late first season nests were not included to help reduce the effect of spring habitat selection in the analysis. To determine which nests to exclude, each nest initiation date was converted to Julian Days. The median start date of the nests was calculated as well as the standard deviation. Only nests that fell within two standard deviations from the median date were included in the analysis. This method excluded two nests, both from the 2010 dataset.

Incubation lengths of Whooping Cranes were analyzed considering the pair as one entity because their locations were not independent. Wintering information was collected by individual because a couple of pairs did not form until after completing spring migration. For each analysis (as described above) cluster analysis was used to group crane pairs based on their habitat selection. Ward's method of hierarchical clustering was used with relative Euclidean distance. Mean incubation times of habitat groups were compared using one-way ANOVA.

Results

A. Winter 2004/2005 ï winter 2008/2009 data analysis

Results of cluster analysis showed three groups explained about 50% of the data (Figures 1, 2).

Group 1 includes eight pairs. These pairs were seen mostly in herbaceous emergent wetland and woody wetland habitats. This group is named WETLAND

Group 2 includes four pairs. These cranes were seen mostly in open water and developed open habitats. This group is named OPEN WATER.

Group 3 includes seven pairs. These cranes were seen most often in pasture and to some extent emergent wetland habitat. This group is named PASTURE.

Mean incubation lengths per group were calculated during the five nesting seasons covered under the dataset (Table 1). Statistical comparison by one-way ANOVA showed no significant difference in mean incubation times among groups ($p = 0.31$).

B. Winter 2009/2010 data analysis

Results of cluster analysis showed three groups explained about 60% of the data (Figures 2, 3).

Group 1 includes three pairs. These pairs wintered mostly on hay/pasture and open water habitats. This group is named PASTURE.

Group 2 includes two pairs. These pairs wintered mostly on crop land. This group is named CROPS.

Group 3 includes four pairs. These pairs wintered mostly on wetland habitats. This group is named WETLAND.
Mean incubation lengths per group were calculated for the 2010 nesting season (Table 2). Statistical comparison by one-way ANOVA showed no significant difference in mean incubation times among the three groups ($p = 0.547$).

C. Winter 2010/2011 data analysis

Results of cluster analysis showed three groups explained about 60% of the data (Figures 3, 4).

Group 1 includes eight pairs. These pairs were seen mostly in herbaceous emergent wetlands and some in herbaceous habitats. This group is named WETLAND.

Group 2 includes six pairs. These pairs were seen mostly in crop land and open water. This Group is named CROPS.

Group 3 includes four pairs. These cranes were seen in a wide range of habitats but most often in pasture and woody wetlands. This group is named PASTURE.

Mean incubation lengths per group were calculated for the 2011 nesting season (Table 3). Statistical comparison by one-way ANOVA showed no significant difference in mean incubation times among groups ($p = 0.25$).

Discussion & Conclusions

Based on the results, the hypothesis that reproductive effort would be related to the energetic quality of winter habitats was rejected. Statistical analysis shows that incubation effort for initial nesting attempts during a breeding season is not affected by the selected habitats of Whooping Crane pairs during the previous winter.

These results may be explained in a couple of different ways. Since the Whooping Cranes of the Eastern Migratory Population do not breed as far north as conspecifics in the Aransas-Wood Buffalo Population, extensive body fat reserves may not be needed for the nesting season in this population. Additionally, there may be enough food already present on the breeding grounds when the cranes arrive that can adequately supply the required energy for nesting. Migration stopover locations may also play a role as pairs may leave their wintering territory and spend nearly a month at one stopover location before arriving back on the breeding grounds.

Improvements can be made to this analysis for more accurate results. Data used for the first analysis (Results: A) are incomplete. Pairs were excluded for various reasons. This data was pulled from a previous analysis and should be re-worked and double checked for accuracy.

The 2001 National Land Cover Dataset is out of date. In order to obtain the most accurate results possible, habitat information collected in the field should be substituted for habitats derived from the National Land Cover Data.

All three analyses can be combined into one. This would provide a larger sample size for better analysis and results.

More data points would be available for analysis if triangulations were used for all years as opposed to just the first section of data.

As previously mentioned, number of sightings per pair relied heavily on location of field staff or volunteers. For a more structured analysis, pairs can be monitored evenly and/or more frequently throughout the winter months.

This first effort at studying the linkage between winter habitat and reproductive effort in the EMP is at a very coarse level. Improvements to this study can be made through more focused habitat use sampling in winter. Other investigations into the nest abandonment issue must also continue.

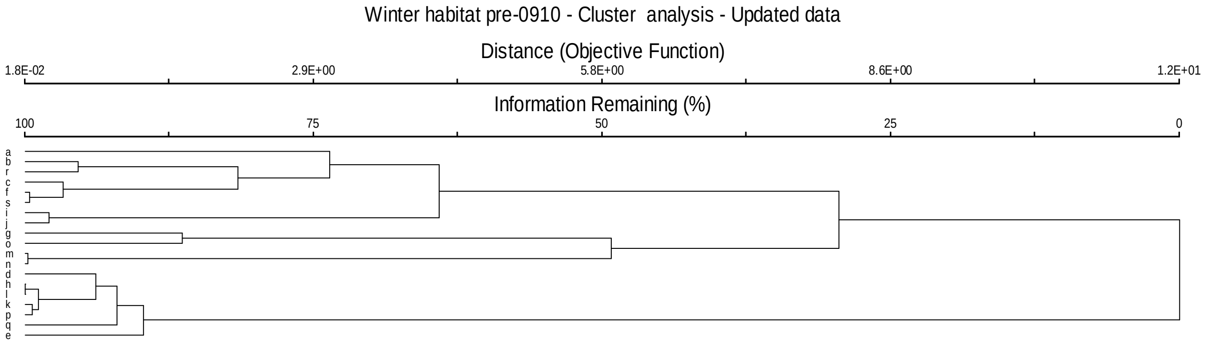

Figure 1: Cluster dendrogram grouping selected habitats of Whooping Cranes in the Eastern Migratory Population, winters 2004/2005 to 2008/2009

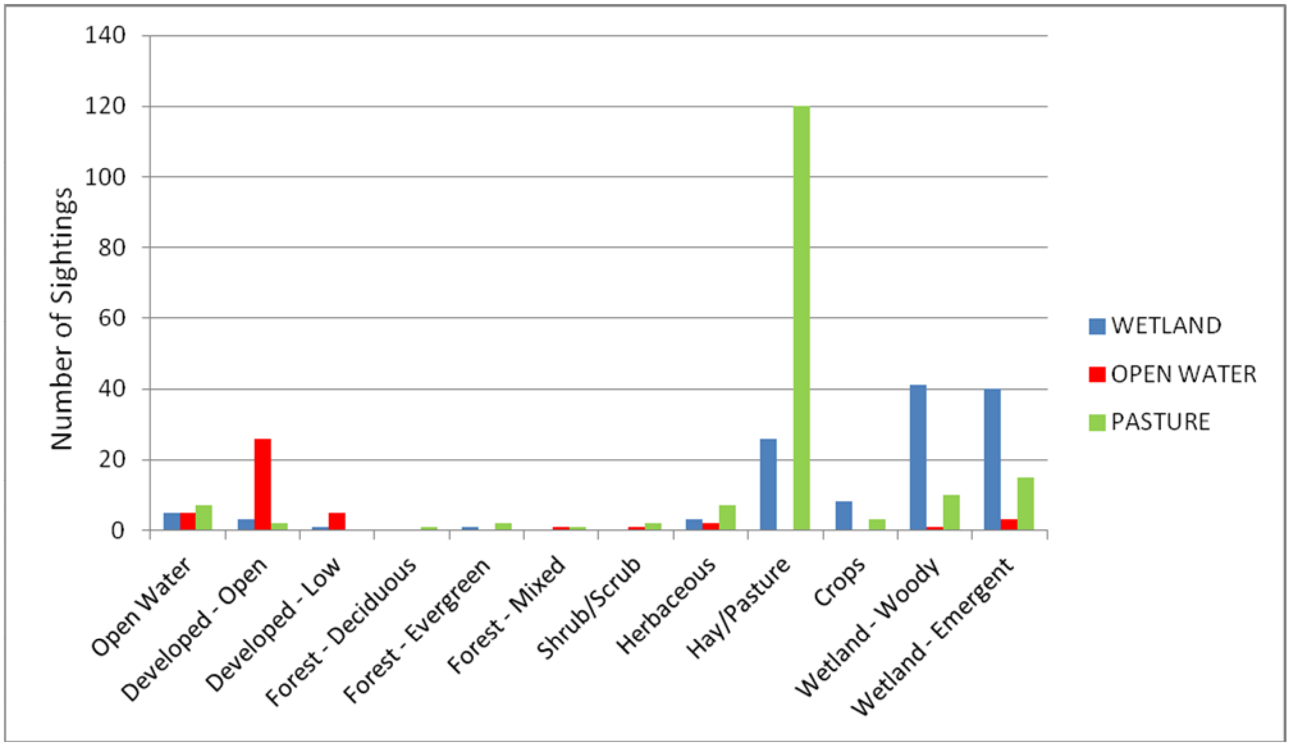

Figure 2: Number of Whooping Cranes sightings in each habitat type per habitat group, winters 2004/2005 to 2008/2009

	Mean incubation time (days)	Min	Max	Med
Wetland	10.4	0	26	8
Open Water	18.3	5	30	19
Pasture	9.4	1	22	10

Table 1: Mean incubation times of Whooping Cranes per winter habitat group, springs 2005-2009

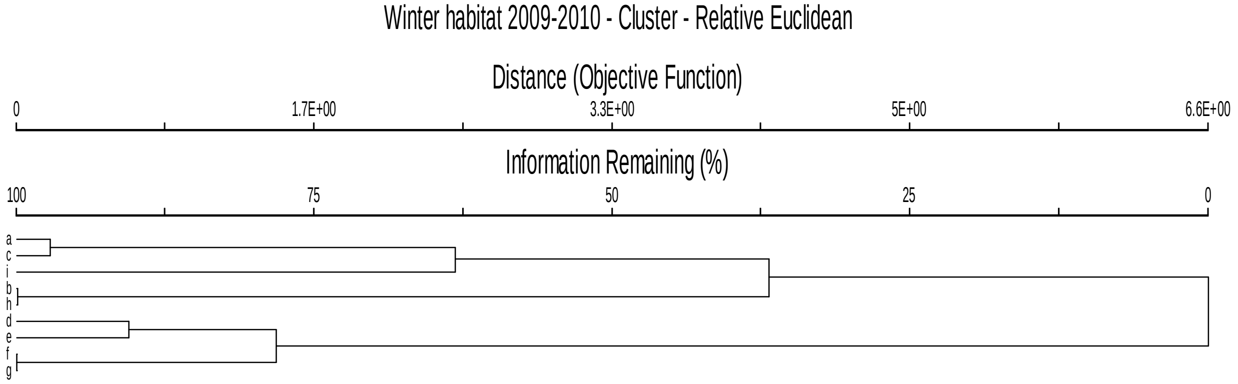

Figure 3: Cluster dendrogram grouping selected habitats of Whooping Cranes in the Eastern Migratory Population, winter 2009-2010

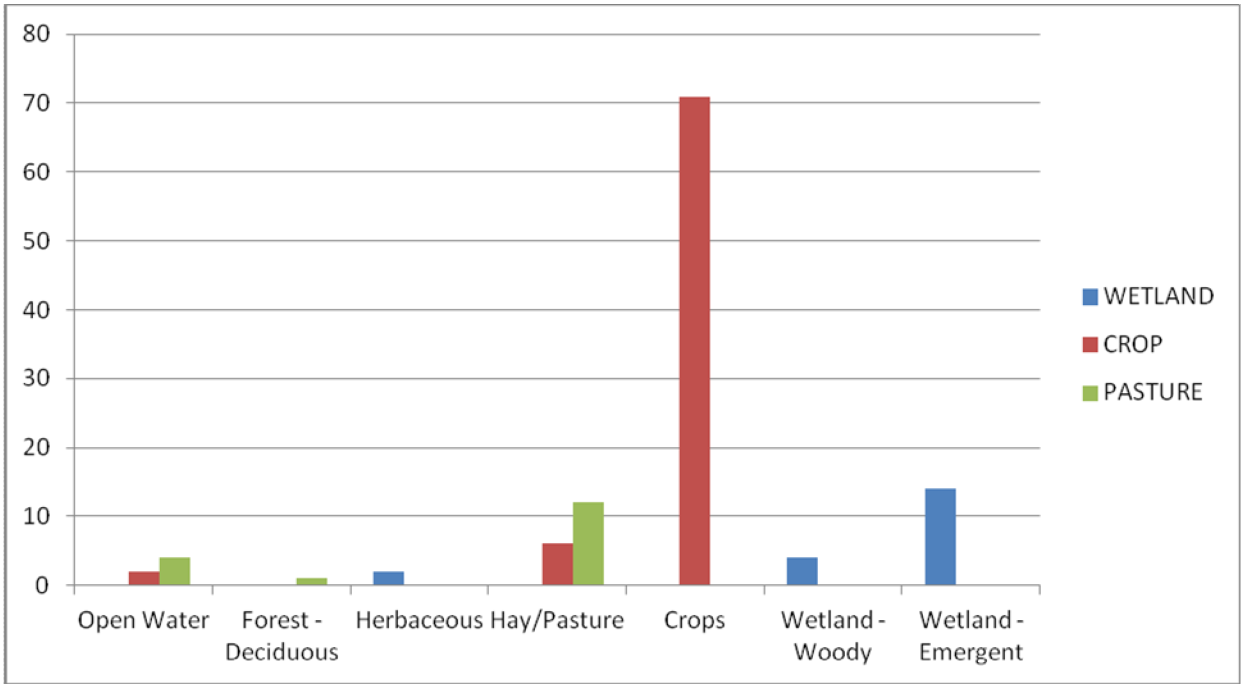

Figure 4: Number of Whooping Cranes sightings in each habitat type per habitat group, winter of 2009-2010.

	Mean incubation time (days)	Min	Max	Med
Pasture	16.3	5	38	6
Crops	8.5	8	9	8.5
Wetland	7	5	9	7

Table 2: Mean incubation time of Whooping Cranes per winter habitat group, spring 2010

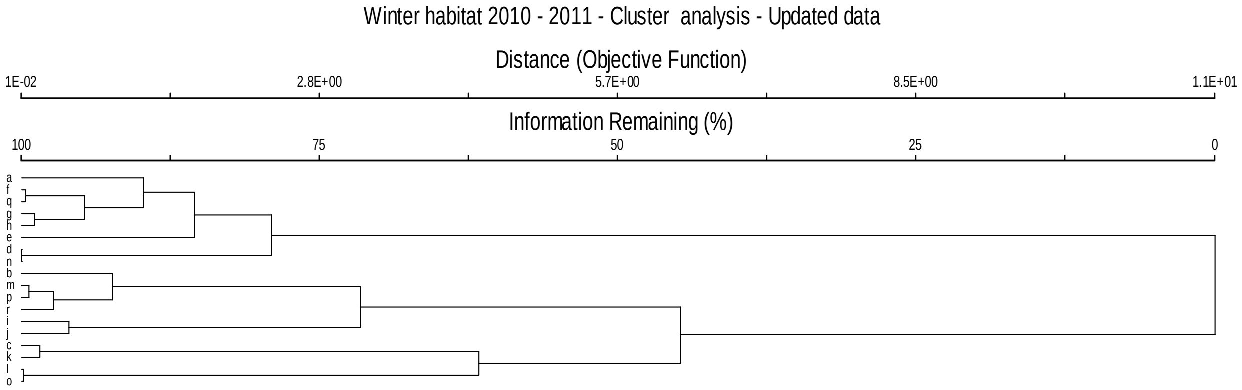

Figure 5: Cluster dendrogram grouping winter habitats of Whooping Cranes in the Eastern Migratory Population, winter of 2010/2011

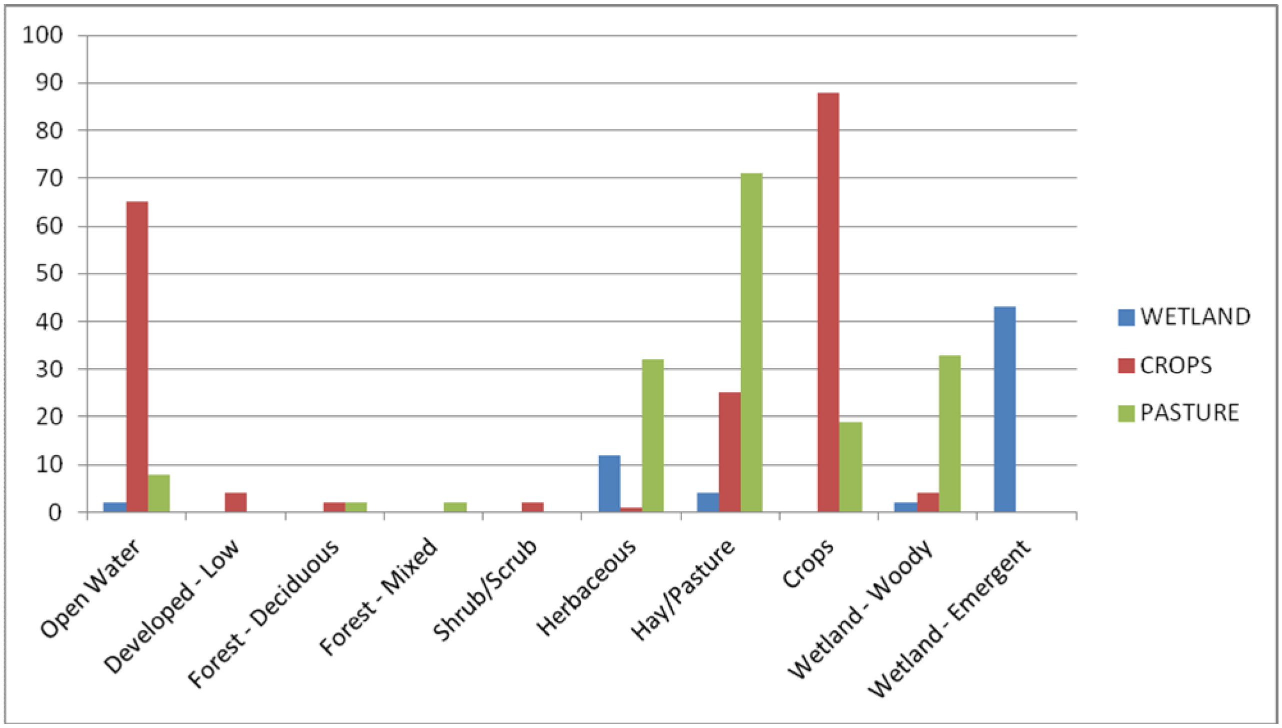

Figure 6: Number of Whooping Cranes sightings in each habitat type per habitat group, winter 2010/2011

	Mean incubation time (days)	Min	Max	Med
Wetland	22.3	2	32	25
Crops	24.2	13	30	26.5
Pasture	14.5	3	23	16

Table 3: Mean incubation time of Whooping Cranes per winter habitat group, spring 2011

THEME 5: Research and Science Team – Research Priorities, 2012 and Beyond

Jeb Barzen, International Crane Foundation and Scott Hull, Wisconsin Department of Natural Resources

On March 5th, 2009, WCEP adopted the establishment of a self-sustaining migratory flock of Whooping Cranes in Eastern North America as its fundamental objective. A self-sustaining population has been identified as one that requires no further reintroductions and requires only minimal management. This objective will be met when there is no more than an acceptably small probability that, in the absence of additional releases, the population will become extinct over a mutually-acceptable number of years (e.g., 50-100), based on the results of an appropriate population viability analysis (WCEP 2009). This fundamental objective was reaffirmed in 2010 as part of the WCEP 5-year strategic plan (WCEP 2010).

In efforts to reach this objective, the Research and Science team has focused our efforts on near-term reproductive success at or near the Necedah National Wildlife Refuge. Low reproductive success and uncertainties about nesting ecology and fledging success at Necedah have been identified as major challenges in the WCEP external review and in the 5-year strategic plan. However, as discussed in the external review, it is imperative that the research plan does not focus exclusively on the Necedah nesting ecology issues but rather takes a broader look at other issues such as comparative reproductive success among different rearing and release techniques or evaluation of new release sites (e.g. Schmidt et al. 2011).

Next Steps

These are short and long-term research projects aimed at informing either the fundamental WCEP objective (a self-sustaining population) or sub-objectives contained within the WCEP strategic plan, or address concerns raised by the external review. Some projects are WCEP-led efforts (e.g. contaminants) and others are primarily being led by WCEP partners (genetics) that will help answer questions pertaining to the fundamental objective of a self sustaining population. Other potential projects and/or research needs are discussed below; there will be further evaluation and some may be identified as research priorities later in this process.

Contaminants ï Preliminary evaluation of exposure and risk assessment for selected contaminants in EMP whooping cranes

Primary project lead: Sarah Warner (USFWS) and Julie Langenberg (ICF)

The USFWS Wisconsin Ecological Services Office and proposal collaborators identify pollutant exposure as an important data gap in assessing the reproductive health of Whooping Cranes. Therefore we propose a preliminary investigation of contaminants in eggs and livers of individuals in the EMP. Analytical data produced from this initial screening will provide information to begin assessing the risk of contaminants to Whooping Cranes where current species-related data is insufficient. The results of this screening assessment will help refine the development of a more comprehensive contaminant analysis on a larger landscape scale if preliminary data suggest this is warranted. Exposure to contaminants such as heavy metals,

pesticides, and PCBs, sometimes at low-level concentrations, has been linked to aberrant nesting behavior in birds, leading to reduced reproductive success.
Contaminant exposure to Whooping Cranes is most likely to occur via direct consumption of prey items and incidental ingestion in sediment/soil and water during normal foraging. Whooping Cranes in the EMP are susceptible to contaminant exposure throughout their annual cycle. On the breeding and wintering grounds, Whooping Cranes could be exposed to contaminants such as mercury, lead, pesticides, legacy organochlorines, and polybrominated diphenyl ethers . During migration, cranes stage in agricultural areas where they could be exposed to organochlorines, heavy metals, and PBDEs.

Genetics: Genome-wide methylation patterns in Whooping Cranes from WCEP and Wood Buffalo/Aransas.

Primary project lead: Mark Berres (UW-Madison) and Jeb Barzen (ICF)

In contrast to traits attributable to a purely genetic origin, many biological phenotypes are caused entirely or in part by environmental factors. For example, numerous chemicals, either naturally occurring or anthropogenic, can effect changes in the genome by altering the specific sequence of nucleotides. In some cases, these changes are known to initiate directly the onset of disease and many induced sequence alterations are permanently integrated into the germline. However, recent evidence suggests that environmental chemicals ï including those that are considered dietaryï are also capable of affecting the development and function of biological systems *without* altering the fundamental genomic composition of an individual. Although some of these epigenetic changes are known to induce visibly detectable changes in a specific phenotype, there is no *a priori* reason to expect phenotypic change to be seen in every case nor should all possible alternations be considered disadvantageous. The purpose of this research is to explore a new direction in epigenetic research that is applicable to conservation of Whooping Cranes. Accumulated evidence suggests that epigenetics has substantial potential for furthering our understanding of the molecular mechanisms of environmental toxicants, as well as for predicting risks to health due to variable conditions of environmental exposure and individual susceptibility. For example, Converseȏs finding in Theme 1 that the number of generations of ancestors in captivity is inversely related to daily nest survival could be explained by epigenetic (albeit negative) effects.

Epigenetics is defined as the study of mechanisms that alter gene expression and/or gene function without changing the underlying DNA sequence. Under exogenous influences, epigenetic pathways consist of flexible genomic parameters which have a capability to effect changes in genetic expression patterns. They may also provide a mechanism allowing for the stable propagation of influence from one generation of cells to the next. Thus, while each organism has but a single genome, the same individual may have multiple epigenomes, which might differ by cell and tissue type, each of which can change over the lifetime of the organism and may even be transmitted to the next generation.

<u>Rationale:</u> Because epigenetic changes are typically subtle, potentially cumulative and transgenerational, it is challenging to establish clear-cut causal relationships between environmental and/or dietary factors, the epigenetic change itself, and a potential response. Nevertheless, several recent investigations have established a relationship between exposure to

environmental (e.g. cadmium, Vinclozolin) and dietary (e.g. folate, methionine) chemicals and epigenetic modification. Albeit still sparse, available evidence supports the concept that epigenetics holds substantial potential for furthering our understanding of the molecular mechanisms of environmental toxicants, as well as for predicting health-related risks due to conditions of environmental exposure and individual susceptibility. The goal of the current research is to explore the possibility of epigenetic processes to explain differences in Whooping Crane breeding success. This approach would be the first of its kind in conservation efforts and could potentially revolutionize how genetics is used in species conservation and reintroduction efforts.

Experimental**:** Current technologies enable us to interrogate the methylation status of genetically uncharacterized genomes. Thus, the distribution of methylated sites can be determined in its entirety without need for a reference genome. Established bisulfite treatment protocols, third-generation high-throughput sequencing, and bioinformatic analyses will be applied to the genomes of multiple birds from the EMP and Aransas-Wood Buffalo (AWBP) populations. Despite an origin from the same founder stock, reproductive outputs between the two populations vary considerably. As all living Whooping Cranes descended from a population of 15-16 individuals (and a complete pedigree is known for birds in the EMP since founding of a captive population, ~3-4 generations ago), confounding effects of variable genetic background will be minimized. The source material required is only a few microliters of whole blood from each selected bird. We expect on average 35-50 Gb of sequence reads per sample yielding a depth of coverage (20 ï 30X) sufficient to achieve the statistical power needed to evaluate specific hypotheses regarding methylation differences within and between populations. Bioinformatic procedures are established and the computational resources are available in Berresô laboratory.

Population comparisons**:** As insufficient time has elapsed to substantially alter the genomic content of the EMP and WBA populations (the extent to which can also be ascertained with the same sequence data), epigenomic variation may be expected to result from differences in environmental conditions and/or different diets. The same may be true for captive populations. Drivers may include: 1. anthropogenic (or natural) contaminants in the soil, air, and water; 2. food sources; and 3. other physiological stressors such as disturbance or temperature. Examination of methylation patterns between Whooping Cranes from EMP and WBA is the obvious first comparison to evaluate both environmental and potentially dietary factors on variation in reproductive output. Many other analyses are possible and will be needed to establish specific effectors. Some effectors would include the effect of captivity, age structure, familial relatedness, and temporal comparisons.

Short-term plan**:** Initially, examination of one individual from EMP and AWBP should be sufficient to gauge if methylation patterns do indeed differ and to provide proof-of-protocol. The birds chosen should be adults of the same age and sex. Note that the initial sampling design reflects a purely exploratory effort which is also affected by funding limitations. However, if differences are discovered, we will have sufficient preliminary data to write a competitive grant proposal to expand the study to a reasonable level. *The initial two-sample comparison has very limited interpretive value.* However, if we establish that differences do exist, we can make a strong case warranting additional exploration, hence a more comprehensive experimental design.

Release techniques comparison and evaluation

The WCEP external review advocated: ñé *rigorous scientific comparisons of the behavioral ecology, survival, and reproductive success across existing and proposed rearing techniques (UL, DAR, PR) – over a period of at least seven years – to determine which technique results in the highest levels of whooping crane recruitment and successful reproduction."* UL=Ultralight, DAR=Direct Autumn Release, PR=Parent Reared.

The Research and Science Team is planning to convene in January, 2012 to begin discussions on this topic. Additional Wisconsin release sites at White River Marsh and Horicon National Wildlife Refuge will allow for a comparison of reproductive ecology across different rearing techniques and different environmental conditions.

Literature Cited

Hayes, M., J. Barzen and J. Austin. In prep. Whooping Crane Distribution and Habitat Use: Past, Present, and Future?

*Schmidt, N., J. Barzen, A. Lacy, and J.M. Engels. 2011. Habitat suitability analysis of east central Wisconsin for breeding Whooping Cranes (*Grus Americana*). Unpublished report to the Whooping Crane Eastern Partnership. International Crane Foundation, Baraboo, Wisconsin. 19 pp.*

ADMINISTRATION AND COMMUNICATIONS TEAM

Team members: Joan Garland, Chair, International Crane Foundation; Liz Condie, Operation Migration; Tom Mackenzie, U.S. Fish & Wildlife Service; Dan Peterson, Necedah NWR; Heather Ray, Operation Migration; Jenny Sauer, International Crane Foundation; Ashley Spratt, U.S. Fish & Wildlife Service; and Marilyn Whitehead, USGS Patuxent Wildlife Research Center.

The 11th year of whooping crane reintroductions by WCEP saw a continued successful effort by the Administration and Communications Team to provide internal communications support to WCEP teams, and lead external communications including outreach, education and media relations.

The team is responsible for and directs all aspects of external communications and public contact on behalf of the project. Comprising communications and education specialists representing WCEP founding members, the Administration and Communications Team remains essential to building support for the project through education, media relations and coordinated public outreach efforts. The team is also responsible for maintaining communications within WCEP, including facilitation of inter-team communication and dissemination of information within the partnership.

Administration and Communications Team Accomplishments for 2011

WCEP media releases/press statements

The Administration and Communications Team issued press releases and statements during project milestones, including:

- Departure of the ultralight-led and DAR fall migrations
- Arrival of the ultralight-led migration at St. Marks NWR and Chassahowitzka NWR (Dec. 2010 release)
- Hatching of chicks at Necedah NWR
- New release sites at Horicon NWR and White River Marsh State Wildlife Area
- WCEP five year strategic plan

The Administration and Communications Team worked with U.S. Fish and Wildlife Service (FWS) public affairs staff on the development of FWS press releases pertaining to the whooping crane shooting sentencing in Indiana and shootings in Alabama and Georgia.

Media coverage

Spikes in media coverage occurred at several points in 2011: following the sentencing of the youths in Indiana for shooting a whooping crane, the shootings in Alabama and Georgia, when the ultralight-led and DAR cranes departed on migration, the arrival of birds at wintering locations, the hatching of chicks at Necedah NWR, and the new release site locations. Major media outlets covering WCEP topics included the New York Times, the Wall Street Journal, the Associated Press, the Chicago Tribune, and the Milwaukee Journal Sentinel. Wire stories continued to enjoy extensive pick-up regionally and nationally. Approximately 375 WCEP-related media articles were generated in 2011.

New outreach opportunities
The addition of Horicon NWR and White River Marsh State Wildlife Area as new release sites provided WCEP with new audiences for media and education and offered opportunities to reinforce key messages about conservation and the WCEP partnership.

Environmental education
Education continues to be a key component of the Administration and Communications Teamôs efforts. The whooping crane reintroduction project has offered a strong opportunity to inform and motivate students along the flyway about cranes and wetland conservation. The migration of these birds highlights the dependence of cranes and other wildlife on wetlands along the migration route. Most of these wetlands are privately owned, so the decisions and conservation outlook of future generations are critical to the survival of these cranes.

The Administration and Communications Team delivered presentations throughout the year at partner organizations, schools, universities, conservation and birding clubs, professional conferences, birding festivals, civic organizations, and zoos. Outreach representatives distribute education materials, including brochures and curricula that help interpret crane migration, behavior and ecology.

Environmental education accomplishments in 2011 involved the continued partnership with Journey North to extend educational outreach efforts into schools throughout North America. Journey North is an internet-based education project that links students across North America to track wildlife migration and seasonal change, including WCEP cranesô status and general locations during the fall and spring migrations. Now in its 19th year, Journey North reaches more than 980,000 students at 45,000 sites and receives over a million page views a month during migrations. A Journey North app. allows people to report sightings and photos. Widely considered a best-practices model for education, Journey North is the nation's premiere "citizen science" project for children.

WCEP education and outreach programs:

Chassahowitzka NWR: Refuge staff continued to provide valuable educational programs on behalf of WCEP. Presentations reached over 150 people. IBEX Puppetry presented a whooping crane kite/puppet show during the Chassahowitzka Refuge Day celebration. Over 1,700 people attended the event (YouTube link of the presentation: http://www.youtube.com/watch?v=S7KnKiqh8dE).

Horicon NWR: Horicon NWR staff presented WCEP environmental education programs to 200 adults and children.

International Crane Foundation: Over 25,000 visitors to the International Crane Foundation received WCEP programs and information as part of their tour of the foundation. ICF staff provided WCEP education outreach programs and materials to over 9,000 people in six states, including Minnesota, Wisconsin, Nebraska, Illinois, Florida, and Texas.

Necedah NWR: A total of 523 people attended WCEP outreach activities on and off the refuge. Necedah NWR staff delivered onsite programs to 861 visitors.

Operation Migration: 231 people viewed ground-training exercises and ultralight flights during blind tours at the White River Marsh State Wildlife Area. Operation Migration staff and volunteers, in partnership with St. Marks NWR volunteers, presented programs to over 2,400 students and adults in four states along the migration route. The programs were presented in Illinois, Kentucky, Alabama, and Florida.

St. Marks NWR: In addition to programs presented in collaboration with Operation Migration (see above), refuge staff delivered programs to 126 people in local schools and at the refuge.

Ultralight flyover events

A crowd of around 1,500 supporters gathered to watch the cranes fly over the town of St. Marks, Florida. The arrival at Dunnellon, Florida attracted around 450 people. Staff and volunteers from the St. Marks and Chassahowitzka refuges coordinated the flyover events respectively. Approximately 800 people attended flyover events along the migration route.

Outreach festivals

WCEP participated in a number of regional and national outreach festivals in 2011, reaching over 15,000 people. Events attended included the Port Aransas Whooping Crane Festival, Texas; Bald Eagle Days, Wisconsin; Wisconsin Wetlands Association Annual Conference; Homosassa Seafood Festival, Florida; Sauk County Earth Day Festival, Wisconsin; Rivers and Wildlife Festival, Nebraska; Wisconsin State Fair; and the St. Marks NWR Wildlife Heritage and Outdoors Festival, Florida.

WCEP website and Facebook

The WCEP website (www.bringbackthecranes.org) and related partner websites continue to be effective and efficient means of communicating up-to-date information to large numbers of stakeholders, news media, students, and the general public. The WCEP Facebook page: www.facebook.com/WhoopingCraneEasternPartnership was launched in 2011. Social media sites provide WCEP with an additional tool to better reach new and existing audiences about the project and its partners.

Public service announcement

In response to the crane shootings in 2011, the Administration and Communications Team developed a public service announcement (PSA) to spread the word that disturbing, harassing or killing whooping cranes is a crime. The PSA was distributed to WCEP partners and media along the flyway. It is posted on YouTube, WCEP and partner websites and social media pages.

Letter to FWS Law Enforcement

WCEP received numerous calls and emails after the sentencing in the case of the whooping crane shooting in Indiana. In response to the public outcry for stiffer penalties in this case and future similar investigations, the Administration and Communications Team sent a letter to the U.S. Fish and Wildlife Service Office of Law Enforcement, requesting that they recommend to the court that various sentencing options be considered for any investigations involving the death of whooping cranes.

Hunter education

The Administration and Communications Team worked with state and federal partners in Tennessee and Kentucky to provide WCEP education outreach materials to assist hunters in identifying whooping cranes during the proposed sandhill crane hunting season in these states.

Landowner outreach regarding *Bti*

In collaboration with the WCEP Research and Science Team, the Administration and Communications Team developed and distributed a letter to Wisconsin landowners in the *Bti* treatment areas, informing them of the whooping crane nesting studies/monitoring and *Bti* study.

WCEP Wiki

To provide a transparent information sharing structure for the partnership, the Administration and Communications Team developed a WCEP intranet site (Wiki). The Wiki serves as a repository for WCEP information that is accessible to all members.