Wisconsin Whooping Crane Management Plan

December 6, 2006

P.O. Box 7921
Madison, WI 53707
PUBL-ER-650 06

Please join me in celebrating a conservation success story. The whooping crane, once one of the rarest birds on the planet, is edging back from the brink of extinction and Wisconsin is playing a key and innovative role.

Thanks to the effort and cooperation of public agencies, private organizations and individuals, the whooping crane is well on its way to a successful reintroduction in Wisconsin. For the first time, whooping cranes reintroduced into the wild are migrating along their ancestral path between the Midwest and Florida. Once again Wisconsin's beautiful landscapes of rivers and wetlands are the home of North America's tallest bird.

This is a time of celebration for all citizens of Wisconsin as we look forward to hearing the call of these magnificent birds, and observe them taking wing over our beautiful state.

Scott Hassett, Secretary
Wisconsin Department of Natural Resources

Cover Photo Credit:
Arielle Shanahan
USFWS

WISCONSIN WHOOPING CRANE MANAGEMENT PLAN
EXECUTIVE SUMMARY

The whooping crane *(Grus americana)* is one of two crane species native to North America, found in large, open wetland ecosystems. The only self-sustaining population of whooping cranes consists of less than 250 birds that breed in Canada and winter in Texas. Since 1999, Wisconsin has played a major role in efforts to restore a migratory whooping crane population in eastern North America, focused around a core breeding area in Wisconsin. There are now 85 wild whooping cranes (November 2006) in the restored Eastern Migratory Population from this effort, with plans for 20-30 birds to be added each year until the population becomes self-sustaining, perhaps by 2020. Already there are signs of success: spring 2006 marked the first Wisconsin hatched whooping cranes in over 100 years.

The United States Fish and Wildlife Service (USFWS) listed the whooping crane as threatened with extinction in 1967 and endangered in 1970. Canada designated the whooping crane as endangered in 1978. An International Whooping Crane Recovery Team (IWCRT) oversees recovery objectives and strategies.

The IWCRT charged members of the Whooping Crane Eastern Partnership (WCEP), a partnership with nine government and private sector organizations, with the mission of restoring a second self-sustaining migratory population. This management plan is intended to help achieve that mission and bring the whooping crane closer to delisting from the Federal List of Threatened and Endangered Species. The plan is designed for Wisconsin but many elements are applicable to crane management throughout the flyway.

For at least five more years, approximately 20-30 whooping crane chicks will be added annually to the Eastern Migratory Population. Chicks are supplied through captive breeding programs such as those at the USGS Patuxent Wildlife Research Center in Maryland and the International Crane Foundation in Wisconsin. The number of chicks available for the reintroduction program is limited by small facility capacity, staff funding, and weather-related events. Hopefully, as the population matures, additional chicks will result from successful nesting in Wisconsin's wetlands.

At five-year intervals (2011, 2016, etc.) a review of the whooping crane's population status and this plan should occur to identify opportunities, concerns, and support of whooping crane management. The body of this document may then be revised; the appendices may be more frequently revised and dated as needed. **To assure the sustainability of the population, the target 2020 interim goal is a MINIMUM population of 100 whooping cranes with 25 breeding pairs that regularly nest and fledge offspring**, in conjunction with the same target numbers for an introduced Florida non-migratory population**. If the Florida reintroduction effort is unsuccessful, the eastern migratory population minimum target becomes 120 whooping cranes with 30 breeding pairs that regularly nest and fledge offspring by 2020** (CWS & USFWS, 2006).

The Wisconsin Whooping Crane Management Plan is a guidance tool specific to released and wild-hatched cranes for use by those individuals and groups charged with maintaining habitat quality, assessing state population goals, monitoring and managing crane activities, addressing landowner needs, developing ecotourism opportunities, and educating the public. In this plan, management strategies and protocol recommendations have been developed to maintain a high level of protection and ensure future success of whooping cranes in Wisconsin, while considering the needs and interests of state citizens and communities.

By contributing to and applying information in this plan, WI DNR together with WCEP and the IWCRT will evaluate the reintroduction program and determine the level of success. Accordingly, the WI DNR Whooping Crane Coordinator confers monthly with other WCEP Project Direction Team members. Wisconsin DNR staff work with state citizens and federal and nongovernmental agencies to assess and manage habitat critical to the establishment and survival of a healthy population.

Whooping crane data are recorded, consistently formatted and used for the following:

1. Documenting bird location, health, behavior, habitat, and relocation needs
2. Analyzing pair formation and reproduction, behavior, and habitat use
3. Comparing release strategies and setting future population goals for Wisconsin
4. Evaluating genetic pedigree of chicks produced in the wild
5. Guiding land management, land acquisition, and public use decisions
6. Conducting environmental analyses for state and federal permit issuance
7. Preparing outreach, education, and funding proposals

Any wetland with minimal human disturbance, even small isolated wetlands, has potential for use by whooping cranes. However, it is expected that the locations of initial high concentration and nesting will occur in the primary rearing and release location of central Wisconsin: at Necedah National Wildlife Refuge in Juneau County and surrounding wetlands of Monroe, Jackson, Wood, Marathon, Adams, and Marquette Counties. (See Appendix 8 for observed whooping crane locations within each county.)

Between 2002 and 2006, cranes were observed in 41 of 72 Wisconsin counties, primarily along major rivers and wetlands. Whooping cranes depend on wetlands for nesting, chick rearing, safe roosting and feeding. Wisconsin encompasses almost 34.8 million acres, of which 5.3 million acres are wetlands; 4 million or 75.2 percent of wetlands are privately owned and managed (WI DNR, 2000). Clearly, wetland habitat restoration on private lands can significantly benefit whooping cranes. Data collected under this plan should help Federal, State and local planners in efforts to prioritize areas for restoration efforts that will benefit whooping cranes and the myriad of other wildlife that inhabits associated wetlands.

Since whooping cranes in Wisconsin are classified as a nonessential experimental population, routine and legal activities on private lands will not put private citizens in conflict with the law. As described in the federal rule announcing the designation of this whooping crane population, the normal Endangered Species Act penalties do not apply if the " take" of the species is incidental to a legal activity.

Whooping cranes can serve as a "flagship" species to educate Wisconsin's citizens and visitors about the importance of conserving both wetlands and the many species dependent on them, while also promoting other statewide conservation programs. The reintroduction of whooping cranes offers an excellent opportunity for the development of an education and outreach program centering on crane biology and ecology, wildlife and landscape management and related environmental issues. Education and outreach efforts must involve a diversity of partners, audiences, and approaches.

The Whooping Crane Eastern Partnership hopes this plan will serve as a template for management plans in other eastern states and provinces as needed. This document is a result of extensive WCEP collaboration between public and private partners.

TABLE OF CONTENTS

1. BACKGROUND
1.1 WHOOPING CRANE EASTERN PARTNERSHIP

2. INTRODUCTION AND PURPOSE

3. HISTORY AND CURRENT DISTRIBUTION
3.1 WISCONSIN HISTORIC RANGE
3.2 ABUNDANCE AND CURRENT DISTRIBUTION
3.2.1 Aransas-Wood Buffalo Population
3.2.2 Florida Non-migratory Population
3.2.3 Eastern Migratory Population
3.2.4 Captive Cranes

4. RECOVERY GOAL AND STRATEGY
4.1 LEGAL ASPECTS OF RECOVERY
4.1.1 Protections
4.1.2 Geographic Scope

5. WHOOPING CRANE BIOLOGY AND ECOLOGY
5.1 SPECIES DESCRIPTION
5.2 MOLT
5.3 LIFE SPAN
5.4 FOOD HABITS
5.5 BREEDING ECOLOGY
5.6 MIGRATORY BEHAVIOR
5.6.1 Spring
5.6.2 Autumn
5.7 HABITAT USE
5.7.1 Historical Migration Habitat
5.7.2 Aransas-Wood Buffalo Population Migration Habitat
5.7.3 Aransas-Wood Buffalo Population Summer (breeding) Habitat
5.7.4 Aransas-Wood Buffalo Population Winter Habitat
5.7.5 Florida Population Habitat
5.7.6 Eastern Population Migration Habitat
5.7.7 Eastern Migratory Population Summer (breeding) Habitat
5.7.7.1 Necedah National Wildlife Refuge
5.7.7.2 Meadow Valley State Wildlife Area
5.7.7.3 Cranberry Beds and Reservoirs
5.7.7.4 Mill Bluff State Park
5.7.7.5 Horicon National Wildlife Refuge
5.7.7.6 Food Preferences
5.7.7.7 Nesting
5.7.8 Eastern Migratory Population Winter Habitat
5.7.8.1 Coastal Salt Marsh Habitat
5.7.8.2 Florida Inland Habitat
5.7.8.3 Habitat in States Other than Florida
5.8 POPULATION DYNAMICS IN THE ARANSAS-WOOD BUFFALO POPULATION

6. MANAGEMENT AND MONITORING
- 6.1 GOAL
- 6.2 POPULATION MANAGEMENT
- 6.3 GENETIC DIVERSITY
  - 6.3.1 Eastern Population Demographics
  - 6.3.2 Eastern Population Genetics
  - 6.3.3 Population Recommendations
- 6.4 DATA MANAGEMENT
  - 6.4.1 Database Goals and Objectives
- 6.5 MONITORING STRATEGIES
  - 6.5.1 Radio Transmitters
  - 6.5.2 Aerial Tracking
  - 6.5.3 Satellite-monitored Radio Transmitters
- 6.6 BIRD INTERVENTIONS
  - 6.6.1 Relocation Options
  - 6.6.2 Methods
  - 6.6.3 Nesting Interventions
- 6.7 HEALTH RISKS AND MORTALITY
  - 6.7.1 Diseases
  - 6.7.2 Contaminants
  - 6.7.3 Traumatic Injury and Death
  - 6.7.4 Collisions with Power Lines, Towers, Turbines and Other Structures
- 6.8 MANAGING PUBLIC AND PRIVATE LANDS
  - 6.8.1 Role of Private Land Management
  - 6.8.2 Property Rights
  - 6.8.3 Agriculture
  - 6.8.4 Invasive Species Control
  - 6.8.5 Water Level Management
  - 6.8.6 Airport Safety
- 6.9 NEST SITE AND TERRITORY MANAGEMENT
  - 6.9.1 Buffer Zones
  - 6.9.2 Timing Activities to Minimize Human Disturbance
  - 6.9.3 Land Acquisition and Habitat Protection Opportunities

7. COMPATABILITY WITH EXISTING WILDLIFE MANAGEMENT PRACTICES
- 7.1 HUNTING
- 7.2 TRAPPING OPTIONS TO CONTROL PREDATION

8. EDUCATION PROGRAMS AND OUTREACH EFFORTS
- 8.1 PARTNERSHIPS
- 8.2 DEVELOPING EDUCATIONAL AND OUTREACH MATERIALS
- 8.3 SHARING INFORMATION
- 8.4 ECOTOURISM
- 8.5 ECONOMIC BENEFITS

9. LEGAL ENFORCEMENT
- 9.1 STATE LAWS
  - 9.1.1 Accidental Shooting
  - 9.1.2 Intentional Shooting
  - 9.1.3 Interstate Transportation

9.2 FEDERAL LAWS
9.2.1 Accidental Shooting
9.2.2 Intentional Shooting
9.3 VIOLATION PROTOCOLS AND SPECIMEN MANAGEMENT

10. PROJECT NEEDS
10.1 RESEARCH
10.1.1 Nest Predation or Abandonment
10.1.2 Dispersal and Movements
10.1.3 GIS Analysis of Habitat and Potential Population in Wisconsin
10.1.4 Nesting Ecology
10.1.5 Habitat Use
10.1.6 Health Issues
10.1.7 Food Habits
10.1.8 Potential Utility Line Collisions
10.2 MONITORING PROTOCOL
10.3 EQUIPMENT

11. LITERATURE CITED

12. APPENDICES
APPENDIX 1: Banding, Marking, Radio and Satellite Transmitters
APPENDIX 2: Eastern Migratory Population Identification
APPENDIX 3: Eastern Migratory Population Genealogy
APPENDIX 4: Capture and Safe Handling of Whooping Cranes to Avoid Capture-Related Stress and Injury
APPENDIX 5: Health Protocols
APPENDIX 6: Response Protocols
1. Founding WCEP Contacts
2. Private Land Issues
3. Citizen Involvement
4. Law Violation
5. Dead Crane Data Sheet
APPENDIX 7: Wisconsin DNR Electronic Data Monitoring Form and Instructions
APPENDIX 8: 2002-2006 Location by Wisconsin County and GIS Representation of Whooping Crane Presence in Wisconsin

ABBREVIATION GLOSSARY

Adm. Code	Administrative code
ANWR	Aransas National Wildlife Refuge
AWBP	Aransas Wood Buffalo population
CRP	Conservation Reserve Program
CWS	Canadian Wildlife Service
DVC	disseminated visceral coccidiosis
EEE	eastern equine encephalomyelitis
EMP	eastern migratory population
FESA	Federal Endangered Species Act
FP	Florida population
GIS	Geographic Information System
ICF	International Crane Foundation
IWCRT	International Whooping Crane Recovery Team
NEP	nonessential experimental population
NRCS	Natural Resource Conservation Service
NWR	National Wildlife Refuge
plan	Wisconsin Whooping Crane Management Plan
PTT	platform transmitter terminal
SARA	Species at Risk Act
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VHF	very high frequency
WBNP	Wood Buffalo National Park
WCEP	Whooping Crane Eastern Partnership
WI DNR	Wisconsin Department of Natural Resources
Wis. Stats.	Wisconsin statutes
WRP	Wetlands Reserve Program

1. BACKGROUND

The United States Fish and Wildlife Service (USFWS) listed the whooping crane *(Grus americana)* as threatened with extinction in 1967 and endangered in 1970. Both listings were "grandfathered" into the Endangered Species Act of 1973. Canada designated the whooping crane as endangered in 1978. The International Whooping Crane Recovery Team (IWCRT), consisting of five Canadian and five United States (U.S.) members, oversees recovery objectives and strategies for the endangered whooping crane. This team recommended the restoration of a migratory, self-sustaining whooping crane population to eastern North America as described in the 2006 International Whooping Crane Recovery Plan (CWS & USFWS, 2006). During its January 2001 meeting, the Recovery Team recommended that Operation Migration staff use their pioneered technique to teach migration routes to birds using ultralight aircraft, to reintroduce a migratory population of whooping cranes to Eastern North America. Operation Migration by this date, had already successfully conducted similar migrations in experimental studies with Canada geese and sandhill cranes.

1.1 WHOOPING CRANE EASTERN PARTNERSHIP

Organized in 1999, the founding members of the Whooping Crane Eastern Partnership (WCEP), a partnership with nine government and private sector organizations (over 70 people), were charged with the mission of restoring a second self-sustaining migratory population. Achievement of this mission will bring the whooping crane closer to delisting from the Federal List of Threatened and Endangered Species.

Founding WCEP members included the USFWS, Wisconsin Department of Natural Resources (WI DNR), International Crane Foundation (ICF), Operation Migration, U.S. Geological Survey (USGS) Patuxent Wildlife Research Center, USGS National Wildlife Health Center, IWCRT, the National Fish and Wildlife Foundation, and the Natural Resources Foundation of Wisconsin. Since its inception, other strategic partners in the restoration effort include the Florida Fish and Wildlife Conservation Commission, and states and organizations along the Atlantic and Mississippi flyways (migration routes).

In September 2003, WCEP suggested development of a state comprehensive Whooping Crane Management Plan (the plan) to attain the 2020 recovery goal of a self-sustaining eastern migratory population of 100-120 whooping cranes consisting of 25-30 breeding pairs that regularly nest and fledge offspring (CWS & USFWS, 2006). The plan might also serve as a template for management plans in other eastern states and provinces as needed. This document is a result of extensive WCEP collaboration.

2. INTRODUCTION AND PURPOSE

This plan is a guidance tool specific to released and wild-hatched cranes for use by those individuals and groups charged with maintaining habitat quality, assessing state population goals, monitoring and managing crane activities, addressing landowner needs, developing ecotourism opportunities, and educating the public. In this plan, management strategies and protocol recommendations have been developed to maintain a high level of protection and ensure future success of whooping cranes in Wisconsin, while considering the needs and interests of state citizens and communities.

For at least five more years, approximately 20 - 30 whooping crane chicks will be added annually to the Wisconsin wild release conditioning programs. Chicks are supplied through captive breeding programs such as at the USGS Patuxent Center in Maryland and the ICF in Wisconsin. The number of chicks available for the reintroduction program is limited by small facility capacity, staff funding, and weather-related events. Hopefully, as the population matures, additional chicks will result from successful wild nesting in Wisconsin's wetlands.

At five-year intervals (2011, 2016, etc.) a review of the whooping crane's population status and this plan should occur to identify opportunities, concerns, and support of whooping crane management. The body of this document may then be revised; the appendices may be more frequently revised and dated as needed. **To assure the sustainability of the population, the target 2020 interim goal is a MINIMUM population of 100 whooping cranes with 25 breeding pairs that regularly nest and fledge offspring,** in conjunction with the same target numbers for an introduced Florida non-migratory population**. If the Florida reintroduction effort is unsuccessful, the eastern migratory population minimum target becomes 120 whooping cranes with 30 breeding pairs that regularly nest and fledge offspring by 2020** (CWS & USFWS, 2006).

By contributing to and applying information in this plan, WI DNR partners with WCEP and the IWCRT to evaluate the reintroduction program, and determine the level of success in restoration of this species to Wisconsin and eastern North America. Accordingly, the WI DNR Whooping Crane Coordinator confers monthly with other WCEP Project Direction Team members. At the same time, Wisconsin DNR staff work with state citizens and federal and nongovernmental agencies to assess and manage habitat critical to the establishment and survival of a healthy population.

Adoption of this plan occurs as WCEP partners embark on the seventh successful year of whooping crane reintroductions. In autumn 2006, the eastern population of whooping cranes migrating between Wisconsin and the southern U.S. included 85 birds.

3. HISTORY AND CURRENT DISTRIBUTION

Historically, whooping cranes ranged widely, primarily relying on diverse, productive wetland ecosystems available for over-wintering, breeding, and migration stopovers. Prior to the influx of white settlers, evidence suggests the historical range extended from the Arctic coast south to central Mexico, and from Utah east to New Jersey, South Carolina, Georgia, and Florida (Allen, 1952; Nesbitt, 1982; Hayes & Barzen, 2003) (Fig. 1).

During the 19th and 20th centuries, the whooping cranes' primary summer (breeding) habitat extended from central Illinois, northwestern Iowa, northwestern Minnesota, and northeastern North Dakota northwesterly through southwestern Manitoba, southern Saskatchewan and into east-central Alberta. The whooping cranes' principal wintering range included the tall grass prairies, southwestern Louisiana, the Gulf Coast of Texas, and northeastern Mexico near the Rio Grande Delta. Other significant wintering areas included the interior tablelands in western Texas and the high plateaus of central Mexico, where whooping cranes coexisted with thousands of sandhill cranes (Allen, 1952).

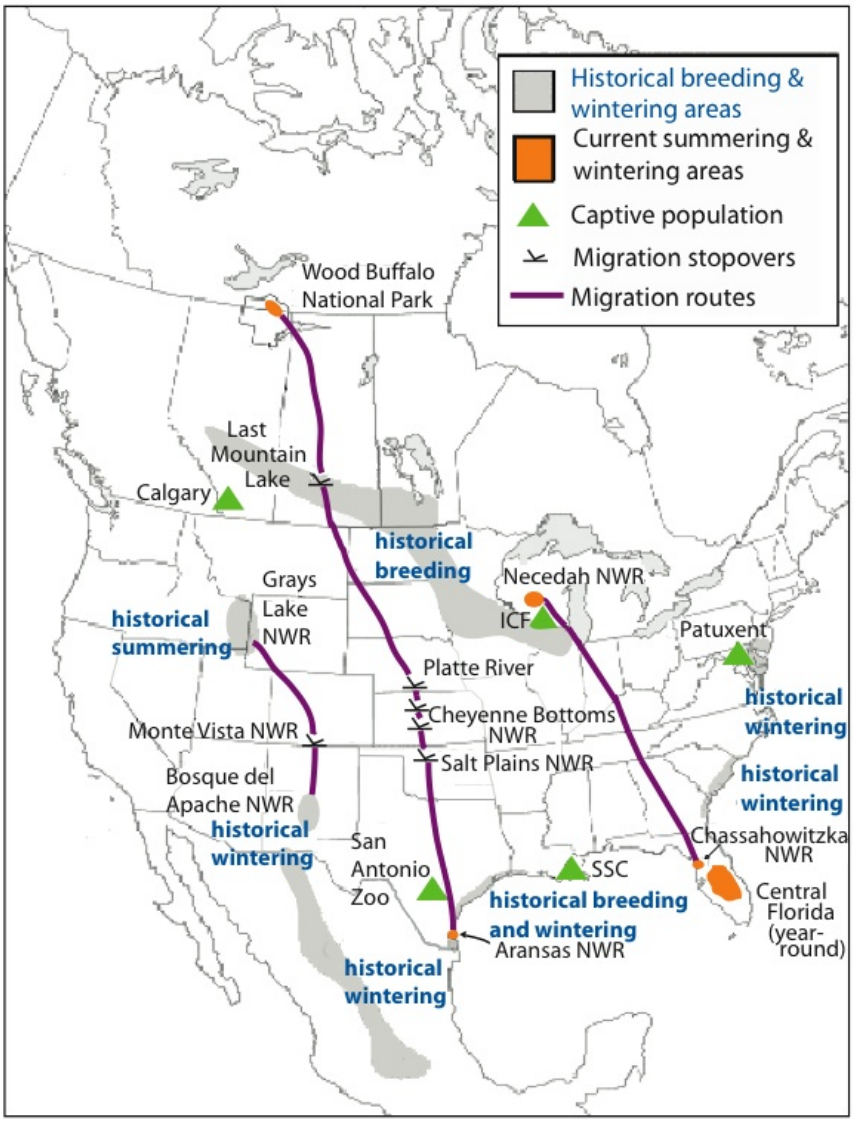


Figure 1. Historical and current breeding and wintering areas and migration routes of whooping cranes (adapted from Meine & Archibald, 1996).

3.1 Wisconsin Historic Range

Limited historical records indicate whooping cranes may have migrated through Wisconsin and may have been “breeding to some extent” (Kumlien & Hollister, 1903). The Milwaukee Public Museum holds the only known Wisconsin specimen, although collection details are incomplete (Robbins, 1991).

Documented whooping crane sightings prior to 1884 include five reports between 1840-1850 (Allen, 1952); occasional sightings in western Wisconsin; twelve sightings in southeastern Wisconsin (Hoy, 1885); observations along the southwest section of the Mississippi River; a specimen located adjacent to the Sugar River in Dane County; a specimen from Green County; and a 1884 Twin Bluffs sighting (Kumlien & Hollister, 1903). An unconfirmed report sites a whooping crane nest in Brown County, Wisconsin (Carr, 1890). There is a confirmed nesting report in Dubuque County, Iowa, adjacent to Grant County, Wisconsin (Allen, 1952).

On April 17, 1959, Owen Gromme observed two birds in Waukesha county. These birds apparently wandered off-course during their northward migration between Texas and Canada. On November 11, 1998, following a period of extremely high westerly winds, a lone whooping crane was sighted and photographed at Illinois Beach State Park, Illinois, just south of the Wisconsin border. The location of this sighting suggests this individual traveled through Wisconsin on its southward path.

3.2 ABUNDANCE AND CURRENT DISTRIBUTION

Historic records of home range size and population trends suggest that over 10,000 whooping cranes may have journeyed across North America. Between 1860 and 1870, the whooping crane population was estimated to be between 500 – 1400 individuals (Banks, 1978; Allen, 1952). By 1870 the species may have already been greatly reduced in number, disappearing from the heart of its breeding range by the 1890s (Stehn & Johnson, 1987).

By 1944, only 21 birds remained in two small breeding populations, a non-migratory population inhabiting the area around White Lake, southwestern Louisiana, and the migratory Texas population that wintered at Aransas National Wildlife Refuge (NWR). The last reported reproduction in the non-migratory Louisiana population occurred in 1939 (Gomez, 1992; Drewien, Tautin, Courville, & Gomez, 2001). In 1950 the Louisiana population ceased to exist. The nesting area of the Texas population was discovered in 1954 in Wood Buffalo National Park (WBNP), in the Northwest Territories of Canada.

Due to the efforts of the IWCRT, WCEP, and the many diverse partners involved in whooping crane recovery**, there are an estimated 145 captive cranes and 354 wild cranes in three separate populations (September 2006) as described below**.

3.2.1 Aransas-Wood Buffalo Population

The Aransas-Wood Buffalo population (AWBP) consists of 214 cranes (March 2006). It is the only self-sustaining wild population. Nesting occurs in the Northwest Territories and adjacent areas of Alberta, Canada, primarily within the boundary of WBNP (Johns, 1998a, 1998b). In 2005, 58 of the 73 known adult pairs nested; 30 chicks fledged.

The AWBP migrates southeasterly through Alberta, Saskatchewan and eastern Manitoba, stops-over in southern Saskatchewan, and continues through the Great Plains states of eastern Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas (Fig. 2). The population winters in estuarine marshes, shallow bays, tidal flats, and adjacent uplands along 56km of the Gulf of Mexico coast in the Aransas NWR and adjacent areas. In spring they reverse the migratory route.

3.2.2 Florida Non-migratory Population

Beginning in 1993, reintroductions over a 13-year period established this non-migratory Florida population (FP). This reintroduced whooping crane population is designated nonessential experimental (refer to Legal Aspects of Recovery, Section 4.1). Located primarily on the Kissimmee Prairie and surrounding areas south of Orlando, Florida, the habitat of this population consists of 500,000 ha of freshwater marsh and open grasslands associated with the flood plain of the Kissimmee River in Osceola and Polk Counties.

Productivity is very low and mortality rates high for this population. In 1999, two pairs produced eggs but no chicks. In 2002, a chick successfully fledged; the first chick fledged in the eastern U.S. since 1939. Between 1999 and 2005, four pairs laid eggs, seventeen chicks hatched, and

four fledged. As of March 2006, approximately 58 wild birds survive from 289 captive-reared reintroduced whooping cranes. Consequently, the IWCRT is reassessing the success of this reintroduction program. No birds are scheduled for 2006 release and none were released in 2005.

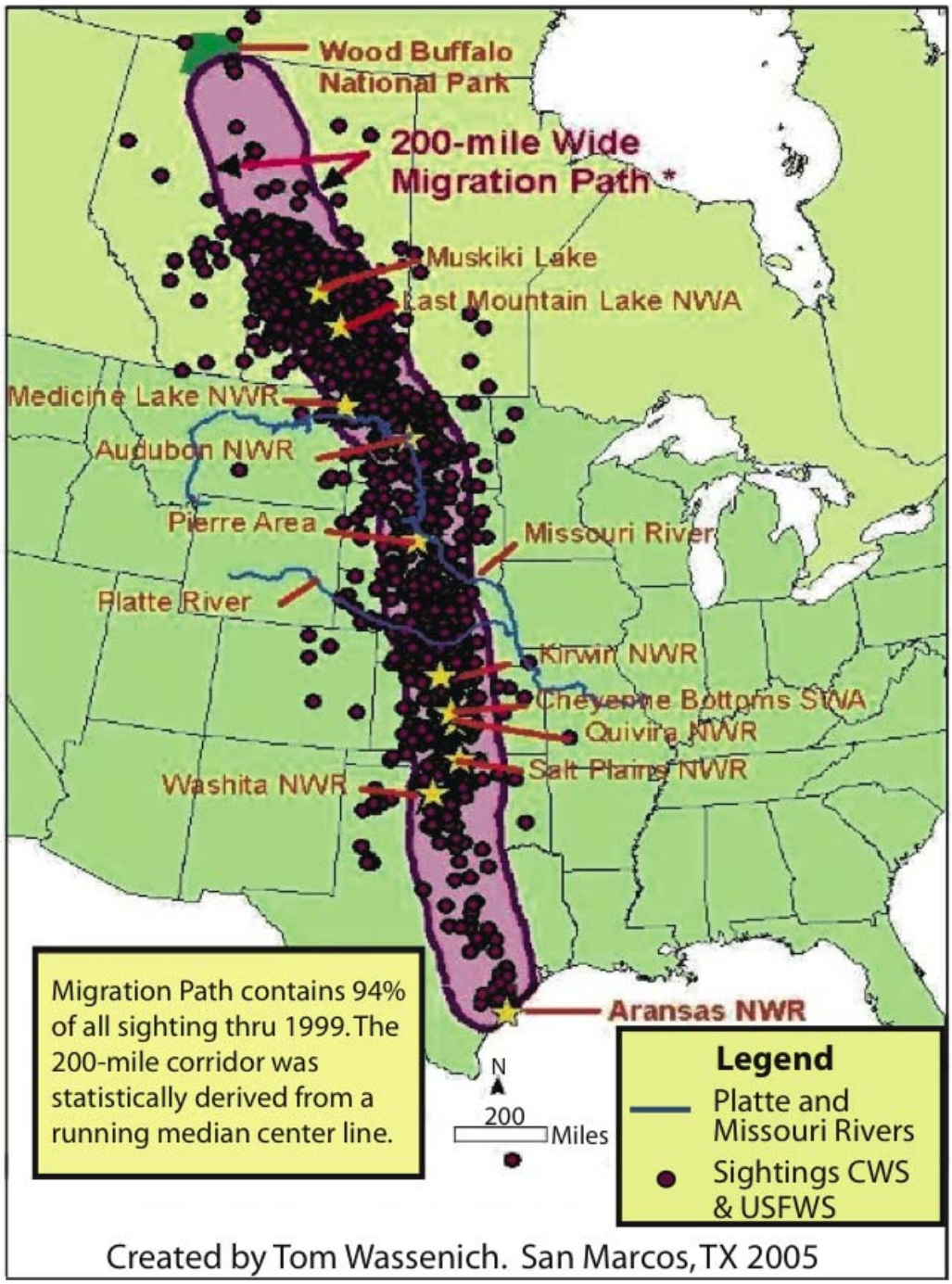


Figure 2. Breeding and wintering areas and primary migration pathway of the Aransas–Wood Buffalo population.

3.2.3 Eastern Migratory Population

In 2001, WCEP began reintroductions of a nonessential experimental eastern migratory population (EMP) of whooping cranes (refer to Legal Aspects of Recovery, Section 4.1). This growing population of at least 85 cranes (autumn 2006) is expected to annually migrate between its Wisconsin breeding grounds to wintering habitat in the southern U.S. Until WCEP goals are reached, approximately 20-30 whooping crane chicks from captive propagation facilities (if available) will be added each year to the Wisconsin wild release conditioning programs.

Two methods of migration conditioning have been successfully piloted through this program. Initially, all captive-reared crane chicks were conditioned by Operation Migration staff to follow an ultralight aircraft from their training and release site at Necedah National Wildlife Refuge (NWR) in central Wisconsin to Chassahowitzka NWR on the Gulf coast of Florida (Fig. 3).

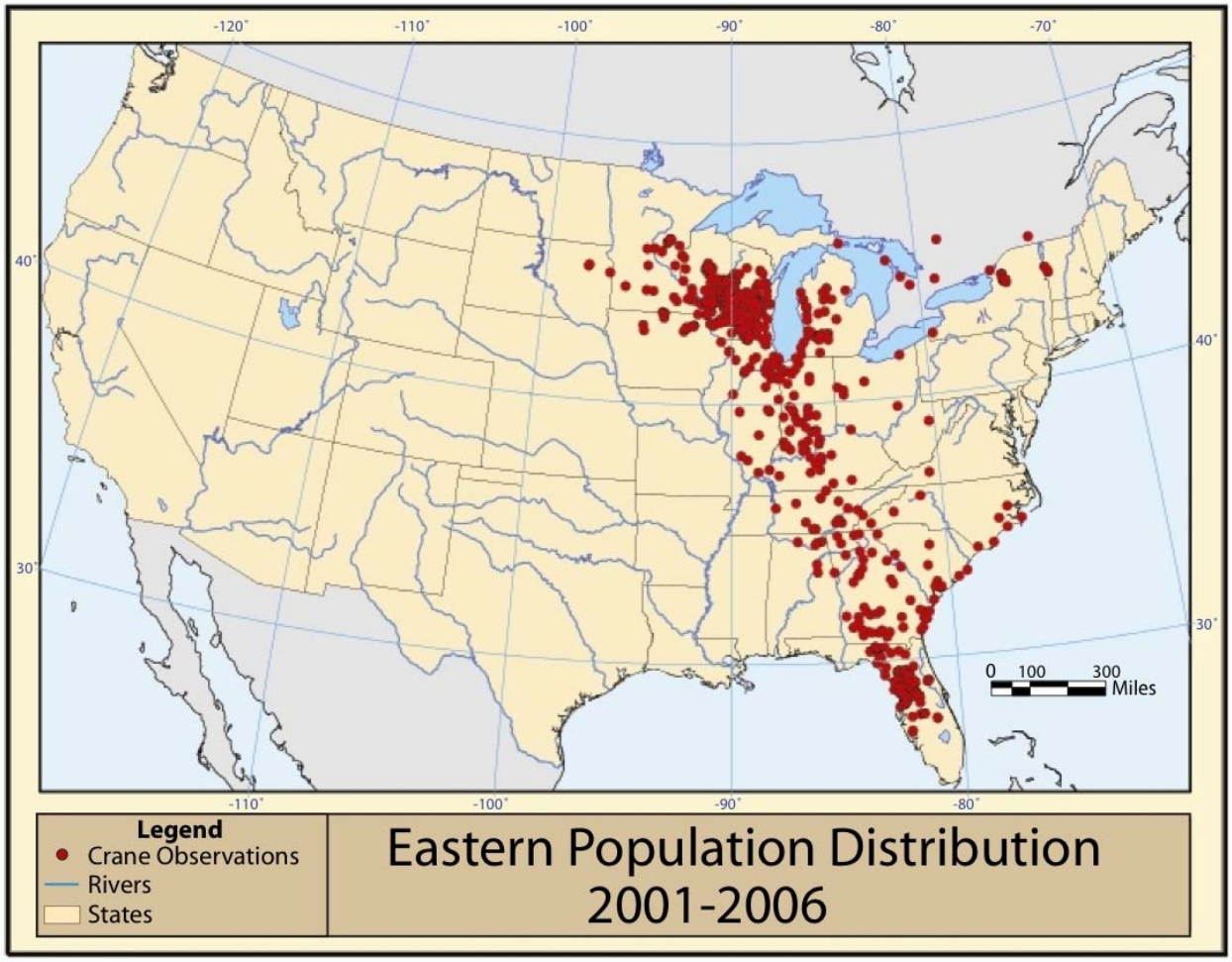


Figure 3. Eastern migratory population (EMP) migration flyway.

Beginning autumn 2005, this program was supplemented with the direct release of captive, isolation-reared crane chicks into groups of whooping or sandhill cranes. The chicks followed these birds from Wisconsin to the southern U.S. without ultralight conditioning and guidance. Project recovery plans outline ultralight-led migrations by Operation Migration staff through at

least 2010, or until the goal of a self-sustaining migratory population of 100-120 individuals and 25-30 consistently breeding pairs is achieved.

3.2.4 Captive Cranes

Captive populations at Patuxent Wildlife Research Center, ICF, the Devonian Wildlife Conservation Center, the Species Survival Center, and the San Antonio Zoo provide genetic material (chicks) for wild release and future captive breeders to ensure genetic retention of the species.

Nine North American locations hold 145 captive whooping cranes (September 2006). Captive propagation centers include:

- 60 at USGS Patuxent Wildlife Research Center, Laurel, Maryland;
- 37 at ICF in Baraboo, Wisconsin;
- 22 at Devonian Wildlife Conservation Center, Calgary Zoo, Alberta, Canada;
- 8 at the Species Survival Center, Belle Chasse, Louisiana; and
- 8 at the San Antonio Zoo in San Antonio, Texas.

Additionally, whooping cranes are publicly displayed at the Calgary Zoo (2), Alberta, Canada; the Lowry Park Zoo (2), Tampa, Florida; the San Antonio Zoo, Texas; the ICF, Baraboo, Wisconsin; the Audubon Zoo (2), New Orleans, Louisiana; and the Homosassa Springs Wildlife State Park (2), Homosassa, Florida.

4. RECOVERY GOAL AND STRATEGY

The AWBP is characterized by low numbers, slow reproductive potential, and limited genetic diversity. A stochastic, catastrophic event could eliminate or greatly reduce this population, especially due to its limited summer and winter habitat distribution. To safeguard the species from possible extinction, the IWCRT recommended the establishment of multiple self-sustaining wild whooping crane populations in North America. The IWCRT goal involves two stages; initially, reclassification of the species to threatened and, ultimately, removal from the Federal List of Threatened and Endangered Species. The recovery strategy is three-fold and involves the protection and enhancement of the AWBP, reintroduction and establishment of separate self-sustaining wild populations within the species' historic range (but geographically separate from the AWBP), and maintenance of a captive breeding population.

The International Whooping Crane Recovery Plan (CWS & USFWS, 2006) set forth two primary objectives and measurable criteria that will allow the species to be reclassified (downlisted) as a threatened species. The first objective calls for the establishment and maintenance of wild self-sustaining whooping crane populations that are genetically stable and resilient to stochastic environmental events. This objective will be met when 1) the AWBP is maintained at a minimum of 160 individuals encompassing 40 breeding pairs, and 2) two self-sustaining geographically separate populations individually contain 100-120 cranes encompassing 25-30 breeding pairs. The two additional populations may be migratory or non-migratory. However, all populations must be self-sustaining for a decade at the designated levels.

The captive breeding population will continue to supply crane chicks for the reintroduction programs. Eventually, reproduction by reintroduced birds and their offspring will result in self-sustaining wild populations. In the event a second and third wild population cannot become self-

sustaining, the AWBP must be self-sustaining and remain above 1,000 individuals encompassing at least 250 breeding pairs before downlisting.

The second objective is to sustain a genetically stable captive population to ensure against the species' extinction. Maintenance of 153 captive whooping cranes, including a minimum of 21 breeding pairs, will meet this objective. Genetic analysis suggests these population numbers can maintain 90 percent of the genetic material for 100 years (Jones & Lacy, 2006).

Due to the status and biology of the species, an estimated 30 years or more will be needed to reach population goals. Current reproduction rates suggest it will take at least 10 years to build a population of more than 100 individuals. These individuals must reach breeding age (three through five years) and produce enough young to become self-sustaining for a decade to meet downlisting criteria.

During this interim, new challenges may arise. In assessing population goals, consideration will be given to 1) the conservation biology of very small populations, including a determination of effective population size to maintain long-term genetic viability, and 2) the consequences of stochastic and catastrophic events on population survival. Information gathered through recovery actions will be incorporated into future population viability analyses as the population approaches its downlisting goals. Criteria for delisting (removal from the Federal List of Endangered and Threatened Species) will be established, and the recovery strategy will be revised as needed.

4.1 Legal Aspects of Recovery

On June 26, 2001, the USFWS published a final rule in the *Federal Register* (FR66:123: 33903-33917) designating a nonessential experimental population (NEP) of whooping cranes in the eastern U.S. This action finalized the proposed rule first published on March 9, 2001 and cleared the way for the release of whooping cranes in the eastern U.S (the future EMP). The designation of this reintroduced population as a NEP was according to section 10(j) of the Endangered Species Act of 1973 (the act), as amended. The geographic boundary of the NEP includes the states of Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, North Carolina, Ohio, South Carolina, Tennessee, Virginia, West Virginia, and Wisconsin (Fig. 4).

Section 10(j) is designed to increase flexibility in managing an experimental population by treating the population as threatened, regardless of the species' designation elsewhere in its range. Threatened designation gives more discretion in developing and implementing management programs and special regulations. Where experimental populations occur, certain endangered species protections may no longer apply. This can help reduce local opposition to reintroductions based on concerns about restrictions and prohibitions on federal and private activities.

4.1.1 Protections

Under the act, species listed as endangered or threatened are afforded protection primarily through the prohibitions of section 9 and the requirements of section 7. Section 9 of the act prohibits the take of a listed species. ''Take'' is defined by the act as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Section 7 of the act outlines the procedures for federal interagency cooperation to conserve federally listed species and protect designated critical habitats. It mandates all federal agencies to determine how to use their authorities to further the purposes of the act to aid in recovering

listed species. It also states that federal agencies will, in consultation with the USFWS, insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species, or result in the destruction or adverse modification of designated critical habitat. Section 7 of the act does not affect activities undertaken on private lands unless they are authorized, funded, or carried out by a federal agency.

For the purposes of section 7, if any NEP-designated cranes are located outside of a National Wildlife Refuge or National Park, they are treated as a species proposed for listing, and the agency is not required to consult with the USFWS. For actions on National Wildlife Refuges or National Parks, NEP-designated cranes are treated as threatened and the consultation requirements of section 7(a) (2) of the act apply.

Due to the lack of the section 7 requirement, fewer conflicts with activities on non-federal lands are likely to occur. In addition, the special rule associated with the NEP of eastern whooping cranes specifically allows for the take of the species, provided such take is accidental and incidental to an otherwise lawful activity. Some typical activities that would be exempted under the special rule include agricultural practices, pesticide application, water management, construction, recreation, trapping, or hunting, provided such activities are in full compliance with all applicable laws and regulations (see Legal Enforcement, Section 9).

4.1.2 Geographic Scope

One unique aspect of section 10(j) experimental populations is that they are defined solely by geographic boundaries (Fig. 4). Experimental populations are established only where the natural wild populations will not interact with members of the experimental population. In the case of whooping cranes, the likelihood of an AWBP whooping crane entering the migratory eastern population NEP area is very low. However, if a whooping crane enters or leaves the NEP area, the individual acquires the listed status prevailing in that geographic area.

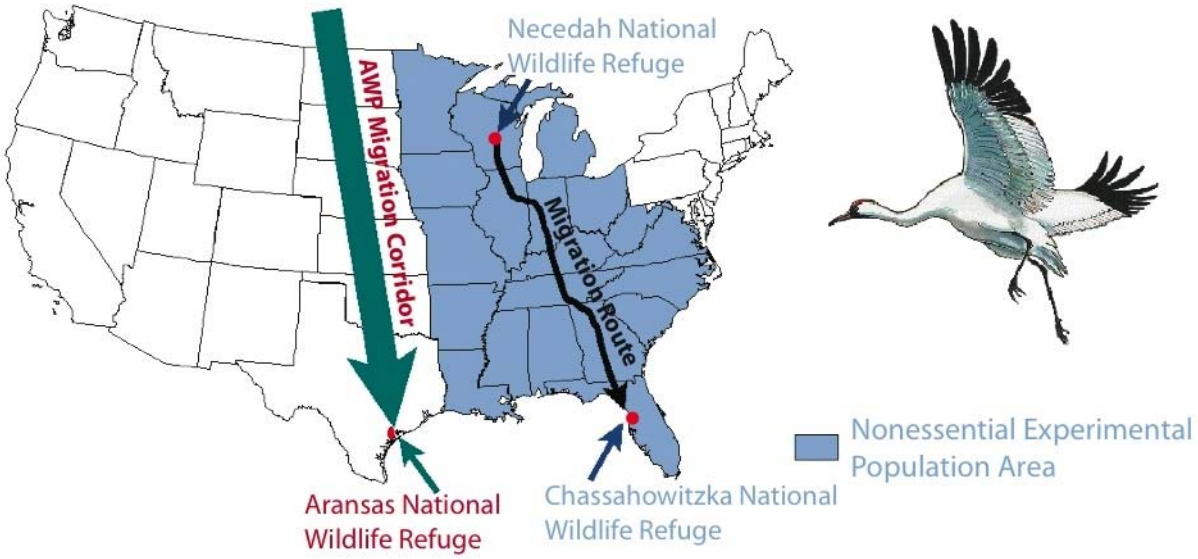


Figure 4. Eastern U.S. nonessential experimental population (NEP) area, showing reintroduction site, migration route and wintering site. Also shown are approximate migration and wintering locations of wild Aransas-Wood Buffalo population (AWBP) of whooping cranes.

For example, if an AWBP whooping crane strays into Wisconsin it takes on the NEP status, and no longer is endangered (its status in North Dakota). Conversely, if an EMP crane flies to North Dakota, it acquires the status of whooping cranes in that geographic area, or endangered. The potential for this scenario was recognized during the development of the NEP rule. In the rule, the USFWS committed to removing any NEP-designated migratory eastern birds that stray into central flyway states, at the request of the respective state. This alleviated concerns that the presence of introduced whooping cranes could affect hunting or other public activities. In June 2003, three NEP cranes did wander into South Dakota, remaining until mid-August. At the request of the USFWS State Central Flyway Council they were captured and returned to Wisconsin. As a result of this intensive management activity, one bird died from capture myopathy.

5. WHOOPING CRANE BIOLOGY AND ECOLOGY

Much of the following information is excerpted and revised as needed with permission from the International Whooping Crane Recovery Team report entitled, *International Recovery Plan for the Whooping Crane* (CWS & USFWS, 2006). Other information is gathered from the EMP and FP recovery actions.

5.1 Species Description

The common name "whooping crane" probably originated from the loud, single-note vocalization repeated by alarmed birds. Taxonomically, the whooping crane is in the Family *Gruidae*, Order *Gruiformes.* The closest taxonomic relatives in continental North America are five races of sandhill crane (*G. canadensis*) encompassing the lesser (*G. c. canadensis*), Canadian (*G. c. rowani*), greater (*G. c. tabida*), Florida (*G. c. pratensis*), and Mississippi (*G. c. pulla*) sandhill crane. In flight, whooping cranes can be distinguished from other large white birds with black wingtips (i.e., American white pelican, tundra swan, and lesser snow goose) by their long, extended neck and trailing legs.

The tallest North American bird, whooping crane males stand 1.5 m, 12-20 cm taller than the greater sandhill crane. Males are generally larger than females. The average weight for wild cranes is unknown, although captive males average 7.3 kg and females average 6.4 kg. A crane’s weight varies seasonally from a summer-time low to a winter-time high.

The whooping crane’s adult plumage is snowy white except for black primaries; grayish or black alulae; sparse, black, bristly feathers on the carmine crown and malar; and a dark gray-black wedge-shaped patch on the neck. The black primaries and alulae can be seen when the wings are extended. In contrast, the short tail is usually hidden by the plumed, decurved tertials. The size of the post-occipital patch varies between individuals. Whooping crane plumage is sexually monomorphic; however, their guard and unison calls are sexually distinct. The bill is dark olive-gray; the base of the bill is pink or rosaceous. During the breeding season the bill becomes lighter. The long, thin legs and feet are gray-black.

Juvenile cranes are a reddish cinnamon color, possibly a protection against predation. When chicks are 80-100 days old, they are capable of sustained flight. By the time they are four months old, white feathers begin to appear on the neck and back. The plumage is predominantly white by the following spring, although rusty juvenile plumage remains on the head, the upper neck, secondary wing coverts, and scapulars. The dark red crown, lores, and

malar areas are visible. At one year of age the iris of the eye has changed from blue to yellow. By their second summer, yearlings typically achieve adult plumage.

5.2 MOLT

Information in this plan on the timing, physiology, and behavioral adaptations of cranes to molt is limited to the Florida non-migratory population, but likely can be applied to the migratory Aransas-Wood Buffalo and eastern populations. Although undocumented, the AWBP and the EMP probably experience a simultaneous molt of flight feathers. Biologists collecting eggs or capturing pre-fledged chicks in the AWBP noted the parents usually flew away during the disturbance. It is likely molt takes place post-offspring fledging, and prior to fall migration.

In Florida, a simultaneous molt of primary and secondary feathers after the breeding season (April – June) leaves whooping cranes flightless for four to six weeks. In Wisconsin, molt is likely to occur from June through August. Most birds undergo molt when they are turning three years of age, although some molt their second year. Every bird recaptured shows evenly worn and yellowed feathers, evidence of a simultaneous molt of flight feathers. The typical bird, after gaining new flight feathers at three years of age, molts again in two to three years. Florida biologists have never witnessed this type of molt two years in a row. All Florida whooping cranes replace their contour plumage every summer or early autumn. The two types of molt are spaced out in time, possibly to reduce stress on the bird.

During molt the cranes typically become secretive and reclusive, taking shelter in marshes and lake edges. This behavior is more commonly seen in pre-fledged chicks or sick or injured adults. Molt behavior is contagious. Non-molting members of a group will assume the secretive nature. When the marshes dry up during drought periods, the bird's flightless status combined with the lack of water makes the birds more vulnerable to predation.

Molt can be difficult to detect directly. A molting bird usually does not flap its wings, perhaps a survival skill to preserve the fragile growing feathers. This makes it difficult to check feather status. Observing a suspect bird flap, stretch, or preen helps. At this time, it is important to look at the more easily-observable primary feathers, since enough wing surface is present without the secondary feathers that they can still fly. Generally, the most visible clue to molt is if a bird has not flown in four to six weeks.

5.3 LIFE SPAN

Whooping cranes are a long-lived species. Current estimates suggest whooping cranes live 24-30 years in the wild and 35-40 years in captivity.

5.4 FOOD HABITS

Whooping cranes are omnivorous, using their long bills to opportunistically forage on available food sources in both wetland and upland habitats. Young chicks are fed by their parents, gradually becoming increasingly independent. They separate from their parents prior to the next breeding season.

Summer foods include large nymphal or larval forms of insects, frogs, rodents, small birds, minnows, and berries. Based on limited research, during migration whooping cranes feed on harvested grain fields, frogs, fish, plant tubers, crayfish, insects, and agricultural grains.

The AWBP winter diet consists mainly of blue crabs (*Callinectes sapidus*), clams, and the plant wolfberry (*Lycium carolinianum*). Most foraging occurs in the brackish bays, marshes, and salt flats lying between the mainland and barrier islands. Occasionally, fresh water and food sources such as acorns, snails, crayfish, and insects attract them to upland sites. Aransas-Wood Buffalo cranes are particularly attracted to upland sites when they are 1) partially flooded by rainfall, 2) burned to reduce plant cover, or 3) when food is limited in the salt flats and marshes. Roosting continues to occur in the marshes. Some whooping cranes use upland sites frequently; however, agricultural croplands adjacent to the ANWR are rarely visited. The EMP forages more heavily on fresh water sources.

5.5 BREEDING ECOLOGY

Like other long-lived bird species, whooping cranes form long-term, monogamous pair bonds, exhibit delayed (age-related) breeding, produce small clutches, and have a prolonged period of parental care (nine through ten months). Although whooping cranes are monogamous, they will re-pair, sometimes within a few days following the death of a mate. The development of pair bonds can occur during spring migration, on the breeding grounds, or in a subadult population over the course of one through three winters.

Nesting can occur at age three, although the average age of first egg production is five years. In the AWBP, experienced pairs begin nest construction upon arrival at their northern breeding grounds (WBNP). Eggs are laid late April through mid-May and incubated for 29 – 31 days. The light brown or olive-buff eggs are covered with dark, purplish-brown blotches concentrated at the blunt end. Whooping crane eggs average 100 mm in length and 63 mm in width.

Whooping cranes usually produce clutches of two eggs laid 48-60 hours apart. Incubation begins with the first egg laid, resulting in asynchronous hatching of the eggs. In nests with two eggs, the first hatched has the greater chance of survival. Habitat conditions, including food availability and predator abundance, affect survival. In years with suitable habitat conditions crane pairs may raise two young.

Whooping crane parents share incubation and brood-rearing duties. Except for brief intervals, one member of the pair remains on the nest at all times. Females tend to incubate at night and take the primary role in feeding and caring for the young. Chicks are capable of swimming shortly after hatching. During the first three to four days, parents and their young return to the nest at night. Later, parents brood their young wherever and whenever needed, such as at night or during foul weather. During the first 20 days after hatching, families generally remain within 1.8 km of the nest site, with daily movements averaging 340 m.

Whooping cranes usually nest in the same general vicinity each year. These nesting territories, termed "composite nesting areas" range from about 1.3 to 47.1 km^2, but average 4.1 km^2. Adjoining pairs usually nest at least 1 km apart; however, nests have been recorded as close as 400 m from each other. Family groups and pairs remain in the breeding territory from egg-laying until the chicks are a few months old.

Whooping cranes may re-nest if their first clutch is destroyed or removed before mid-incubation. However, re-nesting has rarely been observed. Whooping cranes generally nest annually, but may skip a season under poor nesting habitat conditions, if they are nutritionally stressed, or for unknown reasons.

Most juveniles and subadults spend the summer near their natal area. Sexually immature birds (up to four years of age) will pair-up or form small groups of three to five birds on the edges of nesting pair territory.

5.6 Migratory Behavior

Habitats used by whooping cranes vary annually. During their seasonal cycle, whooping cranes leave their summer breeding areas in the northern U.S. and Canada and migrate to their wintering habitat in the southern U.S.

In whooping cranes migration is a learned behavior. In autumn, juvenile birds learn the migration route by following their parents or older members of the population from their summer breeding grounds to their wintering habitat. On the autumn migration route, cranes use both staging and stopover habitats. Staging habitats are used for variable lengths of time (days or weeks) to gain and store nutrients needed for different stages of their annual cycle. Stopover habitats meet immediate needs for food and energy during migration, requiring a short stay (up to several days) unless weather conditions impede migration.

5.6.1 Spring

As spring approaches, “dancing” behavior (i.e., running, leaping and bowing, unison calling and flying) increases in frequency, indicating pre-migratory restlessness. Family groups and pairs usually depart the wintering grounds first, often assisted by seasonal strong southeast winds. Cranes are diurnal migrants, making regular stops to feed and rest. The AWBP normally begins departure between March 25 and April 15. The last AWBP birds usually leave by May 1, but stragglers may linger into mid-May. Parents separate from their young of the previous year upon departure, while in route, or soon after arriving at the northern breeding grounds. Cranes in the EMP (2002-2006) leave their wintering habitat between February 28 and mid-April.

Spring migration is usually completed in two to four weeks, more rapidly than the reverse trip in the fall, as there is no known spring staging area. Between 1938 and 2002, 33 birds summered at ANWR. Some of these birds were ill, crippled, or mates of crippled birds. At present, no birds in the EMP summer in the southern U.S.

5.6.2 Autumn

Unlike the large gatherings of sandhill cranes that form each fall, whooping cranes migrate south as pairs, in family groups, or as small units of three to five birds. Pairs with young are among the last to leave the breeding range.

The AWBP begins migration in mid-September, with most birds arriving on the wintering grounds between late October and mid-November (Fig. 2). Occasionally, stragglers arrive in late December. The first stop often occurs in northeast Alberta or northwest Saskatchewan, about 500 km southeast of the departure area. Although weather conditions influence distance and direction of travel, on the second day the cranes usually reach the autumn staging grounds in the north-central portion of the Saskatchewan agricultural area. The rest of the migration to the Aransas NWR wintering grounds is usually rapid, probably weather-induced, and may be completed in a week.

Autumn migration for the EMP typically begins later. Departure from Wisconsin ranges from late October to early December, with most birds usually departing mid-November.

5.7 HABITAT USE

Whooping cranes use a wide range of habitats, varying their use during different parts of their annual cycle. The two migratory populations (AWBP and EMP) occupy summer breeding habitats radiating outwards from WBNP in Canada and from central Wisconsin in the U.S. During migration they opportunistically use stopover and staging habitats along the migration flyway. The wintering habitat for these two populations occurs in separate regions of the southern U.S. The non-migratory population uses a variety of upland, wetland, and coastal habitats in Florida.

5.7.1 Historical Migration Habitat

In the 19th century, the two most important migration pathways included the route between Louisiana and the nesting grounds in Illinois, Iowa, Minnesota, North Dakota, and Manitoba, and the route from Texas and the Rio Grande Delta region of Mexico to nesting grounds in North Dakota, the Canadian Provinces, and the Northwest Territories. A route through west Texas into Mexico apparently followed the route still used by sandhill cranes, and it is believed the whooping cranes regularly traveled with them to wintering areas in the central interior highlands region (Allen, 1952). An additional migration route crossed the Appalachians to the Atlantic Coast. These birds apparently nested in the Hudson Bay area of Canada. Coastal areas of New Jersey, South Carolina, and more southerly river deltas were the wintering grounds.

From 1857-1928 specimen records or sighting reports can be found in Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kentucky, Michigan, Minnesota, Mississippi, Missouri, New Jersey, Ohio, Ontario, South Carolina, and Wisconsin. Gulf Coast locations include Mobile Bay, Alabama, Bay St. Louis in Mississippi, and numerous records from southwestern Louisiana. Coastal Louisiana contained both a non-migratory population and wintering migrants.

In 1911 the last eastern population of whooping cranes (14 birds) was observed in Alachua County in southern Florida. Two whooping cranes were reported east of the Kissimmee River in 1936, and in 1927 or 1928 a whooping crane was shot and photographed in St. Johns County, Florida.

5.7.2 Aransas-Wood Buffalo Population Migration Habitat

Areas characterized by wetland mosaics appear to provide the most suitable stopover habitat. In the majority of states and provinces, whooping cranes primarily use shallow, seasonally and semi-permanently flooded palustrine (marshy) wetlands for roosting, and cropland and emergent wetlands for feeding.

Spring roosting wetland habitat size has been variably reported as less than 0.5 ha to an average of 36 ha, whereas fall sites average 508 ha. Most roost sites occur within 1 km of a suitable feeding site. Habitat use varies according to family status. Cropland accounts for 70 percent of the feeding sites of non-families, while wetlands account for 67 percent of family feeding sites. Although generally not used, heavily vegetated wetlands are selected by family groups more often than non-families. Large palustrine wetlands used by the AWBP include the Quivira NWR, Kansas; Salt Plains NWR, Oklahoma; Cheyenne Bottoms State Wildlife Area in Kansas; Last Mountain Lake NWA in Saskatchewan; and large reservoir margins in the Dakotas.

Whooping cranes also make use of riverine habitats, especially in Nebraska. Cranes prefer roosting on submerged sandbars in wide unobstructed channels isolated from human disturbance. Frequently used riverine habitats include the South Saskatchewan River,

Saskatchewan; the Platte, North, Middle Loup, and Niobrara Rivers in Nebraska; and the Missouri, North Dakota, and Red Rivers in Texas.

Private lands provide critical fall staging habitat in Saskatchewan. Stewardship and conservation activities should target known staging areas and potential breeding wetlands on the these private lands. Otherwise habitat could be negatively impacted by drainage, cattle grazing, contaminated runoff, or other disturbances associated with agricultural activities.

5.7.3 Aransas-Wood Buffalo Population Summer (breeding) Habitat

Whooping Cranes formerly bred in isolated marshes on prairies and aspen parkland. The current WBNP nesting area lies between the headwaters of the Nyarling, Sass, Klewi, and Little Buffalo rivers. The area is poorly drained and interspersed with numerous potholes. These wetland areas vary considerably in size, shape, and depth. Most possess soft marl bottoms. Narrow ridges supported by an over story of white spruce (*Picea alauca*), black spruce (*P. mariana*), tamarack (*Larix laricina*), and willows (*Salix spp*.), and an understory of dwarf birch (*Betula glandulosa*), Labrador tea (*Ledum groenlandicum*), bearberry (*Arctosta phylos uva-ursi*), and several species of lichen underlain by sphagnum moss, separate the wetlands. Crane nest sites are primarily located in shallow diatom ponds that contain bulrush (*Scirpus validus*), although cattail (*Typha sp*.), sedge (*Carex aquatilis*), musk-grass (*Chara sp*.), and other aquatic plants are common.

Lightening-induced wildfires usually benefit crane habitat. Wildfires increase habitat accessibility by recycling nutrients and reducing vegetation on the forested ridges between nesting ponds. Although molting adults and flightless young are vulnerable to fire, losses of eggs, chicks, or adults are unconfirmed. Due to the potential negative effects of a major fire control operation in the AWBP nesting area, the area is classified as “moderate response,” limiting fire suppression activities.

At WBNP, whooping cranes face little competition from other bird species for nesting territories. Although sandhill cranes are present, it is unlikely they can out-compete the larger whooping cranes for preferred nest sites. Any territory overlap probably occurs on the dryer sedge nest areas.

5.7.4 Aransas-Wood Buffalo Population Winter Habitat

The AWBP occupies winter habitat on and adjacent to Aransas NWR, encompassing about 9,000 ha of salt flats and adjacent islands. Marshes are dominated by salt grass (*Distichlis spicata*), saltwort (*Batis maritima*), smooth cordgrass (*Spartina alterniflora*), glasswort (*Salicornia* sp.), and sea ox-eye (*Borrichia frutescens*). Inland margins of the flats are dominated by Gulf cordgrass (*Spartina spartinae*). Interior portions of the refuge are gently rolling and sandy. This habitat is characterized by oak brush, grassland, swales, and ponds. Typical plants include live oak (*Quercus virginiana*), redbay (*Persea borbonia*), and bluestem (*Andropogon* spp.).

Studies indicate declining territory size as the population increases, with territories averaging 117 ha. Subadult and unpaired adult whooping cranes form small populations outside occupied territories. Paired cranes will often locate their first winter territory near one of their parents.

To assist this population in its recovery efforts, over the last 30 years many upland sites have been grazed, mowed, or burned to maintain oak savannah habitat. Plus, human visitation is carefully controlled. Other potentially conflicting uses of the refuge, such as activities associated with oil and gas exploration, are reduced when whooping cranes are present.

5.7.5 Florida Population Habitat

Captive-reared whooping cranes were released in Florida from 1993 through 2004 (Nesbitt et al., 1997). This non-migratory Florida population (FP) soon became sympatric with Florida sandhill cranes (*G. c. pratensis*). The home range size of whooping cranes and sandhill cranes is similar, 447 ha for paired adults. Nesting territories, i.e. areas actively defended against other cranes, average 169 ha (Nesbitt & Williams, 1990).

Florida cranes are equally upland (grassland) and wetland birds. Nevertheless, usable upland foraging habitat may influence reproductive success to a greater extent than wetland availability. Availability of upland habitat is also a factor in determining whether a territory is occupied year round or periodically (Nesbitt & Williams, 1990). Cranes prefer foraging at the edges of open grasslands with low growth vegetative aspects (vegetation less than 0.5 m). Mast crops like dewberries (*Rhus* spp.) and acorns (*Quercus* spp.) are popular food sources. Maintaining suitable upland conditions can be accomplished with the selective use of fire, mowing, and grazing.

Cranes also forage in agricultural fields, particularly harvested corn and peanut fields, livestock feed lots and areas where supplemental grain is provided. Waste grain feeding can be hazardous to cranes. Up to 10 percent of the cranes that feed in these situations acquire the disease, mycotoxicosis, which produces neck paresis. Infected cranes die of dehydration, starvation, or predation.

Cranes prefer roosting in areas of firm, exposed bottom in relatively shallow (less than 60 cm) water surrounded by denser vegetation. Ideally, wetland habitats are maintained as emergent palustrine wetlands dominated by pickerelweed (*Pontederia cordata*) and maidencane (*Panicum hemitomon*). Water quality and quantity is maintained by preventing the area from developing into a cattail or woody plant dominated community.

Marsh feeding sites are critical to a successful early brood rearing phase (days 1-14). A mixture of open shallow water and vegetated areas aids crane movement and feeding. An open herbaceous marsh can be maintained through annual water level fluctuations. Dynamic pulsing of the wetlands can be periodically reinforced (every 2-5 years) with a dramatic event, deep inundation, complete drying, and occasional fire. Timed management events avoid the period of nesting and chick rearing, at least until the young are able fliers (90 days).

5.7.6 Eastern Population Migration Habitat

Most whooping cranes in the eastern migratory population (EMP) demonstrate a direct migration route with opportunistic stops at any wetland available at the end of the flight day (Fig. 3). They usually remain overnight unless poor flying weather requires a longer stay. These sites include natural or managed palustrine, lacustrine, and riverine wetlands as well as farm ponds, reclaimed surface mines, flooded agricultural fields, catfish production ponds, mountain reservoirs, and river sandbars. Northward migration occurs during late February to mid-April. Autumn migration usually ranges from late October to early December, with most birds migrating during mid-November.

During migration some whooping cranes associate with sandhill cranes. Accordingly, they follow the traditional eastern greater sandhill crane migration flyway, stopping at the expansive wetlands at Jasper-Pulaski State Fish and Wildlife Area in Indiana and at Hiwassee State Wildlife Refuge in Tennessee.

Migration roost habitat ranges from extensive, permanent wetlands to relatively small stock ponds. Sites used generally satisfy safe, short-term habitat requirements (i.e., in water more than 20 feet from shore). In general, whooping cranes improve roost site selection in their first unassisted fall migration over that in their first spring migration. During migration, whooping cranes often feed in grain fields, especially harvested cornfields near the roost site. Due to the broad range of potentially usable sites and the need to use them for only a few days, adequate stopover habitat does not appear limiting even in mountainous parts of the migration route.

However, whooping cranes in fall 2004 often remained at the same stopover sites for extended periods, even when weather conditions were suitable for migration. This behavior raises concerns regarding the risk of an unintentional whooping crane shooting at a stopover site during open waterfowl seasons, especially in areas west of the mainstream sandhill crane route where snow geese are hunted.

5.7.7 Eastern Migratory Population Summer (breeding) Habitat

From spring through early summer, whooping cranes use a diversity of wetland habitats throughout Wisconsin, Minnesota, northeastern Iowa, Illinois, and Michigan. Sometimes they relocate daily. In the first four years of the release program (2001-2005), whooping cranes were observed in 35 of 72 Wisconsin counties, primarily within the lower two-thirds of the state along major rivers and wetlands, including the lower Wisconsin and Mississippi Rivers. Lacustrine marshes, such as those associated with Puckaway, Rush, Yellowstone, and Poygan Lakes are also used. So far, EMP crane habitat use includes any wetland with minimal human disturbance, even small isolated wetlands (Appendix 8). For example, several 2003-released birds spent significant portions of spring and summer along sloughs and oxbow lakes associated with the Little Yellow River south of Necedah NWR. Small numbers of birds used the marshes of the Briggsville area during both summer and autumn, particularly those associated with Neenah and O'Keefe Creeks.

5.7.7.1 Necedah National Wildlife Refuge

Whooping cranes at Necedah NWR appear to shift their daytime movement patterns within the mosaic habitats at the refuge to take advantage of the shifting abundance in food resources. Some older birds established territories around the three ultralight training sites, preventing significant use by 2003 and 2004 released birds.

Birds summering at Necedah typically use the shallow waters and emergent wetland vegetation bordering the managed impoundments. Small numbers of birds use the natural sedge meadows. In addition to the emergent vegetation zones, the birds use palustrine and upland scrub-shrub areas associated with the marshes for daytime foraging and loafing activities.

Use of oak savannah habitat occurs primarily during late spring and early summer. Crane use often follows prescribed burns which open the understory and expose invertebrates. In early and midsummer, birds are often seen foraging on blueberries and sarsaparilla in the upland scrub areas, most notably the Bee Cut area.

At the refuge, pool draw-downs create ephemeral foraging habitat by trapping fish and other aquatic prey. The cranes also probe for food in the newly-exposed mudflats. This phenomenon naturally occurs during drought conditions.

5.7.7.2 Meadow Valley State Wildlife Area
Foraging, roosting and nesting all occur at Meadow Valley. In 2005 and 2006, two pairs started nesting at two different locations. Both attempts failed for unknown reasons. Future nesting attempts are anticipated.

5.7.7.3 Cranberry Beds and Reservoirs
Cranberry farms in the reintroduction area have provided foraging and roosting habitat for many whooping cranes, particularly during the spring and autumn months.

5.7.7.4 Mill Bluff State Park
The unmanaged impoundment marshes and surrounding agricultural areas of Mill Bluff State Park provide summer habitat for small numbers of cranes, and spring and autumn habitat for larger groups of birds. Continued use of these marshes may eventually lead to a shift toward territories being claimed by breeding birds.

5.7.7.5 Horicon National Wildlife Refuge
Summer foraging and habitat needs have been provided from 2002 until present for at least one whooping crane at Horicon NWR and adjacent private lands. Thousands of visitors have either learned of the project or seen the 'Horicon whooper' (bird #7-01) in this region of the state.

5.7.7.6 Food Preferences
In the spring, birds generally forage in the previous year's cornfields and then briefly in the newly planted fields. A few observations noted birds foraging in cornfields over 3-feet high. This behavior may occur more frequently when bare patches or height variations exist in the field. In autumn, many birds begin to leave their summer territories and utilize this rich food source shortly after harvest.

Like sandhill cranes, in spring and autumn whooping cranes feed in grain fields near their roost sites. Harvested cornfields are preferred. In contrast to sandhills, whooping cranes prefer foraging in wetlands, especially in summer. Sandhills roost in wetlands but frequently fly to uplands or croplands for daytime foraging, while whooping cranes often remain in wetlands for most or all of the day. Unlike sandhill cranes, whooping cranes primarily forage in the morning and evening and frequently loaf during the day.

Both whooping and sandhill cranes feed on grain, tubers, rhizomes, blueberries, and terrestrial insects, especially grasshoppers. However, whooping cranes appear to have a broader diet including fish, frogs, and aquatic invertebrates. Both crane species prefer mudflats or shallows on drawn down pools. Whooping cranes, however, made more efficient use of these areas by feeding heavily on animals trapped in the receding water. Bullheads were a major component of the whooping crane's diet, especially on draw-downs on Rice and West Rynearson Pools, and Upper Rice Pool (Necedah 2003). Crayfish were a preferred food item where they occurred (e.g., the prairie sloughs of South Dakota, 2003). At Necedah NWR, a 2004 large blueberry crop on the Bee Cut provided a major mid-summer food source, which encouraged formation of a subadult group of up to eight birds at this site.

5.7.7.7 Nesting
Two 2005 nesting attempts at Necedah NWR by two young pairs were unsuccessful in part due to egg predation. At least one pair of young birds was inattentive and left the nest rather than incubate. In 2006, five nests were incubated by five pairs of whooping cranes for up to two weeks. They failed for unknown reasons. Four nests initially occurred at Necedah NWR; one nest was on the Meadow Valley SWA in the Monroe County Flowage. One pair of fertile eggs

was rescued from an abandoned Necedah nest, incubated at ICF, transferred to Patuxent Wildlife Research Center for hatching, where one chick became part of the 2006 ultralight–led release cohort. On 23 May, a pair renested at Necedah and ultimately by 22 June produced the first two wild-hatched chicks of this project.

Figuring out why nests are being abandoned is a priority for WCEP. The situation of most nests abandoned is beyond the realm of expectation, and plans are underway to set up film cameras at future nest sites to find out why this occurred. This investigation is important enough to take some risks that might cause nest abandonment.

Multiple people in Wisconsin have seen whooping crane pairs on nests and even taken photographs, meaning the pairs are not abandoning nests the first time they see a human. Risks can be minimized by filming a subset of nests and not filming every nest. Camera distance from the nest may depend on available cover, vegetation type, behavior of the pair, and be suit site specific needs.

Future nesting is expected to occur in the primary central Wisconsin release location at Necedah NWR, Meadow Valley State Wildlife Area, and surrounding wetlands of Monroe, Jackson, Wood, Marathon, Adams, and Marquette counties. As whooping cranes spread throughout the state, it is reasonable to assume that nesting may occur in similar suitable habitat along the lower Wisconsin and Mississippi Rivers and near Horicon Federal and State Wildlife Refuges.

5.7.8 Eastern Migratory Population Winter Habitat

The Chassahowitzka NWR salt marsh and surrounding central Gulf Coast area was originally selected as the reintroduced population's wintering grounds, a site closely resembling the AWBP winter habitat at Aransas NWR. Both refuges share a coastal location and an abundance of blue crabs as a key food source. However, although Chassahowitzka NWR serves as a high-quality release area, for each year's new cohort of ultralight-led birds, tidal and other habitat conditions hinder establishment of winter territories by returning birds. During the project's first four years, wintering migratory whooping cranes chose inland freshwater habitat over the originally saltwater coastal wintering area. Some birds visit the salt marsh pen site upon return from fall migration, but then move inland to freshwater habitat for the remainder of winter. Other birds have chosen to winter in Tennessee, South Carolina, and North Carolina wetlands.

5.7.8.1 Coastal Salt Marsh Habitat

Approximately one half of Florida's ~170,000 ha of salt marsh habitat are located within the Big Bend region, which stretches along the Gulf Coast from Aripeka to Apalachicola Bay. Chassahowitzka NWR lies within this region. This area is characterized by a tidal range higher than that of the western panhandle and by low levels of relief and wave energy. The salt marsh is irregularly flooded by lunar and wind blown tides and a seasonal rise in sea level. About 60 percent of northwest Florida's salt marsh is dominated by dense monospecific stands of black needlerush (*Juncus roemerianus*), with a narrow band of smooth cordgrass (*Spartina alterniflora)* often occurring at the edge of the tidal creeks (Montague & Weigert, 1990). The release pen at the Chassahowitzka site encompasses a tidal pool area and a small amount of surrounding upland. Here the needle rush has been burned and flattened to increase suitability for whooping cranes. Patches of less dense salt grass (*Distichlis spicata*) provide natural loafing areas for the birds. A pre-existing oyster bar was augmented to create a smooth, sloping surface to accommodate the cranes' roosting requirements at varying water depths. These alterations to the immediate pen area, along with the supply of fresh drinking water, have created an oasis of suitable crane habitat surrounded by vast areas that have proven undesirable.

Although the high productivity and density of plant stems in the salt marsh provide ample food and cover for birds, the intense fluctuations in salinity and water level result in a physiologically stressful environment. Few animals are adapted to withstand these kinds of fluctuations over time (Montague & Weigert, 1990). Many salt marsh visitors avoid these environmental extremes by leaving when conditions become unbearable. This temporary utilization of salt marsh habitat in Florida as well as Georgia, North Carolina, and South Carolina, has been the dominant pattern in older whooping cranes of this population.

5.7.8.2 Florida Inland Habitat

Whooping cranes have been fairly consistent in their winter habitat selection. Some birds first try out and then abandon salt marshes while others seek out inland areas containing freshwater marshes, including large highland marshes such as Paynes Prairie, Clermont Marsh, and Hawthorne Prairie. More often, the birds utilize smaller highland or flatwood marshes adjacent to dry prairies used for cattle grazing. Many of the birds forage in these upland pastures during the day, particularly utilizing pastures with a nearby water source such as a ditch or small pond.

During the winter of 2004-2005, one pair of whooping cranes foraged on dairy cattle pastures and roosted on an impoundment at Lake Woodruff NWR, part of the formerly extensive St. John's River Marshes complex. Marshes used by whooping cranes may contain plant assemblages characteristic of flag marshes, wet prairies, saw grass marshes, or cattail marsh. Most important appears to be the existence of shallow water suitable for roosting. During the winters of 2003, 2004, and 2005, small numbers of whooping cranes spent all or a significant portion of the season at Hixtown Swamp, a complex of cypress swamps, marshes and ponds in central, north Florida. Agricultural crops such as rye and peanut fields also provide foraging habitat.

5.7.8.3 Habitat in States Other than Florida

During the 2005 to 2006 winter, 10 of 64 birds wintered outside Florida; seven birds wintered in Tennessee, one in South Carolina, and one in North Carolina. One bird was last seen in Alabama prior to its spring migration to Wisconsin. During the previous year, 14 birds from the project wintered in Tennessee, North and South Carolina (Fig. 5). It is reasonable to anticipate ever larger numbers of whooping cranes wintering outside Florida as this restoration effort continues.

In Tennessee, birds remain at or near Hiwassee State Wildlife Refuge (Meigs County), where they roost along river sandbars and forage in harvested cornfields. Birds have also wintered in Franklin County.

In South Carolina, one male crane spent the winter on Bull Island, a private coastal island just west of Hilton Head. Managed primarily for dove hunting, the grain and cornfields planted for dove habitat provided food for the crane, while the man-made ponds supplied freshwater. This crane typically roosted in a brackish impoundment marsh on the island's edge. The remaining South Carolina birds utilized areas within or near the Ace Basin project, which consists of private, state, and federal lands managed for wildlife and human benefits. Much of the area consists of former rice plantations (converted from inter-tidal marshes) that now contain, among other habitat types, flooded cornfields, brackish marshes, or freshwater marshes. Before settling into their final inland freshwater wintering areas, some of these birds temporarily utilized coastal salt marshes dominated by smooth cordgrass (*Spartina alterniflora*), or islands along the Atlantic Coast of Georgia, including some islands of the Savannah NWR complex.

In North Carolina, birds roost and forage in a small flooded clear-cut in a river bottom. Foraging also occurred in an adjacent harvested cornfield, and occasionally in nearby upland farm fields.

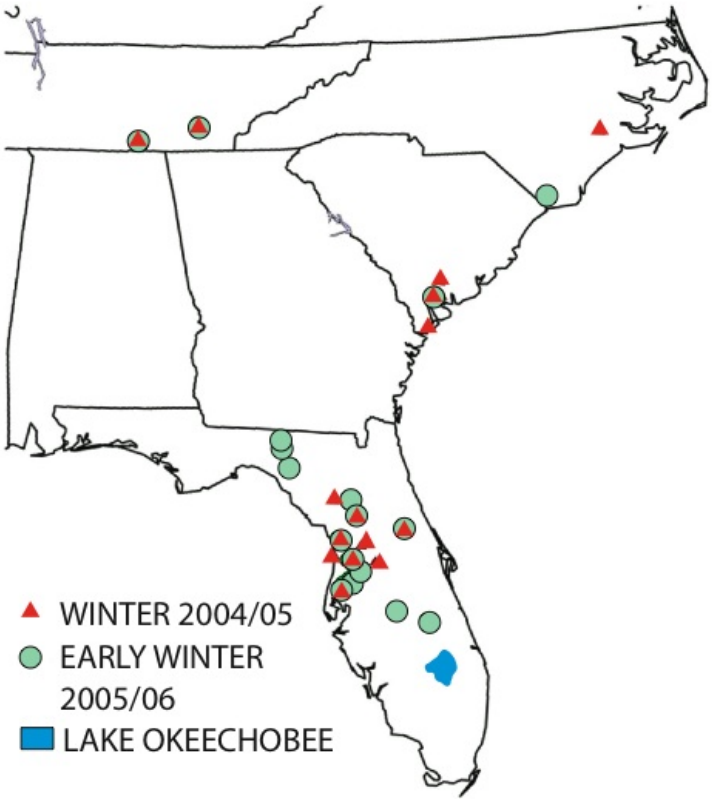


Figure 5. Wintering EMP habitat use, 2004-2006.

5.8 Population Dynamics in the Aransas-Wood Buffalo Population

While whooping crane numbers are increasing, the actual rate of increase is declining. Whooping crane life-history is characterized by a long life span, delayed sexual maturity, permanent pair bonding, small clutch size (one – two eggs), and a long period of bi-parental care. The current northern breeding grounds may be a limiting factor to productivity because of the limited four-month ice free season. During that time, pairs must incubate their eggs for 29-31 days and rear their chicks to flight age in 3 months. Consequently, unless nest loss occurs early in incubation, there is rarely time to lay a second clutch and fledge young if the first clutch fails.

The AWBP is increasing at an exponential rate (R^2=0.973) averaging 4.5 percent per year over a 65-year period. The current population is over nine times the population level 60 years ago. The whooping crane has a long-term recruitment rate of 13.9 percent, the highest of any North American crane population (Drewien, Brown, & Kendall, 1995). However, there is a suggestion of a decline (R^2=0.206) in crane recruitment. Recruitment averaged 0.204 young per adult before the 1938-1966 egg removal program (one egg was removed from a modest number of nests for hatching elsewhere), 0.133 young per adult during the egg removal program (1967-1992), and 0.120 young per adult in recent years (1993-2004). There is also evidence of a ten-

year cycle in recruitment emerging in recent decades as the variance of annual estimates has decreased.

The growth of the AWBP appears to result from increased survival. The disappearance rate of cranes between years averaged 9.8 percent. However, annual mortality of the AWBP declined from 12.1 percent before 1970 to 7.6 percent from 1970-2000. Between 2001 and 2005, annual bird mortality averaged 6.7 percent.

If the exponential growth rate continues, population viability assessments suggest the AWBP will reach 500 cranes around 2040 and 1,000 cranes by 2080 (from updated regression data, Mirande et al., 1991; Mirande et al., 1997; Brook, Cannon, Lacy, Mirande, & Frankham, 1999). No evidence of density-dependence exists; however, this needs to be reevaluated as the population grows beyond the scale of past data. While the large variation in annual growth rate makes predictions difficult, it is likely the AWBP will continue growing over the next 100 years, with a very low probability of extinction (Mirande et al., 1997).

6. MANAGEMENT AND MONITORING

Management and monitoring strategies for the restored eastern population are based on limited knowledge gained through the first five years restoration efforts. The impact of drastic changes in both the landscape and human population in the hundred years or so since whooping cranes were recorded in Wisconsin, along with unknown variables concerning environmental protection and reproduction issues, will require adaptive management and monitoring strategies as new information is gathered and assessed.

6.1 GOAL

The goal of this management plan is to protect the reintroduced whooping cranes and their habitat, thus helping the North American population reach ecologic and genetic stability, while also considering the needs and interests of state citizens and communities. The project's long-term goal is whooping crane recovery and eventual removal (delisting) from the Federal List of Threatened and Endangered Species (CWS & USFWS, 2006). However, present gaps in our knowledge of this species prevents establishment of delisting objectives and criteria. An interim goal for 2020 is the restoration of a self-sustaining EMP with a minimum but growing population of 100-120 birds encompassing 25-30 breeding pairs that regularly nest and fledge offspring.

6.2 POPULATION MANAGEMENT

It is essential to continue to monitor and document the EMP in terms of population size, genetic diversity, habitat use, breeding activity, social interactions, potential hazards, mortality, and movements while in Wisconsin. In addition to the obvious need for population trends over time, it is important to collect estimates of survival and recruitment (and their separate components) which can be used to model population dynamics. Although the EMP is genetically derived from the AWBP, its population dynamics will probably differ due to their dissimilar environments at both ends of their migration routes. Management of the EMP is best based on locally-driven estimates of their population dynamics, rather than using AWBP estimates (refer to Population Dynamics, Section 5.8).

6.3 GENETIC DIVERSITY

The North American whooping crane population is derived from an estimated six to eight founders, with a loss of 66 percent of all genetic material (Mirande, Lacy & Seal, 1993; Glenn, Stephen, & Braun, 1999). Genetic analyses suggest genetic diversity losses in mitochondrial DNA, nuclear DNA, and blood proteins (Jones & Lacey, 2006).
The captive breeding population, derived from the AWBP, has inherited this legacy of genetic loss. Since the eastern population originated from the captive population, this high level of diversity loss has serious implications for whooping crane population management. Genetic changes within the population through inbreeding threaten to reduce productivity before the population is large enough for mutation to offset losses in diversity from genetic drift (Frankel & Soule, 1981; Ballou, Gilpin, & Foose, 1995). Based on the EMP pedigree, the demographic and genetic analysis presented below was completed by Ken Jones to guide future management recommendations and strategies. (A full description and analysis of the genealogy of all North American whooping cranes is contained in the *Whooping Crane Master Plan for 2006* by Ken Jones, as prepared and revised annually for the International Whooping Crane Recovery Team.)

6.3.1 Eastern Population Demographics

As of January 1, 2006, the EMP contained 64 birds. The population is growing at an average rate of 12.8 birds per year. It is expected to reach 100-120 birds by 2011 (Fig. 6) Of the 64 birds, there is a slight skew towards males (36 males and 28 females). The large gender discrepancy in 2003 and 2004 released birds was an attempt to correct a similar sex imbalance in the captive bird population (Fig. 7). A complete genealogy of the first 64 EMP whooping cranes is presented in Appendix 3.

So far the results are encouraging. The EMP has better survivorship than the non-migratory Florida population. If this trend continues, the life expectancy of EMP birds should be significantly longer than Florida birds (Fig. 8).

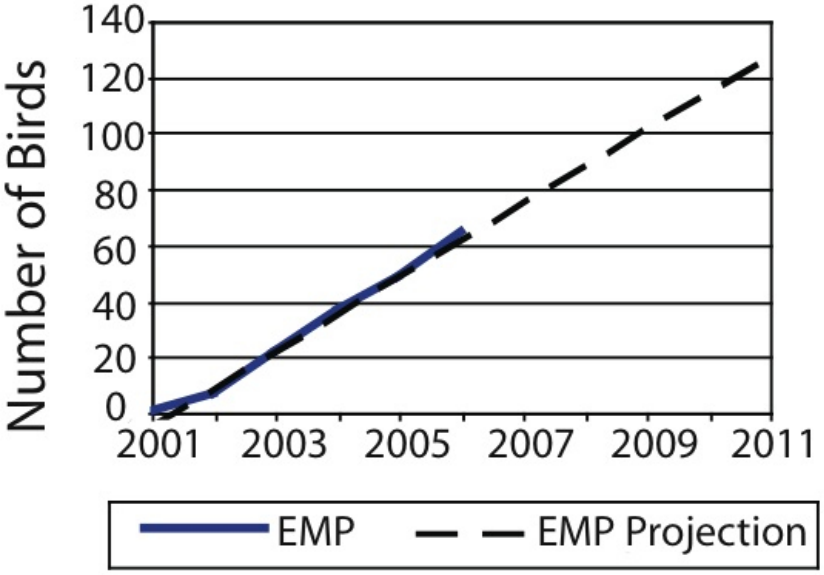


Figure 6. Current and projected EMP growth.

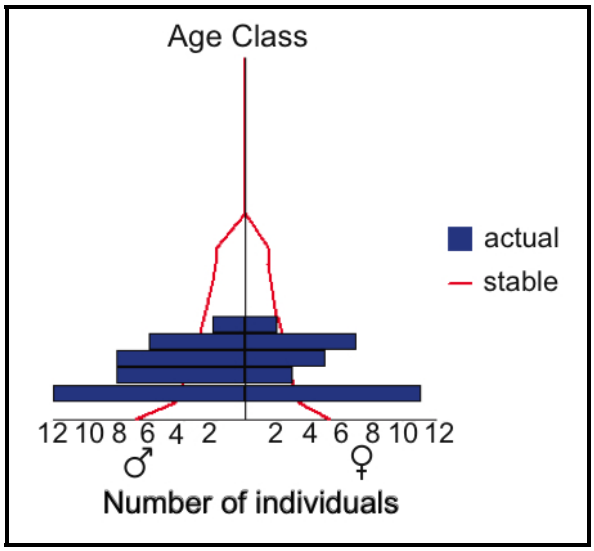


Figure 7. EMP age and sex distribution, January 1, 2006.

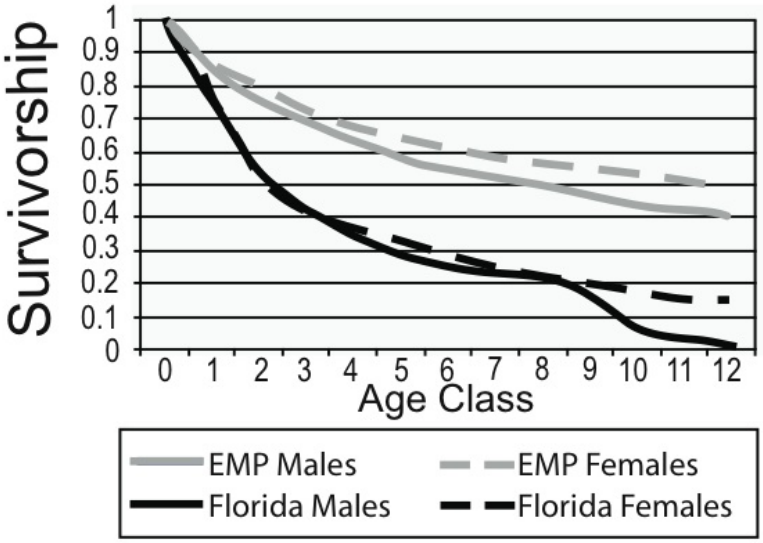


Figure 8. EMP survivorship exceeds the FP survivorship.

6.3.2 Eastern Population Genetics

Analysis of the January 2006 population indicates 52 percent of the population stems from two half-sibling females, numbers 1135 and 1136 (Fig. 9, Table 1). The total population of 64 birds derives from 12 remaining female lines and 13 male lines. One male (1133) has contributed 25 percent of the total offspring as a mate to 1135 (Fig. 10, Table 1). Additionally, a large percentage of released birds descend from two grandparents, 1019 is a grandfather to 29 (45 percent) and 1027 is grandmother to 42 (66 percent) of the population (Appendix 3). Since a disproportionately high number of offspring come from the genetic heritage of 1135 and 1136, under an assumption of random mating, a high rate of sibling mating could occur. As of June 2006, out of seven pairs formed in the EMP, two have been sibling pairs.

Table 1. Sires and Dams of 64 EMP birds (2001-2005).

Sires				Dams			
Rank	SB No.	No. of offspring	percent of total	Rank	SB No.	No. of offspring	percent of total
1	1133	16	25.0	1	1135	21	32.8
2	1144	12	18.8	2	1136	12	18.8
3	1127	6	9.4	3	1154	6	9.4
5	1128	5	7.8	4	1142	5	7.8
5	1147	5	7.8	5	1119	4	6.3
5	1560	5	7.8	9	1098	2	3.1
7	1114	4	6.2	9	1140	2	3.1
10	1130	2	3.1	9	1167	2	3.1
10	1162	2	3.1	9	1188	2	3.1
10	1175	2	3.1	9	1195	2	3.1
10	1182	2	3.1	9	1263	2	3.1
10	1189	2	3.1	9	1292	2	3.1
13	1041	1	1.6	13.5	1101	1	1.6
				13.5	1197	1	1.6

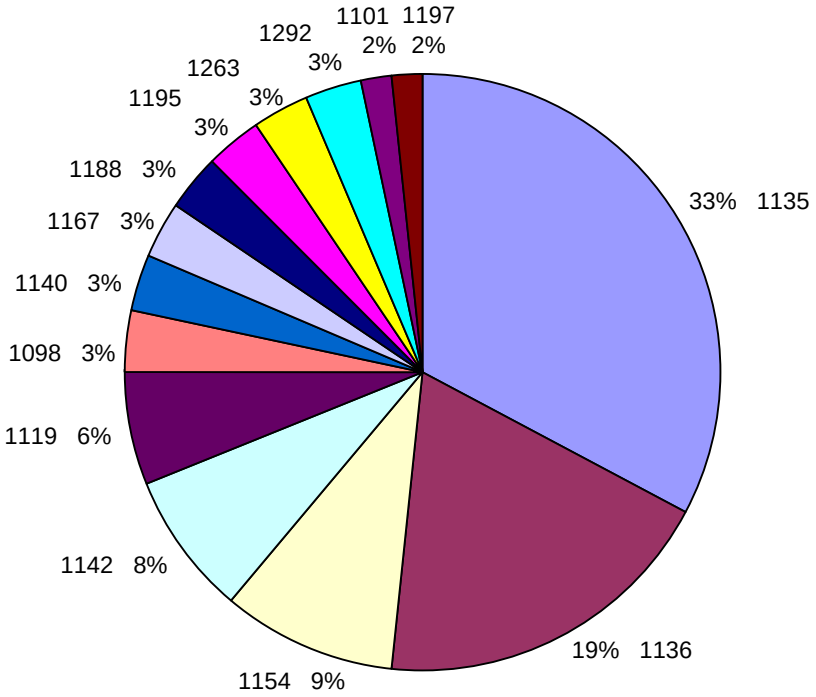


Figure 9. EMP female ancestry.

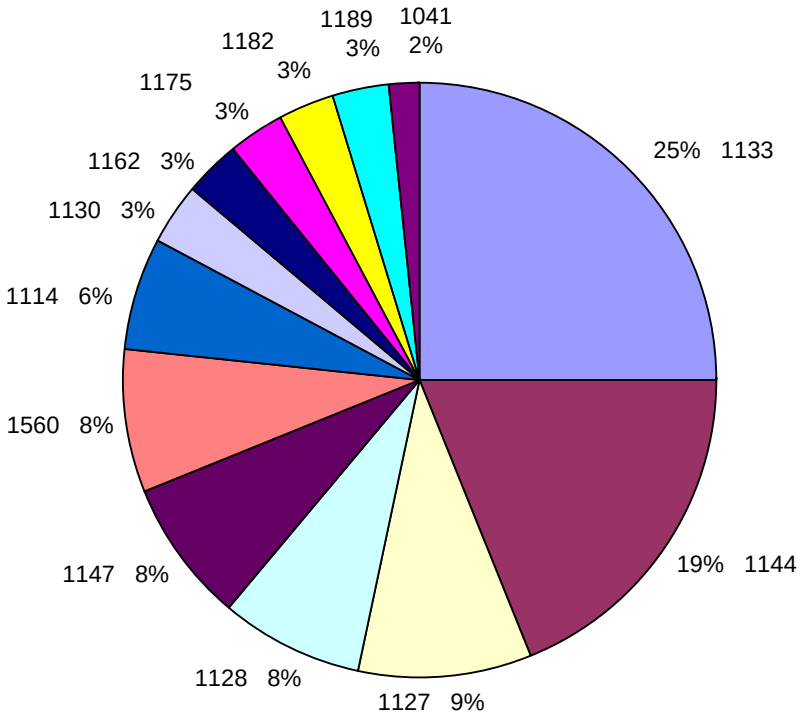


Figure 10. EMP male ancestry.

6.3.3 Population Recommendations

Since the population is demographically stable, attention should focus on its long term genetic health. High levels of inbreeding, such as full sibling mating, produce a decline in hatchability and juvenile fitness in many bird species. Low allelic diversity may also result in increased vulnerability to disease mortality (Jones & Lacey, 2006). Currently, the reintroduction program is faced with inbreeding likely to result from reproduction by paired siblings in the earliest cohorts (2001-2003). It is doubtful these birds will immediately dissolve their pair bonds in favor of less-related mates. In a 14 year study of sandhill cranes, the mean pair bond lasted 5.7 years, severed through either permanent divorce or death of a mate (Hayes & Barzen, 2003). In the long term, genetically poor pairings may be corrected with mate switches by the release of less closely related birds. Meanwhile, several management strategies can help increase genetic diversity in this population.

First, to maintain a healthy female population, future release cohorts should contain an equal representation of males and females.

Second, to improve the EMP's genetic health, the genetics of the EMP and captive population should be analyzed yearly. The resulting analysis should guide annual chick allocation as described below:

- Chicks genetically valuable to both populations should be allocated equally between the captive and migratory eastern population.
- Chicks that will bolster EMP genetic diversity but reduce diversity in the captive population should be allocated to the EMP release program.

- Chicks that would significantly decrease the EMP's genetic diversity should not be released. Specifically, chicks from female 1135 should not be released as she currently has 21 surviving offspring in the release population. Further, chicks from 1136 should only be released if sufficient numbers of chicks are unavailable from more genetically suitable pairs. Suspending the release of offspring from over-represented females (i.e., 1135 and 1136) and preferentially releasing offspring of under-represented females will increase the gene diversity of the population, and ultimately reduce overall inbreeding.

Third, reproduction by sibling pairs should be discouraged until the population grows sufficiently large to assure a low incidence of these pairings. Possible methods include:

- Letting the sibling pair continue first-time nesting. This option will provide an opportunity for the birds to demonstrate successful parenting, thus becoming candidates for future surrogate parenting of non-sibling swapped eggs.
- Swapping eggs from a sibling pair with those of an out-bred pair. The genetically suitable eggs could come from captive birds, as a first choice, or from other EMP nesting pairs. This strategy alleviates the problem in the short term, but takes considerable monitoring to assure that no eggs from the pair hatch prior to swapping. However, removing the eggs selects against the genetic heritage of that family line.
- Removing the male of the pair from the population. This strategy would permanently solve the inbreeding problem caused by that pair. By removing one of the two birds, the genes from that family line would enter the population when each sibling eventually paired with an unrelated bird. Because full sibling mating is more likely when a family line is over-represented, removal of the male would also help equalize family representation within the population.

6.4 DATA MANAGEMENT

Partners in WCEP are committed to collecting and sharing data, project summaries, and project analyses in a timely manner and upon request, with the understanding that any publications will be approved by those involved in the data gathering. Such data sharing is critical to the success of recovery efforts. Three WCEP informational databases compile whooping crane information used to guide the reintroduction effort including:

1. The *Whooping Crane Master Plan,* a studbook maintained by Ken Jones, Kansas State University. This genealogy of all captive and released whooping cranes guides decisions on breeding and chick release for the project.
2. A medical database maintained by ICF, containing information from all WCEP partners during all phases of the reintroduction.
3. An EMP monitoring database with GIS interface maintained by the WI DNR.

6.4.1 Database Goals and Objectives

The newly developed (2006) EMP whooping crane monitoring database is a crucial analytical tool for making informed decisions on issues of habitat quality, landowner needs, whooping crane biology and conservation, and assessment of whooping crane management and recovery goals. The database and GIS interface will enable WI DNR and USFWS staff, ICF biologists, the International Whooping Crane Recovery Team, and other WCEP partners to analyze results of reintroduction efforts systematically and efficiently as a breeding population becomes established in Wisconsin. The expected outcome is a tool for use by WI DNR policy and regional land managers, staff biologists, and WCEP biologists in assessment of whooping crane management and recovery goals.

In creating and applying this monitoring database, Wisconsin DNR has committed to 1) developing, implementing procedures, and maintaining a whooping crane monitoring database from information collected by USFWS, ICF and WI DNR biologists; 2) determining appropriate tool(s) for data access, defining and resolving problems with the application database, and training and supporting staff in use of data access tools; and 3) identifying factors limiting whooping crane populations in Wisconsin (a Species of Greatest Conservation Need).

Whooping crane data will be recorded and electronically submitted by all field staff; WI DNR staff use an electronic monitoring form available on the WI DNR server. Data can be submitted by email or phone to the Whooping Crane Coordinator or database manager (refer to Appendix 7). Information will be compiled, consistently formatted and used for the following:

1. Documenting bird location, health, behavior, habitat, and relocation needs
2. Analyzing pair formation and reproduction, behavior, and habitat use
3. Comparing release strategies and setting future population goals for Wisconsin
4. Evaluating genetic pedigree of EMP chicks produced in the wild
5. Guiding land management, land acquisition, and public use decisions
6. Conducting environmental analyses for state and federal permit issuance (i.e., power line or cell tower placement, wastewater discharge, waste spreading, and water flow regulation)
7. Preparing outreach, education, and funding proposals

Partner investment to help maintain a workable EMP database will assure compilation, exchange, extraction, and application of whooping crane data to address WCEP needs. Data compiled while observing cranes may also provide information on other wetland bird populations in Wisconsin. Further, data management and analysis will promote adaptive management strategies and refinement of the Whooping Crane Management Plan during the course of the reintroduction effort.

6.5 Monitoring Strategies

USFWS biologists have coordinated monitoring activities since project inception. However a growing population of birds and limited resources necessitates increased communication and efficiency among WCEP partners. To this end, development of a long range EMP monitoring plan is under consideration. This plan would assist reintroduction efforts by identifying both priorities and a network of field personnel in Wisconsin and along the migration pathway.

Meanwhile, ground level monitoring and tracking in Wisconsin is provided by USFWS, ICF, and WI DNR staff in specially-equipped vehicles with roof-mounted antenna, or on foot using hand-held receivers. Project interns and graduate students also contribute invaluable field observations. When medical problems arise, information is sent to the WCEP Health Team, including the WI DNR wildlife veterinarian and DNR whooping crane coordinator (see Health Monitoring, Appendix 5).

6.5.1 Radio Transmitters

All EMP birds are marked with color-coded leg bands and conventional very high frequency (VHF) radio transmitters with an approximate battery life of 1.5 years. Radio transmitters are painted to match the bands. Colored leg bands on each leg provide a unique two-way identification system, one color pattern identifies the release-year cohort and the other pattern is unique to the individual. Numbered USFWS leg bands provide long-term marking of individual

cranes, yielding information on longevity and some evidence of mortality and movement. Bands with transmitters are replaced opportunistically (Appendix 1).

Radio transmitters allow tracking of habitat, dispersal patterns, breeding, and survival. Tracking range depends on distance, transmission medium, and other factors. Typical tracker-to-bird ranges for fully functional transmitters may be 3 miles ground-to-ground, 15 miles air-to-ground, 30 miles ground-to-air, and over 100 miles air-to-air. Radio-marking is extended by opportunistic recapture and replacement as needed. Immediate project needs include additional radio receivers to track whooping cranes at Jasper-Pulaski Fish and Wildlife Area in Indiana and Hiwassee Wildlife Refuge in Tennessee.

6.5.2 Aerial Tracking

Aerial tracking may be provided through private aircraft donated by Windway Corporation to ICF researchers, and periodically through USFWS commercial aircraft rental. Use of rented aircraft is limited due to expense ($110-125 per hour), scarcity of commercial planes, and limited number of Office of Aircraft Services certified pilots required by USFWS staff (currently only two such pilots in Wisconsin).

Once an EMP monitoring plan is developed, aerial tracking may be enhanced through collaboration with other monitoring programs. Wisconsin DNR Wildlife Management and Science Services staff currently use cooperative aerial monitoring strategies for programs involving species such as the bald eagle, osprey, trumpeter swan, duck, deer and wolf monitoring programs. Aerial surveys fly seasonally and at times biweekly. Wisconsin DNR also has radio receivers for airplane mounted tracking that can pick up whooping crane transmission frequencies. Even without specific radio identification of individual birds, aerial sighting records will provide useful information to WCEP partners.

6.5.3 Satellite-monitored Radio Transmitters

Several cranes from each year's release cohort are marked with a satellite-monitored platform transmitter terminal (PTT) radio transmitter to better monitor unpredictable movements during migration. The value of the PTT lies primarily in documenting gross movements outside our state. However, they may also aid in following dispersal within Wisconsin that occurs outside the central Wisconsin restoration area. These transmitters can locate a bird within 15-1,000 m of its location. Programming PTT transmission schedules for each unit can maximize their life expectancy (~750 hours, with 8 hours of operation on each pre-defined transmission day).

6.6 Bird Interventions

Capture of released whooping cranes is sometimes necessary to replace nonfunctioning radio transmitters, to retrieve and relocate birds from undesirable locations, or for veterinary assessment. Capture and relocation decisions should be mediated by the following factors:

1. Increased effort required to capture and transport older, more wary birds over younger birds that are still attracted to the crane costume
2. Difficulty of capturing whooping cranes consistently associating with sandhill cranes
3. Evaluation of the subject bird's written history
4. Logistic feasibility of capturing and relocating birds with available staff and resources

6.6.1 Relocation Options

For migration training to be considered successful, the cranes must return to Wisconsin or other nearby areas in the northern part of the southern U.S.-to-Wisconsin migration Flyway (i.e.,

northern Illinois). Under certain conditions, retrieval and relocation of released whooping cranes may be necessary to reinforce learning and use of the same, safe migration route, especially during their first spring migration. Capture and relocation may also be used to reinforce safe habitat use; to avoid habituation to people; or to encourage normal social behavior, pairing, and reproduction. Specifically, birds may be considered for capture and relocation to central Wisconsin under the following conditions:

1. When blocked by physical barriers during their first spring migration (e.g., Lake Michigan). For returning yearlings the recommended relocation date will vary from May 15 to July 31, and is dependent upon the probability of the birds circumventing the barrier.
2. When alone or in a small group that is significantly off course (e.g., greater than 200 miles) for more than two weeks during their first spring migration. Recommended dates of relocation vary from May 1 to June 1, depending on the likelihood of the birds returning on their own. Birds shortstopping within the migration corridor at latitude 41 degrees or greater are considered on-course.
3. After establishment of a multi-year pattern of summering and wintering in an area separate from other whooping cranes. In this case relocation could be coordinated with a routine capture required for transmitter replacement.
4. After removal from the wild for temporary captivity (i.e., medical treatment), and after receiving medical clearance for release.
5. When located in an area where their health or safety is threatened, such as roosting outside of wetland areas or spending excessive time near roads.
6. When consistently in close proximity to and becoming habituated to people (e.g., where they allow or ignore human approach within 30 m or where people intentionally feed them).

Conditions numbers four through six also apply to retrieval and relocation on the migration route and wintering areas. Locations which are significantly off course may need to be defined and addressed in the future. Retrieval decisions may be impacted by the difficulty or inability to monitor birds in certain locations. Bird dispersal after return to the core reintroduction area in central Wisconsin may require attention on a case-by-case basis.

6.6.2 Methods

Capture techniques are consistent with the *Guidelines for Field Capture and Safe Handling of Whooping Cranes to Avoid Capture-Related Stress and Injury* (Appendix 4). Juvenile and sometimes older isolation-reared whooping cranes can be approached and grabbed or guided into a transport box by costumed handlers (Fig.11). These birds will approach a costumed handler near a corn-baited feeding apparatus, familiar from their pre-release days as chicks.

Figure 11. Wild costume-reared birds baited for capture.

However, many older birds will not allow close approach. Possible capture techniques for older cranes include leg nooses and clap traps. Nooses were not effective with sandhill cranes at Necedah NWR; clap traps hold more promise and may be explored further. Standard methods (i.e., rocket-netting or drugging with alpha-chloralose) used for capturing sandhill and whooping cranes in natural populations are not approved for EMP whooping crane capture because of the risk of injury or mortality. One technique developed by WCEP monitoring personnel is costumed drive-trapping for one or more cranes as described below.

1. A favorite site is identified and baited with ear corn. Ear corn is more conspicuous and attractive than shelled or cracked corn, and can be easily manipulated by personnel at the trap site. The trap site may be at a roost or daytime foraging area. However, the trap is more easily set up and maneuvered on a dry site during a capture attempt.
2. After the crane consistently uses the bait site but while it is absent, a 14' wide x 20' deep x 6.5' high portable trap is erected. For example, the trap might be set at a feeding site while the birds are on roost. The trap consists of a 0.5" electrical conduit frame covered with Bird-X netting. One end of the trap consists of two 7' wide doors which open outward to funnel birds into the trap (Fig. 12). Set up requires one through four hours depending on terrain and available personnel.
3. Once the crane becomes accustomed to the trap's presence, costumed personnel carefully attract and guide the birds to the trap entrance. When the birds are positioned in the gateway, costumed personnel move quickly towards them, ushering them through the entrance. The gates are closed and the birds are carefully grabbed and hooded. If the capture is for transmitter replacement, the nonfunctional transmitter is replaced and the bird is released on site. If the capture is for retrieval and relocation, personnel continue to the next step.
4. With hoods removed the birds are placed in cardboard transport boxes.
5. An air-conditioned van arrives and the boxes are loaded into the van.
6. For a short relocation (i.e., a few hours of driving), the birds are transported in the van. For long distances, the birds are transported by van to the nearest suitable airport, transferred to a waiting aircraft, and flown to an airport near the release site.

7. Upon arrival, the boxes are loaded into a waiting air-conditioned van and driven to a prearranged site for medical examination. After examination, the birds are transported to the release site.
8. Boxes are unloaded with the sliding doors facing away from the vehicle. The doors are pulled, and the van quickly leaves as the birds exit the boxes. Alternately, the vehicle leaves the area and costumed personnel release the birds after the vehicle is out of sight.

Figure 12. Portable crane trap.

6.6.3 Nesting Interventions

Successful nesting is crucial to the restoration of a self-sustaining eastern population of whooping cranes. The process of rearing and training cranes for release is labor intensive and costly. At times, human intervention may be needed to avert undesirable reproductive outcomes. Such intervention could include egg removal to prevent exposure or predation, or egg swapping to increase the chance of success for more genetically valuable eggs.

Nest intervention can disturb adult breeding cranes. With guidance from the WCEP Project Direction Team as warranted, field staff will need to exercise their best judgment when making decisions in the field. Circumstances which may warrant nest intervention include preventing reproduction by genetically similar birds, averting interspecies pairing, and rescuing eggs.

Specifically, intervention may be needed to prevent reproduction by full sibling pairs. Several intervention options are available. If the birds demonstrate an ability to be successful parents, it may be desirable to allow them to raise young by swapping their eggs with more genetically desirable eggs. An alternative but more drastic action may be to remove one sibling to encourage the other to pair with an unrelated bird.

Interspecies pairing with sandhill cranes may warrant immediate intervention. No hybrid chicks have been documented in the AWBP. Florida Fish and Wildlife Conservation Commission biologists monitor associations with sandhill cranes, but have had limited success with moving birds to break up a whooping crane/sandhill crane pair. To date, there have been 15 FP whooping cranes that have associated with sandhill cranes rather than whooping cranes. Of these 15 birds, there have been two whooping crane/sandhill crane pairs documented. It is possible that one pair hatched two chicks, but they did not survive long enough to verify whether the chicks were the result of the hybrid pair (M. Folk, personal communication, September 2006).

If ever a female EMP whooping crane pairs with a male sandhill, it may be best to capture and relocate the female to an area with whooping cranes. However, in the case of a male whooping crane paired with a female sandhill, the female should be removed since a male would more likely return to its territory after relocation.

Another intervention may involve removing eggs that could succumb to exposure or predation. Young birds, in particular captive-reared birds, are expected to be less proficient parents during their initial nesting attempts. Cranes normally break for short periods as the parents exchange incubation duties; stand to stretch, preen, or drink; or turn eggs. Based on observations of Florida nesting cranes, such routine breaks can vary from 5 to 20 minutes. However, the adults should always be in sight of the nest.

Nest abandonment may occur anytime between egg laying and late incubation. For example, during late incubation flooding can lead to nest abandonment. When feasible, it is highly recommended that the rescued egg be replaced with a wooden egg. If the adults return to the nest, the fake egg might encourage the cranes to begin incubation—thus learning correct incubation behavior.

Egg collection should occur whenever both adults are off their territory and out of sight for more than two hours. Nevertheless, the time interval may be as short as one hour depending on 1) the behavior and nesting history of the adult pair, 2) the length of time after the egg was laid, 3) the weather, 4) the genetic value of the egg(s) 5) whether darkness is approaching or evidence that the adults are roosting elsewhere. The egg's age in combination with the ambient temperature will determine how long the egg can remain unattended before the embryo is harmed (Table 2). An un-incubated egg can remain unattended for a longer period of time than an incubated egg.

Table 2. Embryo viability.

Ambient temperature	Elapsed time before embryo harm
<4 ° C	45 minutes
4-16 ° C	3-4 hours
16-27° C	1-2 hours
27-32° C	2 hours
>32 ° C	45 minutes

Removed eggs should be handled with plastic gloved hands, placed in an egg box warmed to 34.4 ° C, and carefully transported to a facility with an appropriate incubation program. If the ambient temperature is < 4 ° C, it is better to let the egg warm up to room temperature before placing it in the egg box.

Decisions guiding egg return to a nest should be determined on a case-by-case basis. Consideration should include genetics of the egg, disturbance to adult pair, and length of time the pair has been incubating. The egg might be placed back in the nest if the parents return to the site and appear interested. Based on parental attention, natural incubation in the nest might then be allowed to continue. (Related information is located under Population Recommendations, Section 6.3.3, and Nest Site and Territory Management, Section 6.9)

6.7 Health Risks and Mortality

The WCEP Health Team has primary responsibility for coordinating clinical assessment and health evaluation from egg through death, opportunistic health monitoring, and treatment of all wild cranes in the eastern population. Veterinary network cooperators are available to provide field assistance when a Health Team member is unavailable. Contact the WI DNR wildlife veterinarian or the ICF veterinarian for health assessments and urgent health care issues within Wisconsin.

Field biologists and/or the WI DNR whooping crane coordinator will provide the Health Team with timely updates of current cases and facilitate requests for assistance. All efforts will be made to contact the consulting veterinary staff with a change in health status. Evaluations of wild whooping cranes will be coordinated with the Health Team, and decisions on intervention will be made by the consulting veterinarian. When possible, adequate lead time will be provided to arrange for Health Team personnel presence during radio transmitter changes or other capture/relocation events.

Short-term treatment facilities may be used. Diagnostic work-ups and procedures—under strict isolation protocols—may occur at the Necedah NWR acute care facility or ICF veterinary quarantine facility. The goal of treatment is reestablishment of the affected crane into the wild as soon as medically possible. Birds needing additional care will be removed from the project and transferred to the Milwaukee County Zoo or other approved facility for intermediate-term care and management. As described below, wild cranes may experience infectious and non-infectious diseases, predation, human disturbance, and power line or other fixed structure collisions.

Any incident involving the injury, death, or possession of a whooping crane should be reported to the conservation warden in the relevant county. Reports may be made directly to the warden or through the nearest WI DNR Service Center, sheriff's department, or by calling the WI DNR violation hotline at 1-800-TIP-WDNR (847-9367). Wardens will document the report and subsequent investigation on a law enforcement complaint form (Form #4800-48). (Refer to Appendix 6, Response Protocols, for a sample of the "Dead Crane Data Sheet".)

As soon as practical after receiving a report the warden or the warden supervisor will notify the Regional Enforcement and Science leader and the Bureau of Endangered Resources. The investigating state warden will coordinate the investigation with the USFWS federal warden as appropriate on all intentional shootings. Any unlawfully killed or possessed whooping crane carcass will be tagged by the warden with a seizure record tag (Form # 4100-190). Proper chain of custody will need to be maintained for any incidents that might result in enforcement action.

6.7.1 Diseases

The AWBP and the extirpated Rocky Mountain population frequently experienced infections with avian mycobacteriosis (*Mycobacterium sp*.). Approximately 39 percent of AWBP birds necropsied through the mid 1990's were diagnosed with mycobacteriosis/tuberculosis (Friend & Franson, 1999), though this diagnosis has not been made in AWBP cranes since that time. Captive cranes may be particularly susceptible, although no confirmed cases occurred in the captive populations contributing chicks to the release programs. Screening of birds prior to release should prevent the introduction of tuberculosis into the eastern population; postmortem evaluation should continue to record the possible occurrence of this disease.

Aspergillosis (*Aspergillus fumigatus*) is a common fungal infection usually existing as a secondary problem in a debilitated bird. Most aspergillosis outbreaks occur in fall to early winter, particularly among birds stressed by crippling, oiling, malnutrition, recent capture, environmental contaminants, and concurrent disease conditions (Friend & Franson, 1999). In wild whooping cranes, only the FP has recorded cases of aspergillosis. It is periodically diagnosed in captive cranes, especially in juveniles, and is a contributing factor to lower than desired chick numbers available for EMP release.

Mycotoxins are non-infectious toxic compounds produced by fungi (i.e., *Aspergillus sp*. and *Fusarium sp.*) that typically occur in moldy grain, such as corn and peanuts. Wild sandhill crane mortalities resulted from two types of mycotoxin poisoning, aflatoxicosis and fusariotoxicosis. Most mortality due to toxic levels of these compounds occurs when cranes consume waste grain during fall migration and wintering (Friend & Franson, 1999). Mycotoxin poisoning can also occur when contaminated grain is offered at feeding stations.

Whooping cranes are highly susceptible to the mosquito transmitted eastern equine encephalomyelitis (EEE) virus of eastern and north-central North America. In1984, the disease killed seven captive whooping cranes at the Patuxent Wildlife Research Center, one of the facilities supplying crane chicks for reintroduction (Dein et al., 1986). In 2004, one unvaccinated EMP crane died of EEE near the end of its ultralight-led fall migration. Currently, all captive-reared juvenile whooping cranes are vaccinated against EEE prior to release using a commercially available equine vaccine. The efficacy of the vaccine is unknown for whooping cranes; therefore, disease exposure should be monitored through blood sample and crane mortality analysis.

Disseminated visceral coccidiosis (DVC) is an extra-intestinal form of parasitism by protozoal *Eimeria*. Affecting captive and wild whooping cranes, the pathology of this disease can range from mild to severe. The disease is common among sandhill cranes in Wisconsin and at the Patuxent Wildlife Research Center. Juvenile whooping cranes are highly susceptible to DVC; consequently, the EMP and FP's juvenile diet is supplemented during rearing for release, with the coccidiostat drug, monensin. The drug limits infections to promote an immune response that prevents disease. The effect of this treatment and the impact of DVC on whooping crane survival after release are unknown. Lesions consistent with DVC were observed in some cranes; however, they were not identified as the cause of death.

Whooping cranes can be infected with endoparasites, including acanthocephalans, cestodes, trematodes, and nematodes (Carpenter, 1993). The effect of endoparasites on wild and captive crane survival is unclear. Significant morbidity and mortality due to endoparasitism occurred prior to the release of juvenile cranes into the Florida and eastern populations. Parasite monitoring will become increasingly important as young are recruited into the population.

Avian botulism, a paralytic disease caused by the ingestion of *Clostridium botulinum* biotoxin, is found throughout the eastern migratory Flyway used by whooping cranes. Though not considered a species at risk, whooping cranes could be exposed during a large outbreak in remote areas. Control strategies (i.e., carcass removal and avoidance of water draw-downs in botulism prone areas during warm weather) will reduce the likelihood of whooping crane exposure.

6.7.2 Contaminants

Though cranes usually feed on lower trophic levels, they are long-lived and may accumulate significant amounts of persistent chemicals (Olsen, Langenberg, & Carpenter, 1996). A sampling of whooping crane carcasses and eggs indicated declining DDT pesticide and mercury levels, while other related compounds such as chlorinated hydrocarbons persisted at low levels (Lewis et al., 1992b). Trace elements including aluminum, arsenic, cadmium, chromium, copper, selenium, and zinc were found at levels high enough to justify further monitoring. Although organophosphate and carbamate compounds have been identified in sandhill crane tissue (Olsen et al., 1996), the impact of these chemicals on whooping cranes is unknown.

Consumption of non-food items for grit is a risk factor for heavy metal toxicosis. Lead fishing weights and spent shot, small wire clippings, and zinc alloy coins are only a small number of potential sources of heavy metals that may be ingested by wild whooping cranes.
For example, lead poisoning occurred in a whooping crane following ingestion of a plastic encased battery or fish sinker (Snyder, Richard, Thilsted, Drewien & Lewis, 1992). Zinc toxicosis is a recognized mortality factor in the Florida non-migratory population.

6.7.3 Traumatic Injury and Death

Traumatic injury may impact individual crane survival, and could contribute to stochastic events that threaten the existence of the small Florida and eastern populations. The causes of traumatic injury can be divided into natural events such as predation and severe weather, and anthropogenic causes like contact with humans or human artifacts.

Whooping cranes are preyed upon by both mammalian and avian predators. Bobcat (*Felis rufus*) predation is the most frequent cause of death for Florida cranes. Furthermore, predation is suspected as the cause of death in at least six EMP whooping cranes. Though underlying disease or injury can predispose an animal to predation, management steps may be available to limit the potential impact of predators on healthy individuals in sensitive areas (refer to Trapping, Section 7.2).

Litter such as fishing line, spent shot gun shell casings, and aluminum cans often harm cranes. The risk to whooping crane survival increases as the foreign material wounds or constricts blood flow to critical areas, such as around the beak, limb, or digit. Public awareness regarding the dangers of litter and spent tackle to whooping cranes and other wildlife should be promoted.

The accidental shooting death of two AWBP whooping cranes in Kansas (2004) and an EMP whooping crane in Alabama (2004) illustrates the need to educate the public on proper field identification of whooping cranes. To prevent gunshot injury and mortality during hunting season, in 2005, Texas Parks and Wildlife produced a training DVD entitled, “Be Sure Before You Shoot” that includes whooping crane identification tips (refer to Legal Aspects, Section 4.1, and Appendix 6).

6.7.4. Collisions with Power Lines, Towers, Turbines and Other Structures

Collisions with power lines are a significant cause of whooping crane mortality during migration (Brown, Drewien, & Bizeau, 1987; Lewis et al., 1992a). Cranes often hit power lines after being flushed or disturbed from a roost. To remedy a persistent problem in areas of Florida, in 2004 Progress Energy (the owner of the lines) marked the top "static" smaller diameter lines (typically most problematic for birds to see and avoid) with yellow spiral visibility markers. In June 2005, Progress Energy increased the number of marked lines using a potentially more effective marker (Firefly Bird Flapper by PR Technologies, Portland, Oregon).

Additional power line construction throughout the principal migration corridor will increase the potential for collision mortalities. To address this issue, in 1989 the Avian Power Line Interaction Committee (APLIC)—composed of nine investor-owned electric utilities and the USFWS—was established to protect cranes in the AWBP Flyway (Lewis, 1997). In 1994, APLIC provided voluntary industry guidelines on avoiding power line strikes. Presently, the USFWS is working on memorandums-of-understanding (MOUs) that call for the development of avian protection plans by participating companies (Manville, in press). Tests of line marking devices using sandhill cranes identified techniques effective in reducing collisions up to 61 percent (Morkill, 1990; Morkill & Anderson, 1991, 1993; Brown & Drewien, 1995). Techniques currently recommended include marking lines in frequently used areas, and avoiding new line corridors near wetlands or other crane use areas.

Whooping cranes may also be injured or killed through wind turbine collisions. In the next decade the number of wind turbines may increase from 15,000 to 31,000 (Manville, in press). Of special concern is the development of wind farms in the whooping crane migration corridor. Cranes could die by either striking wind turbines, or by colliding with new power lines associated with wind farm development. Management and research are needed to reduce this new threat.

Increasing numbers of power lines, communication towers, and wind turbines may kill as many as 225 million birds annually in the U.S. (Manville, in press; CWS & USFWS, 2006). Recently, seventeen Florida cranes and two EMP cranes died by hitting power lines. In the 1980s, two of nine radio-marked AWBP whooping cranes collided with power lines and died within the first 18 months of life (Kuyt, 1992). Since 1956, power line collisions caused the death or serious injury of at least 41 whooping cranes.

Specifically, eight Florida cranes died after striking high-voltage transmission lines and nine Florida cranes died by hitting lower voltage local distribution lines (Folk et al., 2006). Seven mortalities took place in a two-year period (March 2003 to March 2005) along an 8 km span of high-voltage lines. The birds were roosting on one side of the line and feeding on the other, thus crossing the lines at least twice daily.

Five Florida birds collided with lines and survived. (Based on recovery of transmitters with broken leg bands under power lines, and subsequent observations of the birds that carried those transmitters.) It is not unusual to see whooping cranes brush power lines or trees with their legs. As the bird brushes the object, the transmitter, which hangs down on the leg, is likely struck hard enough to shatter the plastic band.

Guy wires associated with telecommunication towers present another collision obstacle. Increasing at an estimated 6 to 8 percent annually, the Federal Communication Commission's (FCC) 1999 Antenna Structure Registry listed 48,000 lighted towers over 60.7 m above ground level and over 68,000 towers total in the United States. An estimated 24 to 38 percent of the

towers were improperly registered with the FCC. The future requirement that television stations must be digitized may add an additional 1,000 towers exceeding 305 m in height.

6.8 Managing Public and Private Lands

Any wetland with minimal human disturbance, even small isolated wetlands, bears potential for use by whooping cranes (Fig. 13). However, it is expected that the locations of initial high concentration and nesting will occur in the primary rearing and release location of central Wisconsin: at Necedah National Wildlife Refuge in Juneau County and surrounding wetlands of Monroe, Jackson, Wood, Marathon, Adams, and Marquette Counties. (See Appendix 8 for a county map and description of observed whooping crane locations within each county).

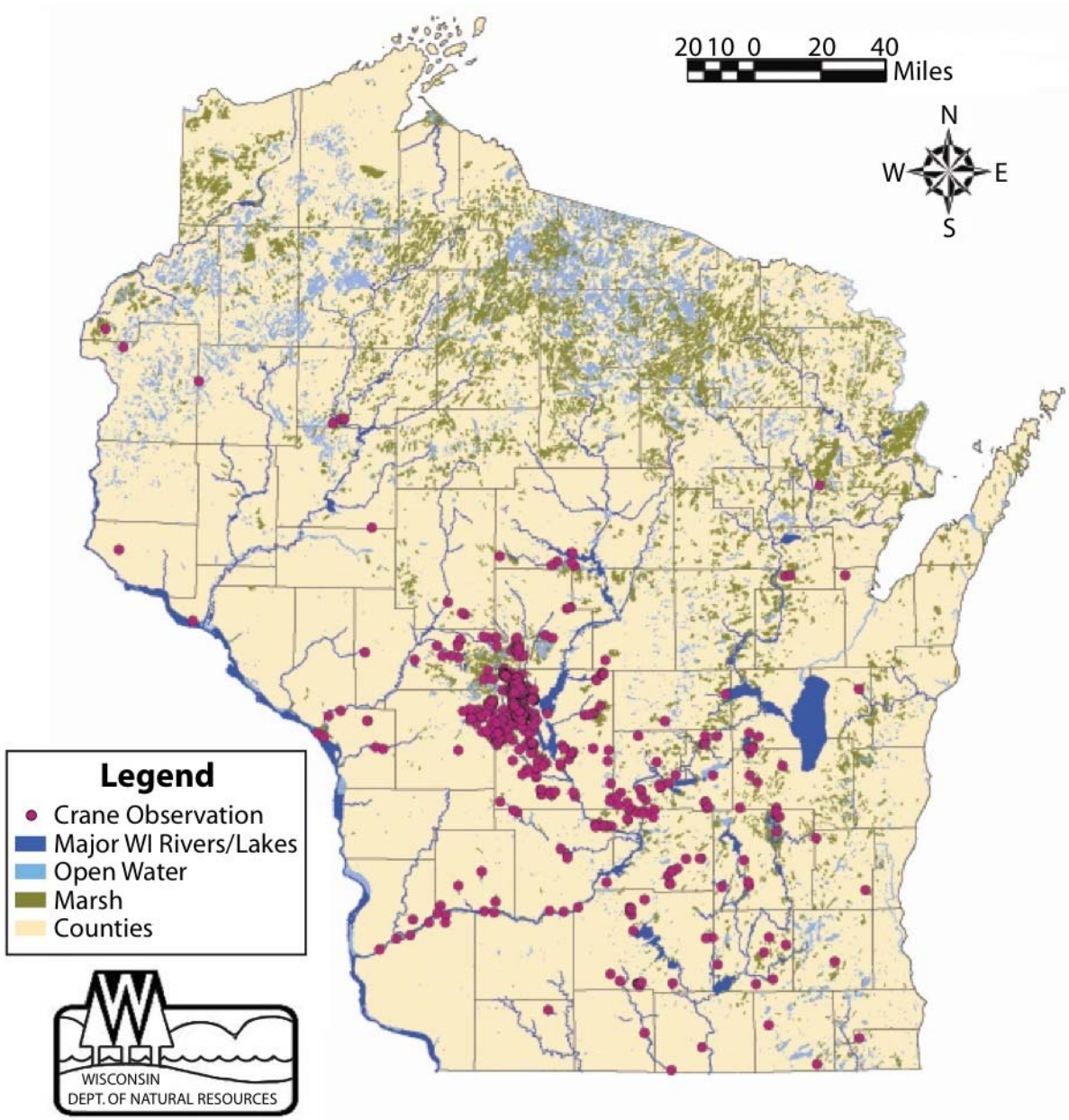


Figure 13. Whooping crane observed locations, 2002-2006.

Between 2002 and 2006, cranes were observed in 41 of 72 counties, primarily along major rivers and wetlands in central and southern Wisconsin (Appendix 8). Sometimes whooping cranes associate with pre-migratory sandhill crane flocks. Autumn sandhill crane staging areas may predict whooping crane habitat use (Fig. 14).

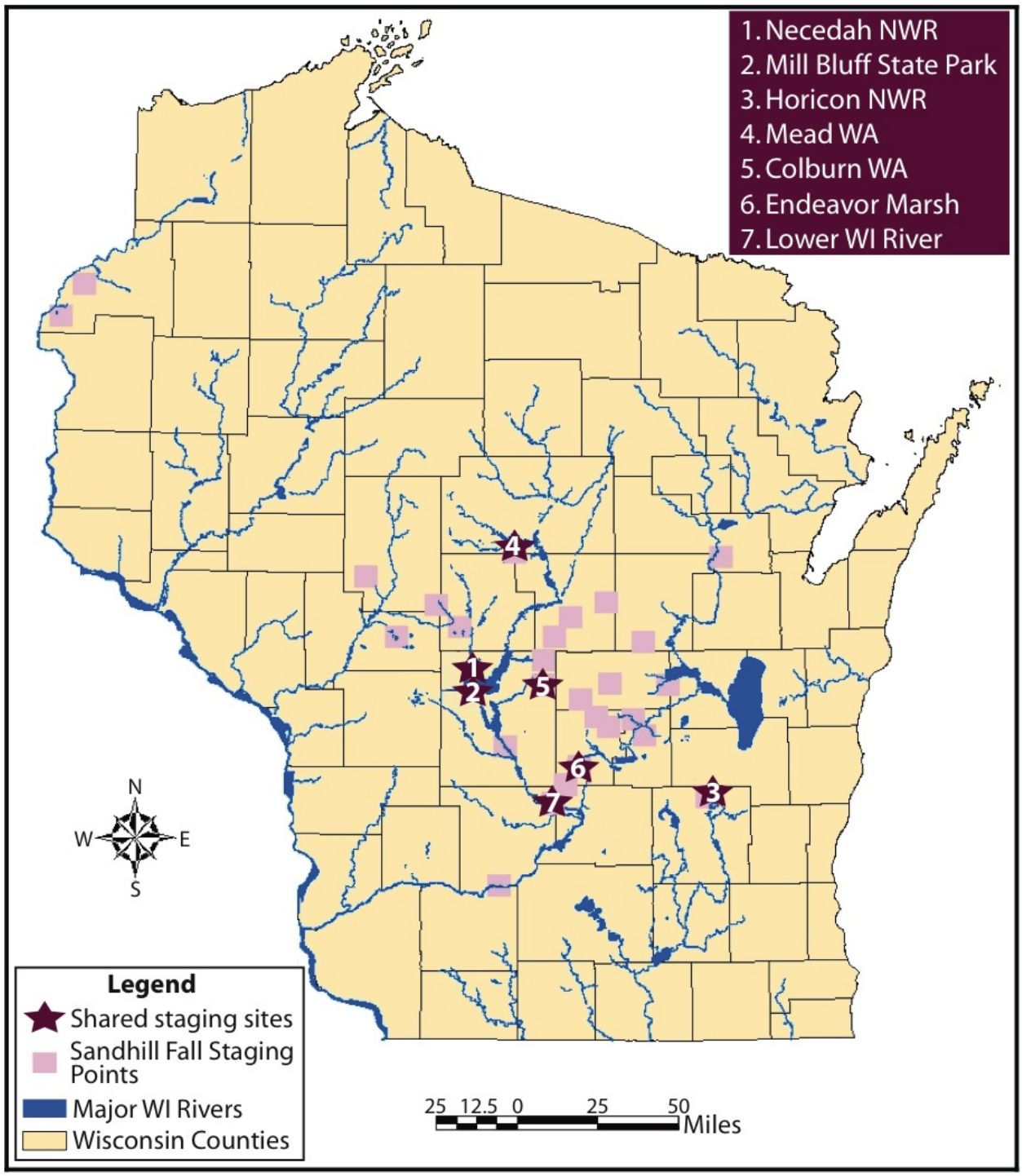


Figure 14. Shared sandhill crane and whooping crane fall staging areas, 2002-2006.

6.8.1 Role of Private Land Management

Whooping cranes depend on wetlands for nesting, chick rearing, and feeding. Wisconsin encompasses almost 34.8 million acres, of which 5.3 million acres are wetlands; 4 million or 75.2 percent of wetlands are privately owned and managed (WI DNR Wetland Team, 2000). Clearly, wetland and grassland habitat restoration on private lands can significantly benefit whooping cranes.

Many government programs inherently aid whooping cranes by providing financial incentives to restore or protect habitat. Examples include the Wetland Reserve Program (WRP) administered by the Natural Resource Conservation Service (NRCS); the Conservation Reserve Program (CRP) administered by the Farm Service Agency; Partners for Fish and Wildlife administered by the USFWS, and; Habitat Restoration Areas administered by the WI DNR. There are also many local options available from non-governmental conservation groups like Ducks Unlimited and the Wisconsin Waterfowl Association.

For instance, the Wetlands Reserve Program (WRP) is a voluntary program to restore and protect wetlands on private property. Landowners receive financial incentives to restore wetlands previously drained for agriculture. For many landowners, WRP makes economic sense. Currently, there are 47,000 acres enrolled in WRP in Wisconsin (USDA, NRCS, 2000).

6.8.2 Property Rights

Some citizens fear the presence of an endangered species on their land could restrict their property rights. Since whooping cranes in Wisconsin are classified nonessential experimental, routine and legal activities on private lands will not put private citizens in conflict with the law. As described in the rule announcing the designation of this whooping crane population, the normal Endangered Species Act penalties would not apply if the ” take” of the species was incidental to a legal activity.

At times property rights can be affected by federal agency involvement (i.e., through funding or a permit approval process). To ensure their actions do not jeopardize a species, federal agencies are required to consult with the USFWS under section 7 of the Endangered Species Act. However, under the nonessential experimental designation the section 7 consultation requirement is eliminated, except for actions on National Wildlife Refuges and National Park Service lands. The intentional “take” of the species would still be strictly illegal, whether on public or private lands (See Legal Aspects, Section 4.1).

6.8.3 Agriculture

It is currently unknown whether agricultural crops suffer damage from whooping cranes. To date, whooping cranes tend to be less associated with upland agriculture activities than sandhill cranes. Although less gregarious than sandhill cranes, whooping cranes are sometimes observed in sandhill flocks; therefore, it is possible that they could damage the same agricultural crops. Similarly, it is unknown if agricultural activities (such as application of registered chemicals to cranberry wetlands) are hazardous to whooping cranes, though to be successful, a mutual co-existence will be needed.

Sandhill crane damage to germinating and emerging corn can cause problems for Wisconsin’s farmers. Corn plants are vulnerable to crane damage from seed germination until the plant is approximately 8 inches tall. In Wisconsin, this period is usually two to three weeks. Sandhill cranes can also damage potato crops in the central sands region of Wisconsin by probing into the potato hill. The consumption of potatoes is limited, but the probe hole damage to a potato can cause a portion of a crop’s yield to be poorly graded. Cranberries are also found in the

release area and could be consumed by cranes; however, cranberry crop depredation by sandhill cranes has not been reported.

If crop damage becomes a problem, farmers can discourage crane foraging with non-lethal abatement techniques such as pyrotechnics, propane cannons, high-output electronic sound, and distress or alarm calls. Chemical deterrents successful towards sandhills include Avitec™', with active ingredient 9, 10 Anthraquinone. This naturally occurring plant substance is a non-water soluble, low-toxicity seed treatment used to repel birds. Under temporary approval by the U.S. Environmental Protection Agency, Wisconsin, Michigan, and Minnesota farmers can apply Avitec™ to prevent corn damage. Cranes are expected to detect Avitec™ at very low levels and avoid treated seed.

Avitec™ use appears to be a win-win solution. The cranes can continue foraging on waste grain and other foods in the field, while the resultant reduction in waste corn and beetle larvae helps prevent problems as crops mature.

If non-lethal techniques fail the landowner may be eligible for a USFWS depredation permit to lethally remove a set number of sandhill cranes. Landowners with sandhill crane depredation permits must be able to differentiate between a sandhill crane and a whooping crane. Technical aid regarding crane damage to agricultural crops can be obtained by calling the U.S. Department of Agriculture (USDA)-Wildlife Services office in Waupun, Wisconsin at 1-800-433-0688.

6.8.4 Invasive Species Control

Prior to European settlement, fire maintained the biological integrity of oak forests, oak savannas, native prairies, and wetlands. Today, land managers and conservationists use prescribed burning to mimic wild land fires. Prescribed burns provide an ecological and economical method of controlling brush and trees. They also limit or eliminate non-native plant growth while stimulating native plant growth. Most invasive non-native plants were brought here intentionally. These species include grassland plants such as leafy spurge (*Euphorbia esula*), wild parsnip (*Pastinaca sativa*), yellow and white sweet clover (*Melilotus officinalis* and *alba*) and Canada thistle (*Cirsium arvense*). Invasive non-native wetland plants include purple loosestrife (*Lythrum salicaria*) and reed canary grass (*Phalaris arundinacea*). The prevalence of invasive non-native species has dramatically increased, threatening ecosystem health through biodiversity loss. Most invasive non-native plants are controlled by burning, cutting, or herbicide application at specific times of the year.

Prescribed burns benefit native landscapes while also helping whooping cranes. Most whooping cranes complete their spring migration to Wisconsin in April; some return in March or May. In the first years of this project, recently burned land provided attractive foraging areas for returning cranes. By timing prescribed burns before or after the cranes return to a specific area, land managers can prevent flushing these birds. Each spring the WI DNR whooping crane coordinator will attempt to alert regional, federal, and state land managers; field biologists, and; county biologists to the locations of whooping cranes in their areas to assist them in planning for prescribed burns. This need for up-to-date reporting of monitoring information underscores the value of the EMP monitoring database. After a prescribed burn, land managers can further assist the reintroduction project by summarizing both the biological outcome and whooping crane use.

6.8.5 Water Level Management

Water level management techniques are used on state and federal lands to enhance habitat for ducks, geese, swans, shorebirds and other water birds (especially at Crex, Mead, and Horicon State and Federal Wildlife Areas). They usually favor whooping cranes because they forage on mudflats and shallows on drawn down pools and impoundments. If many pools exist in one area, a staggered annual or semi-annual draw down schedule between pools will provide a diversity of food resources along a continuum from deep water to shallow water to mudflat. By slowly lowering the water level, new shallow water sections are created and new mudflat sections are exposed over a greater length of time.

At Necedah NWR, large reservoirs are generally drawn down every third year on a rotational basis such that a draw down occurs somewhere on the refuge almost annually. This provides two years of "full pool" to drown-out encroaching woody vegetation. In the third year, water levels are gradually lowered in mid-May, with a goal of complete reservoir dewatering by June. Smartweed, millet, and bidens grow on the exposed mudflats. The reservoir remains dewatered through September 15, when water levels are raised approximately 6 inches every two weeks. This technique continually floods new areas, providing waterfowl access to the millet seed heads and other plants.

In "full-pool" years, reservoir water levels are gradually lowered in early October to concentrate invertebrates for diving ducks. Lowering water levels also creates sandbars. Thousands of sandhill cranes roost on these sandbars, making daily flights off-refuge for feeding.

Water level management at Horicon NWR is similar to that of Necedah, but is usually conducted over a five to seven year period. Following complete draw down the unit is left dry for one or two years, depending on the type of emerging vegetation. Though Horicon has the capability to pump and fill the units after a draw down, the impoundments are normally allowed to fill naturally through a combination of precipitation and inflow.

6.8.6 Airport Safety

Because whooping cranes are large, heavy birds with limited flight speed and maneuverability, collisions could lead to aircraft damage, and death or injury to passengers and people on the ground. Since Wisconsin has such a small population of whooping cranes, conflicts at airports are unlikely. If whooping cranes are frequently observed near an airport they should be encouraged to leave by using harassment techniques. Airport managers can call the USDA – Wildlife Services office in Waupun, WI at 1-800-433-0663 for technical help on dealing with wildlife hazards at airports.

Airports are often issued depredation permits from the USFWS to remove a set number of a given species that are presenting hazards to aircraft In the case of whooping cranes, because it is a federally-listed species, this action would require a recovery permit (section 10A-1A) to harass whooping cranes off the airport operating area.

There is already at least one USFWS permit in effect for this purpose, at Volk Field Combat Readiness Training Center, in Camp Douglas, Wisconsin. Since this permit was issued in July of 2005, there has been no need to disperse any whooping cranes from the airfield vicinity.

6.9 Nest Site and Territory Management

Whooping cranes usually choose nesting sites distant from human activities. However, the management and use of public and private lands for turkey hunting, fishing, camping, birding,

hiking, off-road vehicle use, agricultural activities, roadside mowing, construction activities, road maintenance, dog training, biking, boating and other activities can be widespread from April through May. These human activities can disrupt critical nesting and chick rearing periods. Flushing incubating cranes can expose the eggs to heat or cold; either could lead to embryo death. During the brood rearing stage, frequently disturbed adults may not protect chicks from predators, or find enough food for the young to survive.

Despite significant efforts to avoid undue influence while being reared in captivity, some Wisconsin whooping cranes are at least partially habituated to humans. While it is difficult to predict how tolerant these birds will be to disturbance within their nesting territories, it seems prudent to be cautious in providing protections to nesting birds. Cranes are likely to be most sensitive to disturbance during incubation and the early stages of brood rearing. Based upon nesting bald eagles, disruptive activities require a greater distance from the nest site. For cranes, the recommended strategy is to carefully time the activity and maintain a minimum distance from nesting birds (refer to Buffer Zones, Section 6.9.1).

Domestic pets may pose a threat during nesting or brood rearing. From hatching to fledging, chicks follow their parents as they forage, usually in open grassy areas. Domestic pets could harass or kill flightless chicks in these exposed areas. Targeting educational messages to people near nesting whooping cranes is important as the population expands.

6.9.1 Buffer Zones

Nest sites should be surrounded by a 125 m (±400 ft) buffer (based on Florida sandhill crane research). This distance includes flushing distances (75 m, ±250 ft) and an "awareness zone" that would allow nesting birds to react to disturbance without flushing (Stys, 1997). This distance is probably enough for a few people on foot, but is minimal for highly disruptive activities. The distance needed to avoid disruption from heavy construction or other severe disturbances should be evaluated on a case-by-case basis. However, a good starting point is 1/4 mile, or 400 m (±1320 ft). Cranes usually do not use a nest site more than once, but they will use the same general nesting area in subsequent years if conditions (water levels and vegetation) remain favorable. Therefore, any restrictions put in place should be considered in subsequent years.

Communal roost sites are also vulnerable to disturbances. The recommended buffer distance for communal roost sites is 200 m. Unless habitat conditions become unfavorable, cranes will use the same communal roost site for years. In Florida, some roost sites have been used seasonally for at least 15 years (Wood and Nesbitt, 2001).

6.9.2 Timing Activities to Minimize Human Disturbance

The nesting phenology of whooping cranes in Wisconsin is unclear. Whooping cranes generally arrive from the wintering grounds in March and early April. In 2005 and 2006, whooping cranes laid eggs in early to mid-April. Because of the brief period between arrival and nesting, any nest site protections should start by April 1.

As young cranes become increasingly mobile it may be necessary to extend certain protections. After fledging most buffer protections won’t be needed, except for communal roosting sites. Many activities that were delayed near nesting sites could be resumed in August. The type and scope of the activity should be evaluated on a case-by-case basis. Since cranes migrate south in the fall, a safe period exists from early December through mid-March.

To protect cranes during incubation and early brood-rearing, WI DNR may restrict access to nesting areas by seasonal closure on state property within defined boundaries (1/4 mile

recommended) as described in s. NR 45.04(1)b. This would not include closing hunting grounds. Although turkey hunting is the only hunting activity that corresponds to crane nesting periods, the two habitats are unlikely to overlap. Similar protection of nesting sites is encouraged on lands managed by federal, county, and private owners.

6.9.3 Land Acquisition and Habitat Protection

Wetlands are a conservation priority in Wisconsin and crucial to whooping cranes. The potential exists for the state, USFWS, U.S. Forest Service, and county and municipal governments to include whooping crane habitat needs in their land acquisition plans. Wisconsin DNR has an active land acquisition program funded by the state's "Stewardship Program." Over many years, WI DNR has acquired thousands of acres of wetlands. In addition, WI DNR has utilized various federal programs such as the USDA Wetland Reserve Program (WRP), the USFWS North American Wetlands Conservation Act (NAWCA), and the Federal Coastal Wetlands program funding to acquire wetlands. WI DNR plans to continue wetland acquisition in the future through the end of the current Stewardship Program as part of overall land acquisition efforts through 2010. Recently, WI DNR worked with the Wetland Reserve Program, the Madison Audubon Society, and Pheasants Forever to restore two large wetlands in Jefferson and Walworth Counties, each about 2,000 acres. One of the project's goals was to provide whooping crane habitat. Amazingly, after the restoration began, whooping cranes did in fact use these areas.

Several statewide land planning projects identified wetland and upland areas needing protection for recreational activities, wildlife habitat, and water quality. For example, planning under the Upper Mississippi – Great Lakes Joint Venture of the North American Waterfowl Plan prioritizes important waterfowl areas. Application of this plan will provide whooping crane habitat in the state. The Wisconsin Land Legacy Study (Pohlman, Bartelt, Hanson, Scott, & Thompson, 2006) identified many areas of the state that merit increased land protection. Many of the areas in this study include wetland areas and wetland complexes important to whooping cranes in the state. It is important that the future habitat needs of whooping cranes be considered and incorporated into the implementation of this study. Future implementation will involve many private, non-profit and public stakeholders. It will be important to inform these stakeholders how their land protection efforts can benefit whooping cranes, especially when wetlands are involved.

Other studies identify important coastal wetlands along Lakes Michigan and Superior needing protection. Plus, there is growing interest in the state to improve wetland protection and restoration for flood control and groundwater aquifer regeneration.

In addition, most Wisconsin counties and townships are preparing "Smart Growth" land use plans that often define wetland areas as "conservancy zoning" and "green space". Local governments may wish to purchase these lands for public recreation. Some counties have land acquisition budgets and/or seek grants for the state and federal governments. The ability of a county to promote its habitat protection efforts as helping whooping cranes would probably be well received.

As whooping crane habitat preferences become more apparent, it will be helpful to identify wetland types, size, spatial arrangement, and locations that would predict future whooping crane use. The addition of whooping cranes to these ecosystems should generate even greater interest in wetland protection and restoration among private and public landholders.

7. COMPATABILITY WITH EXISTING WILDLIFE MANAGEMENT PRACTICES

As a reintroduced endangered species, whooping cranes warrant special considerations relative to other wildlife management practices. In particular, these considerations include hunter education tools to prevent accidental whooping crane shootings and the potential impact of trapping activities on the restoration program.

7.1 HUNTING

Unregulated hunting was one of the primary reasons for the whooping crane's historic decline from colonial times until the Migratory Bird Treaty Act (Allen, 1952). Hunting whooping cranes is now illegal; in spite of that, shootings occasionally take place (Lewis et al., 1992a). Whooping cranes in the AWBP and the EMP associate with sandhill cranes during migration. As a result, whooping cranes have been accidentally shot in states of the central flyway (west of Wisconsin) during sandhill crane hunting season and during snow goose hunting in the central and Mississippi flyways. The potential also exists for hunters to misidentify a whooping crane as a tundra swan, although Wisconsin has no swan hunting season.

In the AWBP, unexplained losses during the fall and winter seasons may be the result of accidental hunting mortality that has gone unreported. The whooping crane's low reproductive potential makes it vulnerable to annual mortality increases that exceed annual reproduction. However, the illegal kill of whooping cranes during hunting is considered a small fraction of total AWBP mortality (T. Stehn, personal communication, January 2006).

While many people participate in waterfowl and other bird hunting seasons in Wisconsin, the risk of accidentally shooting a whooping crane is low. Snow goose hunting is uncommon (average harvest for 1995-2004 was160 snow geese per year), and no hunting season exists for sandhill cranes and tundra swans.

Although sandhill crane hunting is illegal in the Mississippi and Atlantic flyways, their populations continue to increase and may someday support hunting seasons in limited areas. While restoration of the whooping crane will not preclude sandhill crane hunting in the two eastern flyways, whooping cranes need to be considered in the geography and timing of any future regulations to minimize the potential for mistaken identification. Educational programs, such as those in Texas and Kansas, could reduce the likelihood of accidental shootings in Wisconsin. For instance, in 2005, Texas Parks and Wildlife produced a DVD training tool entitled, "Be Sure before You Shoot," which includes whooping crane identification tips.

Vandalistic shootings—such as whooping cranes in Texas and Florida and trumpeter swans in Wisconsin—are an omnipresent challenge despite the best educational efforts.

7.2 TRAPPING OPTIONS TO CONTROL PREDATION

Regulated trapping is an important technique in wildlife research and an essential tool in wildlife management. The timing of trapping activities occurs when there is a low likelihood of conflicts with whooping cranes. No trappers are likely to be found in whooping crane habitat during the critical nesting and rearing periods, and most birds depart the state sometime during the month of November.

While population reduction is not a goal for most furbearer management programs, trapping predators such as the fox, raccoon, coyote, and bobcat can be an effective management tool for the protection of rare species (Northeast Furbearer Resources Technical Committee, 2001). For the whooping crane population to become self-sustaining it must be able to increase its size through reproduction. Trapping potential predators in late February and early March prior to whooping crane return may be an effective management tool to reduce nest predation. Trapping coordination is being considered near areas believed to be future nesting sites at Necedah NWR.

8. EDUCATION PROGRAMS AND OUTREACH EFFORTS

The whooping crane can serve as a "flagship" species to educate Wisconsin's citizens and visitors about the importance of conserving both wetlands and the species dependent on them, while also promoting other statewide conservation programs. The reintroduction of whooping cranes offers an excellent opportunity for the development of an education and outreach program centering on crane biology and ecology, wildlife and landscape management, the reintroduction program, and related environmental issues. To capitalize on these opportunities, education and outreach efforts must involve a diversity of partners, audiences, and approaches.

8.1 PARTNERSHIPS

Successfully managing the growing EMP of whooping cranes requires the support and involvement of partners at the federal, state, county, and regional levels. This is equally true for educational efforts focusing on cranes. To be effective educators and ambassadors, agency and private land managers, formal and non-formal educators, project staff and volunteers will receive educational materials, project resources, and training about whooping cranes and the reintroduction effort. To highlight cultural ties between cranes and the Native American community, education specialists will collaborate with tribal experts to develop targeted educational materials that focus on these connections.

Educating Wisconsin's citizens and visitors about whooping cranes and the reintroduction effort is a huge undertaking. Agency staff and educators may be unable to meet the demand for educational programs, monitoring efforts, and other needs. The reintroduction program has captured the attention and support of groups ranging from sporting clubs and local conservation groups to birding organizations and environmental groups. These groups can offer valuable help in developing materials, providing training, and promoting educational outreach. For example, WCEP staff can work collaboratively with local communities; wildlife refuge, state park, and nature center staff; University of Wisconsin Cooperative Extension personnel, and nonprofit organizations to present special events like bird festivals and field trips. Also, opportunities exist to collaboratively develop and market crane-related service learning opportunities such as habitat enhancement and restoration to interested groups (i.e., scout and 4-H groups, schools, nonprofit organizations). Existing public monitoring programs such as e-Bird and NatureMapping will be explored to support and enhance existing partner monitoring efforts.

However, having a well-trained corps of volunteers ready to contribute to such efforts will be critical. A volunteer speakers' bureau will be organized and trained to present whooping crane education programs. Special interest groups can work with other partners to develop citizen monitoring and reporting programs for crane sightings. To assist crane monitoring efforts, a citizen science program will train volunteer monitors and provide necessary educational

materials and reporting forms, including access through the Internet. These efforts will be integrated with other biological and research needs to maximize the value of data collected. In addition, the citizen monitoring program will be integrated with similar programs like the Friends of Wisconsin State Parks, local “friends” groups, volunteer naturalist programs, and e-Bird or NatureMapping electronic reports of sightings.

8.2 Developing Education and Outreach Materials

To maximize the effectiveness of educational materials and resources, an education team comprising agency personnel and classroom and non-formal educators will review existing educational resources (i.e., crane trunks) and develop additional educational materials. More crane trunks will be produced and distributed to key public properties and educators through WCEP partners.

Integrating whooping crane education efforts with existing environmental education programs in Wisconsin will broaden distribution while also encouraging vital linkages between programs and people. Crane educational efforts can be integrated with related programs at the International Crane Foundation, and through programs such as the Aldo Leopold Project, Project WILD and Project WET, One Bird-Two Habitats, Wisconsin State Parks interpretive programs, and other existing or newly developed programs in Wisconsin. Because whooping crane reintroduction is linked to habitat protection, education efforts will also focus on wetland conservation and restoration.

Educators will have a key role in teaching youth and adults about whooping cranes and the management plan to restore this migratory population. Regularly scheduled workshops will enable educators to access materials, learn from resource and education experts, and gain hands-on teaching experience. In addition, other educational resources will be promoted and distributed through WCEP partners, networks such as the University of Wisconsin-Stevens Point’s Environmental Education Liaison and the Wisconsin Association for Environmental Education, and nonprofit organizations like The Wildlife Society and the Wisconsin Society for Ornithology.

New publications are planned, such as a “Landowners’ Guide to Whooping Cranes.” This outreach tool will provide information on crane biology, safe viewing practices, and related issues like agricultural damage. Media such as display boards and informational brochures will be distributed to key public properties, libraries, and other highly visible public sites. Other public outreach approaches may include production of a new endangered resources license plate highlighting the whooping crane.

8.3 Sharing Information

The future success of this program hinges on the understanding and support of Wisconsin’s citizens. Project staff and partners will regularly distribute media releases highlighting crane “happenings,” success stories, educational events, and related issues to keep the program visible. Periodic field days may be scheduled to offer non-disruptive whooping crane viewing opportunities.

All informational materials will include safe viewing guidelines. Whooping cranes are extremely sensitive to disturbance by people. In most cases, people are just hoping to get a closer look or take a photograph, unaware of the potential negative impact of their actions. Safe viewing

guidelines, project brochures, videos, and other materials for distribution will be available to field staff, visitor center personnel, and staff at all properties at which the public may have viewing opportunities. Safe viewing locations at Necedah NWR and the ICF will be publicized to encourage crane watching at these easily observable sites. In addition, an electronic public domain photo file will be created and publicized to discourage close approach by the media and other interested parties. The Bird Watcher's Code of Ethics developed by the Wisconsin Society for Ornithology is available at http://www.uwgb.edu/birds/wso/ethics.htm.

Whooping cranes in Wisconsin use habitat on private and public lands, encompassing federal, state and county parks, forests, and wildlife areas. Field staff may serve as a liaison to landowners when whooping cranes use private property habitat. The DNR whooping crane coordinator together with the whooping crane educator and other WCEP partners can help provide project information to landowners, and may request monitoring aid from these landowners. Electronic list-serves will be created to share information and media releases with special interest groups.

Continuing legislative support at the state and federal levels is critical. To keep the legislature abreast of the reintroduction program, an annual report may be developed and distributed. State and federal legislators may be alerted when cranes are spotted in their districts, and they will be invited to attend educational and special events and “media days” held in their districts.

Using the whooping crane as a flagship species to help conserve wetlands and promote statewide conservation programs will raise public awareness and enhance the education efforts put forth in this plan. A strong educational component at all prominent public viewing sites including signs, printed materials, and trained interpretive staff will insure that the public hears messages designed to answer their questions and enlighten them on the value of bringing cranes back to Wisconsin.

8.4 ECOTOURISM

Ecotourism is one of the fastest growing segments of the U.S. travel industry (The International Ecotourism Society, 2005). Combined with rural and agricultural tourism, nearly 90 million people seek out rural communities and nature in their travels each year. From canoeing the Kickapoo River to warbler watching at Wyalusing State Park to wildlife viewing from a vehicle window, people travel to and in Wisconsin to observe, experience, and learn about the unique biological and physical resources found here.

The restoration of whooping cranes will provide this growing segment of the population—ecotourists—with another reason to make Wisconsin a preeminent nature destination. Ecotourism provides people with outdoor travel experiences that enrich their lives with the sights, smells, and sounds of nature. Within minutes or days from their homes and communities, people can experience something new and learn new skills while building connections with nature in their own unique way. Reaching this additional audience with our education and outreach efforts will benefit both ecotourists and whooping cranes.

8.5 ECONOMIC BENEFITS

Crane related activities stand to contribute significantly towards state and local economies. More than two-thirds of Americans participate in at least one outdoor activity annually (Outdoor Industry Foundation, 2005.) In Nebraska, approximately 80,000 people visit the Platte River area during the peak spring sandhill and whooping crane migrations. At the AWBP wintering

site, the Rockport, Texas, Chamber of Commerce estimated that whooping crane-related activities resulted in annual gross economic benefits of $6 million to the local economy (CWS & USFWS, 2006).

In 2001, nearly two million people watched wild birds in Wisconsin, both in their own backyards and away from their homes. Resident and non-resident wildlife watchers in Wisconsin expended $1.3 billion on food, lodging, transportation and equipment needed to watch birds and other wildlife (USFWS & U.S. Census Bureau, 2002).

Raising awareness of whooping cranes and the reintroduction program while providing opportunities for businesses to share the success of outreach efforts will build support at the critical local level. Travelers come for an experience that is real and worth their time and money. In return, Wisconsin must offer access to crane viewing experiences, well-designed educational materials, quality customer service, and comfortable travel amenities provided by the local community. Ecotourism can be a winning proposition for both Wisconsin's cranes and communities.

9. LEGAL ENFORCEMENT

The state is normally responsible for the investigation and enforcement of any unintentional whooping crane killing. The intentional killing of a whooping crane in Wisconsin is a dual violation of both state and federal law and may be investigated by either WI DNR or USFWS. It is expected that both agencies will cooperate in a coordinated effort.

9.1 STATE LAWS

The Conservation Act, s. 23.09 (1), Wisconsin Statutes (Wis. Stats.), requires the WI DNR to provide an adequate and flexible system for the protection, development and use of forests, fish and game, lakes, streams, plant life, flowers and other outdoor resources. Section NR 1.015(1)(a), Wisconsin Administrative Code (Wis. Adm. Code) and s. 29.039 Wis. Stats., further establishes the specific authorities and missions of the department for wildlife protection and use to include the protection and management of non-game species—particularly endangered, threatened and uncommon species.

The Wisconsin state legislature, through s. 29.604, Wis. Stats., determined that certain wild animals and wild plants are endangered or threatened, and are entitled to preservation and protection as a matter of general state concern. The Federal Endangered Species Act of 1973 and the Lacey Act together provide for the protection of wild animals and wild plants threatened with worldwide extinction by 1) prohibiting the importation of endangered or threatened wild animals and wild plants, and 2) by restricting and regulating interstate and foreign commerce in wild animals and wild plants taken in violation of state, federal and foreign laws. The state, however, also has assumed its responsibility for conserving these wild animals and for restricting the taking, possession, transportation, processing or sale of endangered or threatened wild animals within this state to assure their continued survival and propagation for the aesthetic, recreational, and scientific purposes of future generations.

The department is required under s. 29.604(3), Wis. Stats., to establish an endangered and threatened species list consisting of three parts:

1. Wild animals and wild plants on the U.S. list of endangered and threatened foreign species
2. Wild animals and wild plants on the U.S. list of endangered and threatened native species
3. A list of endangered and threatened Wisconsin species

Whooping cranes, in general, are considered an endangered species in Wisconsin. They are listed under the U.S. foreign and native endangered and threatened species portion of the departments list of endangered species found in s. NR27.03(1), Wis. Adm. Code. Unless permitted by the department, no person may take, transport, possess, process, or sell within this state any wild animal specified by the department's endangered and threatened species list [s. 29.604(4)(a), Wis. Stats.].

In addition to generally being considered an endangered species, all cranes, including the whooping crane are defined under Wisconsin state law as “Protected Wild Animals” under ss. NR 10.02(5) and 19.001(14), Wis. Adm. Code. It is unlawful for any person to take, attempt to take, transport, harass, disturb, pursue, shoot, trap, catch, kill or possess any protected wild animal at any time unless specifically authorized in writing by the department [NR 10.02 and NR 19.25, Wis. Adm. Code].

9.1.1 Accidental Shooting (State Law)

Even though whooping cranes are classified as a Wisconsin endangered species, federal rules establishing the nonessential experimental population (NEP) of whooping cranes in the eastern U.S. created a provision that the Federal Endangered Species Act penalties would not apply if the take of an NEP whooping crane occurred accidentally and incidental to an otherwise legal activity [66 Fed. Reg. 123 (June 26, 2001) (to be codified at 50 CFR pt. 17)]. In other words, NEP whooping cranes accidentally shot or killed in the course of lawful activities (i.e., hunting other species in accordance with all laws and regulations), would not be considered in violation of the FESA, therefore, also not a violation of the Wisconsin endangered species prohibitions or penalties established in s. 29.604(4) and (5), Wis. Stats. The status of whooping cranes is defined on a purely geographic basis. For example, if Wisconsin birds travel to North Dakota, they take on an endangered species status there, while birds from Aransas would be considered part of the NEP if they travel to Wisconsin

Because of the NEP designation, any whooping crane unintentionally shot or killed in Wisconsin would be treated as a “Protected Wild Animal,” not an endangered species. Wisconsin Administrative Codes s. NR 10.02 and 19.25 states that no person may harass, disturb, shoot, trap, catch, take, or kill a protected wild animal. Wisconsin statute s. 29.971 states that whoever violates a statute or regulation pertaining to hunting, taking, transportation, or possession of game shall forfeit not more than $1,000 [s. 29.971(3), Wis. Stats.]. In addition, the court may impose a wild animal protection surcharge of $17.50 [s.29.983(1)(b)7. Wis. Stats.], and revoke or suspend any or all privileges and approvals granted under this chapter for a period of up to three years [s. 29.971(12), Wis. Stats.] . The 2006 Uniform Deposit and Bail Schedule for Conservation Violations sets the deposit permitted in lieu of an appearance in court at $75. With the required court costs and surcharges, the total deposit required for this violation would be $303.30.

Whoever unintentionally takes, shoots, or kills a whooping crane in a state where they are not part of the NEP, and then transports, possesses, processes, or sells the bird in Wisconsin would be required to forfeit not less than $500 nor more than $2,000. In addition, the court is required

to order the revocation of all hunting approvals issued to the person under this chapter and shall prohibit the issuance of any new hunting approvals under this chapter for one year [s. 29.604(5)(a)1., Wis. Stats.]. The court may also impose a wild animal protection surcharge of $875 [s.29.983(1)(b)1., Wis. Stats.]. The 2006 Uniform Deposit and Bail Schedule for Conservation Violations sets the deposit permitted in lieu of an appearance in court at $500. With the required court costs and surcharges, the minimum total deposit required for this violation would be $2,008, and the maximum $4,165.50.

9.1.2 Intentional Shooting (State Law)

Penalties for violation of Wisconsin's Endangered Species Law under s. 29.604((4), Wis. Stats., apply to the intentional shooting of any whooping crane, even an NEP whooping crane in Wisconsin. Whoever intentionally takes, shoots, kills, transports, possesses, processes, or sells an endangered species shall be fined not less than $2,000 nor more than $5,000, or imprisoned for not more than nine months, or both. In addition, the court shall order the revocation of all hunting approvals issued to the person under this chapter and shall prohibit the issuance of any new hunting approvals under this chapter for three years [s. 29.604(5)(a)1., Wis. Stats.]. Because this is a criminal violation, a mandatory appearance would be required. With all court costs and applicable surcharges, the minimum penalty for intentionally shooting a whooping crane in Wisconsin would be $4,165.50, and the maximum $11,053.

9.1.3 Interstate Transportation

Under s. 29.047(1)(b), Wis. Stats., no person may transport into or through Wisconsin any whooping crane, or its carcass, from any other state in violation of any law of the other state. Similar to the shooting of a protected wild animal, a person who transports a whooping crane taken in violation of the laws of another state shall forfeit not more than $1,000 [s. 29.971(3), Wis. Stats.]. In addition, the court may revoke or suspend any or all privileges and approvals granted under this chapter for a period of up to three years [s. 29.971(12), Wis. Stats.] and impose a wild animal protection surcharge of $875 [s.29.983(1)(b)1., Wis.Stats.]. The 2006 Uniform Deposit and Bail Schedule for Conservation Violations sets the deposit permitted in lieu of an appearance in court at $500 (fifty-percent of the maximum penalty). With the required court costs and surcharges, the total deposit for this violation would be $2,008. In addition, there could be a Federal Lacey Act violation.

9.2 Federal Laws

In the United States, the whooping crane was listed as threatened with extinction in 1967 and endangered in 1970; both listings were "grandfathered" into the Endangered Species Act of 1973. Critical Habitat was designated in 1978. In Canada it was designated as endangered in 1978 by the Committee on the Status of Endangered Wildlife in Canada and listed as endangered under the Species at Risk Act (SARA) in 2003. Critical Habitat in Canada is officially designated upon publication of a final SARA Recovery Strategy or Action Plan on the SARA Public Registry.

Before whooping cranes were reintroduced into the eastern U.S., all eastern whooping cranes were designated as "experimental nonessential" under the Endangered Species Act. This designation allows for greater management flexibility of the reintroduced population. Local citizens in the areas where endangered or threatened species are proposed for introduction are often concerned about the placement of restrictions and prohibitions on federal and private activities. Under section 10(j), the Secretary of the Interior can designate reintroduced populations established outside the species' current range, but within its historical range, as

‘‘experimental’’. Experimental populations carry fewer restrictions, since most federal activities are then exempt from the requirement to consult with the USFWS under Section 7 of the Act.

9.2.1 Accidental Shooting (Federal Law)

As part of the final rule establishing the nonessential experimental population (NEP) of whooping cranes in the eastern United States, a provision was included that Endangered Species Act penalties would not apply if the taking of a NEP whooping crane occurred accidentally, and incidental to an otherwise legal activity. Accidental shooting, occurring in the course of a lawful activity (i.e., hunting in accordance with all laws and regulations), would be covered under that provision. 66 Fed. Reg. 123 (June 26, 2001) (to be codified at 50 CFR pt. 17), (f).

Although Endangered Species Act penalties would not apply in that situation, applicable federal penalties under the Migratory Bird Treaty Act and, or state penalties may still apply. The incidental take provision was included in an effort to allay concerns of hunters and other sectors of the public. There was concern that federal penalties or restrictions of property rights, business, or recreational activities might be imposed if a whooping crane was injured or killed unintentionally on private property as a result of a legal activity (66 Fed.Reg. 123, June 26, 2001, to be codified at 50 CFR pt. 17).

In the AWBP, it is difficult to assess the impacts of shooting since most losses of adult birds occur between departure from the wintering grounds and return the next fall (USFWS, 1994). Given the numbers of hunters present in different areas during the fall migration period, the greatest level of risk for accidental shooting likely occurs in the Central flyway and on the Texas wintering grounds. Within this area, the similarly-colored snow geese are abundant, and inexperienced hunters could potentially mistake a whooping crane for a snow goose. Sandhill crane hunting is also permitted in the Central flyway, again presenting the potential for misidentification and accidental shooting.

However, even given the occurrence of similar species within the migration corridor that may lead to accidental shooting, it is thought the loss of whooping cranes to hunters in the AWBP is a small fraction of total mortality. Only four or five mortalities have been documented incidental to hunting activities within the past 20 years (T. Stehn, personal communication, January 2006). A November 2004 incident in Kansas during opening day of sandhill crane hunting season resulted in the deaths of two whooping cranes. As a result, seven hunters were each fined $3,000 and lost their hunting privileges for two years.

9.2.2 Intentional Shooting (Federal Law)

In the event a whooping crane is shot intentionally the penalties of the Endangered Species Act would still apply, which could result in a maximum $50,000 fine and up to a year in prison (66 Fed. Reg. 123, June 26, 2001, to be codified at 50 CFR pt. 17). Over the past 20 years, there have been several deaths due to intentional shootings. Recently (2003), a Texas man shot an adult whooping crane in a closed area. He was subsequently sentenced to six months imprisonment and a $2000 fine. In Florida (2000), a teenager intentionally shot and killed two members of the nonmigratory population.

Because sandhill cranes are not hunted in Wisconsin, any whooping crane shooting would likely be considered intentional. In the past few years, several trumpeter swans in the restored Wisconsin population were shot. Based on these occurrences, it is possible a whooping crane may be intentionally killed. In this event, the full penalties of the Endangered Species Act would apply [66 Fed. Reg. 123 (June 26, 2001) (to be codified at 50 CFR pt. 17].

9.3 VIOLATION PROTOCOLS AND SPECIMEN MANAGEMENT

Any incident involving the injury, death, or possession of a whooping crane should be reported to the conservation warden in the relevant county. Reports may be made directly to the warden or through the nearest WI DNR Service Center, sheriff's department, or by calling the WI DNR violation hotline at 1-800-TIP-WDNR (847-9367). Wardens will document the report and subsequent investigation on a law enforcement complaint form (Form #4800-48). (Refer to Appendix 6, Response Protocols, for a sample of the "Dead Crane Data Sheet".)

As soon as practical after receiving a report the warden or the warden supervisor will notify the Regional Enforcement and Science leader and the Bureau of Endangered Resources. The investigating state warden will coordinate the investigation with the USFWS federal warden as appropriate on all intentional shootings. Any unlawfully killed or possessed whooping crane carcass will be tagged by the warden with a seizure record tag (Form # 4100-190). Proper chain of custody will need to be maintained for any incidents that might result in enforcement action.

10. PROJECT NEEDS

10.1 RESEARCH

The EMP is being reintroduced based upon the knowledge derived from the FP and AWBP. Major differences in the habitats and ecosystems between these populations suggest there can be corresponding dissimilarity in aspects of their ecology. Management of the eastern population is best based on locally-derived data. Accordingly, a strong research program is needed to provide data to underpin the management of this population in the face of regional uncertainties. The relative importance of research needs vary among the topics of the EMP's ecology.

10.1.1 Nest Predation or Abandonment

Figuring out why nests are being abandoned is a priority for WCEP. Most every nest abandoned is beyond the realm of expectation, and plans are underway to set up film cameras at future nest sites to find out why this occurs. This investigation is important enough to take some risks that might cause nest abandonment.

Multiple people in Wisconsin have seen whooping crane pairs on nests and even taken photographs, meaning the pairs are not abandoning nests the first time they see a human. Risks can be minimized by filming a subset of nests and not filming every nest. Camera distance from the nest may depend on available cover, vegetation type, behavior of the pair, and site specific needs.

10.1.2 Dispersal and Movements

Almost all data collected so far on movements and dispersal are new to science. Although differences in dispersal between males and females may be significant, they have received little previous study in whooping cranes and only limited study in other crane species (Urbanek & Bookhout, 1994). A pronounced spring exploratory period, first identified in this project, is being given special attention by the WCEP tracking team.

10.1.3 GIS Analysis of Habitat and Potential Population in Wisconsin

Wisconsin DNR staff plan to use monitoring data for integration with GIS spatial habitat coverage. Future analyses will assist land managers and administrators in identifying and prioritizing conservation actions locally, and at the landscape level. Examination of breeding habitat characteristics, home range, and spatial distribution will be useful in setting future population management goals for the state.

10.1.4 Nesting Ecology

Territory formation, nest building, egg-laying, and production of young by breeding pairs are all areas in need of study. This reintroduced population of whooping cranes constitutes the most intensively monitored population of migratory birds in history. Almost all of the birds are monitored by radio tracking during the course of the reintroduction. Monitoring data are compiled in the new monitoring database, which will support research on the evolution of social structure within this population. To reach the project's goal of a self-sustaining population of 100-120 whooping cranes encompassing 25-30 regularly breeding pairs, it will be particularly important to document associations among individuals and subsequent pair bond formation.

10.1.5 Habitat Use

Wisconsin:

1) For two field seasons (mid-March 2005 through November 2006), Kelly Maguire, ICF Aviculturist, researched whooping crane habitat use in the core reintroduction areas of Necedah National Wildlife Refuge, adjacent State Wildlife Areas, cranberry properties, and nearby wetlands in northern Juneau, southern Wood, eastern Jackson, northeastern Monroe, and southeastern Clark Counties, while pursuing a master's degree in Wildlife Ecology at the University of Wisconsin-Madison. The area is characterized by interspersed open shallow water, emergent vegetation, and wet meadow.

   Global positioning system (GPS) locations and habitat type are being recorded for groups of birds aged one through four years. Data collection occurs two to three times weekly at variable times. Habitat type is classified using the Wisconsin Natural Heritage Inventory system and WISCLAND, a Landsat Thematic Mapper using satellite imagery obtained between 1991 and 1993. Kelly's research objectives are 1) to describe habitat selected at different times of the day, 2) to describe habitat selected throughout summer and fall, 3) to describe and compare habitat selected by adult versus juvenile birds, and 4) to evaluate the amount of preferred habitat available in these areas.

2) Prescribed burns benefit native landscapes while also helping whooping cranes. After a prescribed burn, Wisconsin land managers can further assist the reintroduction project by summarizing both the biological outcome and whooping crane use.

Florida:

During winter of 2004-2005 and 2005-2006, Lara Fondow, ICF and USFWS tracking team leader, monitored winter habitat use of EMP whooping cranes in Florida, while pursuing a master's degree in Wildlife Ecology at the University of Wisconsin-Madison.

Research thesis objectives are to provide description of both the habitat preferences and requirements of EMP cranes in Florida and some of the possible mechanisms involved in habitat selection. In the face of rapid urban development, this work will help biologists to project habitat needs over time and to determine whether sufficient Florida habitat exists to meet the needs of wintering whooping cranes.

10.1.6 Health Issues

Determining EMP mortality risk factors is an ongoing research need. The WCEP Health Team meets biannually to discuss current and potential health issues, management options and research plans. Current research includes analyzing the first five years of health data, assessing disease prevention and control strategies and investigating the potential impacts of emerging diseases, such as avian influenza and West Nile virus. Future research is needed to reduce the impacts of musculoskeletal and other diseases on the survivorship and fitness of chicks for reintroduction.

10.1.7 Food Habits

Little is known about the basic foraging ecology and diet of the EMP cranes. Future studies may be undertaken to determine whether whooping cranes affect Wisconsin agriculture and to identify potential impacts of environmental contaminants on whooping cranes.

10.1.8 Potential Utility Line Collisions

Little is known about the potential areas of concern for utility line collisions in Wisconsin. Future studies may be undertaken to understand which sections of power lines it may be useful to mark to prevent collisions. Increasing numbers of power lines, communication towers, and wind turbines may kill as many as 225 million birds annually in the U.S. (Manville, in press; CWS & USFWS, 2006). Recently, seventeen Florida cranes and two EMP cranes died by hitting power lines. In the 1980s, two of nine radio-marked AWBP whooping cranes collided with power lines and died within the first 18 months of life (Kuyt, 1992). Since 1956, power line collisions caused the death or serious injury of at least 41 whooping cranes.

10.2 MONITORING PROTOCOL

Development of a long range EMP monitoring plan is under consideration. This plan would assist reintroduction efforts by identifying both priorities and a network of field personnel and equipment in both Wisconsin and states along the migration route.

10.3 EQUIPMENT

Additional radio reception towers are needed to enable monitoring of whooping cranes at Jasper-Pulaski Fish and Wildlife Area in Indiana and Hiwassee Wildlife Refuge in Tennessee. Similarly, PTT transmitters may become increasingly valuable in providing the project data on crane movements.

11. LITERATURE CITED

Allen, R. P. (1952). The whooping crane. *National Audubon Society Resource Report 3*. New York: National Audubon Society.

Ballou, J. D., Gilpin, M., & Foose, T.J. (1995). Population management for survival and recovery. In M.C. Pearl (Ed.). *Methods and cases in conservation science.* New York: Columbia Univ. Press.

Banks, R. (1978). The size of the early whooping crane populations. *Whooping crane coordinator files*. Albuquerque, New Mexico. United States Fish and Wildlife Service. Unpublished report.

Brook, B. W., Cannon, J.R., Lacy, R.C., Mirande, C., & Frankham, R. (1999). A comparison of the population viability analysis packages GAPPS, INMAT, RAMAS, and VORTEX for the whooping crane *Grus americana*. *Anim. Conserv., 2*(1), 23-31.

Brown, W. M., Drewien, R.C., & Bizeau, E.G. (1987). Mortality of cranes and waterfowl from power line collisions in the San Luis Valley, Colorado. In J. C. Lewis, (Ed.), *Proc. 1985 Crane Workshop* (pp. 128-136). Grand Island, NE: Platte River Whooping Crane Habitat Maintenance Trust.

Brown, W. M., & Drewien, R.C. (1995). Evaluation of two power line markers to reduce crane and waterfowl collision mortality. *Wildl. Soc. Bull*., *23*(2), 217-227.

Canadian Wildlife Service and U.S. Fish and Wildlife Service (2006). International recovery plan for the whooping crane (revised). Ottawa: Recovery of Nationally Endangered Wildlife (RENEW), and U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Carpenter, J. W. (1993). Infectious and parasitic diseases of cranes. In M. E. Fowler, (Ed.), *Zoo and wild animal medicine, Current therapy 3* (pp. 229-237). Philadelphia, PA: W. B. Saunders Co.

Carr, C. F. (Ed.). 1890. A list of the birds known to nest within the boundaries of Wisconsin, with a few notes thereon. *The Wisconsin Natura*list, *1*(2-6).

Dein, F. J., Carpenter, J. W., Clark, G. G., Montali, R. J., Crabbs, C. L., Tsai, T. F., & Docherty, D. E. (1986). Mortality of captive whooping cranes caused by eastern equine encephalitis virus. *J. Am. Vet. Med. Assoc., 189*, 1006-1010.

Drewien, R.C., Brown, W.M., and Kendall, W.L. (1995). Recruitment in Rocky Mountain greater sandhill cranes and comparison with other N. Am. Crane populations. *J. Wildl. Manage., 59(2),* 339-356.

Drewien, R.C., Tautin, J., Courville, M. L., & Gomez, G. M. (2001). Whooping cranes breeding at White Lake, Louisiana, 1939: observations by John J. Lynch, U.S. Bureau of Biological Survey. *Proc. N. Am. Crane Workshop 8*, 24-30.

Ellis, D.H., Lewis, J.C., & Mirande, C.M. (Eds.). (1996). *Cranes: Their biology, husbandry, and conservation.* Washington, D.C.: Natl. Biological Service and International Crane Foundation.

Folk, M., Nesbitt, S.A., Parker, J., Spalding, M.G., Baynes, S., & Candelora, K.L. (2006). Current status of the non-migratory whooping cranes (*Grus Americana)* in Florida. *Proc. N. Am. Crane Workshop, 10*. Zacatecas, Mexico. Unpublished report.

Frankel, O.H., & Soule, M.E. (1981). Design criteria for nature reserves. In *Conservation and evolution* (pp. 98-122). Cambridge, London: Cambridge University Press.

Friend, M., & Franson, J. C. (Eds.). (1999). *Field manual of wildlife diseases: General field procedures and diseases of birds*. Washington, D.C.: U.S. Department of the Interior, U.S. Geological Survey Biological Resources Division.

Glenn, T.C., Stephan, W., & Braun, M.J. (1999). Effects of a population bottleneck on mitochondrial DNA variation in whooping cranes. *Conserv. Biol., 13(5),* 1097-1107.

Gomez, G. M. (1992). Whooping cranes in southwest Louisiana: History and human attitudes. *Proc. N. Am. Crane Workshop, 6*, 19-23.

Hayes, M.A., Hartup, B.K., Pittman, J.M., & Barzen, J.A. (2003). Capture of sandhill cranes using alpha-chloralose. *J. Wildl. Dis., 39*(4), 859-868.

Hayes, M.A., & Barzen, J.A. (2003) *Proc. N. Am. Crane Workshop, 9*. Sacramento, CA. Unpublished report.

Hoy, P.R. (1885). Man's influence on the avifauna of southeastern Wisconsin. *Proc. Natural History Society of Wisconsin (March, 1885), 4-9.*

The International Ecotourism Society. (September 2005). *Ecotourism fact sheet*. Retrieved June 30, 2006 from the World Wide Web: www.ecotourism.org

Johns, B. W. (1998a). Whooping cranes nesting in Alberta. *Blue Jay, 56*, 31-33.

Johns, B. W. (1998b). 1997 - Year of the crane. *Alberta Naturalist, 28*, 3-4.

Jones, K. L., & Lacy, B. (2006). *Whooping crane master plan for 2006*. Unpublished report for Tom Stehn, USFWS and the International Whooping Crane Recovery Team.

Kumlien, L., & Hollister, N. (1903). The birds of Wisconsin. *Bulletin of the Wisconsin Natural History Society, 2,* 1-143.

Kuyt, E. (1992). Aerial radio-tracking of whooping cranes migrating between Wood Buffalo National Park and Aransas National Wildlife Refuge, 1981-84. *Occas. Pap. 74*. Ottawa: Canadian Wildlife Service.

Lewis, J.C., Kuyt, E., Schwindt, K.E., & Stehn, T.V. (1992a). Mortality in fledged cranes of the Aransas-Wood Buffalo population. In D.A. Wood, (Ed.), *Proc. 1988 N. Am. Crane Workshop* (pp. 145-148). Tallahassee, FL: Florida Game and Fresh Water Fish Commission.

Lewis, J. C., Drewien, R. C., Kuyt, E., & Sanchez, Jr., C. (1992b). Contaminants in habitat, tissue, and eggs of whooping cranes. *Proc. N. Am. Crane Workshop, 6*, 159-165.

Lewis, J.C. (1997). Alerting the birds. *Endangered Species Bulletin, XXII*(2).

Manville, A.M., II. (in press). Bird strikes and electrocutions at power lines, communication towers, and wind turbines: State of the art and state of the science – next steps toward mitigation. In C.J. Ralph and T. D. Rich, (Eds.) *Bird conservation implementation in the Americas: Proceedings 3rd International Partners in Flight Conference 2002* (GTR-PSW-191). Albany, CA: U.S.D.A. Forest Service.

Meine, C. D., & Archibald, G. W. (Comps.) (1996). *The cranes: Status survey and conservation action plan*. Gland, Switzerland AND Cambridge, UK: IUCN SSC Crane Specialist Group.

Mirande, C., Lacy, R., & Seal, U. (1991). *Whooping crane (Grus Americana) conservation viability assessment workshop report*. Apple Valley, MN: IUCN SSC Captive Breeding Specialist Group.

Mirande, C., Lacy, R., & Seal, U. (1993). *Whooping crane (Grus americana) conservation viability assessment workshop report.* Apple Valley, MN: Captive Breeding Specialist Group, IUCN.

Mirande, C.R., Cannon, J. R., Agzigian, K., Bogart, R. E., Christiansen, S., Dubow, J., Fernandez, A. K., Howarth, D. K., Jones, C., Munson, K. G., Pandya, S. I., Sedaghatkish, G., Skeri, K. L., Stenquist, S. A., & Wheeler, J. (1997). Computer simulations of possible futures for two flocks of whooping cranes. *Proc. N. Am. Crane Workshop, 7*, 181-200.

Montague, C. L., & Weigert, R. G. (1990). Salt marshes. In R.L Meyers & J.J. Ewel (Eds.), *Ecosystems of Florida* (pp. 481-516). Gainesville, FL: University Press of Florida.

Morkill, A. E. (1990). *Effectiveness of markers in reducing sandhill crane collisions with power lines*. Unpublished master thesis. University of Wyoming, Laramie.

Morkill, A. E., & Anderson, S. H. (1991). Effectiveness of marking power lines to reduce sandhill crane collisions. *Wildl. Soc. Bull, 19*, 442-449.

Morkill, A. E., & Anderson, S. H. (1993). Effectiveness of yellow aviation balls in reducing sandhill crane collisions with power lines. In *Proc. International Workshop on Avian Interactions with Utility Structures* (pp. 21-1 to 21-17). Pleasant Hill, CA: Elect. Power Res. Institute.

Nesbitt, S.A. (1982). The past, present, and future of the whooping crane in Florida. In J.C. Lewis (Ed.). *Proc. 1981 International Crane Workshop* (pp. 151-154). Tavernier, FL: National Audubon Society.

Nesbitt, S.A., & Williams, K.S. (1990). Home range and habitat use of Florida sandhill cranes. *J. Wildl. Manage. 54*, 92-96.

Nesbitt, S. A., Folk, M. J., Spalding, M. G., Schmidt, J. A., Schwikert, S. T., Nicolich, J. M., Wellington, M., Lewis, J. C., & Logan, T. H. (1997). An experimental release of whooping cranes in Florida – the first three years. *Proc. N. Am. Crane Workshop 7*, 79-85.

Northeast Furbearer Resources Technical Committee. (2001). *Trapping and furbearer management in North American wildlife conservation.* United States and Canada: Northeast Furbearer Resources Technical Committee.

Olsen, G. H., Langenberg, J. A., & Carpenter, J. W. (1996). Medicine and surgery. In D. H. Ellis, G. F. Gee, & C. M. Mirande (Eds). *Cranes: their biology, husbandry, and conservation* (pp. 137-174). Washington D.C.: National Biological Service.

Outdoor Industry Foundation. (2005). *Outdoor recreation participation and spending study: A state by state perspective.* Retrieved July 9, 2006 from the World Wide Web: http://www.outdoorindustry.org/found.wild.report.html

Pohlman, J.D., Bartelt, G.A., Hanson, A.C., III, Scott, P.H., & Thompson, C.D. (Eds.). (2006). *Wisconsin land legacy report: An inventory of places to meet Wisconsin's future conservation and recreation needs.* Madison, WI: Wisconsin Department of Natural Resources.

Robbins, S.D. (1991). *Wisconsin birdlife*. Madison, WI: University of Wisconsin Press.

Snyder, S. B., Richard, M. J., Thilsted, J.P., Drewien, R.C., & Lewis, J.C. (1992). Lead poisoning in a whooping crane. In D. A. Wood (Ed.), *Proc. 1988 N. Am. Crane Workshop, Florida* (pp. 207-211). (Nongame Wildlife Program Technical Report 12). Tallahassee, FL: Florida Game and Fresh Water Fish Commission.

Stehn, T., & Johnson, E. F. (1987). The distribution of winter territories of the whooping crane on the Texas coast. In J. C. Lewis & J. W. Ziewitz (Eds.), *Proc. 1985 Crane Workshop* (pp. 180-195). Grand Island, NE: Platte River Whooping Crane Habitat Maintenance Trust and USFWS.

Stys, B. (1997). *Ecology of the Florida sandhill crane*. (Nongame Wildlife Technical Report #15). Tallahassee, FL: Florida Game and Fresh Water Fish Commission.

U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). (2000). *Wisconsin wetlands reserve program.* Retrieved July 12, 2006 on the World Wide Web: http://www.nrcs.usda.gov/PROGRAMS/wrp/states/wi.html

U.S. Fish and Wildlife Service & U.S. Census Bureau. (2002). *2001 National survey of fishing, hunting, and wildlife-associated recreation*. Retrieved July 10, 2006 on the World Wide Web: http://www.census.gov/prod/2002pubs/FHW01.pdf

Urbanek, R. P., & Bookhout, T. A. (1994). Performance of captive-reared cranes released into a migration route in eastern North America. In H. Higuchi & J. Minton (Eds.), *The future of cranes and wetlands* (pp.121-129). Tokyo, Japan: Wild Bird Society.

Wisconsin Department of Natural Resources Wetland Team. (December 2000). *Restoring the loss: A strategy for protecting & restoring wetlands in Wisconsin* (WI DNR Publication No. FH-232-2000). Madison, WI: Wisconsin Department of Natural Resources.

Wisconsin Department of Natural Resources. (2006) *Wisconsin land legacy report: An inventory of places to meet Wisconsin's future conservation and recreation needs* (WI DNR Publication No. LF-040-2006). Pohlman, J. D., Bartelt, G. A., Hanson III, A. C., Scott, P. H. & Thompson, C. D., (Eds.). Madison, WI: Wisconsin Department of Natural Resources.

Wood, D. A., & Nesbitt, S. A. (2001). Sandhill crane. In D.A. Wood (Ed.), *Florida's fragile wildlife: Conservation and management* (pp. 108-123). Gainesville,FL: University of Florida Press.

12. APPENDICES

APPENDIX 1: Banding, Marking, Radio and Satellite Transmitters

Each released EMP whooping crane is individually marked with color-coded plastic leg bands above the hock of each leg. There are two sizes of bands, small bands and transmitter bands. Each bird carries a VHF transmitter on one leg; some birds also carry a satellite transmitter (PTT) on the other leg. An aluminum lock-on Bird Banding Lab (BBL) band is attached above the toes of the right leg. A team of bird banders from USFWS, ICF and other involved partners collaborates to band the birds.

Color Bands: The color-marking scheme consists of different combinations of red, green, and white bands with all colors on each bird. These bands are wrap-around type with no protrusions. They are custom-fabricated of Gravoply ABS acrylic. Due to fading, beginning September 2004 small red bands are made of Darvic PVC. One to three small bands, each 1" tall, is stacked on one leg. Each transmitter is attached to two transmitter bands, each 1.5" tall.

Transmitters: Each bird carries a VHF transmitter operating at a different frequency in the 164-166 MHz range. The standard transmitter is manufactured by ATS (Isanti, MN) and powered by a single lithium AA battery. PTT's are 30-g SiV's manufactured by Microwave Telemetry (Columbia, MD).

Aluminum Bands: The BBL does not offer a band of the correct size for attachment above the toes of a whooping crane. No. 9 lock-on bands are therefore cut down to size and reformed before attachment to project birds.

APPENDIX 2: **Eastern Migratory Population ID** (6/2006, update biannually).

Hatch year	Crane no.	Sex	BBL Band no.	Color code (left:right)	PTT ID	Studbook no. Own	Sire	Dam	Mate
2001	1	M	659-00215	L **G/W**:**G/R/G**		1629	1114/1144[a]	1119	2-02
2001	2	F	659-00201	L **G/W**:**R**		1630	1147	1142	
2001	5	M	659-00213	L **G/W**:**R/G**		1633	1147	1142	4-02
2001	7	F	659-00214	L **G/W**:**W/R**		1635	1127	1154	
2002	1	F	599-32111	L **R/W**:L **G**(PTT)	--	1660	1133	1135	6-03
2002	2	F	599-32112	L **R/W**:**G/W**		1661	1133	1135	1-01
2002	3	F	599-32116	L **R/W**:**W/G/W**		1662	1114	1119	17-03
2002	4	F	599-32117	L **R/W**:**R/G/W**		1663	1114	1119	5-01
2002	5	M	599-32118	L **R/W**:**G/R/W**		1664	1133	1135	
2002	8	M	599-32113	L **R/W**:**W/G**		1668	1144	1136	
2002	9	F	599-32127	**G/W**:L **R/W**		1670	1133	1135	
2002	11	M	599-32114	L **R/W**:**R/G**		1672	1147	1142	17-02
2002	12	M	599-32121	L **R/W**:**W/R/G**		1673	1114	1119	
2002	13	M	599-32122	L **R/W**:**G/R/G**		1674	1127	1154	18-02
2002	16	M	599-32125	L **R/W**:**R/G/R**		1677	1147	1142	3-03
2002	17	F	599-32115	L **R/W**:**G/R**		1678	1144	1136	11-02
2002	18	F	599-32126	**G**:L **R/W**		1679	1128	1101	13-02
2003	1	F	599-34041	**W**:L **G/R**		1696	1175	1188	
2003	2	M	599-34044	**G/W**:L **G/R**		1697	1133	1135	
2003	3	F	599-34056	L **G/R**:**W**		1698	1144	1136	16-02
2003	6	M	599-34047	**G/W/G**:L **G/R**		1701	1133	1135	1-02
2003	7	M	599-34048	**R/W/G**:L **G/R**		1702	1133	1135	
2003	9	F	599-34042	L **W/G**(PTT):L	62171	1704	1144	1136	
2003	10	M	599-34049	**W/G/R**:L **G/R**		1705	1175	1188	
2003	11	M	599-34050	**G/W/R**:L **G/R**		1706	1127	1154	
2003	12	F	599-34043	L **W/R**(PTT):L	--	1707	1133	1135	
2003	13	F	599-34051	**R/W/R**:L **G/R**		1708	1133	1135	
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	3-02
2003	18	M	599-34054	**G/R/W**:L **G/R**		1713	1147	1142	
2004	1	M	599-37449	**R/G/W**:L **W/G**		1744	1133	1135	
2004	2	M	599-37450	**W/R/W**:L **W/G**		1745	1127	1154	
2004	3	M	599-37451	**G/R/W**:L **W/G**		1746	1133	1135	
2004	7	M	599-37453	**W/R/G**:L **W/G**		1750	1144	1136	
2004	8	M	599-37454	**G/R/G**:L **W/G**		1751	1133	1135	
2004	12	M	599-37455	**G/W/R**:L **W/G**		1755	1127	1154	
2004	15	F	599-37446	L **R/G**(PTT):L	38636	1758	1144	1136	
2004	16	M	599-37457	**W/G/R**:L **W/G**		1759	1144	1136	
2004	17	M	599-37458	**R/G/R**:L **W/G**		1760	1133	1135	
2004	19	F	599-37447	L **W/R**(PTT):L	38637	1762	1128/1100[b]	1263	
2004	20	F	599-37448	L **G/R**(PTT):L	15331	1763	1133	1135	
2005	1	F	599-37231	L **G/W**:**R/G/W**		1782	1162	1167	
2005	2	F	599-37237	L **R/W**(PTT):L	62169	1783	1144	1136	
2005	3	M	599-37232	L **G/W**:**W/R/W**		1784	1144	1136	

G = Green **W** = White **R** = Red
L = long bands (38 mm) for transmitter attachment.
[a] Sire could be either 1114 or 1144.
[b] Sire could be either 1128 or 1100.

2005	5	M	599-37233	L **G/W**:**G/R/W**		1786	1133	1135	
2005	6	M	599-37234	L **G/W**:**R/W/G**		1787	1133	1135	
2005	7	F	599-37235	L **G/W**:**W/R/G**		1788	1144	1136	
2005	8	F	599-37239	L **W/R**(PTT):L	44263	1790	1127	1154	
2005	9	M	599-37236	L **G/W**:**R/W/R**		1791	1162	1167	
2005	10	F	599-37240	**R/G/W**:L **G/W**		1792	1560	1135	
2005	11	M	599-37241	**W/R/W**:L **G/W**		1793	1041	1197	
2005	12	M	599-37242	**G/R/W**:L **G/W**		1794	1560	1135	
2005	14	M	599-37243	**R/W/G**:L **G/W**		1796	1182	1098	
2005	16	M	599-37244	**W/R/G**:L **G/W**		1799	1189	1195	
2005	19	F	599-24696	**G/R/G**:L **G/W**		1802	1560	1135	
2005	20	F	599-37238	L **R/G**(PTT):L	62170	1803	1182	1098	
2005	21	F	599-24697	**G/W/R**:L **G/W**		1804	1189	1195	
2005	22	M	599-24698	**R/W/R**:L **G/W**		1805	1130	1292	
2005	23	M	599-24699	**W/G/R**:L **G/W**		1806	1130	1292	
2005	24	M	599-24700	**R/G/R**:L **G/W**		1807	1560	1135	
2005	27	F	599-32128	L **G/W**:L	15045	1811	1128	1263	
2005	28	F	599-32129	L **G/W**:L	15050	1812	1128	1140	
2005	32	M	599-37459	L **G/W**:**G/W/R**		1817	1560	1135	
2005	33	F	599-32130	L **R**(PTT):L **G/W**	38635	1819	1128	1140	

G = Green **W** = White **R** = Red
L = long bands (38 mm) for transmitter attachment.

APPENDIX 3: EMP Genealogy (November 2005)

G-great grand-parents Sire Dam	Great grand-parents Sire Dam	Grand-parents Sire Dam	Father	Released Birds	Mother	Grand-parents Sire Dam	Great grand-parents Sire Dam	G-great grand-parents Sire Dam
W/Wild	0002	1019	1133	1-02 F, 2-02 F, 5-02 M, 9-02 F 2-03 M, 6-03 M, 7-03 M, 12-03 F, 13-03 F 1-04 M, 3-04 M, 8-04 M, 17-04 M, 20-04 F 5-05 M, 6-05 M	1135	1063	0026	W/Wild
W/Wild	0003						0027	W/Wild
W/Wild	0006	1053				1027	0012	W/Wild
W/Wild	0007						0013	W/Wild
222/223	0133	1213	1560	10-05 F, 12-05 M, 19-05 F, 24-05 M, 32-05 M				
006/007	0183							
W/Wild	0099	1163						
032/033	0066							
	Wild	0034	1144	8-02 M, 17-02 F 3-03 F, 9-03 F, 16-03 M, 17-03 M 7-04 M, 15-04 F, 16-04 M 2-05 F, 3-05 M, 7-05 F	1136	1032	0032	W/Wild
	Wild						0033	W/Wild
	Wild	0035				1027	0012	W/Wild
	Wild						0013	W/Wild
	W/Wild	0024	1127	7-01 F 13-02 M 11-03 M 2-04 M, 12-04 M 8-05 F	1154	0236	W/Wild	
	W/Wild	0025				0237	W/Wild	
W/Wild	0006	0069	1147	2-01 F, 5-01 M 11-02 M, 16-02 M 18-03 M	1142	1041	Wild	
W/Wild	0007						Wild	
	Wild	0075				1027	0012	W/Wild
	Wild						0013	W/Wild
W/Wild	0002	1019	1114	1-01 M* 3-02 F, 4-02 F, 12-02 M	1119	0036	Wild	
W/Wild	0003						Wild	
W/Wild	0006	1053				0037	Wild	
W/Wild	0007						Wild	
W/Wild	0012	0101	1182	14-05 M, 20-05 F	1098	1020	0008	W/Wild
W/Wild	0013						0009	W/Wild
	W/Wild	0088				1022	W/Wild	

W/Wild	0018	0067	1162	1-05 F, 9-05 M	1167	0112	0055	026/027
W/Wild	0019						0040	W/Wild
	Wild	0074				0142	0006	W/Wild
	Wild						0007	W/Wild
	Wild	1041	1175	1-03 F, 10-03 M	1188	1019	0002	W/Wild
	Wild						0003	W/Wild
008/009	1020	1098				1053	0006	W/Wild
W/Wild	1022						0007	W/Wild
		Wild	1189	16-05 M, 21-05 F	1195	0014	W/Wild	
		Wild				0144	W/Wild	
W/Wild	0002	1019	1128	19-04** F 27-05 F	1263	1041	Wild	
W/Wild	0003						Wild	
	Wild	1022				1027	0012	W/Wild
	Wild						0013	W/Wild
W/Wild	0002	1019	1128	28-05 F, 33-05 F	1140	1041	Wild	
W/Wild	0003						Wild	
	Wild	1022				1027	0012	W/Wild
	Wild						0013	W/Wild
W/Wild	0002	1019	1128	18-02 F	1101	1031	0006	W/Wild
W/Wild	0003						0007	W/Wild
	W/Wild	1022				1036	W/Wild	
W/Wild	0002	1019	1130	22-05 M, 23-05 M	1292	0124	0028	W/Wild
W/Wild	0003						0029	W/Wild
	W/Wild	1036				0089	W/Wild	
		Wild	1041	11-05 M	1197	0139	00036	W/Wild
							0037	W/Wild
		Wild				0117	0067	018/019
							0074	W/Wild

* Sire might be 1144.

** Sire might be 1100.

Grandparents with Greatest Proportion of EMP Birds

Grandparents of EMP releases	Parents to birds alive in the released population	Number of chicks alive from these breeders
Sire 1019	1114*	4
	1128	5
	1130	2
	1133*	16
	1188*	2
	Total number of chicks with 1019 as grandfather	**29**
Dam 1027	1135	21
	1136	12
	1140*	2
	1142*	5
	1263*	2
	Total number of chicks with 1027 as grandmother	**42**

*full siblings

APPENDIX 4: Capture and Safe Handling of Whooping Cranes to Avoid Capture-Related Stress and Injury Barry K. Hartup, DVM, PhD (The report below, including a complete set of references, is available from the ICF library as a pdf file by request; contact through website: www.savingcranes.org)

This report provides a general set of guidelines for the safe capture and handling of free-ranging whooping cranes in North America. The target audience consists of aviculturists, biologists and veterinarians that work directly to capture whooping cranes. This report is not intended to provide exhaustive information on specific capture techniques; it is assumed that the methods chosen by the biologists meet the standards of the profession and are appropriate for the situation at hand (for further technique information, see Hayes, et. al., 2003. Capture of sandhill cranes using alpha-chloralose. *Journal of Wildlife Diseases*, *39*(4), 859-868). The intentions of this report are to reinforce a standard set of conditions to be followed when choosing and implementing a particular capture technique, and to offer tips on how to minimize bird stress while in hand. The goal is to achieve maximum safety for the cranes and people involved, and keep capture-related morbidity to less than 2 percent.

Etiology of Capture Morbidity in Cranes

Musculoskeletal trauma and repercussions from severe physiological stress, often manifested as exertional myopathy or capture myopathy, are common negative impacts among captured cranes. With greater numbers of free-ranging whooping cranes subjected to direct manipulation, such harmful impacts are likely to arise with increasing frequency.

Capture and handling techniques should be designed to minimize the risks of direct trauma, as many complications and stressors are exacerbated by pre-existing tissue damage. Contingency plans must be available in the event of injury during capture/handling, including prompt treatment and potential rehabilitation.

Exertional myopathy (EM) is an insidious non-infectious disease that may present as an acute capture shock syndrome that develops within minutes to hours, or a debilitating, necrotizing muscle condition that takes days to manifest. The disease has been described in a wide array of mammals and birds. Long-legged birds may be more susceptible to EM than other birds as suggested by a disproportionate number of published case reports involving Mississippi sandhill cranes, greater sandhill cranes, whooping cranes, grey crowned cranes, emus, ostriches, a white stork, and greater and lesser flamingos.

Several factors are associated with the EM onset in animals, including fear, anxiety, stress, overexertion, hyperthermia, metabolic acidosis, and vitamin E/selenium deficiency. Genetic predisposition has also been suggested as a potential risk factor. Certain plant and chemical toxicants can induce disease similar to EM. Anthropogenic factors, such as capture and handling conditions, are recognized risk factors for EM, including rate and length of pursuit, prolonged manual restraint with extended muscle tension, repeated handling, and transportation and translocation of an exhausted animal. In addition, environmental conditions may aggravate the factors described above. High temperatures and captures in summer months have been associated with the EM development. Exertional myopathy may also develop secondary to severe trauma, but it is infrequently documented compared to the “classical capture and pursuit” disease.

Prevention of EM is paramount; there is generally a low rate of success in treating EM in wildlife, and perhaps whooping cranes in particular. Taken together, published accounts

suggest that minimizing stress, prompt immobilization, proper restraint, efficient transportation, and limiting handling time are critical to preventing EM in susceptible species. It is assumed that similar steps would help prevent the disease in captured whooping cranes.

Proposed Guidelines for Preventing Capture Associated Morbidity

1. Pre-planning the Capture

To maximize safety, considerable time must be spent evaluating specific situations in which whooping cranes will be captured. A flexible timetable is desirable in situations involving significant distance or logistics to allow assembly of sufficient staff, arrange transportation and equipment.

Prior to capture, personnel need to investigate the site(s) used by the cranes and their behavioral routines and disposition. Health status, habitat use, timing of local movements, feeding or roosting and social behavior, and presence of other cranes may require considerable adjustment in capture techniques or equipment needed. Some situations may make capture difficult or impossible; therefore, flexibility is required in the techniques that may be applied.

All techniques, however, should limit the pursuit of the target bird(s), rapidly apply safe handling with proper restraint and leg positioning, minimize stressors and external stimuli once birds are in-hand, and prevent hyperthermia. Chemical methods must reach an adequate plane of anesthesia to prevent partial sedation and struggling.

Staffing requirements should be met with experienced personnel; handlers of free-ranging whooping cranes should have considerable practical experience handling captive or wild cranes in various conditions. The personnel should also be well trained with the techniques to be used and communicate and work together as a well-functioning team.

When birds are baited for capture, whole corn should be avoided to prevent possible aspiration. Pelleted food or cracked corn should be substituted at the time of capture. Food should be removed from the mouth if present after capture.

Capture should occur only when temperatures are below 75-80 degrees, typically before 1000 hours or towards evening, with due consideration to seasonal influences on bird behavior and condition. Hot and humid weather should result in postponement of capture, or significant modifications in technique such that turn-around time to release is extremely short (minutes).

Transportation of birds after capture needs to be planned carefully. Air conditioned, closed-top vehicles for local or regional transport and non-commercial airplanes for long distance translocations are ideal. Carefully coordinated timetables are needed to minimize the time the spent in transport crates and keep stress under control. Currently, there are no sedatives tested that appear to ease handling or shipment.

While captures for relocation provide opportunities to change radio transmitters or take blood samples, field events may make such extra handling inadvisable. Final decision on such actions should be based on an assessment of the bird’s condition and response to capture and handling. All necessary equipment and arrangements for the acquisition, storage and transport of biological samples must be secured prior to the target capture date.

Finally, a contingency plan in the event of injury must be formulated prior to capture. Contact with project veterinary staff prior to capture is useful in facilitating a timely response in the event

of an emergency. It may be desirable to hand carry an injured crane, rather than transport it in a crate to avoid further injury.

2. Physical Restraint

Though initial immobilization of cranes may be facilitated by nets, snares or chemical methods, manual restraint is common to all capture protocols. The strategy for the restraint of each individual is unique, especially given the bird's size, behavioral disposition and health status.

Fundamental safe handling techniques are well described in chapters 2 & 5 of the Crane Husbandry Manual (*Cranes: Their Biology, Husbandry and Conservation*, Ellis, Gee & Mirande, 1996). The full text of the manual is accessible from the internet at: http://www.pwrc.usgs.gov/resshow/gee/cranbook/cranebook.htm

Handling of cranes involves the following central tenets:

- Handlers should wear eye protection and long pants or other leg covering to prevent injuries from claws and bills.
- For manual capture of adults, two people are normally required. The handler may quickly grab the bustle (elongated tertial feathers), both wings or the humerus of one wing and the neck.
- Restrain the wings and legs as soon as possible after catching a crane by pulling the crane's body against captor's own and turning away from the bird's bill to avoid facial injury. A second person should restrain the crane's head and secure a hood on the bird to minimize stress and struggling. Hoods should be sized and shaped according to the species being restrained.
- Restrain legs with one arm while the body is held with the other. Legs should be restrained above the hocks with one finger between them to avoid abrasions. The lower limbs should be left unrestrained (hanging down/not folded) except to control obvious flailing and to guard against catching toes or nails in clothing. *Briefly* securing the lower limbs with masking tape or low-stick tape is advisable if limited movement is required.
- Move the crane to shade or other shelter.
- Sit and hold the bird in a comfortable position in the lap or place a foot on a chair or stool to ease resting the bird on the handler's thigh.
- Hold the bird's head away from hard objects to prevent striking them when struggling.
- If a manual release is performed, allow the limbs to touch the ground before letting go of the body or wings. The handler may elect to hold the bustle or one wing to be sure the crane is stable before release.
- Crane chicks are very fragile. Use a scoop method to handle young chicks where one or two fingers are slipped between the chick's legs and its body is held gently in the palm, while the legs dangle between the fingers or over the side of the hand. The other hand covers the chick's back to prevent it from jumping off the palm. The legs are left unrestrained, but must be prevented from clawing the chick's face or neck.
- When releasing chicks, support the body until the legs support the bird's weight.
- Birds over 10 days old may be held by the bouquet method where the bird's weight is supported by one hand under the keel and the legs are held with the other with a finger between them. The bird's body is held horizontally or more upright with the legs back so the chick cannot claw itself.
- Restraint of older chicks must consider the emergence of new feathers. Chicks over six weeks of age are normally carried like small adults.
- It is highly recommended that all chicks are held with the legs in extension, rather than in a folded position to prevent injury.

3. Timing and Monitoring Cranes In-hand
Cranes should not be held any longer than necessary; time should be kept from the moment capture and restraint begins. Recommended maximum lengths of time for physical restraint of healthy cranes range from ~15-25 minutes for single bird capture, and slightly longer if multiple birds are processed simultaneously. Keeping the handling time to a minimum likely helps reduce stress, lowers the probability of overexertion, and helps to maintain group cohesion after release (if the bird was a member of a pair, family, or subadult group).

If time is limiting, tasks must be prioritized, with some abandoned if necessary. Information is collected quickly, using a standard form for data entry. It may be possible to accomplish some tasks simultaneously on single birds if personnel and conditions allow. Work could be organized assembly-line style if multiple birds are processed.

Open-mouth breathing (increased effort), increased respiratory rate, and overheating (legs warm to the touch) are all signs of stress and hyperthermia in birds which can lead to the serious complications described above. Handling must be cut short when these signs are observed. Hyperthermia can be counteracted by spraying or pouring cool water on the bird's legs, application of ice packs in the axillary and/or inguinal area between the extremities and body, and movement to a cooler environment (see chapter 8 in Crane Husbandry Manual).

4. Translocations
During all translocations, enclosed vehicles with air conditioning are most useful to mitigate the effects of heat stress or hyperthermia. Well ventilated crates are useful for all motor vehicle transfers, as well as aircraft-aided translocations. A guideline on crate sizes and materials appropriate for whooping cranes can be found in the Crane Husbandry Manual. Manual restraint is generally not recommended during transportation for relocation or other needs, except when the distance is considerably short.

Repeated bouts of handling are to be discouraged during translocation, except in the case of emergency treatment that is under the direction of a veterinarian. All translocations should be of the shortest duration possible, with contingency plans made in the event of delays (i.e., provision of food and water if greater than 2-4 hours).

5. Release and Follow-up
When possible, cranes are released close to water so the bird can quickly cool off and drink if needed. The capture team leaves the area quickly so that the birds can recover as soon as possible from the intrusion. Close monitoring of birds via telemetry or observation after release is highly desirable to determine short-term outcomes after capture and identify potential problems. A decision can then be made regarding intervention and treatment of the problems observed.

Personnel should meet soon after each capture event and debrief one another to encourage improvement in communications, techniques and results. Notes of these discussions should be logged and archived for potential later use.

APPENDIX 5: Health Protocols

Opportunistic Health Monitoring

Whenever birds are captured for transmitter changes, relocation, or evaluation of a health problem by Wisconsin personnel, the following health monitoring should be included:

- Physical examination (including weight, molt condition, auscultation, oral examination and collection of any ectoparasites found)
- Blood collection for complete blood count, hemoparasite screen, blood lead, serum zinc, chemistry profile, serology (Newcastle disease, avian influenza, West Nile virus, eastern equine encephalitis, infectious bursal disease), and serum banking
- Collect fresh feces for *Salmonella* culture, fecal smear for acid fast staining, and for parasite evaluation (wet mount, flotation), banking remainder frozen and in dichromate

Medical Records

The DNR Wildlife Health Laboratory collates and manages data on any birds sampled in Wisconsin. All health related observations made at recaptures and after release should be forwarded to DNR in a timely manner. All health related data collected by any member of WCEP should be forwarded to ICF for inclusion in the WCEP health database, which can then be forwarded to other veterinary team members as needed.

Treatment

All efforts will be made to maintain cranes requiring treatment at the Necedah Annex treatment facility or temporary pen structure in WI and FL respectively, or other facility designated by the Health Team. *The goal is to re-release healthy individuals as soon as possible back to the wild, avoiding lengthy rehabilitation that may compromise behavioral avoidance of humans.*

Behavioral and physical criteria will be assessed by project personnel in order to ensure the greatest probability of success of the release. The development of a condition that precludes any type of release may also occur in a project bird. The following are various dispositions that may apply to free-ranging cranes requiring medical treatment.

- Release at an approved site appropriate to the annual cycle.
- Placement with an approved zoological institution for display purposes or at one of the smaller breeding centers. The Whooping Crane Health Advisory Team will assess the risk to resident whooping crane flocks on a case-by-case basis. This option may apply to permanently disabled and other non-releasable project birds (e.g., behavioral problems) that have been exposed to wild habitat. Arrangements for standard quarantine and health evaluation will be made with the receiving institution. In Wisconsin, maintenance of these individuals would occur at the Necedah Annex holding/hospital facility, or at the Milwaukee County Zoo. Elsewhere, a bird would be maintained with help from the Tracking Team and/or local cooperator at a site approved by the Health Team.
- Euthanasia. This option will apply to seriously injured or diseased cranes with limited expectation of survival.

The WCEP Health Team along with core team leaders will provide a formal recommendation to the Project Direction Team and WC Recovery Team as the need arises for outcomes other than a wild release.

Evaluation of Predation-Related Mortalities

USDA-Animal Plant Health Inspection Service-Wildlife Services (WS) is available to assist with evaluation of mortality sites and carcasses for evidence of predation. After a mortality is detected (or in some cases when a mortality is suspected), Chip Lovell (WS) may be contacted for assistance (920-324-4514). When possible, entry into the mortality site will be coordinated with the WS field investigator for examination of the undisturbed carcass and site. When a timely response from WS is not feasible the field biologist will photo document the undisturbed carcass and as much of the site as possible and then will remove and preserve the carcass for necropsy following the Dead Crane Data Sheet section of this document. The field biologist will then coordinate a follow-up visit to the mortality site with the WS field investigator as soon as possible after retrieval of the carcass.

No dissection/skinning, etc. will occur in the field. Where possible, USGS National Wildlife Health Center (NWHC) staff will coordinate examination and necropsy of the carcass with the WS field investigator at the NWHC necropsy lab.

Records (including field notes, photos, reports) will be forwarded to ICF for inclusion in the WCEP health database and distribution to partners.

APPENDIX 6: Response Protocols

WCEP Contact Information

Beth Goodman
Wisconsin Dept. of Natural Resources
PO Box 7921
Madison WI 53707-7921
(608) 266-3219

John Christian
U.S. Fish and Wildlife Service
1 Federal Drive
Fort Snelling, Minnesota 55111-4056
(612) 713-5101

Joe Duff
Operation Migration
174 Mary St. Suite 3,
Port Perry, ON., L9L 1B7
(905) 982-1096

John French
U.S. Geological Survey
Patuxent Wildlife Research Center
c/o BARC-East Bldg 308, Rm 221
Beltsville, MD 20705
(301) 497-5702

Jim Hook
International Crane Foundation
E-11376 Shady Lane Rd.
P.O. Box 447
Baraboo, WI 53913 USA
(608) 356-9462

Tom Stehn
U.S. Fish and Wildlife Service
Aransas National Wildlife Refuge
P.O. Box 100
Austwell, TX 77950
(361) 286-3559 ext.221

USGS National Wildlife Health Center
6006 Schroeder Road
Madison, WI 53711-6223
(608) 270-2400

Charlie Luthin
Natural Resources Foundation of Wisconsin
PO Box 2317
Madison, WI 53701-2317
(608) 261-4384

Donn Waage
National Fish and Wildlife Foundation
1 Federal Drive
Ft. Snelling, MN 55111
(612) 713-5173

Private Land Issues
Contact WI DNR Regional biologist, DNR Whooping Crane Coordinator, or USFWS biologist as situation warrants.

Citizen Involvement

The public should contact their local WI DNR office to report all whooping crane observations. Probable sightings or known observations should be recorded by staff on the Whooping Crane Observation Form (Appendix 7) for the WCEP monitoring database maintained by WI DNR. The form can be downloaded from the WI DNR central computer server and electronically submitted or mailed to the state whooping crane coordinator and database manager. Data management is accomplished through the main whooping crane database by the data management staff and whooping crane coordinator. A series of validations ensures that only true records will be added to the main database. All probable sightings are shared with WCEP field staff.

Field staff may serve as a liaison to private property owners when whooping cranes reside on their land. The WI DNR whooping crane coordinator and WCEP partners are available to help provide project information as needed. Additionally, all field staff has access to project brochures and other educational materials for public distribution. In certain instances, WCEP may request monitoring assistance from landowners.

Preventing human disturbance is important to a bird's success in the wild. Human disturbance can cause the birds to leave an area, which may limit their ability to obtain food. Wild cranes are particularly sensitive to human disturbance on their summer breeding grounds (i.e., Wisconsin and central Canada). One-year old released birds are more likely to become habituated to humans. As they get older, the birds become increasingly wary.

When encountering a whooping crane, every effort should be made to remain at least 100 yards from the bird. If possible, remain concealed in a vehicle. Binoculars or a spotting scope are recommended to increase visibility. It is especially important to avoid disturbing a crane during evening roosting or when nesting. To learn more about bird watching guidelines, refer to The Bird Watcher's Code of Ethics developed by the Wisconsin Society for Ornithology at http://www.uwgb.edu/birds/wso/ethics.htm. Additional information on the effects of disturbance on nesting cranes can be found under Nest Sites and Territory Management, Section 6.9).

Law Violation
When a report or complaint is received of the intentional or unintentional killing of a whooping crane, it should be reported to the local conservation warden for the county in which the incident occurred. Such reports may be made either directly to the warden or through the nearest DNR Service Center, Sheriff's Department or by calling the DNR violation hotline at 1-800-TIP-WDNR (847-9367). Wardens will document the report and disposition of the investigation into the killing or possession of a whooping crane on law enforcement complaint form (Form #4800-48).

As soon as practical after receiving a report of the killing or possession of a whooping crane the warden or the warden supervisor shall notify the Regional Enforcement and Science leader and the Bureau of Endangered Resources. The investigating state warden will coordinate the investigation with the USFWS federal warden as appropriate on all intentional shootings. Any seized carcass of an unlawfully killed or possessed whooping crane will be tagged by the warden with a seizure record tag (Form # 4100-190). Proper chain of custody will need to be maintained for any incidents that might result in enforcement action.

Dead Crane Data Sheet

Contact: Wisconsin to Georgia	Contact: Georgia and Florida
USGS National Wildlife Health Center 6006 Schroeder Road Madison, WI 53711 Phone: 608-270-2445 Fax: 608-270-2415	Marilyn G. Spalding Department of Pathobiology Box 110880 College of Veterinary Medicine, University of Florida Gainesville, Florida 32610 Ship to: 2015 SW 16 Avenue, Bldg. 1017, Rm. V3-111 Work. 352 392-4700 ext 5816 Lab phone. 352 392-4700 ext 5849 FAX: 352 392-9704 Home: 352-495-9275 Email: rosie@nersp.nerdc.ufl.edu

Carcass Handling

1. Chill the carcass with wet ice bag(s). Birds may be shipped with frozen blue ice packs.
2. Contact USGS National Wildlife Health Center or Marilyn (see above) and include this data sheet in package with carcass.
3. Courtesy call to conservation warden and USFWS Law Enforcement Agent if needed. Reports may be made directly to the warden or through the nearest WI DNR Service Center, sheriff's department, or by calling the WI DNR violation hotline at 1-800-TIP-WDNR (847-9367). The investigating state warden will coordinate an investigation with the USFWS federal warden as appropriate on all shootings.

Agent contacted, name and number:

Submitter:

Cell phone number:

Date collected:

Crane identification number:

FWS band:

Found dead (circle one): Yes No Euthanized (circle one): Yes No

Euthanasia method:

Specific location where found including county and state:

Describe site features (vegetation, water, feathers, tracks, fences, roads, power lines):

Clinical signs? Any unusual behaviors or changes in physical appearance:

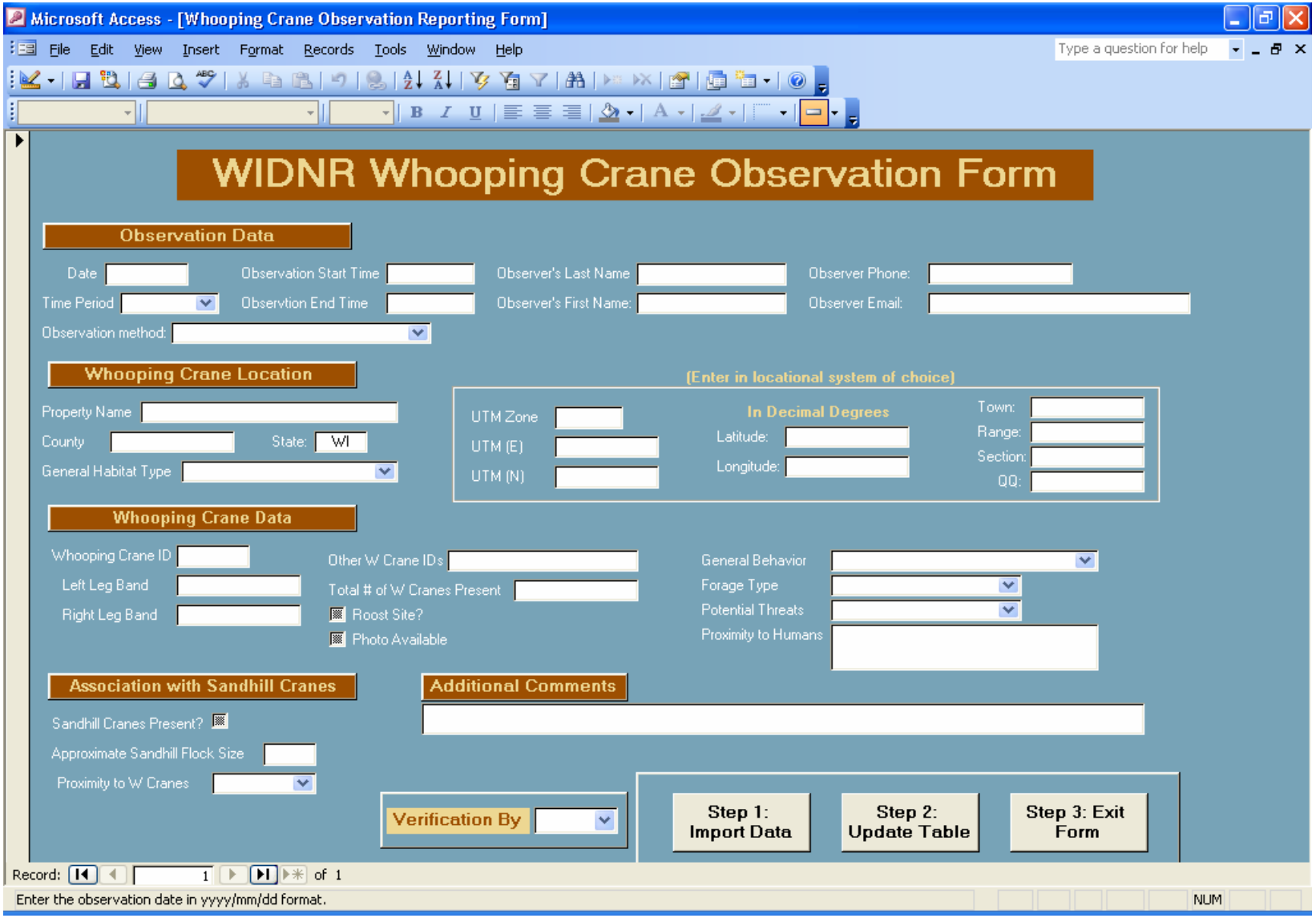
History:

continued on next page

Environmental factors:

Additional comments or observations:

APPENDIX 7: Wisconsin DNR Electronic Data Monitoring Form Screen Shot



Instructions for using DNR Whooping Crane Observation Input Form

We're asking for help monitoring Whooping Cranes. If you see or receive a report about a whooping crane, please contribute to our restoration effort by submitting observation data. The form below is part of an Access 2003 database created to capture information useful in evaluating project success and for future management decisions. Only DNR staff has access to the link provided below, since the form links to our common network drive. The 'Crane Observation' form makes it easier for us to track your observations and those reported to you by the general public. Thanks for your help!

Access 2003 Users: \\central\wcrane\CraneObs.mdb

Want to **print** a form to carry into the field and enter data into the system later?
Click here: \\central\wcrane\Field_Form.doc

Data records are regularly removed from this entry database by Whooping Crane Data Management staff, verified, then added to a permanent table in another database.

Status Bar: All fields in the electronic form are equipped with status bar instructions. By holding your curser over an entry field, hints relating to the type of information and / or format requested will appear in the bar at the bottom of the screen.

Crane ID field: This field should remain blank except in cases where the transmitter frequency has been verified or the crane is close enough for accurate leg band readings. It is expected that many submitted observations will not have an ID associated with them. It is more important that observers do not try to approach the birds to verify the ID as minimizing exposure to humans is critical for the birds' successful recovery.

Location fields: Latitude and longitude are best, along with a property description if known. If unavailable, a detailed distance and direction to a specific point found on the WI Atlas & Gazetteer is helpful. Town, Range, and Section are also useful if accompanied by a word description.

Questions and comments may be directed to either:

Beth Goodman
Whooping Crane State Coordinator
Bureau of Endangered Resources
beth.goodman@dnr.state.wi.us
(608)266-3219

Heidi Nelson
Whooping Crane Database Manager
Bureau of Endangered Resources
heidi.m.nelson@dnr.state.wi.us
608-267-0797

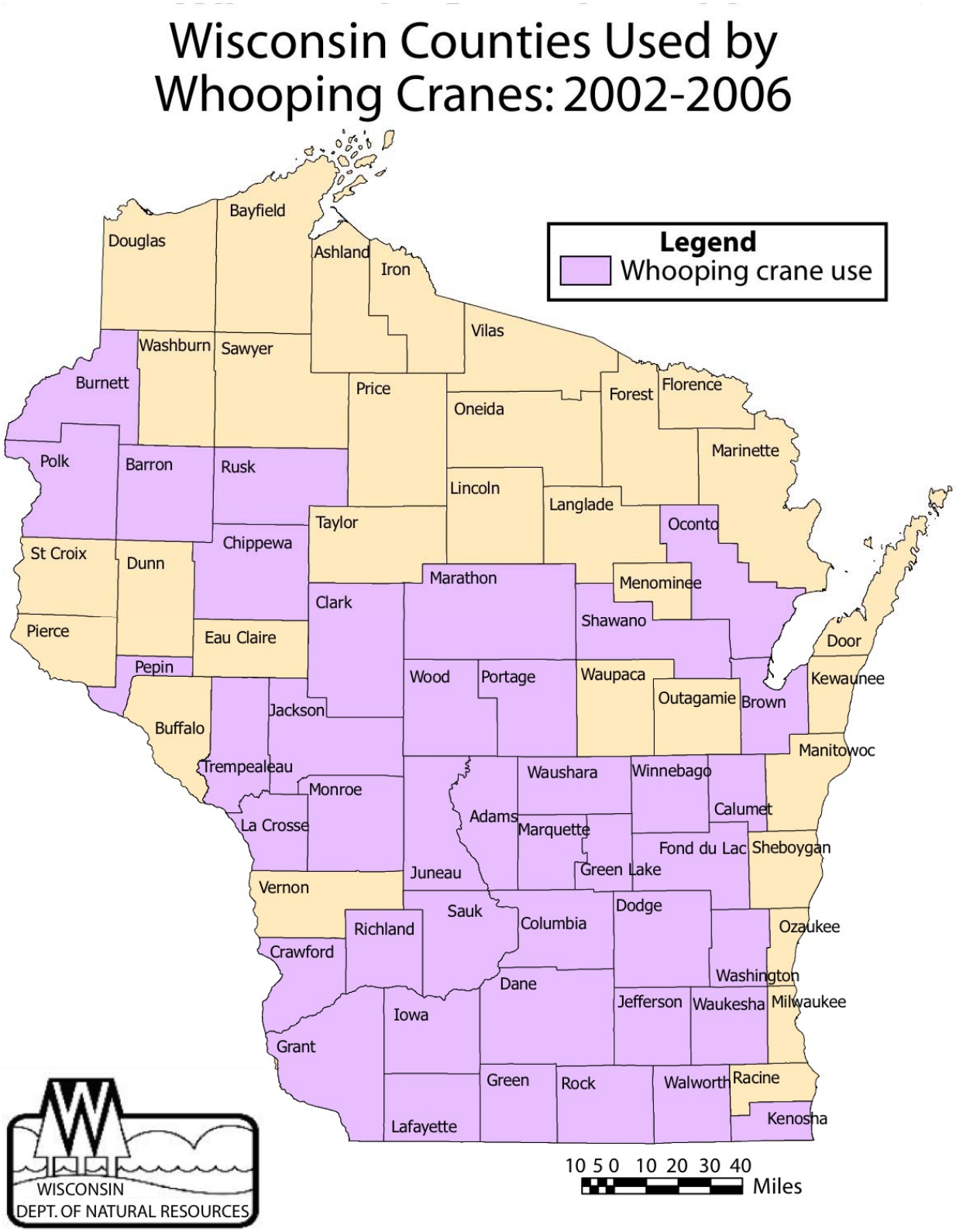
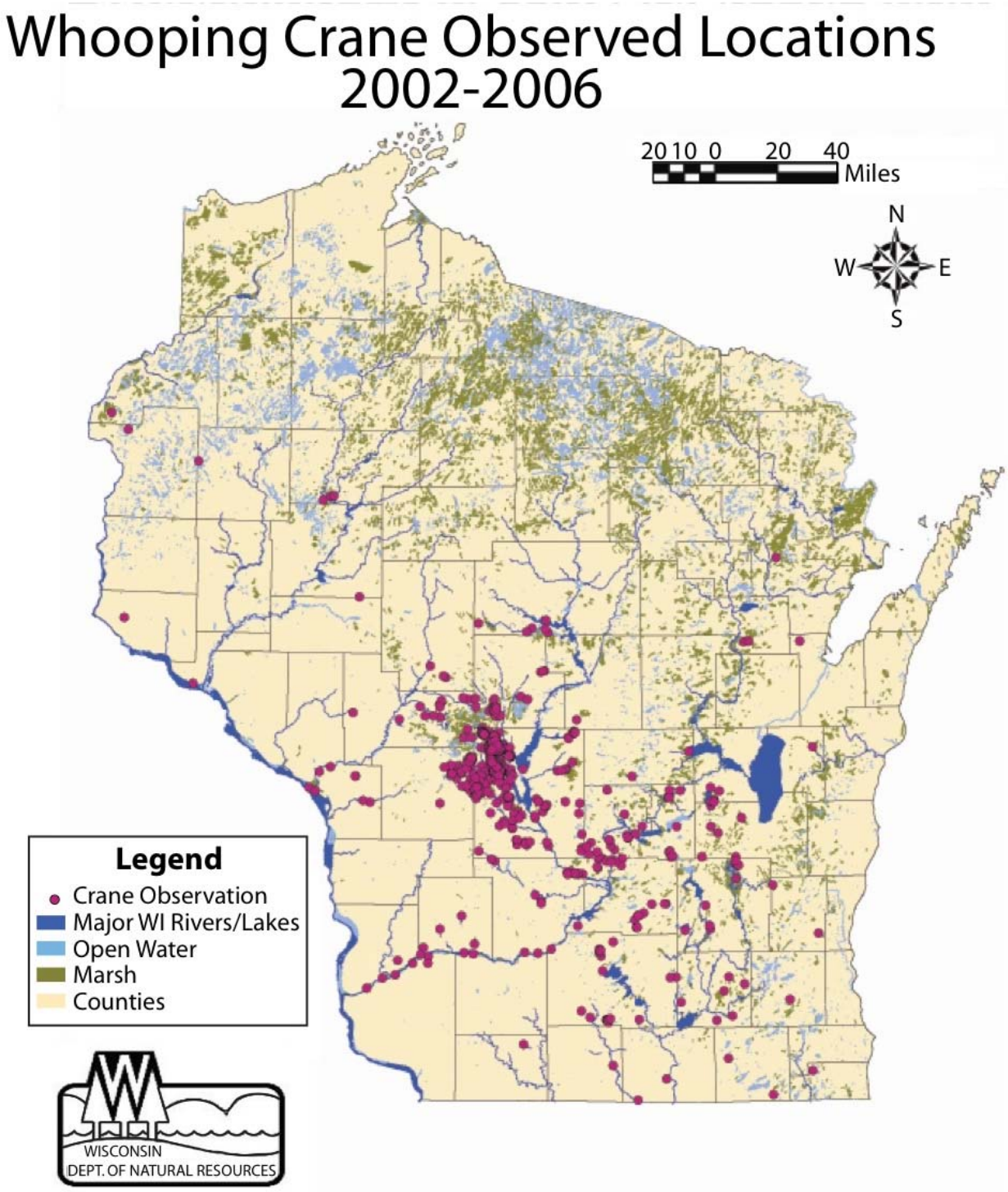
APPENDIX 8: 2002-2006 Whooping Crane Location by Wisconsin County

County	Location	County	Location	County	Location
Adams	Adams Co NWPA / Brooks, N	Columbia	Grouse Dr / County CM	Fond du Lac	Eldorado SWA
Adams	Colburn SWA	Columbia	Haugen Rd, N of	Fond du Lac	Horicon NWR
Adams	Cottonville Wetlands	Columbia	Kronke Rd / Hall Rd	Fond du Lac	Reeds Corners
Adams	CTH H & CTH Z	Columbia	Lake Wisconsin	Fond du Lac	Rock River, S Branch / Waupun
Adams	Glen Ln / Briggsville	Columbia	Leeds Center	Fond du Lac	Sportsman Rd / Cork Rd
Adams	H.C. Kurtz Memorial Forest	Columbia	Lewiston Bluff / Briggsville	Grant	Lower Wisconsin River SWA
Adams	Hwy D / STH W	Columbia	Lower WI River / Inglebretson Rd	Green	Albany
Adams	Lake Sherwood	Columbia	Mud Lake SWA	Green	Decatur Lake
Adams	Aniwa Lane Cranberry	Columbia	Neenah Creek	Green Lake	Fox River Marsh / Berlin
Adams	Leola Marsh SWA	Columbia	Portage	Green Lake	Manchester
Adams	Lone Rock Lake	Columbia	Poynette - CTH C / CTH CS	Green Lake	Spring Lake
Adams	Oxford	Columbia	WIlcox	Green Lake	White River Marsh SWA
Adams	Patrick Lake	Columbia	Wisconsin River - CTH T	Iowa	Lower Wisconsin River
Adams	Petenwell Dam	Crawford	Lower Wisconsin River / Gran Grae Creek	Jackson	Ammundson Marsh
Adams	Quincy Bluff SNA / Lone Rock	Crawford	Steuben	Jackson	Bear Bluff
Adams	Wisconsin River - Clark Island	Crawford	Wauzeka	Jackson	Black River Falls
Adams	Wisconsin River - Fox Point	Dane	Bass Lake	Jackson	Black River State Forest
Barron	Loon Lake SWA	Dane	Bell Brook Rd	Jackson	City Point
Brown	Pittsfield - CTH B & Brookside Dr	Dane	Brooklyn SWA	Jackson	Crawford Creek Cranberry
Burnett	Fish Lake SWA	Dane	CTH V Pond	Jackson	Goodyear Marsh
Calumet	Brillion SWA	Dane	Mazomanie SWA	Jackson	Northland Cranberry
Chippewa	Bradley Lake	Dane	Mt Vernon Creek	Jackson	Old Rte 54 Marsh
Clark	Neillsville	Dane	Pheasant Branch Marsh	Jackson	Potter Flowage
Clark	Pray Ave Pond	Dane	Sugar River, W Branch	Jackson	Saddlemound Cranberry/Johnson Marsh
Clark	Shortville	Dane	Waunakee Marsh	Jackson	Taylor
Columbia	Crawfish River	Dodge	Horicon NWR	Jackson	White Creek Reservoir
Columbia	Dates Millpond	Dodge	Ledge Rd	Jackson	Wilson Marsh Flowage
Columbia	Englewood	Dodge	Mud Lake SWA / Reeseville	Jefferson	Cold Spring / Galloway Creek
Columbia	Fox River / Neenah Creek	Dodge	Nolan Creek	Jefferson	Farmington
Columbia	French Creek SWA	Dodge	Shaw Marsh SWA	Jefferson	Goose Lake / Concord
Columbia	Grassy Lake SWA	Fond du Lac	Brandon	Jefferson	Helenville

County	Location	County	Location	County	Location
Jefferson	Princess Point SWA	Juneau	Wisconsin River / Castle Rock Lake	Monroe	Tomah
Jefferson	Red Cedar Lake	Juneau	Yellow River Cranberry	Monroe	Tomah Cranberry
Juneau	30th St. Marsh	Kenosha	Bong SRA	Monroe	Valley Junction SWA
Juneau	46th St Marsh / Castlerock	La Crosse	Fleming Creek / Mindoro	Oconto	Sleeter Road
Juneau	Bear Creek & Lemonweir River	La Crosse	La Crosse River / 162 bridge / Bangor	Pepin	Upper Mississippi River NWFR
Juneau	Beaver Flowage	La Crosse	Lake Onalaska	Polk	Alabama Lake
Juneau	Brown Road	La Crosse	Upper Mississippi River NWFR	Portage	Evergreen Ave & CR F
Juneau	Cattail Valley Creek	La Crosse	Van Loon SWA	Richland	Knapp Creek, lower
Juneau	Cutler Cranberry	Lafayette	Yellowstone Lake SP / SWA	Richland	Lower WI River SWA / Lower Lake
Juneau	Finley	Marathon	Big Eau Pleine CP	Richland	Mill Creek / Boaz
Juneau	Georgeson Farms	Marathon	McMillan Marsh SWA	Richland	Pine River / Gotham
Juneau	Juneau County Fprest	Marathon	Mead SWA	Richland	Richland Center
Juneau	Lemonweir River / Dandy Creek	Marquette	20th Court Marsh	Rock	Avon Bottoms SWA
Juneau	Little Yellow River	Marquette	Duffy's Marsh WRP	Rock	Bass Creek / Afton
Juneau	Lyndon Creek	Marquette	Endeavor Marsh	Rusk	Marsh Lake
Juneau	Lyndon Station / Cattail Creek	Marquette	Fox River Marsh / Lake Puckaway	Rusk	Washington Creek SWA / Sawdust Rd
Juneau	Mauston / Brewer Creek	Marquette	Fox River NWR	Sauk	CTH F & Seep Rd
Juneau	Mauston Wastewater	Marquette	Montello / Fox River	Sauk	LaValle
Juneau	Meadow Valley SWA	Marquette	Neenah Creek	Sauk	Lower Wisconsin River SWA
Juneau	Mill Bluff State Park	Marquette	Newton / CTH Z	Sauk	Rock Springs
Juneau	Monroe County Flowage	Marquette	Widow Green Marsh	Sauk	Wonewoc
Juneau	Mubarak field	Monroe	Bear Creek / Lemonweir River	Shawano	Navarino SWA
Juneau	Necedah Lake	Monroe	Brandy Creek Marsh	Trempealeau	Black River SF
Juneau	Necedah NWR	Monroe	Dandy Creek Flowage	Walworth	Pell Lake
Juneau	Necedah Screw Factory	Monroe	Enterprise Rd Cranberry	Walworth	Peterkin Pond
Juneau	New Lisbon	Monroe	Fort McCoy	Walworth	Turtle Creek
Juneau	Sevenmile Creek	Monroe	FRS Farms / Bear Creek Cranberry	Waukesha	Waukesha - Hwy X & Hwy H
Juneau	Spencer	Monroe	Lemonweir River / Shennington	Washington	Rockfield
Juneau	Union Center	Monroe	Meadow Valley SWA	Washington	Theresa SWA
Juneau	Valley Junction SWA	Monroe	Mill Bluff SP	Waushara	Poygan Marsh SWA
Juneau	Volk Field	Monroe	Mud Creek Cranberry	Waushara	White River Flowage

County	Location
Winnebago	CTR M & Banville Rd
Winnebago	Rush Lake SNA
Wood	Amundsen Cranberry
Wood	Cranberry Farm / Cranmoor
Wood	Cranberry Farm / Walker
Wood	Krabb Hill Cranberrry
Wood	Paul J. Olson SWA
Wood	Rattlesnake Marsh
Wood	Sandhill SWA
Wood	STH 54 / Dairy Rd
Wood	Wood County SWA

APPENDIX 8: GIS Representation of Whooping Crane Presence in Wisconsin



APPENDIX 8: GIS Representation of Whooping Crane Presence in Wisconsin