U.S. Fish & Wildlife Service

International Recovery Plan

Whooping Crane

(Grus americana)

Third Revision

March 2007

International Recovery Plan for the

WHOOPING CRANE

(*Grus americana*)

(Third Revision)

U.S. RECOVERY PLAN

(Original Approved, January 23, 1980)

(First Revision Approved, December 23, 1986)

(Second Revision Approved, February 11, 1994)

CANADIAN RECOVERY PLAN

(Original Approved, December 4, 1987)

(First Revision Approved, June, 1993)

2006

Approved: _____

Regional Director, U.S. Fish and Wildlife Service, Southwest Region

Date: 7/21/06

Concurrence: _____

Executive Director, Texas Parks and Wildlife Department, Austin, Texas

Date: March 30, 2007

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LITERATURE CITATION

The Literature Citation should read as follows:

Canadian Wildlife Service and U.S. Fish and Wildlife Service. 2007. International recovery plan for the whooping crane. Ottawa: Recovery of Nationally Endangered Wildlife (RENEW), and U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 162 pp.

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ACKNOWLEDGMENTS

The principal compilers of this document were Brian Johns and Tom Stehn, co-chairmen of the International Whooping Crane Recovery Team, along with retired co-chairman Dr. James Lewis. Biologists who provided updated material and reviewed sections of the document include Dr. George Archibald, Doug Bergeson, Mark Bradley, Joe Duff, Dr. David Ellis, Marty Folk, Dr. George Gee, Wally Jobman, Ken Jones, Dwight Knapik, Julie Langenberg VMD, Claire Mirande, Steve Nesbitt, Debbie Nordstrom, Dr. Glenn Olsen, Dr. Mike Putnam, Scott Swengel, Dr. Richard Urbanek, and Earl Wiltse. Wendy Brown, Stuart Leon, and Tracy Melbihess provided agency review of the document for the United States Fish and Wildlife Service, and Dave Duncan and Mary Rothfels for the Canadian Wildlife Service.

The 5 Canadian and 5 U.S. members currently serving on the Recovery Team provided overall recovery objectives and strategies. Members in March, 2006, were Dr. George Archibald, Sandie Black DVM, Stuart Macmillan, Anne Riemer, Dr. John French, Brian Johns, Deborah Johnson, Marty Folk, Dr. Felipe Chavez-Ramirez, and Tom Stehn.

TABLE OF CONTENTS

Page
DISCLAIMER/LITERATURE CITATION i
ACKNOWLEDGMENTS ii
TABLE OF CONTENTS iii
LIST OF TABLES AND FIGURES vi
GLOSSARY OF ACRONYMS viii
PREFACE x
EXECUTIVE SUMMARY xi

PART I. BACKGROUND INFORMATION
INTRODUCTION 1
SPECIES INFORMATION 2
Status 2
Description 2
Life Span 3
Mortality – Documented Losses 3
Breeding Ecology 5
Migratory Behavior 7
Winter Ecology 7
Diet 8
DISTRIBUTION 9
Historical Distribution and Numbers 9
Current Distribution and Abundance 13
HABITAT REQUIREMENTS 15
Breeding Habitat 15
Migration Habitat 17
Wintering Habitat 18
RATE OF POPULATION GROWTH 18
THREATS AND REASONS FOR LISTING 20
Human Settlement 20
Freshwater Inflows 20
Shooting 21
Disturbance 22
Disease/Parasites 23
Predation 24
Life History 24
Food Availability/Sibling Aggression 25
Climatic Factors 25
Loss of Genetic Diversity 26
Red Tide 26
Chemical Spills 27
Collisions with Power Lines, Fences and Other Structures 28
Collisions with Aircraft 29
Pesticides 29
CONSERVATION MEASURES 29
Critical Habitat – United States 31
Wintering Grounds 31

Migration – United States 31
Potential Critical Habitat – Canada....31
Breeding Grounds 31
Migration – Saskatchewan Staging Area 32
Summary 33
RECOVERY TEAM....33

PART II. RECOVERY
RECOVERY GOAL 35
RECOVERY STRATEGY 35
RECOVERY POTENTIAL AND RATIONALE 35
DOWNLISTING RECOVERY OBJECTIVES AND CRITERIA 37
DELISTING CRITERIA 38
2003 SARA RECOVERY OBJECTIVES....39
SHORT-TERM RECOVERY OBJECTIVES....39
LONG-TERM ACTIONS NEEDED....39
REDUCTION OR ALLEVIATION OF THREATS TO WHOOPING CRANES THROUGH IMPLEMENTATION OF RECOVERY ACTIONS 40
RECOMMENDED SCALE FOR RECOVERY ACTIONS....41
ANTICIPATED CONFLICTS OR LOGISTICAL DIFFICULTIES....41
POTENTIAL IMPACTS FOR OTHER SPECIES/ECOLOGICAL PROCESSES....41
OUTLINE OF RECOVERY ACTIONS TO ACHIEVE OBJECTIVES....42
NARRATIVE OUTLINE FOR RECOVERY ACTIONS TO ACHIEVE OBJECTIVES....44
INFORMATION NEEDS....55
Survey Requirements 55
Biological/Ecological Research Requirements....56
Threat Clarification Research Requirements 56
FUTURE CONSIDERATIONS 56

PART III. IMPLEMENTATION SCHEDULE....58

PART IV. CONTACT INFORMATION
LEAD ORGANIZATIONS RESPONSIBLE FOR SPECIES RECOVERY AND KEY CONTACTS 62
CANADA/U.S. INTERNATIONAL RECOVERY TEAM MEMBERS 62
Contact Information 63
OTHER CONTACTS 65
PREPARED BY....66
KEY LANDS ON WHICH SPECIES OCCURS AND ASSOCIATED CONTACTS 66
DATE COMPLETED....66

PART V. REFERENCES....67

APPENDICES

APPENDIX A: MINIMUM VIABLE POPULATION AND GENETICS A-1
Minimum Viable Population..... A-1
Downlisting Based on MVP Criteria A-1
Population Growth and Retention of Genetic Material A-2
Loss of Genetic Diversity and Estimate of Relatedness A-3

APPENDIX B: SOCIAL AND ECONOMIC CONSIDERATIONS B-1

APPENDIX C: ACTIONS ALREADY COMPLETED OR UNDERWAY.....C- 1
Breeding Grounds Management and Research.....C- 1
Management of Wood Buffalo National Park .....C- 1
Egg Collection .....C- 1
Color Banding.....C- 5
Migration Monitoring .....C- 5
Migration Habitat Management and Research .....C- 6
Wintering Grounds Management and Research .....C- 9
Health Management.....C-13
Captive Propagation.....C-13
Research and Propagation at Patuxent Wildlife Research Center C-13
Propagation at the International Crane Foundation C-20
Propagation at the Calgary Zoo C-23
Propagation at San Antonio Zoo.....C-24
Propagation at Freeport McMoran Audubon Species Survival Center C-24
Cross-fostering, Translocation, and Guide-bird Studies.....C-25
Reintroducing a Non-migratory Population in Florida.....C-30
Research on Reintroducing Migratory Populations.....C-35
Proposed Migratory Reintroductions.....C-36

APPENDIX D: SUMMARY OF COMMENTS ON THE DRAFT REVISED RECOVERY PLAN AND USFWS RESPONSE ..... D- 1

LIST OF TABLES AND FIGURES

Tables

Table 1. Whooping Crane peak winter numbers in North America, 1938–2005 12

Table 2. Known number of nesting pairs, productivity, and distribution of eggs removed from Aransas-Wood Buffalo Population, 1966-2005 .....C- 3

Table 3. Age of captive whooping cranes when they first produced eggs, Patuxent Wildlife Research Center, 1975-1993.....C-16

Table 4. Size and productivity of the captive whooping crane flock at Patuxent Wildlife Research Center, 1975-2005.....C-17

Table 5. Size and productivity of the captive whooping crane flock at International Crane Foundation, 1989-2005 .....C-21

Table 6. Hatching and fledging rates of Aransas-Wood Buffalo Population eggs transferred to International Crane Foundation, 1990-1996.....C-23

Table 7. Size and productivity of the captive whooping crane flock at Calgary Zoo, 1992-2005 .....C-24

Table 8. Eggs transplanted, hatched and chicks fledged at Grays Lake, 1975-1988.....C-27

Table 9. Number of birds released and surviving in the Florida non-migratory population, 1993–2005 .....C-35

Table 10. Number of birds released and surviving in the eastern migratory population, 2001–2005 .....C-40

Figures

Figure 1. Whooping crane pair with young 2

Figure 2. Breeding and wintering areas, and migration pathway of the Aransas Wood Buffalo Population.....4

Figure 3. The principal known breeding and wintering areas of the whooping crane (*Grus americana*) (adapted from Meine and Archibald 1996) 11

Figure 4. Wintering area of the Aransas-Wood Buffalo Population, Aransas National Wildlife Refuge and Critical Habitat boundary on the Gulf of Mexico coast of Texas.....15

Figure 5. Breeding area of the Aransas-Wood Buffalo Population, Wood Buffalo National Park 16

Figure 6. Whooping crane captive propagation, 1941-1979.....C-15

Figure 7. Summer and winter ranges and migration route of the reintroduced Rocky Mountain whooping crane population C-26

Figure 8. The Florida peninsula, showing the primary range of the Florida non-migratory population C-33

Figure 9. Eastern United States whooping crane population summering and wintering areas and 2001 migration route.....C-38

GLOSSARY OF ACRONYMS

A	Alberta
AFLP	Amplified Fragment Length Polymorphisms
ANWR	Aransas National Wildlife Refuge
APLIC	Avian Power Line Interaction Committee
AWBP	Aransas Wood Buffalo Population
BR	Bureau of Reclamation
CCWHC	Canadian Cooperative Wildlife Health Centre
CNWR	Chassahowitzka National Wildlife Refuge
CG	Coast Guard
CH	Critical Habitat
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
CZ	Calgary Zoo
DVC	Disseminated Visceral Coccidiosis
EEE	Eastern Equine Encephalitis
EMP	Eastern Migratory Population
ES	Ecological Services (USFWS)
ESA	United States Endangered Species Act
FAA	Federal Aviation Authority
FCC	Federal Communications Commission
FERC	Federal Energy Regulatory Commission
FL	Florida Fish and Wildlife Conservation Commission
FP	Florida Population
GIS	Geographical Information System
GIWW	Gulf Intracoastal Waterway
GL	Grays Lake National Wildlife Refuge
IBD	Infectious Bursal Disease
ICF	International Crane Foundation
IFIM	Instream Flow Incremental Methodology
LDWF	Louisiana Department of Wildlife and Fisheries
LE	Law Enforcement (USFWS)
M	Manitoba
MOU	Memorandum of Understanding
MVP	Minimum Viable Population
NAS	National Audubon Society
N_e	Effective Population Size
NEPA	National Environmental Policy Act
NNWR	Necedah National Wildlife Refuge

NGO	Non-Government Organization
NWA	National Wildlife Area
NWF	National Wildlife Federation
NWHC	National Wildlife Health Center (USGS)
NWI	National Wetland Inventory
NWR	National Wildlife Refuge
OM	Operation Migration
PA	Public Affairs (USFWS)
PCA	Parks Canada Agency
PWRC	Patuxent Wildlife Research Center (USGS)
PRT	Platte River Whooping Crane Habitat Maintenance Trust
RMP	Rocky Mountain Population
RW	Refuges and Wildlife (USFWS)
S	Saskatchewan
SARA	Canadian Species at Risk Act
SAZ	San Antonio Zoo
SSC	Audubon Species Survival Center
TC	Transport Canada
TNRCC	Texas Natural Resources Conservation Commission
TPWD	Texas Parks and Wildlife Department
USACE	U. S. Army Corps of Engineers
USFWS	U. S. Fish and Wildlife Service
USGS	U. S. Geological Survey
WBNP	Wood Buffalo National Park
WCCA	Whooping Crane Conservation Association
WCCMT	Whooping Crane Captive Management Team
WCEP	Whooping Crane Eastern Partnership
WCHAT	Whooping Crane Health Advisory Team
WCRT	Whooping Crane Recovery Team
WI	Wisconsin Department of Natural Resources
WNV	West Nile Virus

PREFACE

The Whooping Crane Recovery Plan (Plan) was prepared under the authorities of the U.S. Endangered Species Act (ESA) of 1973, as amended, the Canada Wildlife Act of 1974, and the Canadian Species at Risk Act of 2003. Decision-makers are provided with an orderly set of events that, if carried to successful completion, will change the status of this species from the Endangered to the Threatened level. The Plan describes management and research actions that are underway and proposes additional actions needed to ensure the recovery of the whooping crane. Funding levels and time schedules are estimated, and priorities have been set for each management and research action. This revision of the Whooping Crane Recovery Plan describes recovery actions and costs required for the birds and habitat in both Canada and the United States. Part I covers basic biology of the species, historical and present distribution, habitat requirements, numbers and rate of growth, biological factors limiting the population, human threats, and conservation measures. Part II states the recovery goals, strategy, objectives and criteria, provides a step-down outline of specific actions needed for recovery, and describes protective actions to alleviate threats. Part III provides an implementation schedule for recovery. Parts IV and V provide contact information and key references. Appendices C and D, respectively, address recovery actions completed or underway, and summarize responses to public comments on the draft plan.

The recovery program for the whooping crane is an excellent example of international cooperation to save a species. Cooperative recovery actions of the 2 nations are outlined in a *Memorandum of Understanding on the Conservation of the Whooping Crane* approved in 1991 and updated at 5-year intervals. Development of this Plan by a joint Canada/U.S. Recovery Team is appropriate because the whooping crane's recovery is dependent upon conservation and management of the species in both countries.

As an international document, the Plan has a unique format to satisfy the requirements of both Canada and the United States. It was written in conjunction with 2 Canadian documents; *National Recovery Strategy for the Whooping Crane* (*Grus americana*) and *Action Plan for the Whooping Crane* (Johns and Stehn 2005a,b).

EXECUTIVE SUMMARY

Current Status and Distribution: In the United States, the whooping crane (*Grus americana*) 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 the whooping crane was designated as endangered in 1978 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 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.

Whooping cranes occur only in North America. They currently exist in the wild at 3 locations and in captivity at 9 sites. The February 2006 total wild population was estimated at 338. This includes: 215 individuals in the only self-sustaining Aransas-Wood Buffalo National Park Population (AWBP) that nests in Wood Buffalo National Park (WBNP) and adjacent areas in Canada and winters in coastal marshes in Texas; 59 captive-raised individuals released in an effort to establish a non-migratory Florida Population (FP) in central Florida; and 64 individuals introduced between 2001 and 2005 that migrate between Wisconsin and Florida in an eastern migratory population (EMP). The last remaining wild bird in the reintroduced Rocky Mountain Population (RMP) died in the spring, 2002. The captive population contained 135 birds in February, 2006, with annual production from the Calgary Zoo (CZ), International Crane Foundation (ICF), Patuxent Wildlife Research Center (PWRC), Species Survival Center (SSC), and the San Antonio Zoo (SAZ). The total population of wild and captive whooping cranes in February, 2006, was 473.

Habitat Requirements: The whooping crane breeds, migrates, winters, and forages in a variety of habitats, including coastal marshes and estuaries, inland marshes, lakes, ponds, wet meadows and rivers, and agricultural fields.

Reasons for Listing and Limiting Factors: Historic population declines resulted from habitat destruction, shooting, and displacement by activities of man. Current threats include limited genetics of the population, loss and degradation of migration stopover habitat, construction of additional power lines, degradation of coastal ecosystems, and threat of chemical spills in Texas.

Recovery Goal**:** The recovery goal is to establish multiple self-sustaining populations of whooping cranes in the wild in North America, allowing initially for reclassification to threatened status and, ultimately, removal from the List of Threatened and Endangered Species (delisting). Populations may be migratory or non-migratory.

Recovery Strategy: The wild whooping crane population is characterized by low numbers, slow reproductive potential, and limited genetic diversity. A stochastic, catastrophic event could eliminate the wild, self-sustaining Aransas-Wood Buffalo population (AWBP). Therefore, the recovery strategy involves: protection and enhancement of the breeding, migration, and wintering habitat for the AWBP to allow the wild flock to grow and reach ecological and genetic stability; reintroduction and establishment of self-sustaining wild flocks within the species' historic range and that are geographically separate from the AWBP to ensure resilience to catastrophic events; and maintenance of a captive breeding flock to protect against extinction. Offspring from the captive breeding population will be released into the wild to establish these

populations. Production by released birds and their offspring will ultimately result in self-sustaining wild populations. The continued growth of the AWBP, establishment of additional populations, and maintenance of the captive flock will also address the loss of genetic diversity.

RECOVERY OBJECTIVES AND CRITERIA:

This plan sets forth 2 primary objectives and measurable criteria that will allow the species to be reclassified to threatened (downlisted). The numerical population criteria can only be achieved if threats to the species are sufficiently reduced or removed, i.e., the population criteria are a benchmark for threat reduction.

Objective 1 – Establish and maintain self-sustaining populations of whooping cranes in the wild that are genetically stable and resilient to stochastic environmental events.

> **Criterion 1 –** Maintain a minimum of 40 productive pairs in the AWBP for at least 10 years, while managing for continued increase of the population. Establish a minimum of 25 productive pairs in self-sustaining populations at each of 2 other discrete locations. A productive pair is defined as a pair that nests regularly and has fledged offspring. The two additional populations may be migratory or non-migratory. Population targets are 160 in the AWBP, and 100 each in the Florida non-migratory population and the eastern migratory population. All 3 populations must be self-sustaining for a decade at the designated levels before downlisting could occur.
>
> **Alternative Criterion 1A** – If only one additional wild self-sustaining population is re-established, then the AWBP must reach 400 individuals (i.e. 100 productive pairs), and the new population must remain above 120 individuals (i.e. 30 productive pairs). Both populations must be self-sustaining for a decade at the designated levels before downlisting could occur. This alternative is based on the principle that with the re-establishment of only one additional population separate from the AWBP, then crane numbers must be higher in both populations than if there are three distinct populations.
>
> **Alternative Criterion 1B -** If establishment of second and third wild self-sustaining populations is not successful, then the AWBP must be self-sustaining and remain above 1,000 individuals (i.e. 250 productive pairs) for downlisting to occur. The *Memorandum of Understanding on Conservation of Whooping Cranes*, approved by Canadian and U.S. federal officials, recognizes a goal of 1,000 individuals in the AWBP population. This higher number ensures a better chance for survival of the AWBP in the event of a catastrophic event within its extremely limited range. The target of 1,000 is reasonable for downlisting given the historical growth of the AWBP and theoretical considerations of minimum population viability. To ensure sufficient genetic variability, the AWBP must increase to the level where the creation of new alleles through genetic mutation will offset the loss of genetic diversity. After reaching the goal of 250 pairs, the population should gain genetic variation faster than the population loses genetic material.

Objective 2 – Maintain a genetically stable captive population to ensure against extinction of the species.

Criterion 2 - Maintain 153 whooping cranes in captivity (21 productive pairs). Genetic analysis suggests that 90% of the genetic material of the species can be sustained for 100 years at this population size (Jones and Lacy 2003). To achieve this, this Plan recommends having 50 captive breeder pairs of whooping cranes by 2010, including 15 pairs at PWRC, 12 at ICF, 10 at CZ, 10 at SSC, and 3 at SAZ. A breeder pair (as differentiated from a productive pair) is defined as a pair that breeds or is intended to breed in the future. Production from PWRC, ICF, CZ, SSC and SAZ will be the principal source of birds for release to the wild for reintroduced populations. However, sources of release birds should be based on the optimal genetic mix to ensure long-term population viability.

Delisting Criteria

Delisting criteria have not yet been established because the status and biology of the species dictate that considerable time is needed to reach downlisting goals. In addition, new threats are expected to arise and will have to be overcome before downlisting occurs. Additional information is also needed on the conservation biology of small populations, including a determination of effective population size (N_e) for whooping cranes to maintain genetic viability over the long-term, and impacts of stochastic and catastrophic events on population survival.

Actions Needed:

1. Continue to build the AWBP and protect and manage its habitat to minimize the probability that a catastrophic event will eradicate this population.

2. Attain breeder pair and productivity goals at 4 captive facilities in the United States and 1 in Canada to produce the birds required for reintroductions. Continue research to improve production of captive flocks.

3. Establish 2 additional self-sustaining wild populations. Continue research to identify appropriate reintroduction sites and improve reintroduction techniques. Protect and manage habitat of reintroduced populations.

4. Continue to use genetic information and advances in conservation biology to conserve flock genetics, and determine N_e and revise criteria as warranted.

5. Maintain an outreach program.

Date of Recovery: The estimated time to achieve downlisting is the year 2035. At current rates of reintroduction it takes over 10 years to build a population of more than 100 individuals. These individuals must then reach breeding age (3-5 years) and produce enough young to become self-sustaining for a decade to meet criteria for downlisting. This is expected to take a minimum of 30 years. New information gathered through recovery actions will be incorporated into additional population viability analyses as the population approaches its downlisting goals. Delisting criteria will be established at that time, and the overall recovery strategy and actions will be revised as appropriate.

Total Estimated Cost of Recovery ($000s):

The current budget expenditures needed annually for recovery are $6.1 million (US). The cost through 2010 is estimated at just over $30 million (US) and nearly $126 million (US) through 2035.

Year	Action 1	Action 2	Action 3	Action 4	Action 5	Total $ (000's)
2006	1394	1705	3030	0	15	6144
2007	1388.25	1705	3042.5	30	15	6180.75
2008	1388.25	1705	3042.5	0	15	6150.75
2009	1388.25	1705	3042.5	0	15	6150.75
2010	1388.25	1705	3042.5	0	15	6150.75
2011	1419.8	1609	3045	0	15	6088.8
2012	1419.8	1609	3045	5	15	6093.8
2013	1419.8	1609	3045	0	15	6088.8
2014	1419.8	1609	3045	0	15	6088.8
2015	1419.8	1609	3045	5	15	6093.8
2016	1009	188	2025	0	6	3228
2017	1009	188	2025	0	6	3228
2018	1009	188	2025	0	6	3228
2019	1009	188	2025	0	6	3228
2020	1009	188	2025	0	6	3228
2021	1009	188	2025	0	6	3228
2022	1009	188	2025	5	6	3233
2023	1009	188	2025	0	6	3228
2024	1009	188	2025	0	6	3228
2025	1009	188	2025	0	6	3228
2026	1009	188	2025	0	6	3228
2027	1009	188	2025	0	6	3228
2028	1009	188	2025	0	6	3228
2029	1009	188	2025	0	6	3228
2030	1009	188	2025	0	6	3228
2031	1009	188	2025	0	6	3228
2032	1009	188	2025	5	6	3233
2033	1009	188	2025	0	6	3228
2034	1009	188	2025	0	6	3228
2035	1009	188	2025	0	6	3228
Total	34,226	20,330	70,925	50	270	125,801

PART I. BACKGROUND INFORMATION

INTRODUCTION

The whooping crane is a flagship species for the North American wildlife conservation movement, symbolizing the struggle for survival that characterizes endangered species worldwide. It is a large, distinctive, and photogenic bird, popular with the public and the media, and it is often used to illustrate endangered species literature.

Canadian Wildlife Service (CWS), Parks Canada Agency (PCA), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS)-Biological Resources Division, Provincial Wildlife Agencies, the Florida Fish and Wildlife Conservation Commission (FL), Texas Parks and Wildlife Department (TPWD), Wisconsin Department of Natural Resources (WI), and other State Wildlife Agencies implement recovery with the support of many non-profit groups and private individuals (Lewis 1991). The Audubon Species Survival Center (SSC), Calgary Zoo (CZ), International Crane Foundation (ICF), National Audubon Society (NAS), National Fish and Wildlife Foundation, National Wildlife Federation (NWF), Operation Migration Ltd., San Antonio Zoo (SAZ), World Wildlife Fund, and the Whooping Crane Conservation Association (WCCA) are among the primary groups that have been or currently are active in promoting recovery.

The important role of the private citizen and private landowner in saving the whooping crane needs to be emphasized. Many migration stopovers occur on private lands. Sportsmen and other conservationists have helped protect wetlands throughout North America that cranes depend on during migration. In winter, a little over one-third of the flock is found on private lands (Tom Stehn, ANWR, pers. comm.). Many actions to protect the species have been carried out by private citizens, conservation organizations, sportsmen, and governments. Many people today can remember just how close the species was to extinction - there were fewer than 50 whooping cranes in North America prior to 1968, with an all-time low of 21 as recently as 1954.

Historically, population declines were caused by shooting and destruction of nesting habitat in the prairies from agricultural development. The species was listed because of low population numbers, slow reproductive potential (sexual maturity is delayed and pairs average less than 1 chick annually), cyclic nesting and wintering habitat suitability, a hazardous 4,000 km migration route that is traversed twice annually, and many human pressures on the wintering grounds. Current threats to wild cranes include collisions with manmade objects such as power lines and fences, shooting, predators, disease, habitat destruction, severe weather, and a loss of two thirds of the original genetic material. Threats to the captive flock include disease, accidents, and limited genetic material.

Whooping cranes in Canada nest in and near WBNP, migrate through Alberta, Saskatchewan, and occasionally Manitoba in spring and fall, and stage in fall in southern Saskatchewan. Spring and fall migration occurs in the central Great Plains of the U.S. The cranes winter on the central Gulf Coast of Texas at Aransas National Wildlife Refuge (ANWR) and vicinity. No individuals remain from reintroduction attempts in the Rocky Mountains that took place from 1975 to 1989, and in 1997, except for one male in captivity at ICF. In 1993, introduction of a non-migratory flock was initiated in the Kissimmee Prairie and surrounding area in central Florida south of Orlando. An attempt to establish a migratory flock between central Wisconsin and the central

Gulf Coast of Florida began in 2001. Captive whooping cranes are maintained at PWRC, Laurel, Maryland; ICF, Baraboo, Wisconsin; SSC, Belle Chasse, Louisiana; the Devonian Wildlife Conservation Center, Calgary Zoo, Calgary, Alberta; the SAZ, San Antonio, Texas; the New Orleans Zoo, New Orleans, Louisiana; the Lowry Park Zoo, Tampa, Florida; and Homosassa Springs State Wildlife Park in Homosassa, Florida.

SPECIES INFORMATION

Status

The whooping crane was listed as Endangered in 1970 in the United States by the USFWS, and in 1978 in Canada by the Committee on the Status of Endangered Wildlife (COSEWIC).

In the U.S., under Section 4(a)(2) of the ESA, the USFWS is charged with periodically reviewing the status of listed species to determine whether any species warrants reclassification. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reviewed the status of the Whooping Crane in 1978 and again in 2000. The whooping crane was listed as an endangered species in Canada under the Species at Risk Act in 2003. COSEWIC must review the classification at least once every ten years. In both countries, the whooping crane remains endangered due to its low population size and the limited range of the single self-sustaining wild population.

Description

The whooping crane is in the Family *Gruidae*, Order *Gruiformes* (Krajewski 1989, Meine and Archibald 1996). The closest taxonomic relatives in continental North America are 5 races of sandhill crane (*G. canadensis*): the lesser (*G. c. canadensis*); Canadian (*G. c. rowani*); greater (*G. c. tabida*); Florida (*G. c. pratensis*); and Mississippi (*G. c. pulla*) (the last also listed as endangered by the USFWS (Meine and Archibald 1996). The common name "whooping crane" probably originated from the loud, single-note vocalization given repeatedly by the birds when they are alarmed.

Figure 1. Whooping crane pair with young.

Photo by Marty Folk, Florida Fish and Wildlife Conservation Commission.

As the tallest North American bird, males approach 1.5 m (5 ft) when standing erect, and exceed the greater sandhill crane in height by 12 to 20 cm (5 to 8 in) (Fig. 1). Males are generally larger than females. Captive males average 7.3 kg (16 lbs), and females average 6.4 kg (14 lbs). Seasonal weight variation in captivity is considerable, with a maximum in December and January and a minimum in July and August. Whooping cranes are sexually monomorphic

(Walkinshaw 1973). However, the guard call vocalization is sexually distinct (98.8% accurate, Carlson 1991) and the vocalization and visual components of the unison call are sexually distinct (Archibald 1975).

Adult plumage is snowy white except for black primaries, black or grayish alula (specialized feathers attached to the upper leading end of the wing), sparse black bristly feathers on the carmine crown and malar region (side of the head from the bill to the angle of the jaw), and a dark gray-black wedge-shaped patch on the nape. The size of the post-occipital patch located on the posterior portion of the crown varies considerably between individuals. The black primaries and alula are not visible when the wings are folded back, and the plumed, decurved tertials (type of wing feather located close to the body) ordinarily conceal the short tail. The strong bill is a dark olive-gray which becomes lighter during the breeding season. The area at the base of the bill is pink or rosaceous. The iris of the eye is blue at hatching, gradually turns gray in chicks, and by one year of age is yellow (Jane Chandler, PWRC, pers. comm.). The legs and feet are gray-black.

The juvenile plumage is a reddish cinnamon color. At age 80-100 days, the chick is capable of sustained flight. At age 120 days, white feathers begin to appear on the neck and back. Juvenile plumage is replaced through the winter months. The plumage is predominantly white by the following spring and the dark red crown, lores (area between eye and bill), and malar areas are apparent. Rusty juvenile plumage remains only on the head, the upper neck, secondary wing coverts (smaller feathers covering middle of wing), and scapulars (wing feathers arising from the shoulder) (Stephenson 1971). Yearlings achieve typically adult plumage late in their second summer.

Life Span

Whooping cranes are a long-lived species. Wild whooping cranes were not individually marked until 1975 (Drewien and Bizeau 1978, Kuyt 1978a, 1979a); consequently, some aspects of their life history and population biology remain uncertain. Current estimates suggest a maximum longevity in the wild of at least 30 years (Mirande et al. 1993).

Binkley and Miller (1983) suggested a maximum life span of 22-24 years of age, however at present, 1 wild female died at age 28 and 1 male is currently 28 years old (Tom Stehn, ANWR, pers. comm.). Captive individuals live 35-40 years (Moody 1931, McNulty 1966). A 38-year-old male was still reproductively active in the captive flock at PWRC in 2002; he died in January 2003.

Mortality – Documented Losses

A complete census of the Aransas-Wood Buffalo population can only be done during the 5-6 months the flock is on the wintering grounds. A total census has never been attempted in WBNP because the area occupied by whooping cranes, and particularly by subadults, is too extensive for such counts (Lewis et al. 1992a). Aerial counts have provided an annual estimate starting in 1950 of how many whooping cranes arrive at Aransas in the fall and how many depart in the spring. Lewis et al. (1992a) analyzed data on mortality of fledged whooping cranes. Prior to fledging, chick mortality is high and usually occurs during the first 2 weeks of life (Kuyt 1981b). Between 1950 and 1986, a total of 26 whooping cranes were lost on the wintering grounds

Figure 2. Breeding and wintering areas and primary migration pathway of the AWBP.

(Lewis et al. 1992a). This represents 1.4% of 1,893 wintering cranes. About 15% of the annual losses occurred during the 5 to 6 months the cranes spent on the wintering grounds (Lewis et al. 1992a). During these same years, birds that started migration in the spring and failed to return in the fall (e.g., April to November mortality) numbered 131, or 83.4% of the total losses (157). Mortality during April through November was 5 times greater than mortality on the wintering grounds. Data has not been analyzed subsequent to 1987. Aerial surveys in summer in WBNP indicate that summer losses are infrequent (Brian Johns, CWS, pers. comm.). Two losses

occurred among cranes summering on ANWR. Sixty to 80% of losses occur during migration, a period comprising only about 9 weeks (17%) of the bird's year, but a time when loses are high because the cranes are exposed to new hazards as they travel through unfamiliar environments (Lewis et al. 1992a).

Few carcasses are ever found, thus no known causes of mortality can be attributed to a high percentage of losses. As previously noted, the principal known cause of loss during migration is collision with utility lines. Probable cause of death has been identified for 8 whooping cranes, including 2 radio-tagged birds, which died on the wintering grounds from 1950 to 1987 (Lewis et al. 1992a). Known losses were due to: shooting (2 known and a third suspected); avian tuberculosis (1); shooting injuries that were likely sustained during fall migration (2) (i.e. birds arrived injured at Aransas NWR and later died), avian predation (1), and non-shooting trauma injury following fall migration (1) (Lewis et al. 1992a). Carcasses of 13 birds in migration have been recovered. Five of the 13 losses were due to collision with power lines, 4 others suffered trauma injuries due to collisions or gunshot injuries, 1 was shot, 1 died in a muskrat trap, 1 may have had a heart muscle disease and 1 may have had a viral infection (Lewis et al. 1992a).

Breeding Ecology

Whooping cranes may start nesting, defined as laying eggs, as early as 3 years of age (Kuyt and Goossen 1987, Brian Johns, CWS, pers. comm.). However the average age of first egg production is 5 years (Kuyt and Goossen 1987). From the results of color-banding studies in the AWBP, 3-year-old whooping cranes have been documented nesting 10 times (5 males and 5 females), including one instance where both members of the pair were 3 years old (Kuyt and Goossen 1987, Brian Johns, CWS, pers. comm.). In the FP, 3-year-olds have nested on 4 occasions, including 1 pair with both cranes that were 3-years-old. The first two nesting attempts documented for the EMP included one female that was 3-years-old and a pair with both cranes that were 3-years-old.

Pair formation can occur rapidly or be a lengthy process. Bishop (1984) observed pair bonds that developed over 1 to 3 winters from associations in subadult flocks on the wintering grounds. Stehn (1997) observed that 27.7% of pair bonds formed during spring migration or on the breeding grounds without any prior association at Aransas. Bishop and Blankinship (1982) documented several instances in which 2- and 3-year-old color-banded birds paired with unmarked birds. Whooping cranes are monogamous, but will re-pair, sometimes within only a few days, following the death of their mate (Blankinship 1976, Stehn 1992c, 1997).

Experienced pairs arrive at WBNP in late April and begin nest construction. They show considerable fidelity to their breeding territories, and normally nest in the same general vicinity each year. Several pairs have nested in the same areas for 22 consecutive years. These nesting territories, termed "composite nesting areas", vary considerably in size, ranging from about 1.3 to 47.1 km^2 (0.8 to 29 mi^2) but averaging 4.1 km^2 (2.5 mi^2) (Kuyt 1976a, 1976b, 1981a, 1993a). Adjoining pairs usually nest at least 1 km (0.6 mi) apart; however, nests have been recorded as close as 400 m (435 yds) from each other (Brian Johns, CWS, pers. comm.). From the initiation of egg laying until chicks are a few months of age, the activities of pairs and family groups are restricted to the breeding territory.

Eggs are normally laid in late April to mid-May, and hatching occurs about 1 month later. The incubation period is from 29 to 31 days (Kuyt 1982). Kuyt (1995) reported that "Among 514 clutches observed between 1966 and 1991, 454 (90.8%) contained 2 eggs, 43 (8.6%) only 1 egg, and 3 (0.6%) 3 eggs." Eggs are light brown or olive-buff overlaid with dark, purplish-brown blotches concentrated primarily at the blunt end. Eggs average 100 mm in length and 63 mm in width (Bent 1926, Allen 1952, Stephenson and Smart 1972, Kuyt 1995). Whooping cranes may re-nest if their first clutch is destroyed or lost before mid-incubation (Erickson and Derrickson 1981, Kuyt 1981b, Derrickson and Carpenter 1982). However, egg predation is uncommon, and re-nesting by whooping cranes has only been documented a few times (Kuyt 1981b). Whooping cranes generally nest annually, but may skip a season when nesting habitat conditions are unsuitable, if they are nutritionally stressed (Chavez-Ramirez et al. 1997, Johns 1998b), or for other (not apparent) reasons. In 2005, 12 out of 70 known adult pairs (17.1%) failed to nest in WBNP.

Whooping cranes usually produce clutches of 2 eggs laid 48-60 hours apart. Incubation begins with the first egg laid, resulting in asynchronous hatching of the eggs. This asynchrony may follow the insurance hypothesis, as discussed by Forbes and Mock (2000), where parents add marginal offspring to their clutch/brood as a hedge against early failure of core brood members. Hatching asynchrony may be an adaptation to the availability of food resources or a means of ensuring that the adults do not expend an inordinate amount of time attending to 2 young if they are in marginal habitat. In whooping cranes, eggs laid after incubation has begun usually only produce fledged young if the earlier laid egg fails to hatch or the chick dies soon after hatching. Not attempting to breed in a particular year may be a time and energy saving adaptation to prepare for a future breeding season (Stenning 1996).

Erickson (1975) noted that although whooping cranes may lay 2 eggs, only about 10% of families arriving on the winter range have 2 chicks. About 90% of nests therefore contain 1 egg that is unlikely to result in a fledged chick. However, the second egg plays an unknown role in providing insurance that at least one chick survives. Boyce et al. (2005) suggest that removal of the second egg could actually increase the likelihood that one chick fledges. In nests with 2 eggs, the first hatched has the greater chance of survival in the wild. Habitat conditions, including food availability and predator abundance, affect survival. In years with suitable habitat conditions crane pairs may raise 2 young (Johns 1998a). For example, during the 1958-59 winter, 8 of the 9 young that arrived at Aransas were from twin pairs. In 1997 and 1998, at least 9% of second hatched whooping crane young survived to fledging age (Bergeson et al. 2001a).

During the years from 1938-l964, prior to egg-removal at WBNP, 101 single chicks and 15 pairs of "twin" siblings arrived at Aransas NWR from 230 nests or 213 2-egg clutches (Kuyt 1987). "Twins" arrived in 9 of the 29 years. No pairs brought 2 juveniles during the egg-pickup years 1965-1996 even though a few nests were left with 2 eggs in most years. Between 1997-2004, with no egg pickup, 8 pairs successfully raised twin chicks to fledging age (Brian Johns, CWS, pers. comm.), however only 4 pairs brought twin chicks to Aransas NWR (Tom Stehn, ANWR, pers. comm.).

Whooping crane parents share incubation and brood-rearing duties. Except for brief intervals, 1 member of the pair remains on the nest at all times. Females tend to incubate at night (Allen 1952, Walkinshaw 1965, 1973) and take the primary role in feeding and caring for the young (Blankinship 1976). Chicks are capable of swimming shortly after hatching; however, parents

and young return to the nest each night during the first 3-4 days after hatching. Later, parents brood their young wherever they are at night or during foul weather. During the first 20 days after hatching, families generally remain within 1.8 km of the nest site (Ernie Kuyt, pers. comm.) with daily movements averaging 340 m (Doug Bergeson, pers. comm.).

Information on marked individuals suggests that most juveniles and subadults spend the summer near their natal area (Kuyt 1979b, 1981a). Sexually immature birds (up to 4-year-olds) spend the summer as singles, pairs or in small groups of 3 to 5 birds. These birds usually occur on the peripheries of territories of nesting pairs.

Migratory Behavior

As spring approaches, "dancing" behavior (running, leaping and bowing, unison calling, and flying) increases in frequency, and is indicative of pre-migratory restlessness (Allen 1952, Blankinship 1976, Stehn 1992b). Family groups and pairs are usually among the first to depart wintering grounds, often assisted by seasonal strong southeast winds. First departure dates are normally between March 25 and April 15, with the last birds usually leaving by May 1. Occasional stragglers may linger into mid-May, and in 19 years, between 1938-2005, 1 to 4 birds (34 birds total) have remained at ANWR throughout the summer. Some of these birds were ill or crippled or mates of birds that were crippled. The spring migration is usually completed in 2-4 weeks, more rapidly than the reverse trip in the fall, as there is no known spring staging area.

Parents separate from their young of the previous year upon departure from ANWR, in northward migration while in route to the breeding grounds or soon after arrival on the breeding grounds (Allen 1952, Stehn 1992a, B. Johns, CWS, pers. comm.).

Autumn migration normally begins in mid-September, with most birds arriving on the wintering grounds between late October and mid-November. Occasionally, stragglers may not arrive until late December. Whooping cranes migrate south as singles, pairs, in family groups, or as small flocks of 3 to 5 birds (Johns 1992). They are diurnal migrants and make regular stops to feed and rest. Large groups of up to 20 sometimes use the same stopover location. Pairs with young are among the last to leave the breeding range (Allen 1952, Archibald et al. 1976, Stephen 1979). The migration corridor (Fig. 2) was determined by mapping confirmed sightings reported by individuals (Stephen 1979, Johnson and Temple 1980, Austin and Richert 2001) and radio-tracking whooping cranes during the period 1981-1984 (Kuyt 1992). Their first stop often occurs in northeast Alberta or northwest Saskatchewan, about 500 km southeast of their departure area in WBNP. Local weather conditions influence distance and direction of travel, but whooping cranes generally are capable of reaching the autumn staging grounds in the north-central portion of the Saskatchewan agricultural area on the second day of migration. Most of the cranes remain for 2 to 4 weeks in the large triangle between Regina, Swift Current, and Meadow Lake, where they feed on waste grain in barley and wheat stubble fields and roost in the many wetlands (Johns 1992). The remainder of the migration from Saskatchewan to the wintering grounds is usually rapid, probably weather-induced, and may be completed in a week (Kuyt 1992).

Winter Ecology

For almost half of the year, whooping cranes occupy winter areas on and adjacent to ANWR. Although close association with other whooping cranes is tolerated at times on the wintering

grounds, pairs and family groups typically occupy and defend relatively discrete territories. Studies indicate a declining territory size as the population increases, with territories averaging 117 ha (Stehn and Johnson 1987). Limited expansion of the wintering area has occurred (Tom Stehn, pers. comm.). Subadult and unpaired adult whooping cranes form small flocks and use areas outside occupied territories (Blankinship 1976, Bishop and Blankinship 1982). Subadults tend to winter near the territories where they spent their first year (Bishop 1984). Paired cranes will often locate their first winter territory near the winter territory of one of their parents (Bishop 1984, Stehn and Johnson 1987).

Diet

Whooping cranes are omnivorous (Walkinshaw 1973), probing the soil subsurface with their bills and taking foods from the soil surface or vegetation. Young chicks are fed by their parents. They gradually become more independent in their feeding until they separate from the parents preceding the next breeding season. Summer foods include large nymphal or larval forms of insects, frogs, rodents, small birds, minnows, and berries (Allen 1956, Novakowski 1966, Bergeson et al. 2001b). Foods utilized during migration are poorly documented but include frogs, fish, plant tubers, crayfish, insects, and agricultural grains. The largest amount of time is spent feeding in harvested grain fields (Johns et al. 1997). The winter diet consists predominately of animal foods, especially blue crabs (*Callinectes sapidus*), clams (*Tagelus plebius, Ensis minor, Rangia cuneata, Cyrtopleura costada, Phacoides pectinata, Macoma constricta*), and the plant wolfberry (*Lycium carolinianum*)(Allen 1952, Uhler and Locke 1970, Blankinship 1976 and 1987, Hunt and Slack 1987, Chavez-Ramirez 1996). Most foraging occurs in the brackish bays, marshes, and salt flats on the edge of the mainland and on barrier islands. Occasionally, cranes fly to upland sites when attracted by fresh water to drink or by foods such as acorns, snails, crayfish and insects, and then return to the marshes to roost (Hunt 1987, Chavez-Ramirez et al. 1995). Uplands are particularly attractive when partially flooded by rainfall, burned to reduce plant cover or when food is less available in the salt flats and marshes (Bishop and Blankinship 1982). Some whooping cranes use upland sites frequently in most years, but agricultural croplands adjacent to ANWR are rarely visited.

High fall tides and heavy rains sometimes flood tidal flats. In these circumstances, the birds forage almost exclusively on blue crabs and wolfberry in flooded areas. In December and January, tidal flats typically drain as a result of lower tides, and the birds move into shallow bays and channels to forage primarily on clams, although blue crabs are occasionally captured while probing the bottom. Clams are a significant dietary item when water depths are low, temperatures cold, and following drought when the blue crab population is low. Most clams and small blue crabs (5 cm or less in width) are swallowed whole. Larger crabs are pecked into pieces before being swallowed (Blankinship 1976).

The AWBP whooping cranes spend their summers and winters in restricted locations. Therefore, their pressure on local invertebrate food species may cause depletions, especially of blue crabs at Aransas. However, the total whooping crane population is so small that it is unlikely to exert any ecological effects except in small areas.

DISTRIBUTION

Historical Distribution and Abundance

Fossilized whooping crane remains from the Upper Pliocene in Idaho (Miller 1944, Feduccia 1967), and from the Pleistocene in California, Kansas, and Florida (Wetmore 1931, 1956) appear indistinguishable from the present form. Current evidence indicates that the species' 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). Distribution of these fossil remains suggests a wider distribution during the Pleistocene.

The major nesting area during the 19th and 20th centuries extended from central Illinois, northwestern Iowa, northwestern Minnesota, and northeastern North Dakota northwesterly through southwestern Manitoba, southern Saskatchewan, and into east central Alberta (Allen 1952)(Fig. 3). Some nesting apparently occurred at other sites such as Wyoming in the 1900's, but documentation is limited (Kemsies 1930, Allen 1952). Allen (1952) believed the whooping crane's principal wintering range was the tall grass prairies, in southwestern Louisiana, along the Gulf Coast of Texas, and in northeastern Mexico near the Rio Grande Delta. Other significant wintering areas were the interior tablelands in western Texas and the high plateaus of central Mexico, where whooping cranes occurred among thousands of sandhill cranes. Cannon (1998), Hayes, M. A. and J. Barzen (*In press*) and Gomez et al. (*In press*) provide additional insight into the historical distribution of the species.

In the 19th century, there were several migration routes. The two most important ones (Allen 1952:103) were "... those between Louisiana and the nesting grounds in Illinois, Iowa, Minnesota, North Dakota, Manitoba, and the other from Texas and the Rio Grande Delta region of Mexico to nesting grounds in North Dakota, the Canadian Provinces, and 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).

Another migration route crossed the Appalachians to the Atlantic Coast. These birds apparently nested in the Hudson Bay area of Canada. Wintering grounds included coastal areas of New Jersey, South Carolina, and more southerly river deltas. The specimen record or sighting reports for some eastern and mid-western locations are Alabama 1899; Arkansas 1889; Florida 1927 or 1928; Georgia 1885; Illinois 1891; Indiana 1881; Kentucky 1886; Michigan 1882; Minnesota 1917; Mississippi 1902; Missouri 1884; New Jersey 1857; Ohio 1902; Ontario 1895; South Carolina 1850; and Wisconsin 1878 (Burleigh 1944, Sprunt and Chamberlain 1949, Allen 1952, Hallman 1965).

Prior to 1950, Atlantic Coast locations used by whooping cranes included the Cape May area and Beesley's Point at Great Egg Bay in New Jersey; the Waccamaw River in South Carolina; the deltas of the Savannah and Altamaha Rivers, and St. Simon's Island in Georgia; and the St. Augustine area of Florida. Gulf Coast locations included Mobile Bay, Alabama; Bay St. Louis in Mississippi; and numerous records from southwestern Louisiana where the last bird was captured in 1950. Coastal Louisiana contained both a non-migratory flock and wintering migrants (Allen 1952).

Nesbitt (1982) summarized the following evidence that whooping cranes occurred in Florida, perhaps well into the 20th century. 0. E. Baynard, a respected field naturalist, said the last flock of whooping cranes (14 birds) he saw in Florida was in 1911 near Micanopy, southern Alachua County. Two whooping cranes were reported east of the Kissimmee River on January 19, 1936, and a whooping crane was shot and photographed north of St. Augustine, St. Johns County, 1927 or 1928.

Records from interior areas of the southeast include: the Montgomery area, Alabama; Crocketts Bluff on the White River, and near Corning, Arkansas; Jackson County near Kansas City, near Corning, Lawrence County southwest of Springfield, Audrain County, and near St. Louis, Misourri; and near Louisville and Hickman, Kentucky. It is unknown whether these records represent wintering locations, remnants of a non-migratory population, or wandering birds.

Although whooping cranes may never have formed large flocks and were thus reported infrequently, they ranged widely and utilized the vast wetland acreages available prior to the influx of white settlers. The growth of the AWBP at the end of the 20th century may provide insight for densities that could have occurred prior to colonial times. At WBNP, Kuyt (1993a) reported 13 nesting pairs had a mean home range size of 4.1 km sq (414 ha) and Doug Bergeson (pers. comm.) reported the mean home range size for 14 pairs as 3.8 km sq (384 ha). At ANWR, Stehn and Johnson (1987) found 86 whooping cranes distributed over 8,175 ha with an average territory size of 117 ha on the refuge where the density was highest. If these densities are expanded to the known historical distribution of the species, it is reasonable to assume that more than 10,000 whooping cranes once roamed across North America (Tom Stehn, ANWR, pers. comm.). This analysis differs from previously published information that was not based on current crane densities. Within the wintering area at ANWR and the nesting area in WBNP, the cranes are found within a relatively small area. Expanded throughout the known historical nesting and wintering range, the species may have been more numerous than reported, and by 1870 may have already been greatly reduced in number. It is erroneous to think that the whooping crane is not well adapted to its environment, was never numerous, and was about to become extinct even before human actions threatened the species (Tom Stehn, ANWR, pers. comm.).

Allen (1952:83) estimated that the whooping crane population in "... 1860, or possibly 1870, totaled between 1300 and 1400 individuals." Banks (1978), using 2 independent techniques, derived estimates of 500 to 700 whooping cranes present in 1870. The whooping crane disappeared from the heart of its breeding range in the north-central United States by the 1890s. The last documented nesting in the aspen parklands of Canada occurred at Eagle Lake (now called Kiyiu Lake), Saskatchewan, in 1922 (Hjertaas 1994). By 1944 only 21 birds remained in 2 small breeding populations: a non-migratory population that inhabited the area around White Lake in southwestern Louisiana, and the migratory AWBP that wintered on ANWR in coastal Texas and nested in an unknown location (Table 1). The last reported reproduction in the non-migratory Louisiana population occurred in 1939 (Lynch 1956, Gomez 1992, Drewien et al. 2001). In March, 1950, the Louisiana population ceased to exist as the last individual was captured and turned loose at Aransas but did not survive the summer. The nesting area of AWBP was discovered in 1954 in WBNP, Northwest Territories, Canada (Fig. 3).

Figure 3. The principal known breeding and wintering areas of the whooping crane (*Grus americana*) (adapted from Meine and Archibald 1996).

Table 1. Whooping crane peak winter numbers in North America 1938-2005.

AWBP					Louisiana	
Winter	**Adult[a]**	**Young[a]**				**Total**
1938-39	14	4			11	29
1939-40	15	7			13	35
1940-41	21	5			6	32
1941-42	14(13)	2			6	22
1942-43	15	4			5	24
1943-44	16	5			4	25
1944-45	15	3			3	21
1945-46	18(14)	4(3)			2	24
1946-47	22	3			2	27
1947-48	25	6			1	32
1948-49	27	3			1	31
1949-50	30	4			1	35
1950-51	26	5			0	31
1951-52	20	5				25
1952-53	19	2				21
1953-54	21	3				24
1954-55	21	0				21
1955-56	20	8				28
1956-57	22	2				24
1957-58	22	4				26
1958-59	23	9				32
1959-60	31	2				33
1960-61	30	6				36
1961-62	34	5				39
1962-63	32	0				32
1963-64	26(28)	7				33
1964-65	32	10				42
1965-66	36	8				44
1966-67	38	5				43
1967-68	39	9				48
1968-69	44	6				50
1969-70	48	8				56
1970-71	51	6				57
1971-72	54	5				59
1972-73	46	5				51
1973-74	47	2	**Rocky Mountain**			49
1974-75	47	2	**Adult**	**Young**		49
1975-76	49	8		4		61
1976-77	57	12	3	3		75
1977-78	62	10	6	2		80
1978-79	68	7	6	3		84
1979-80	70	6	8	7		91
1980-81	72	6	15	5		98
1981-82	71	2	13	0		86
1982-83	67	6	10	4		87
1983-84	68	7	13	17		105

Table 1, continued

AWBP			Rocky Mountain					Total
Winter	**Adult**	**Young**	**Adult**	**Young**				
1985-86	81	16	27	4				128
1986-87	89	21	20	1				131
1987-88	109	25	16	0				150
1988-89	119	19	14	0				152
1989-90	126	20	13	0				159
1990-91	133	13	13	0				159
1991-92	124	8	12	0	**Florida[b]**			144
1992-93	121	15	9	0	**Adult**	**Young**		145
1993-94	127	16	8	1	8			152
1994-95	125	8	4	0	16			153
1995-96	130	28	3	0	25			186
1996-97	144	16	3	0	56			219
1997-98	152	30	3	3	60			248
1998-99	165	18	4	0	57			244
1999-00	171	17	2	0	65		**Eastern[b]**	255
2000-01	171	9	2	0	74		**Migratory[b]**	256
2001-02	161	15	1	0	87		6	270
2002-03	169	16	0	0	85	1	21	292
2003-04	169	25	0	0	85	2	36	317
2004-05	183	34	0	0	66	5	47	335
2005-06	190	30	0	0	59	0	64	343

[a] Where two numbers occur in a column, the one in parentheses is the original count and the other is the adjusted number as explained in Boyce (1987). The 1945 count at ANWR and vicinity was 14 and 3, but 22 adult-plumaged birds returned to the refuge in the winter of 1946. Consequently, it is evident that some birds were not counted in 1945. The all-time low for the AWBP was either 15 or 16 in 1941.

[b] Number of birds present on December 31.

Current Distribution and Abundance

Whooping cranes occur only in North America within Canada and the United States. Approximately 83% of the wild nesting sites occur in Canada and 17% occur in Florida and Wisconsin. Sixty-four percent of the February, 2006, wild population (215 of 338 individuals) had summered in Canada, with 59 in Florida and 64 in the Wisconsin – Florida population. Currently, 16% of the captive individuals (22) remain in Canada and the balance (113) is housed in the United States.

The AWBP contained 215 individuals in February, 2006, and is the only self-sustaining wild population. This population nests in the Northwest Territories and adjacent areas of Alberta, Canada, primarily within the boundary of WBNP (Johns 1998b). In 2005, 58 of the 72 known adult pairs nested (Brian Johns, CWS, pers. comm.). These cranes migrate southeasterly through Alberta, Saskatchewan, and eastern Manitoba, stopping in southern Saskatchewan for several weeks in fall migration before continuing migration into the United States (Fig. 2). They migrate through the Great Plains states of eastern Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. Their spring migration is more rapid and they simply reverse the route followed in fall. They winter along the Gulf of Mexico coast at ANWR and adjacent areas

(Fig. 4). The winter habitat extends 48-56 km along the coast from San Jose Island and Lamar Peninsula on the south to Welder Point and Matagorda Island on the north (Tom Stehn, ANWR, pers. comm.), and consists of estuarine marshes, shallow bays, and tidal flats (Allen 1952, Blankinship 1976). Some individuals occur occasionally on nearby privately owned pasture or croplands.

The second population of wild whooping cranes is non-migratory (Nesbitt et al. 1997) and occurs in central Florida. This population, known as the Florida Population (FP), has been designated experimental nonessential in the United States by the USFWS. First reintroduced in 1993, approximately 59 birds survived in February, 2006, from 289 captive-reared whooping cranes released over a 13-year period (Table 9). Two pairs first produced eggs in 1999 and the first chick fledged in 2002, the first chick in the U.S. to do so since 1939. In 2005, 8 pairs nested, 1 chick hatched, and none fledged. In summary, 41 pairs laid eggs between 1999 and 2005, 17 chicks hatched, and 4 fledged (Table 9). The FP is found primarily on the Kissimmee Prairie and surrounding areas. The Kissimmee Prairie is south of Orlando and consists of 500,000 ha of freshwater marsh and open grasslands in Osceola and Polk Counties associated with the flood plain of the Kissimmee River. Most grasslands are improved pasture used for livestock grazing and are heavily used by the cranes for foraging.

A third population of wild whooping cranes is migratory and was reintroduced starting in 2001. This population is referred to as the Eastern Migratory Population (EMP). Captive whooping cranes reared at PWRC are brought to the Wisconsin summering area, trained to fly behind ultralight aircraft, and led to Florida. This population migrates from the Necedah NWR (NNWR) in central Wisconsin to Chassahowitzka NWR (CNWR), a 12,500 ha expanse of salt marsh on the Gulf Coast of Florida. All 5 whooping cranes led south in 2001 survived the winter, returned to summer in central Wisconsin on their own, and returned to western Florida the subsequent winter. Additional birds are released directly into groups of older whooping cranes in central Wisconsin. As of February, 2006, this population numbered 64 birds.

No whooping cranes remain in the Rocky Mountains. The last bird from the cross-fostering experiment disappeared during migration from the winter grounds in 2002 at the age of 19. These birds had summered in Idaho, Montana, Utah, and Wyoming and wintered in New Mexico, staging in spring and fall near the Monte Vista NWR, Colorado. In 1989, because of the lack of breeding attempts and high mortality (Garton et al. 1989), the Recovery Team recommended to discontinue the reintroduction attempt. Additional guide bird and ultralight experiments were carried out through 1997, but not with an expectation of establishing a population in the Rocky Mountains.

As of February, 2006, 135 whooping cranes occur in captivity at 9 North American locations. The U.S. Geological Survey (USGS) maintains 55 adults at PWRC in Laurel, Maryland. The USFWS funds, cooperatively with ICF, 36 adult cranes at the Foundation facility in Baraboo, Wisconsin. Twenty adult birds are kept at the Devonian Wildlife Conservation Center operated by CZ. Eight whooping cranes are present at SSC, Belle Chasse, Louisiana. Their first egg was produced in 2003. Nine adult whooping cranes are at SAZ in San Antonio. The captive flocks at PWRC, ICF, CZ, SSC, and SAZ are the sources for captive-reared cranes used in the FP and EMP wild flocks. Since 1993, 14 to 48 young have been released annually into the wild in Florida with a total of 289. Between 2001 and 2004, a total of 54 young started the fall migration in Wisconsin behind ultralight aircraft. Whooping cranes are on public display at 6

locations, all in North America. Two birds each are present on display at CZ, Calgary, Alberta, Lowry Park Zoo, Tampa, Florida, SAZ in Texas, ICF in Baraboo, Wisconsin, and Audubon Zoo in New Orleans, Louisiana. One bird is at Homosassa Springs Wildlife State Park in Homosassa, Florida.

Figure 4. Wintering area of the Aransas Wood Buffalo Population, Aransas National Wildlife Refuge and Critical Habitat boundary on the Gulf of Mexico coast of Texas.

HABITAT REQUIREMENTS

Breeding Habitat

Whooping Cranes formerly bred in isolated marshes on the prairies and in aspen parkland. The current nesting area within WBNP lies between the headwaters of the Nyarling, Sass, Klewi, and Little Buffalo rivers (Fig. 5). The area is poorly drained and interspersed with numerous potholes. Wetlands vary considerably in size, shape and depth, and most possess soft marl bottoms (Timoney et al. 1997). Wetlands are separated by narrow ridges which support an over-story of white spruce (*Picea alauca*), black spruce (*P. mariana*), tamarack (*Larix laricina*),

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 (Novakowski 1966). Bulrush (*Scirpus validus*) is the dominant emergent in the potholes used for nesting, although cattail (*Typha* sp.), sedge (*Carex* aquatilis), musk-grass (*Chara* sp.), and other aquatic plants are common (Allen 1956, Novakowski 1965, 1966, Kuyt 1976a, 1976b, 1981a). Nest sites are primarily located in shallow diatom ponds that contain bulrush (Timoney 1997).

Figure 5. Breeding area of the Aransas Wood Buffalo Population, Wood Buffalo National Park.

Wildfires, caused primarily by lightning, are generally thought to have beneficial effects on crane habitat by recycling nutrients and removing and thinning vegetation on the forested ridges between nesting ponds, making the area more accessible to cranes. Fires have burned large portions of the nesting area during drought (e.g., 1981); however, wildfires do not appear to have influenced whooping cranes' choice of nest sites (Timoney 1999). Although molting adults or flightless young are vulnerable to fire, losses of eggs, chicks, or adults have not been confirmed. Due to the potential negative effects of a major fire control operation in the nesting area, it was advised that the area be classified as a modified response area where fire suppression activities are limited (Timoney 1997).

There is little competition by other species for nesting territories in WBNP (Kuyt 1989). Sandhill cranes are present on the nesting grounds; however, it is unlikely they would out-compete the larger whooping cranes for preferred nest sites and territories. Most territory overlap would probably occur on the drier sedge nest areas.

Although the quality of nesting habitat can be debated, there is no evidence that growth of the AWBP is limited by availability of summer habitat. Hatching success is high in most years (Kuyt 1976c, 198la, 1981b) and the area is remote from human activities. Thousands of hectares of unoccupied, apparently similar habitat are available in the area. Some new pairs have pioneered unoccupied nesting habitat adjacent to occupied range as the population has increased (Kuyt 1978b, Johns 1998a, Johns et al. *In press*). Wetlands suitable for breeding may still exist in the historical range on the Canadian prairies, although dry conditions in recent years and agricultural practices have greatly decreased the number and extent of these wetlands. A project of the CWS and Parks Canada was completed to identify suitable unoccupied nesting habitat within WBNP and adjacent areas (Olson and Olson 2003).

In 2005, 6 pairs nested just outside of WBNP. Additional expansion of the flock out of WBNP into adjacent areas of the Northwest Territories would occur on land with no formal protection. Land uses such as forestry, agriculture, and activities such as hunting could cause disturbance or change the quality of habitat available for cranes.

Migration Habitat

Whooping cranes use a variety of habitats during migration (Howe 1987, 1989, Lingle 1987, Lingle et al. 1991, Johns et al. 1997). Nine radio-tagged whooping cranes monitored for one or more seasons and others that associated with them fed primarily in a variety of croplands and roosted in palustrine (marshy) wetlands (Howe 1987, 1989). Seventy-five percent of the roosting wetlands were less than 4 ha and within 1 km of a suitable feeding site. More than 40% of the roosting wetlands were smaller than 0.5 ha. Johns et al. (1997) found that on average, wetlands were larger than those of Howe (1987, 1989), with spring sites averaging 36 ha and fall sites averaging 508 ha in size. The majority (94.9% spring; 72.9% fall) of these roost sites were also within 1 km of a suitable feeding site. Heavily vegetated wetlands were generally not used, but family groups appeared to select more heavily vegetated areas than non-families (Howe 1987, 1989). Cropland accounted for 70% of the feeding sites of non-families, but wetlands accounted for 67% of the feeding sites of families.

Clusters of migratory observations suggested relationships with large-scale spatial patterns in land cover (Richert et al. 1999, Richert and Church 2001). Areas characterized by wetland mosaics appear to provide the most suitable stopover habitat (Johns et al. 1997, Richert et al. *In press*). In states and provinces, excluding Nebraska, whooping cranes primarily used shallow, seasonally and semipermanently flooded palustrine wetlands for roosting, and various cropland and emergent wetlands for feeding (Johns et al. 1997, Austin and Richert 2001). Large palustrine wetlands included in this category (and the number of confirmed sightings through spring 2005) are those at Quivira NWR in Kansas (126), Salt Plains NWR in Oklahoma (84), Cheyenne Bottoms State Wildlife Area in Kansas (56), Last Mountain Lake NWA in Saskatchewan (58), and large reservoir margins in the Dakotas (Wally Jobman, USFWS files, Brian Johns, CWS files). Known staging areas and potential breeding wetlands on the prairies could be negatively impacted by drought, drainage, cattle grazing, contaminated runoff, or other disturbances associated with agricultural activities. Since fall staging habitat in Saskatchewan is primarily on private lands, conservation activities should include stewardship actions (Johns et al. 1997).

During migration, whooping cranes often are recorded in riverine habitats, especially in Nebraska. Frequently used riverine habitats (and the number of confirmed sightings through spring 2005) include: the South Saskatchewan River in Saskatchewan (42)(Brian Johns, CWS files); the Platte River (66), North and Middle Loup Rivers (18), and Niobrara River (14) in Nebraska; the Missouri River in North Dakota (8); and the Red River (3) in Texas (Wally Jobman, USFWS files). Cranes roost on submerged sandbars in wide, unobstructed channels that are isolated from human disturbance (Armbruster 1990).

Wintering Habitat

About 9,000 ha of salt flats on ANWR and adjacent islands comprise the principal wintering grounds of the whooping crane (Fig. 4). 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 and are characterized by oak brush, grassland, swales, and ponds. Typical plants include live oak (*Quercus virginiana*), redbay (*Persea borbonia*), and bluestem (*Andropogon* spp.) (Stevenson and Griffith 1946, Allen 1952, Labuda and Butts 1979). In the last 30 years, many upland sites have been grazed, mowed, or burned under controlled conditions (Labuda and Butts 1979) to maintain oak savannah habitat. The refuge maintains as many as 3,300 ha of grassland for cranes, waterfowl, and other wildlife. Human visitation is carefully controlled, and other potentially conflicting uses of the refuge, such as activities associated with oil and gas exploration, are reduced when whooping cranes are present.

RATE OF POPULATION GROWTH

The whooping crane has a long-term recruitment rate of 13.9%, the highest of any North American crane population (Drewien et al. 1995). Annual growth of the population during the past 65 years has averaged 4.5% per year. Population studies indicate a 10-year cycle of unknown cause in survivorship (Boyce and Miller 1985, Boyce 1987, Nedelman et al. 1987). M. Boyce (pers. comm.) has correlated the crane cycle with that of boreal forest predator cycles. From 1983 to 1989, the AWBP population increased from 75 to a high of 146 birds, chiefly

because of suitable nesting habitat conditions during that period, then dropped to the anticipated 10-year low of 132 by the 1991-92 winter (Table 1). The AWBP then increased to a record high of 188 in the 1999-00 winter. Again, with the expected 10-year cycle, the population declined to 180 in 2000-01 and 176 in 2001-02, then rebounded to 185 in 2002-03, 194 in 2003-04 and 217 in 2004-05.

The growth of the AWBP up to the year 2000 seems to have resulted primarily from a decline in the mortality rate rather than an increase in recruitment. Between 1938-2000, 341 whooping cranes disappeared from the wild population. Annual mortality averages 9.8% (12.1% prior to 1970 and 7.6% since that time). In addition, recruitment has also declined from the pre-1970 average of 15.9% to 10.8%. If recruitment can be increased and if losses of white-plumaged birds can be reduced, population growth will accelerate. The factors causing the decline in recruitment are unknown, but identifying these sources and implementing remedial actions where feasible should be a high priority.

A Population Viability Assessment Workshop held in 1991 for the whooping crane was funded by the USFWS as a cooperative endeavor with CWS, U. S. Whooping Crane Recovery Team, Canadian Whooping Crane Recovery Team, ICF, The Captive Breeding Specialist Group, and Species Survival Commission of the International Union for Conservation of Nature. The final report included priorities for research and management of the wild and captive populations as a meta-population to maximize retention of genetic heterozygosity and minimize the risk of extinction (Mirande et al. 1993).

Several population viability analysis packages have been tested using whooping crane data from the AWBP (Mirande et al. 1997a, Brook et al. 1999). Annual growth of the population during the past 65 years has averaged 4.5% per year. If this rate continues, starting with a peak population of 185 birds in 2002, the population will reach 500 birds by 2025 and 1,000 birds by 2041 (John Cannon, pers. comm.). However, the standard deviation of the annual growth rates over the past 65 years has been 12.9%, almost triple the average annual growth rate. For example, the growth rate was as high as 33% in 1954-55 and as low as -38% in 1940-41. In the last 15 years, with a total population of >100 birds, the annual growth rate has varied from a high of 19% in 1994-95 to a low of -10% in 1990-91. This variation makes it difficult to predict the future population size for any given year. However, it is likely that the AWBP will continue to grow with a low probability (<1.0%) of extinction over the next 100 years (Mirande et al. 1997a).

Mirande et al. (1993) modeled the captive population from its establishment to 1991 and found a growth rate of 1.1% (SD+-0.114). At that rate a population of 127 birds would retain only 89% of the initial heterozygosity at the end of 100 years. However, many of the captively bred cranes were released during the cross-fostering experiment in the Rocky Mountains between 1975 and 1989. Expansion and major improvements in production occurred in the 1990s and the program now demonstrates the capacity to support the non-migratory reintroduction program in Florida. The captive flocks have contributed 289 young to the Florida introduction between 1993-2005, with 250 from captive-produced eggs, and 39 from WBNP eggs hatched in captivity.

THREATS AND REASONS FOR LISTING

The 1967 Federal document that first listed the whooping crane as in danger of extinction did not address the five factor threats analysis later required by Section 4 of the 1973 ESA. However, we address these factors in the summary below to organize threats to the species in a manner consistent with current listing and recovery analyses under the ESA. The five factor analysis is also utilized in Part II to address how threats are minimized by proposed recovery actions (see *Reduction or Alleviation of Threats to Whooping Cranes through Implementation of Recovery Actions*).

Listing Factor A: The present or threatened destruction, modification, or curtailment of habitat or range.

Human Settlement: The growth of the human population in North America has resulted in significant whooping crane habitat alteration and destruction. Historically, whooping cranes declined or disappeared as agriculture claimed the northern Great Plains of the U.S. and Canada (Allen 1952). By the mid-1900s, only one small population survived. Ironically, the steadfast use of a traditional summer area that appears to have saved the whooping crane as a small, relict breeding population in WBNP, prevents its voluntary return to what was once its principal nesting range. Re-colonization of these historic breeding areas remains unlikely unless humans assist with reintroductions or habitat restoration.

Conversion of pothole and prairie to hay and grain production made much of the historic nesting habitat unsuitable for whooping cranes. Disruptive practices included draining, fencing, sowing, and the human activity associated with these actions. Settlement of the mid-continent and coastal prairies and associated disturbance, in addition to alteration of habitat, may have interfered with continued use of prairie and wetlands by breeding whooping cranes. The extensive drainage of wetlands in the prairie pothole region of Canada and the United States also resulted in a tremendous loss of migration habitat available to whooping cranes. Water diversions on major river systems, such as the Platte River, have degraded migration habitat.

Freshwater Inflows: Currently, expanding human populations throughout the range of the whooping cranes continue to threaten survival and recovery of the birds. Impacts are particularly severe on the winter grounds. Freshwater inflows starting hundreds of kilometers inland, primarily from the Guadalupe and San Antonio rivers, flow into whooping crane critical habitat at Aransas; these inflows are needed to maintain proper salinity gradients, nutrient loadings, and sediments that produce an ecologically healthy estuary (TPWD 1998). Spring flows originating from the Edwards Aquifer are also crucial, especially in times of drought when they can make up 70% of Guadalupe River water. Inflows are essential to maintain the productivity of coastal waters and produce foods used by the whooping cranes. Coastal waters with low saline levels are maintained by these in-stream flows, providing drinking water for cranes that would otherwise fly inland for freshwater.

TPWD has recommended target inflow levels needed to maintain the unique biological communities of the Guadalupe Estuary (TPWD 1998), which includes whooping crane critical habitat. Unfortunately, mechanisms to guarantee these flows are not provided by Texas water law, and critics have challenged the size of the target inflows. In 2000, the San Marcos River Foundation applied for a water right that would leave 1.15 million acre-feet in the river, in

accordance with the flows recommended by TPWD for the Guadalupe estuary. The application was denied in 2003 but has been appealed and in February, 2005, was sent back by the court to the Texas Council on Environmental Quality for a re-hearing. Conservation flows were proposed in Senate Bill 3 in the Texas Legislature in 2005, but the bill was not acted upon in the House.

Upstream reservoir construction and water diversions for agriculture and human use reduce freshwater inflows. Many existing water rights are currently only partially utilized, but greater utilization is expected over time. Water rights continue to be granted on the Guadalupe, and some sections of the river are already over-appropriated. A proposal included in the state water plan proposes a diversion at the mouth of the Guadalupe River, pumping at least 94,500 acre-feet annually back to San Antonio for municipal use. As the San Antonio region grows, with population expected to double in the next 50 years (SAWS 2003), pumping from the Edwards Aquifer in times of drought threatens spring flows.

Projections indicate the river will be significantly threatened during periods of low flow and could cease to flow into the bay if all currently authorized water-use permits are utilized (National Wildlife Federation 2004). In 2002, American Rivers named the Guadalupe on their annual list of the 10 most endangered rivers in the U.S. because of the inflow issue. In a report entitled *Bays in Peril,* a "Danger" ranking was given to San Antonio Bay because drought periods were predicted to increase by 250%, and years with low freshwater pulses in the spring were calculated to increase 26% from naturalized levels (National Wildlife Federation 2004). Texas Water Development Board data indicate natural droughts already threaten the Guadalupe ecosystem. Withdrawals of surface and groundwater for municipal and industrial growth are predicted to leave insufficient inflows to sustain the ecosystem in less than 50 years. Modeling indicates that if all existing water rights were exercised during a repeat of the 1950-1956 drought, estuary inflows would be reduced by 17% to 43% below current levels and by 36% to 72% below historic levels, depending on the year (Norman Johns, National Wildlife Federation, Austin, TX, pers. comm., in Fitzhugh and Richter, 2004). Additionally, there are pending water right applications for much of the remaining unappropriated water in the Guadalupe.

A simple inverse relationship exists between blue crab catch rates and mean salinity within an estuary (Longley 1994). Inflows are already at times insufficient and reduced over historic levels, leading to increases in mean salinity and decreases in blue crabs, the primary food of the whooping cranes. Long before ecosystem collapse, due to lack of inflows, significant adverse impacts to blue crab populations would occur (Kretzschmar 1990). By 2040, due to constructed diversions, a decrease of freshwater inflows into the crane's winter range is projected in an average year to cause an 8% decline in blue crab populations (Texas Department of Water Resources 1980), but could have a much larger impact in drought years (Norman Johns, National Wildlife Federation, Austin, Texas, pers. comm.).

<u>Listing Factor B: Overutilization for commercial, recreational, scientific, or educational purposes.</u>

Shooting: Hunting was one of the primary reasons for the whooping crane's historical decline. Allen (1952:75) recorded 389 whooping cranes known to have died from gunshot or other causes from colonial times to 1948. The majority of documented mortalities (274 cranes) occurred between 1870 and 1930. Most losses (about 66%) occurred during migration, especially

between the 1880s and 1920s (Allen 1952). Allen (1956) reported that nearly 200 taxidermy mounts, study skins, skeletons, and an undetermined number of eggs were in museums in the United States and Canada. Hahn (1963) indicated that 309 mounts and 9 skeletons existed in museums throughout the world. The lack of records associated with most of these specimens suggests few were collected by museum employees. Considering the low reproductive potential of the species, the shooting mortality possibly exceeded annual reproduction by the early 1900s.

Human-caused mortality of cranes declined following enactment of protective legislation. Although hunting whooping cranes is now illegal, shootings occasionally occur (Lewis et al. 1992a). Four documented shootings of AWBP whooping cranes occurred during migration or on the wintering grounds between 1968-1991. One whooping crane was shot by a snow goose hunter in 1968 just north of the ANWR boundary; another was shot reportedly mistaken for a snow goose (*Anser caerulescens*) along the bay edge of San Jose Island in January 1989. A vandal shot a whooping crane in Saskatchewan in April 1990, and another vandal shot one in April, 1991 as it migrated through Texas. Vandals shot 3 whooping cranes in Florida in 1999 and 2000. The most recently documented losses associated with hunting were an adult shot in migration near Ennis, Texas in November, 2003 and 2 (possibly 3) birds killed by sandhill crane hunters in central Kansas in November, 2004. A total of 12 documented shootings of whooping cranes in North America has occurred in the last 17 years (1989-2005). It is not known what percentage of shootings go undetected, nor what percentage of unexplained losses can be attributed to shootings. Although examinations of retrieved carcasses rarely have revealed the presence of shotgun pellets, 3 lead pellets were found during the post-mortem examination of a male from the Rocky Mountain population in January, 1984, that had died from disease (Snyder et al. 1992), and a pellet was found in the foot of a dead whooping crane in Michigan in 2004.

Whooping cranes of the AWBP occasionally associate with sandhill cranes during migration and RMP birds frequently associated with sandhill cranes. Hunting of sandhill cranes and snow geese occurs in and adjacent to areas used by migrating and wintering AWBP whooping cranes. Hunters may misidentify and shoot whooping cranes as these species. Sandhill crane hunting seasons in Canada and the United States in the migration corridor were originally seasonally timed or geographically limited to protect whooping cranes (Buller 1967, Archibald et al. 1976, Thompson and George 1987). Recent expansions of sandhill crane hunting seasons offer an increased potential for overlap with whooping crane migration periods and increased risks to whooping cranes (Konrad 1987, Brian Johns, CWS, pers. comm.). In some instances, large land units have been closed to sandhill crane or waterfowl hunting due to the presence of a flock or flocks of whooping cranes. Quivira NWR in Kansas is closed during most fall migrations whenever whooping cranes stop-over (David Hilley, Quivira NWR, pers. comm.). Tundra swan hunts recently initiated in the northern Great Plains (Montana, 1983; North Dakota, 1988; South Dakota, 1990) also present opportunities for misidentification and accidental shooting of whooping cranes.

Although occasional shootings do occur, some of these shootings are strictly acts of vandalism. Sportsmen and other conservationists have played crucial roles in helping whooping cranes (see Conservation Measures – page 31).

Disturbance: The whooping crane is sensitive to disturbance on the breeding grounds and will not remain near human activity. However, the egg transfer and banding programs have demonstrated that cranes will tolerate human intrusion for short intervals. Some disturbances

cause the birds to leave an area; the effects of others may be more subtle. The public does not have access to most of the whooping crane nesting habitat, but does have significant access to whooping crane winter habitat, as these water areas are public domain.

The accessibility of the cranes to humans at Aransas has led to a great number of people coming specifically to see the cranes. Up to 10,000 people ride whooping crane tour boats and in excess of 70,000 people visit the refuge annually, many hoping to see the cranes. These interactions build support for the species both locally and nationally, create awareness of existing threats to the cranes, and provide educational opportunities. Other human activities in the wintering area including waterfowl hunting and sport and commercial fishing are undertaken regardless of the presence of whooping cranes.

Increasing disturbance to whooping cranes on the wintering grounds has been a concern for many years (T. Lewis *In prep*.). As the Texas coast is developed, whooping cranes will have more interactions with people. Cranes are somewhat tolerant of people in carefully operated boats and land vehicles (Mabie et al. 1989). On the Aransas NWR, whooping cranes responded negatively to 40% of all disturbances (T. Lewis *In prep.*). Whooping cranes disturbed for 17 minutes for each hour observed, moved an average of 525 m from human disturbances and were displaced most often from open bay and wet marsh habitats (T. Lewis *In prep*.). Airboats, low-altitude aircraft, and especially helicopters cause disturbance, and cranes are particularly sensitive to humans on foot (Lewis and Slack 1992). Crane displacement results in short-term or long-term loss of habitat and social disruption of the flock (T. Lewis *In prep.*). Furthermore, disturbance to cranes limits their ability to obtain food resources and thus impacts fitness (T. Lewis *In prep.*). Although whooping cranes sometimes may be found close to humans in familiar situations, it is unknown what levels of stress may be associated with these encounters.

Listing Factor C: Disease or Predation.

Disease/Parasites: Little is known about the importance of diseases or parasites as mortality factors for wild whooping cranes. Loss of wetlands has concentrated birds using aquatic habitat, thereby increasing the risk of disease exposure and transmission. For example, avian cholera epizootics occur fairly regularly in several areas used by cranes; this disease has been confirmed in one whooping crane. Avian tuberculosis is known to impact the species, and infectious bursal disease (IBD) has had a major impact on reintroduction programs in Florida in some years. Additionally, human impacts on the environment and movements around the globe are resulting in emerging disease problems of possible significance to whooping cranes. For example, West Nile virus appeared for the first time in North America in 1999 and is now spreading rapidly. The H5N1 strain of avian influenza that has surfaced globally in 2005 is an emerging threat to both captive and wild flocks. Coccidia have been found in a whooping crane with an injured wing captured in WBNP and in whooping crane droppings collected on the Texas wintering grounds (Forrester et al. 1978), are common in cranes in the Florida release population (Spalding et al. 1996), and have caused deaths of several whooping crane chicks at PWRC (Carpenter et al. 1980). The defense of large territories and small brood size ensures low density use of the WBNP natal area, and thereby reduces the likelihood of coccidia oocysts being ingested in quantities sufficient to cause significant disease. However, the disseminated form of coccidiosis (DVC) is believed to have contributed to the mortality of 2 released whooping cranes in Florida (Marilyn Spalding, U. of Florida, pers. comm.) A variety of other parasites has been documented in released whooping cranes in Florida, but none have been proven to cause

significant disease (Spalding et al. 1996).

Although wild whooping cranes are presumably susceptible to a variety of infectious and toxicological diseases, evidence of disease-related mortality is infrequently documented. From 1976 to 1989, the USFWS necropsied or examined 25 whooping crane carcasses found dead in the field or removed from the wild because of sickness or debility. Of these, nine were diseased. Seven had avian tuberculosis (Snyder et al. 1997), a subadult crane captured in New Mexico was suffering from avian cholera (Snyder et al. 1987), and an adult died from acute lead poisoning (Brand et al. 1992, Snyder et al. 1992). The high incidence of avian tuberculosis indicates that whooping cranes may be particularly susceptible to this disease.

Predation: Adult whooping cranes generally are not susceptible to predation unless they are weakened by disease or injury, or are flightless during feather molt. However, eggs and chicks are predated (Bergeson et al. 2001a). Potential predators in the WBNP nesting ground include the black bear (*Ursus americanus*), wolverine (*Gulo luscus*), gray wolf (*Canis lupus*), red fox (*Vulpes fulva*), mink (*Mustela vison*), lynx (*Lynx canadensis*), and raven (*Corvus corax*). Black bears and other mammals destroy eggs, and wolves, foxes, and ravens kill chicks (Kuyt 198la, 198lb, Bergeson et al. 2001a). The overall impact of predation on AWBP recruitment remains uncertain but may be a factor in the 10 year population cycle (Boyce et al. 2005). Predator control is not considered an appropriate management technique within Canadian National Parks. Whooping cranes are also exposed to predators during migration (Lewis et al. 1992a). On numerous occasions, golden eagles disrupted human-led sandhill crane migrations behind trucks and ultralights. In the west, two attacks on juvenile whooping cranes were documented during migration. In 2002, a bald eagle killed a whooping crane hatchling in Florida. Bobcats (*Lynx rufus*) and alligators (*Alligator mississippiensis*) are significant predators of reintroduced whooping cranes in Florida. Bobcat predation appears most severe on individuals that do not show proper roosting behaviors or use habitat with heavy cover. Bobcats and coyotes also take cranes that are sick or injured at ANWR. Predation rates are significant in Florida, but appear to be very low in wild birds in Texas where cranes spend more time in coastal wetlands.

<u>Listing Factor D: The inadequacy of existing regulatory mechanisms.</u>

The whooping crane became endangered primarily from shooting and habitat loss prior to the enactment of major conservation legislation. The current legal framework (ESA, Migratory Bird Treaty Act, SARA, and NEPA) should provide for adequate protection and conservation of the whooping crane and its habitat.

<u>Listing Factor E: Other natural or anthropogenic factors affecting its continued existence.</u>

Multiple factors limit the growth of the AWBP. Some are related to the biological environment of the whooping crane, others are human-related.

Life History: Delayed sexual maturity, small clutch size, and low recruitment rate preclude rapid population recovery. Nesting can occur as early as age 3 (Brian Johns, pers. comm.), with the average age of first egg production at age 5 and the first fertile eggs at 5.4 years (Kuyt and Goossen 1987). The climate of the current northern breeding grounds may be another handicap to productivity as the ice-free season is only 4 months long (and may be getting shorter). 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.

Food Availability/Sibling Aggression: About 734 crane chicks were observed to hatch at WBNP during 1976-2001, and 381 (59% survival) arrived at Aransas the following winter (Brian Johns, CWS, pers. comm). Factors limiting chick survival are only partially known. Most mortality occurs soon after hatching, and chicks that fledge have a high probability of successfully completing their first migration (Kuyt 1976a). Most immediate post-hatching mortality may be related to sibling aggression and short-term food shortage because eggs hatch asynchronously and the precocial young are extremely aggressive toward each other. The dominant chick apparently obtains principal access to food made available by the parents; consequently brood-size is rapidly reduced during periods of food shortage (Drewien 1973, Miller 1973, Bergeson et al. 2001b). Prolonged food shortage, possibly related to drought, and drought-increased predation (Kuyt 1981b), may account for additional mortality.

Climatic Factors: Cold weather and precipitation soon after hatching may lead to loss of chicks; in particular, pairs with two young often lose one during these periods of adverse weather (Brian Johns, CWS, pers. comm.). While flooding of nests in WBNP is thought to be rare, drought is a far greater hazard. During drought, the attractiveness of traditional nest sites is reduced, food supplies are diminished, and newly-hatched chicks are forced to travel long distances between wetlands. Drought conditions also increase exposure of eggs and chicks to terrestrial predators. Whooping cranes are exposed to various natural obstacles and threats during migration. Snow and hailstorms, low temperatures, and drought can present navigational handicaps or reduce food and habitat availability. Hurricanes and drought can create problems on the wintering grounds. A late-season hurricane could place cranes at risk due to high wind velocities and flooding. Fortunately, the hurricane season ends (November 30) just after most whooping cranes arrive. Drought at Aransas influences availability and abundance of the natural food supply by altering salinity of tidal basins and estuaries (Blankinship 1976).

Global warming and associated climate changes constitute a potential threat to whooping crane recovery. Based on climate records and calculated rates of rises in greenhouse gas concentration from human activities, models of global climate change suggest that average global surface temperatures will increase by 1.4 and 5.8ºC (2.5 and 10.4ºF) by the end of this century (National Academy of Sciences 2005 website: http://www4.nas.edu/onpi/webextra.nsf/web/climate?OpenDocument). In the Northern Hemisphere, from 1951 to 1990, average minimum winter temperature rose 2.9ºC, while average summer maximum temperature rose 1.3ºC (Crozier 2003). In addition to rising temperatures, other climate factors such as the rising of sea level, flooding of coastal wetlands, drying of interior wetlands, and intensifying of precipitation events may impact the whooping crane. Although the frequency of future hurricanes is uncertain, hurricanes are expected to become stronger and bring more intense rainfall than hurricanes at present, due to increases in sea surface temperatures (NOAA website: http://www.gfdl.noaa.gov/~tk/glob_warm_hurr.html, updated March 23, 2006). Coastal wetlands are particularly vulnerable to erosion, changes in salinity and microclimate conditions, changes in groundwater tables, and habitat loss from expected rises in sea level and hurricane damage (EPA Global Warming Impacts Coastal Zones website: http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ImpactsCoastalZones.html).

Climate change is expected to alter the physiology, distribution, phenology, and adaptation of organisms (Hughes 2000, Menzel et al. 2001, Stenseth et al. 2002, Peterson 2003, Parmesan and Yohe 2003). In turn, these processes may affect growth rates, individual size, individual mobility, overall fitness, reproductive success, and population demographics (Stenseth et al. 2002). Changes in ecosystem functioning, such as cycling of nutrients, and interactions among whooping cranes and their biotic resources, such as food species, plant communities, predators, parasites, competitors, and mutualists, are difficult to predict and involve an understanding of an ecosystem's resistance and resiliency to interference (Chapin et al. 2000). Habitat specialization of birds has been associated with sharper declines in population abundance (Julliard et al. 2003, Peterson 2003, Thomas C. et al. 2004, Thomas J. et al. 2004). Warming temperatures have caused a northward shift in bird species' ranges, hastened the timing of winter and summer activities, and are predicted to decrease biodiversity world-wide (Thomas and Lennon 1999, McCarty 2001, Thomas C. et al. 2004). For the whooping crane, this could affect current wintering areas, summering locations, and the timing of breeding and migration. These changes may alter the extent to which a bird's life cycle is synchronized with its food supply and nest site availability.

If climate change results in drier conditions either on the summer or wintering grounds, whooping cranes would face great difficulties from disruptions to the ecology of those areas. Any changes that adversely affect the water regime of WBNP could have severe impacts on whooping crane reproduction. Permanently lowered water tables, for example, would shrink wetlands, reduce the availability of quality nesting sites, reduce invertebrate food availability, and allow predators to access nests and young. Chick survival is reduced during dry years in WBNP (Kuyt et al. 1992). On the winter area, a reduction in rainfall would reduce inflows and reduce the blue crab population that the cranes rely on for food. Global warming and associated sea level rise, combined with land subsidence, is projected to be about 17 inches on the Texas coast over the next 100 years (Twilley et al. 2001). This would reduce suitability of salt marsh and open water areas, making much of the present acreage too deep for use by whooping cranes (Tom Stehn, ANWR, pers. comm.).

Loss of Genetic Diversity: As a consequence of the 1941 population bottleneck, the current population is derived from an estimated 6 to 8 founders, with a loss of 66% of all genetic material (Mirande et al. 1993, Glenn et al. 1999). Subsequently, the captive population, which is derived solely from the AWBP, has received this legacy of a reduced gene pool. This high level loss of genetic diversity may have serious implications for this population.

Genetic theories suggest that small populations can continue to lose genetic diversity with each generation, and that continued loss of genetic material leads to inbreeding depression and declining productivity (Jimenez et al. 1994, Frankham 1995, Lacy 1997, Brook et al. 2002, Woodworth et al. 2002). There is concern that the limited genetic material of the whooping crane may lead to reduced productivity in WBNP, and may contribute to increasing difficulty in captive propagation. Limited genetic diversity is a detriment to a population currently threatened with unprecedented global ecosystem change as well as introduced diseases. The AWBP is challenged to grow to a level where the creation of new alleles through mutation will offset its past, current, and future losses in genetic diversity. [A detailed discussion on genetic issues is presented in Appendix A.]

Red Tide: Red tide is a bloom of phytoplankton (*Gymnodinum breve*), a microscopic algae that

historically occurred infrequently on the Texas Coast. In recent years, it has occurred nearly annually during late summer and fall, lasting for several months. It is not known what factors are causing the increased number of outbreaks of red tide. A toxin produced by the algae can concentrate in filter-feeding mollusks, including clams. It has been known to cause bird die-offs and could pose a significant threat to whooping cranes that feed heavily on clams in mid-winter. Although red tide has been documented in critical habitat in recent years, no severe outbreaks have occurred.

Chemical Spills: The only self-sustaining wild population remains vulnerable to extirpation from a contaminant spill due to its limited wintering distribution along the Gulf Intracoastal Waterway (GIWW) on the Texas coast. Numerous oil and gas wells and connecting pipelines are located in bay and upland sites near the cranes winter habitat. Many barges carrying toxic chemicals travel the GIWW daily through the core of whooping crane winter habitat. A spill or leak of these substances could contaminate or kill the cranes' food supply, or poison the cranes (Robertson et al. 1993). Spills that occur in summer, when whooping cranes are absent, could adversely affect survival by reducing productivity of the environment or leaving a toxic residue.

Gulf Engineers and Consultants, Inc. (1992) assessed threats to the whooping crane and its habitat from spills of vessel fuels and cargoes. They concluded that the hazard of spill exists, but the probability of occurrence is low. Catastrophic events such as a large spill are infrequent, and therefore, difficult to predict. Ratification of the 1993 North American Free Trade Agreement and industrial growth in South Texas makes increased traffic likely on the GIWW, with a greater potential for accidents. Thus, the probabilities of occurrence of the most likely spill (1 per 1,075 years) and worst spill (1 per 7,982 years) predicted by Gulf Engineers and Consultants, Inc. (1992) are likely conservative and may increase over time. The worst spill estimated by the Environmental Protection Agency (1992) would involve approximately 33,000 barrels of liquids.

During July 1974, 25 to 50 barrels of # 6 crude petroleum leaked from a barge at ANWR. Nothing could be done to keep the oil from washing into canal banks and emergent vegetation along 16 km of shoreline between Mustang Lake and Sundown Bay. A barge-loaded dragline, marsh buggy, and hand labor removed contaminated soil and vegetation over an 18-day cleanup period. No losses of wildlife were noted, and fortunately the spill was small and occurred during summer when no whooping cranes were present.

The U.S. Coast Guard (CG) has the lead responsibility for spill response and containment. The USFWS has response plans for the Gulf of Mexico (USFWS 1979) and specifically for Aransas NWR (Robertson et al. 1993). It is impossible to provide full protection for the cranes as long as chemicals are transported on the GIWW through the heart of the winter range. Spills of hazardous chemicals may limit human approach to only those personnel wearing special protective suits and breathing apparatus. Spill of gaseous materials could directly kill all cranes downwind. The Aransas oil spill plan emphasizes rapid response time to limit the amount of habitat impacted. Minimum response time by refuge staff is 1-2 hours, and 3-4 hours for spill control specialists. An event occurring at night or in bad weather (the most probable times) would further slow response. High winds greatly reduce the effectiveness of containment booms for products floating on the surface.

If crane habitat becomes contaminated, the Aransas oil spill plan calls for hazing cranes away from the spill area and capturing individuals that become seriously contaminated.

The response of whooping cranes to spilled materials, and to humans trying to haze the cranes away, is currently unknown. Since adult cranes are territorial, it is likely not possible to haze them from their large territories. Food supplies such as grain or milo could be placed on the edges of crane territories, but the cranes would still return to salt marsh ponds at night for required safe roosting habitat. Oiled cranes would be captured when possible and cleaned, although wild cranes are very difficult to capture and susceptible to death from capture myopathy, especially when young (Tom Stehn, ANWR, pers. comm.).

Whooping cranes on the winter range also are exposed to contaminants associated with runoff from agricultural and industrial activities and subjected to risks associated with offshore and onshore gas and oil operations. Nearby Lavaca Bay was closed for multiple years to the harvesting of fish and crabs because of industrial pollution including high levels of mercury (Lewis et al. 1992b).

Collisions with Power Lines, Fences and Other Structures: Human settlement in the prairies brought rural electrification and the fencing of open lands. Currently, the number of power lines, communication towers, and wind turbines is increasing in the U.S. and may kill as many as 225 million birds annually (Manville 2005).

Collisions with power lines are a substantial cause of whooping crane mortality in migration (Brown et al. 1987, Lewis et al. 1992a). Collisions with power lines are responsible for the death or serious injury of at least 44 whooping cranes since 1956. In the 1980s, 2 of 9 radio-marked whooping cranes from AWBP died within the first 18 months of life as a result of power line collisions (Kuyt 1992). Of 27 documented mortalities in the RMP, almost 2/3 were due to collisions with power lines (40.1%) and wire fences (22.2%) (Brown et al. 1987). Twenty individuals within the Florida populations and 2 individuals in the migratory Wisconsin population have died hitting power lines.

Currently, an estimated 804,500 km of bulk transmission lines and millions of km of distribution lines exist in the U.S. (Manville 2005). Whooping cranes can collide with both types of lines (Stehn, and Wassenich *In prep*). Additional power line construction throughout the principal migration corridor will increase the potential for collision mortalities. An Avian Power Line Interaction Committee (APLIC) composed of 9 investor-owned electric utilities and the USFWS was established in 1989 to address the issue of whooping crane collisions (Lewis 1997). In 1994, APLIC provided voluntary guidelines to the industry on avoiding power line strikes (APLIC 1994). At present, the USFWS is working on MOUs that call for the development of avian protection plans by participating companies to reduce bird strikes (Manville 2005). Tests of line marking devices, using sandhill cranes as surrogate research species, have identified techniques effective in reducing collisions by up to 61% (Morkill 1990, Morkill and Anderson 1991, 1993, Brown and Drewien 1995). Techniques recommended include marking lines in areas frequently used by cranes and avoiding placement of new line corridors around wetlands or other crane use areas.

Guy wires associated with telecommunication towers (radio, television, cellular, and microwave) present another collision obstacle to cranes. Such towers have been increasing at an estimated 6 to 8% annually. The USFWS Office at Grand Island, Nebraska, reviewed 260 tower site actions for Nebraska in fiscal year 2000. The Federal Communication Commission's (FCC) 1999 Antenna Structure Registry (November 1, 1999) listed 48,000 lighted towers over 60.7 m above

ground level and over 68,000 towers total in the United States. They estimated 24 to 38% of the towers were not properly registered with FCC. In the future, all television stations must be digitized, adding potentially 1,000 new towers exceeding 305 m height.

An estimated 16,000 new wind turbines may be constructed in the U.S. in the next decade, adding to the existing 15,000 turbines (Manville 2005). The development of wind farms in the whooping crane migration corridor has the potential to cause significant mortality. Cranes could be killed directly by wind turbines or from colliding with new power lines associated with wind farm development. Management and research are needed to reduce this new threat.

Collisions with Aircraft: One whooping crane was killed in June 1982 during a KC-135 tanker takeoff from Minot Air Force Base, North Dakota (Harrison 1983). Feather remains were identified by the Smithsonian Institute. Whooping crane collisions with aircraft are anticipated to be rare because of the small number of whooping cranes.

Pesticides: There is no evidence that pesticide contamination is a significant threat to whooping cranes. Whooping crane egg and tissue specimens examined for pesticide residues at PWRC have shown concentrations well below those encountered in most other migratory birds (Robinson et al. 1965, Lamont and Reichel 1970, Anderson and Kreitzer 1971, Lewis et al. 1992b). Eggshell thickness, a measure of contaminant exposure, has been measured in eggs taken from the wild and those in captivity from the 1970s to the present; no evidence of shell thinning has been detected. However, our knowledge of potential indirect or sublethal effects of pesticides on whooping cranes is inadequate and poorly understood. The baseline contaminant impacts research comes from research on other birds including sandhill cranes, but has never been done on whooping cranes. Contaminants could be impacting the FP, especially since some of the females in Florida have been found with improperly developed reproductive organs.

CONSERVATION MEASURES

Before the mid-1950s, a few significant events helped protect whooping cranes. The most important pieces of early protective legislation for whooping cranes were the Migratory Bird Treaty Act in the United States and the Migratory Birds Convention Act in Canada. These acts were ratified by the U.S. Congress on December 8, 1916, and by the Canadian Parliament on August 29, 1917. The Acts assured legal protection for migratory bird species in Canada and the United States and provided a basis for preventing the hunting of species requiring complete protection.

The significance of the establishment of WBNP in the Northwest Territories in December, 1922, was not realized until three decades later when the whooping crane nesting grounds were discovered there (Allen 1956). WBNP is a vast boreal forest and muskeg area (4,288,542 ha) designated by the Canadian government (Raup 1933) as a preserve and management area for the wood bison (*Bison bison athabascae*). The portion of the Park occupied by nesting whooping cranes is primarily located northwest of the intersection of the boundaries of Saskatchewan, Alberta and the Northwest Territories (Kuyt 1978b). The location of the crane summering grounds allows them to be protected by provincial and territorial wildlife acts as well as the National Parks Act. The breeding grounds also are designated as a Wetland of International Importance by the RAMSAR Convention and are an Important Bird Area in Canada. Some of the Canadian prairie wetlands used regularly by migrating whooping cranes have received

protection as Migratory Bird Sanctuaries, National Wildlife Areas (NWA), or under the Saskatchewan Wildlife Habitat Protection Act. Also, several stopover areas are designated as Important Bird Areas in Canada.

ANWR, purchased for $463,500 for the Bureau of Biological Survey's refuge program, was established in 1937 to protect the whooping crane and other wildlife of coastal Texas (Stevenson and Griffith 1946, Howard 1954). Leroy Denman (San Antonio Loan and Trust) retained mineral rights. These rights included a clause that used oil and gas royalties to refund to the government the entire purchase price of the refuge. The Refuge includes 22,148 ha of Blackjack Peninsula and adjacent properties, and provides essential wintering habitat for whooping cranes. Matagorda Island (44,606 ha of State and Federal ownership) is managed in conjunction with ANWR. Adjoining bay waters (5,236 ha) surrounding the Blackjack Peninsula, known as the Proclamation Boundary, were closed to hunting of migratory birds by Presidential Proclamation in 1938 for additional protection.

In the U.S., the whooping crane was listed as threatened with extinction in 1967 (Fed. Reg. Vol. 32, Number 48, March 11), and as endangered in 1970 (Fed. Reg. Vol. 35, Number 199, October 13). Both of these listings were "grandfathered" into the Endangered Species Act of 1973 (U.S.C., 1531-1 543; 87 Stat. 884), which resulted in establishing the U.S. Whooping Crane Recovery Team and facilitated further conservation actions on behalf of the species.

In 1974, the Canada Wildlife Act authorized the federal government to conduct research on endangered species. In 1976 the Committee on the Status of Endangered Wildlife was established and the whooping crane was designated as endangered in 1978 (Edwards et al. 1994). The Species at Risk Act was proclaimed in Canada in 2003, which designated the whooping crane as endangered and provided for additional protection for cranes and their habitat.

In April, 1985, Bert Tetreault, Director General of the CWS, and Robert A. Jantzen, Director of the USFWS, signed an MOU entitled *Conservation of the Whooping Crane Relating to Coordinated Management Activities* (Lewis 1991). The MOU provides a more formal structure to the cooperative working relationships that have characterized these 2 nations' joint efforts in management and research of whooping cranes. Under the new agreement, each Service appointed an employee to be responsible for inter- and intra-national coordination of whooping crane management and research. The MOU discusses disposition of birds and eggs, postmortem analysis, population restoration and objectives, new population sites, international management, recovery team, recovery plans, and consultation and coordination. The MOU was renewed in April, 1990, again in October, 1995, and August, 2001. The current MOU was signed by the USFWS, USGS, CWS, and Parks Canada.

A plan for *Federal-State Cooperative Protection of Whooping Cranes* was approved in 1985 and is updated periodically by the USFWS and 13 States where whooping cranes occurred (Lewis 1992). The CWS and 3 Canadian provinces approved the *Federal-Provincial Cooperative Protection of Whooping Cranes* in 1987 (Cooch et al. 1988). The plan describes response options when whooping cranes are observed in hazardous situations due to avian disease outbreaks, environmental contaminants, or hunting activities, or when whooping cranes are found injured, sick, or dead. Plan objectives are to provide added protection to whooping cranes, especially during migration, and to increase the opportunities to recover and rehabilitate birds found injured or sick.

Sportsmen and other conservationists have played a crucial role in protecting wetlands used by whooping cranes throughout the whooping crane migration corridor crossing 2,500 miles of North America. Duck Stamp funds have helped protect numerous acres of wetlands used by the cranes. Many sportsmen turn in whooping crane sighting reports to the monitoring network. Sport hunting programs help disperse waterfowl concentrations, reducing the threat of waterfowl disease outbreaks that can affect whooping cranes, and reducing instances of waterfowl crop depredation problems that arise. State hunting programs cooperate to protect whooping cranes by providing educational materials to hunters to help them identify whooping cranes, and by implementing hunting closures where necessary. (For more information on conservation measures, see Appendix C).

Critical Habitat – United States

Critical habitat is defined in the U.S. Endangered Species Act as habitat that contains those physical or biological features, essential to the conservation of the species, which may require special management considerations or protection. Critical habitat in the U.S. was designated in 1978 (43 FR 20938-942). Critical habitat is in effect for 5 sites in 4 states. A proposal for additional areas in the Central Flyway to be listed as critical habitat published in March, 1979, (44 FR 12382-384) was later withdrawn.

Wintering Grounds: ANWR and vicinity, Texas (Fig. 4), has been designated as critical to the conservation of the species. At ANWR, the listing of critical habitat has been extremely important in protecting habitat along the GIWW.

Migration – United States: Cheyenne Bottoms State Waterfowl Management Area and Quivira NWR, Kansas; the Platte River bottoms between Lexington and Denman, Nebraska; and Salt Plains NWR, Oklahoma, have been designated as critical to the conservation of the species.

Potential Critical Habitat - Canada

Critical habitat is defined in the Species at Risk Act as "…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species." Critical habitat in Canada is officially designated upon publication of a final SARA Recovery Strategy or Action Plan on the SARA Public Registry**.** The location and extent of critical habitat is subject to change pending new information as identified in the National Recovery Strategy for the Whooping Crane in Canada.

Breeding Grounds: Potential critical habitat in WBNP includes suitable marshes within the northeast corner of the park bounded by the Little Buffalo River to the east and south; the north boundary of the park from the Little Buffalo River to Territorial Highway #5; south along Highway #5 to 1140 West Latitude; and south at 1140 West Latitude to 600 North Longitude then southeast to the Little Buffalo River closest to Conibear Lake.

Potential critical habitat outside of WBNP includes suitable marshes adjacent to the northeast corner of WBNP bounded by the Buffalo River to the west, Highway 6 to the north, and the

Canadian Shield to the east. Additional habitat for recovery includes wetlands available for re-introductions in other areas and jurisdictions.

The majority of breeding habitat is located in WBNP (Olson and Olson 2003) and is protected under the Canada National Parks Act. The breeding grounds also were designated as a Wetland of International Importance by the Ramsar Convention and an Important Bird Area by BirdLife International. Because of these designations, the potential critical habitat is protected from a number of anthropogenic threats. It may be threatened however, by climate change that could result in more severe weather events including drought. Also, increasing atmospheric pollution may be a concern.

Expansion of the AWBP has led to breeding of whooping cranes outside of WBNP as predicted by Olsen and Olsen (2003), into adjacent areas of the Northwest Territories without formal protection. Land uses, such as forestry and agriculture, and activities, such as hunting, could cause disturbance or change the quality of habitat available for cranes. In these instances stewardship opportunities will be pursued with the appropriate land managers (DeWandel 2003). CWS and Parks Canada are currently investigating suitable unoccupied nesting habitat within WBNP and adjacent areas that may be necessary for the recovery of whooping cranes.

Migration – Saskatchewan Staging Area: During fall migration whooping cranes typically stop in south central Saskatchewan for several days or weeks. This area of Saskatchewan, which forms a diamond between Meadow Lake, Swift Current, Estevan, and the Quill Lakes, can be described as a staging area for whooping cranes. The cranes spend their evenings roosting in shallow wetlands, while their days are occupied with feeding in harvested agricultural fields, chiefly wheat and barley (Johns et al. 1997). Fall staging wetlands are primarily on private lands (85%) (Johns et al.1997). Few wetlands are used repeatedly from one year to the next since most staging wetlands are ephemeral and their availability to cranes fluctuates annually due to variations in precipitation. Preferred staging wetlands have the following characteristics: permanent (32%) or semi-permanent (53%) flooding; soft mud bottoms (83%); sizes from less than ½ ha to several thousand hectares; average roost site water depths of 13 cm (SD 7.5); and roost site locations within 2 km of suitable feeding areas (agricultural fields), and over 1 km from human habitation (Johns et al. 1997). Large wetlands with a secure water supply are extremely important as staging sites since they provide refuge when ephemeral wetlands are dry. Threats to the migration/staging habitat include land use changes such as drainage of wetlands.

The Last Mountain Lake and Stalwart National Wildlife Areas and the Last Mountain Lake Migratory Bird Sanctuary are used repeatedly by cranes and are potential critical habitat for the survival and recovery of the species. These habitats are already protected under the Canada Wildlife Act and the Migratory Birds Convention Act.

The South Saskatchewan River and its sandbars between Outlook and Saskatoon and the North Saskatchewan River between the Maymont and Petrofka Bridges are potential critical habitat for the survival and recovery of the species. Currently there is no formal protection for this habitat; however, it is under the jurisdiction of the Province of Saskatchewan and stewardship agreements with the Saskatchewan Watershed Authority will be investigated.

Several wetland areas exhibit repeated use by whooping cranes and may be considered as potential critical habitat as well. These specific wetlands and adjacent smaller wetlands in the vicinity are: Midnight Lake, Witchekan Lake, Blaine Lakes, Radisson Lake, Buffer Lake,

Muskiki Lake, Quill Lakes, Kutawagan Lake, Luck Lake, Creelman Marsh, and wetlands near Tribune and Bromhead. Upland areas on provincial crown land associated with some of these and other known roosting sites for whooping cranes have already been protected under the Saskatchewan Wildlife Habitat Protection Act.

Due to the ephemeral nature of most prairie wetlands and their use by whooping cranes, it is difficult to predict which wetlands may be used by whooping cranes at any particular time. However, wetlands in the migration corridor that meet the criteria listed in Johns et al. (1997) may be used by whooping cranes at any time. Each of these wetlands may be critical to the survival and recovery of the species. At the present time these wetlands (including the bed, the bank, and the boundary) are under the jurisdiction of the Province of Saskatchewan and stewardship agreements with the Saskatchewan Watershed Authority will be investigated. Exceptions include wetlands that are wholly surrounded by a single land owner's property. In these instances separate stewardship agreements with individual landowners will be investigated.

Summary

Protective legislation, such as the Migratory Bird Treaty Act (US) and the Migratory Birds Convention Act (Canada) of the early 1900s, followed by the National Parks Act, Canada Wildlife Act, and Species at Risk Act in Canada and the Endangered Species Act in the US, has played a crucial role in raising awareness of the whooping crane's predicament and establishing the authority to implement conservation measures. As a species with particular breeding, wintering, staging, and migrating territories, the whooping crane has benefited directly from the designation of preserved areas, like the WBNP and ANWR, which provide habitat and wetland resources critical to supporting the whooping crane's complex life cycle. Critical habitat continues to be extremely important for the recovery of this species.

Research focusing on understanding whooping crane ecology, building whooping crane populations, and minimizing threats to the whooping crane has been an integral part of the whooping crane's recent history. In the 1970s and 1980s, efforts were focused on building and improving the productivity of the captive flocks, doing research on the AWBP and maintaining its growth, and trying to reintroduce an additional population into the wild. Second eggs were picked up from WBNP and used to increase captive populations and carry out a reintroduction in the western U.S. In 1993 and 2001, efforts began to reintroduce a non-migratory population in Florida and a migratory flock in the eastern U.S. Actions already completed or underway are covered in Appendix C. Continued work is needed to protect the AWBP from increasing threats from human population growth, development, and climate change, make the reintroductions a success, increase the size of the captive breeding flock, and maximize genetic diversity of all populations. Future actions needed to reach recovery are presented in Part II.

RECOVERY TEAM

The Canada/United States Whooping Crane Recovery Team consists of 5 representatives from Canada and 5 from the U.S. appointed by the CWS and the USFWS, respectively. The team, co-chaired by the whooping crane coordinators of the two countries, is responsible for making recommendations on actions needed to recover the species.

Whooping crane recovery teams were initially formed in 1975 in the U.S. and 1985 in Canada,

although ad hoc committees were in existence before that. Whooping crane coordinators were appointed in 1981 in Canada and 1984 in the U.S. In 1995, the separate recovery teams from both countries were joined as an international team. A Memorandum of Understanding (MOU) on the conservation of the whooping crane signed in 1985 and renewed periodically governs recovery actions that are outlined in a recovery plan written by the team.

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PART II. RECOVERY

The following section presents a strategy to recover the species, including objective and measurable recovery criteria and site-specific management actions to monitor and reduce or remove threats to the whooping crane, as required under section 4 of the ESA and under section 41 of the SARA. The Recovery Plan also addresses the five statutory listing/recovery factors (section 4(a)(1) of the ESA) and the short and long term goals of the SARA (section 41(1)(d)) to the current extent practicable, to demonstrate how the recovery criteria and actions will lead to removal of the whooping crane from the lists of Threatened and Endangered Species.

RECOVERY GOAL

The goal of this plan is to protect the whooping crane and its habitat, and allow the overall population to reach a level of ecological and genetic stability so that it can be reclassified to threatened status (downlisted). The ultimate goal is to recover the whooping crane and remove it from the lists of Threatened and Endangered Species (delist).

RECOVERY STRATEGY

The recovery strategy involves: protection and enhancement of the breeding, migration, and wintering habitat for the AWBP to allow the wild flock to grow and reach ecological and genetic stability; reintroduction and establishment of self-sustaining wild flocks geographically separate from the AWBP to ensure resilience of the species to catastrophic events; and maintenance of a captive breeding flock to protect against extinction.

Implementation of recovery actions will continue to reduce existing threats (habitat loss and degradation, disease, mortality from power lines, loss of genetic diversity), as well as new threats that may arise. Because of the limited range of the AWBP in both summer and winter (i.e., pioneering new habitat is limited to areas adjacent to existing use areas), efforts have been initiated to reintroduce a second population in Florida and a third population in eastern North America. These additional populations provide protection against extinction of the species in the wild, in the event that a catastrophic event impacts the AWBP, or if that flock begins to decline in size. These reintroduced populations must be geographically isolated from the AWBP so that potential negative influences of the captive-raised birds do not impact the AWBP. Negative factors could include disease transmission and behavioral differences, including vocalizations. Further, reintroduced populations listed as experimental nonessential under Section 10(j) of the ESA are required to be geographically distinct from existing wild populations.

In order to be genetically viable over the long-term, the whooping crane population must be large enough so that creation of new alleles through genetic mutation will offset the loss of genetic material in a small population. Growth of the AWBP and the two reintroduced populations is expected to increase numbers to a level at which the population should not lose any more genetic material. However, the effective population size (N_e) required to maintain genetic viability over the long term needs to be calculated.

RECOVERY POTENTIAL AND RATIONALE

The inherent capacity of whooping cranes to rebound demographically is low due to delayed sexual maturity (age 3-4 years) and a low reproductive rate (2 eggs in the annual nesting attempt

with only 1 chick typically fledging). Furthermore, given the many threats to breeding, migration, and wintering habitat, it is unlikely the whooping crane will ever become abundant. Nevertheless, if breeding pairs are protected from excessive mortality, a breeding pair's breeding experience and longevity can compensate for low reproductive rate. As nesting pairs gain experience, they become more successful in rearing chicks. At the same time, cranes can reproduce over a relatively long lifetime: 3 to 5% are predicted to live and remain productive beyond age 30 years (Mirande et al. 1993).

Threats to whooping cranes have been alleviated to a degree sufficient to allow an average annual growth of 4.5% for a half century in the AWBP. Some power lines are being marked to make them more visible, a technique shown to reduce sandhill crane collisions with power lines (Morkill 1990, Morkill and Anderson 1991, Brown and Drewien 1995), which would also help reduce whooping crane mortality. The Cooperative Protection Plans implemented by provincial, state, and federal agencies are believed to reduce losses to shooting and disease (Lewis 1992). Erosion losses of critical winter habitat along the Gulf Intracoastal Water Way have been reduced significantly through the use of concrete matting (Zang et al. 1993, Evans and Stehn 1997). Dredged material has been used to create winter habitat (Evans and Stehn 1997). Thus the whooping crane has responded positively to some conservation efforts.

The present nesting habitat at WBNP may not be as productive as the major historical nesting wetlands in the prairie grasslands (Brian Johns, CWS, pers. comm.). However, WBNP provides suitable protected nesting habitats that have supported population recovery from 3 or 4 adult pairs in 1941 to 73 adult pairs in 2005. Sufficient migratory stopover habitat is available to support the present population and numbers likely to be attained in the near future. Winter habitats at Aransas are presently sufficient to support at least 500 individuals (Tom Stehn, ANWR, pers. comm.). Uncertainty remains concerning possible long-term declines in ecosystems used by the cranes as a consequence of expanding human populations and their demands for fresh water, housing, recreation, agricultural production, and industrial products. Some of the prime historical grassland nesting habitat could be restored in southern Canada and the northern United States. However, such actions would be costly and would require purchase of large land blocks and restoration of wetlands.

Based upon overall habitat availability, a positive growth rate, success in captive breeding, and effective conservation measures, the potential for continued survival of the species and ultimate recovery is good. Average annual population growth in the AWBP was 4.5% from 1938-1991. Based on this growth rate, Mirande et al. (1993) projected the AWBP population to reach 500 individuals within 17 years, with no measurable probability of extinction over 100 years. Currently, 5 captive flocks, those at CZ, ICF, PWRC, SSC, and SAZ are producing offspring. Captive production has been sufficient to provide 289 birds for the non-migratory reintroduction experiment in Florida since 1993. In 2001, another reintroduction using captive-produced young was initiated in the eastern U.S with Wisconsin as the proposed nesting area and western Florida the wintering site. Continued conservation of this species will require vigilant management and the interest and concern of an informed public. Therefore, an important component of this Plan is its focus on outreach and education.

DOWNLISTING RECOVERY OBJECTIVES AND CRITERIA

This plan sets forth 2 primary objectives and measurable criteria that will allow the species to be reclassified to threatened (downlisted). These numerical population criteria can only be achieved if threats to the species are sufficiently reduced or removed, i.e., the population criteria are a benchmark for threat reduction. Specific actions to reduce these threats are addressed in the narrative outline (page 55) and are cross-referenced with the listing factors (page 53). Due to the length of time expected to reach downlisting goals and current information gaps in our knowledge of the species, it is not feasible to establish delisting objectives and criteria at this time. Recovery plans undergo periodic revisions, and if appropriate, delisting criteria will be added at that time. This recovery plan provides recovery actions that will enable us to fill information gaps and determine delisting criteria in the future.

Objective 1 – Establish and maintain self-sustaining populations of whooping cranes in the wild that are genetically stable and resilient to stochastic environmental events.

> **Criterion 1 –** Maintain a minimum of 40 productive pairs in the AWBP for at least 10 years, while managing for continued increase of the population. Establish a minimum of 25 productive pairs in self-sustaining populations at each of 2 other discrete locations.
>
> A productive pair is defined as a pair that nests regularly and has fledged offspring. The two additional populations may be migratory or non-migratory. Multiple populations provide protection against stochastic, catastrophic events in nature. A single wild population remains vulnerable to extinction during singular, or a series of, adverse events, regardless of its size.
>
> Population targets are 160 in the AWBP, and 100 each in the Florida non-migratory population and the eastern migratory population. These targets are consistent with a population viability assessment of what is needed to maintain genetic variability for the population (see Appendix A). All 3 populations must be self-sustaining for a decade at the designated levels before downlisting could occur. A self-sustaining population is defined as a stable or growing population that is not supplemented with any additional reintroductions from captivity.
>
> The AWBP has been maintained at above 40 productive pairs since 1992; however, additional populations are not yet self-sustaining. An alternative criterion may be applied for downlisting in the event that attempts to establish additional self-sustaining populations do not succeed.
>
> **Alternative Criterion 1A** – If only one additional wild self-sustaining population is re-established, then the AWBP must reach 400 individuals (i.e. 100 productive pairs), and the new population must remain above 120 individuals (i.e. 30 productive pairs). Both populations must be self-sustaining for a decade at the designated levels before downlisting could occur. This alternative is based on the principle that with the re-establishment of only one additional population separate from the AWBP, then crane numbers must be higher in both populations than if there are three distinct populations.

Alternative Criterion 1B - If establishment of second and third wild self-sustaining populations is not successful, then the AWBP must be self-sustaining and remain above 1,000 individuals (i.e. 250 productive pairs) for downlisting to occur. The *Memorandum of Understanding on Conservation of Whooping Cranes*, approved by Canadian and U.S. federal officials, recognizes a goal of 1,000 individuals in the AWBP population. This higher number ensures a better chance for survival of the AWBP in the event of a catastrophic event within its extremely limited range. The target of 1,000 is reasonable for downlisting given the historical growth of the AWBP and theoretical considerations of minimum population viability. To ensure sufficient genetic variability, the AWBP must increase to the level where the creation of new alleles through genetic mutation will offset the loss of genetic diversity. After reaching the goal of 250 pairs, the population should gain genetic variation faster than the population loses genetic material.

Objective 2 – Maintain a genetically stable captive population to ensure against extinction of the species.

Criterion 2 - Maintain 153 whooping cranes in captivity (21 productive pairs). Genetic analysis suggests that 90% of the genetic material of the species can be maintained for 100 years at this population size (Jones and Lacy 2003). To achieve this, this Plan recommends having 50 captive breeder pairs of whooping cranes by 2010, including 15 pairs at PWRC, 12 at ICF, 10 at CZ, 10 at SSC, and 3 at SAZ. A breeder pair (as differentiated from a productive pair) is defined as a pair that breeds or is intended to breed in the future. Production from CZ, ICF, PWRC, SAZ, and SSC will be the principal source of birds for release to the wild for reintroduced populations. However, sources of release birds should be based on the optimal genetic mix to ensure long-term population viability.

DELISTING CRITERIA

It is not feasible to establish well-defined objectives and criteria for delisting at this time. The extremely endangered status and the slow reproductive rate of the species dictate that considerable time will be needed to reach downlisting goals. Considering the historic slow growth of the AWBP and the challenges of reintroducing populations, downlisting is unlikely to be reached before year 2035. It is unrealistic to predict the environmental conditions and threats to the species that will prevail at that time. New threats are expected to manifest and will have to be overcome before downlisting occurs. Additional information is also needed regarding the conservation biology of small populations, including impacts of stochastic and catastrophic events on survival. For whooping cranes, the effective population size (N_e) required to maintain genetic viability over the long-term needs to be calculated. Appendix A provides detailed information on genetic issues and conservation of small populations.

De-listing criteria will require the establishment of a population target with a high level of confidence. Without knowledge of a minimum population size needed to ensure species survival, it would be unreasonable to provide delisting criteria. Current estimates of the population needed to ensure survival range widely between 1,000 and 7,000 and would provide little confidence if a specific numerical target for delisting were set at this time. With additional knowledge regarding the dynamics and long-term survival of small populations, numerical population targets can be set to remove the whooping crane from the List of Threatened and Endangered Species. Recovery action 4.0 addresses the need for this information.

New information gathered through recovery actions will be incorporated into additional population viability analysis as the population approaches its downlisting goals. Delisting criteria will be established at that time, and the overall recovery strategy and actions will be revised as appropriate. Future revisions of this recovery plan are anticipated, and a delisting goal for the species will be set prior to downlisting anticipated in 2035.

2003 SARA RECOVERY OBJECTIVES

In Canada, the 1978 COSEWIC designation of the whooping crane as endangered did not include a formal list of recovery objectives and actions later required under section 41(1)(d) of the 2003 SARA. The section below describes the recovery objectives and actions proposed and/or underway.

SHORT-TERM RECOVERY OBJECTIVES

Objective 1: The short-term recovery objective of 40 productive pairs in the AWBP for 10 consecutive years has been met. To reach the long-term recovery goal of 1000 birds in North America by the year 2035 the AWBP needs to increase to 240 individuals and 70 productive pairs by 2010.

Objective 2: Increase the captive populations to 45 breeding pairs by 2010.

Objective 3: Increase FP to 100 individuals and 10 productive pairs by 2010. Establish a third population containing 80 adults by 2010.

Objective 4: Analyze banding data and determine the N_e/N ratio for the AWBP.

Objective 5: Promote education of whooping crane recovery through innovative media technologies.

LONG-TERM ACTIONS NEEDED

1. Continue to build the AWBP and protect and manage its habitat to minimize the probability that a catastrophic event will eradicate this population.

2. Attain breeder pair and productivity goals at 4 captive facilities in the United States and 1 in Canada to produce the birds required for reintroductions. Continue research to improve production of captive flocks.

3. Establish 2 additional self-sustaining wild populations separate from the AWBP. Continue research to identify appropriate reintroduction sites and improve reintroduction techniques. Protect and manage habitat of reintroduced populations.

4. Continue to use genetic information and advances in conservation biology to effectively manage flock genetics and determine N_e and revise criteria as warranted.

5. Maintain an information/education program.

REDUCTION OR ALLEVIATION OF THREATS TO WHOOPING CRANES THROUGH IMPLEMENTATION OF RECOVERY ACTIONS

The following section describes recovery actions proposed or underway for recovery of the whooping crane and identifies the tasks in the Recovery Outline in Part III that specifically address threats to the whooping crane as they relate to the 5 listing factors.

Listing Factor A: The present or threatened destruction, modification, or curtailment of a species habitat or range

Habitat destruction and curtailment of the species' range are addressed in Tasks 1.1 – 1.54 through: population and habitat monitoring on the breeding, migration, and winter grounds; reduction of collision and disease mortality; public education to prevent accidental shooting; habitat protection and management; and monitoring and regulation of specific threats and impacts such as chemical spill, coastal erosion, dredging, changing salinity from water withdrawal, and changes in in-stream flows. Establishment of two additional wild populations (Tasks 3–3.4) also addresses this threat through augmentation of the current population and expansion of whooping crane range in historical habitats. Development and maintenance of a captive population (Tasks 2–2.4) provides protection against extinction in the wild and produces birds for reintroduction to the wild.

Listing factor B: Overutilization for commercial, recreational, scientific, or educational purposes

Task 1.3.1 addresses prevention of accidental shooting of whooping cranes. Tasks 1.4–1.4.2 address protection from disturbance. Tasks 5.1-5.3 address public education regarding whooping cranes.

Listing Factor C: Disease and predation

Disease and predation are important factors in population dynamics of whooping cranes. Diseases such as avian tuberculosis have been documented in the AWBP, and both West Nile virus and H5N1 avian influenza virus are emerging new threats of unknown proportion to both captive and wild populations. Disease research and management are needed to reduce this risk (Tasks 1.3.2, 2.3.4).

Predation is a significant source of mortality of flightless chicks in WBNP and of reintroduced populations in Florida. Efforts must be taken to reduce predation where practical, especially in the reintroduced populations (Tasks 1.3, 3.1).

Listing Factor D: The inadequacy of existing regulatory mechanisms

The CWS and the USFWS believe that the ESA, Migratory Bird Treaty Act, SARA, and NEPA provide an adequate legal framework for protection and conservation of the whooping crane and its habitat. However, as the human population continues to grow and development potentially impinges on whooping crane habitat, governments and their partners must not only fully utilize these regulatory tools, but continue to develop innovative and voluntary partnerships to protect whooping cranes throughout their 2,400-mile range (Tasks 1.3 -1.3.3; 1.4 – 1.4.3; 1.5 – 1.5.5).

Listing/Recovery Factor E: Other natural or human-caused factors affecting its continued existence

The primary source of mortality for fledged AWBP whooping cranes is collision with power lines. This threat needs to be analyzed and actions developed to minimize losses (Task 1.3.3). Collisions with fences and other man-made objects such as towers also need to be reduced (Task 1.3.3).

Although accidental shootings are believed to cause a low percentage of whooping crane mortality, Federal and State agencies need to continue to educate hunters to minimize and/or eliminate all such take (Tasks 1.3.1, 5, 5.1). "Take" in the form of harassment is a threat primarily in winter as human uses of salt marshes increase (fishing, hunting, bird watching, nature photography) as the human population continues to grow (Tasks 1.4, 1.4.1, 1.4.2). Current restriction of aircraft flights over summer and winter habitat is successfully reducing disturbance (Task 1.4.2). The loss of genetic diversity can only be overcome as population numbers increase to the level where the creation of new alleles through mutation will offset its past, current, and future losses in genetic diversity (Tasks 2-2.2, 3-4.1).

RECOMMENDED SCALE FOR RECOVERY ACTIONS

Recovery plans are usually produced for individual species. However, habitat management recommendations in recovery plans often affect numerous wildlife species. Recommendations in this plan range from specific objectives for crane management to larger scale habitat objectives. For example, habitat restoration in the Platte River Valley of Nebraska benefits other endangered species as well as other water birds. Consequently, recovery activities described within this plan are integrated with larger-scale recovery efforts wherever possible.

ANTICIPATED CONFLICTS OR LOGISTICAL DIFFICULTIES

There are no unique conflicts or logistical difficulties that can be identified at the present time. There will continue to be challenges of the type that impede new research and untested recovery techniques. Funding is always a potential constraint in implementing recovery actions. Competition for government and private sources of funding is increasing at the same time as are some threats to whooping cranes, including human population growth, development, and climate change. In addition, the large size and opportunistic use of the migration corridor used by whooping cranes precludes providing full protection during migration. Because recovery plans are advisory rather than regulatory in nature, implementation of the recovery actions will depend upon the commitment of governments and many dedicated partners on both sides of the border.

POTENTIAL IMPACTS FOR OTHER SPECIES/ECOLOGICAL PROCESSES

In general, preservation and management of crane habitats will benefit those species that already inhabit such sites. For example, protecting freshwater inflow into coastal areas will benefit all native coastal species. A possible exception may be predator control (e.g., alligator, bobcat, wolf, fox, raven, and coyote) if it should become necessary in nesting or winter habitats in the initial stages of reintroduction. A few bobcats and alligators have been removed from reintroduction sites in Florida. Hunting seasons for whooping crane look-alike species may be affected by the presence of whooping cranes. These issues are discussed in THREATS AND REASONS FOR LISTING – Shooting.

OUTLINE OF RECOVERY ACTIONS TO ACHIEVE OBJECTIVES

1. Increase the AWBP

1.1. Monitor population numbers, including annual recruitment and mortality.

1.1.1. Conduct aerial surveys in WBNP to determine distribution, productivity, recruitment and mortality.

1.1.2. Analyze data on egg management and develop a strategy to maximize size of the AWBP. Develop management options regarding egg manipulation.

1.1.3. Conduct aerial surveys at ANWR to determine total population numbers, movements, territories, habitat use, and mortality.

1.2. Monitor movements in migration.

1.3. Reduce mortality.

1.3.1. Prevent shooting.

1.3.2. Diminish losses to disease.

1.3.3. Reduce collisions/mortality.

1.4. Restrict detrimental human activities.

1.4.1. Restrict construction periods.

1.4.2. Restrict aircraft altitude.

1.4.3. Restrict other disturbance.

1.5. Identify, protect, manage, and create habitat.

1.5.1. Identify essential habitat.

1.5.2. Measure food resources in summer, winter, and during migration.

1.5.2.1. Monitor habitat in WBNP, including water levels and crane foods. Expand the surface-water monitoring network to measure water level fluctuations and their effect on nesting success. Define specific factors that impact cranes in relation to water levels in WBNP.

1.5.2.2. Monitor food resources and salinities at ANWR and relate these to energy budgets of the cranes and winter mortality. Hire a technician to carry out this task.

1.5.2.3. Complete measurement of availability of migration stopover habitat and monitor changes over time.

1.5.3. Protect habitat.

1.5.3.1. Maintain WBNP.

1.5.3.2. Ensure long-term protection of migration stopover sites.

1.5.3.3. Maintain ANWR and other NWRs.

1.5.3.4. Prevent contamination of habitat.

1.5.3.5. Prevent erosion of winter habitat at Aransas.

1.5.3.6. Better manage deposition of dredge material.

1.5.3.7. Maintain freshwater inflows.

1.5.3.8. Maintain appropriate in-stream flow.

1.5.3.9. Monitor global warming.

1.5.4. Manage habitat.

1.5.4.1. Manage fire.

1.5.4.2. Maintain upland water sources.

1.5.4.3. Manage vegetation.

1.5.5. Create wetland habitat.

2. Develop and maintain captive populations.

2.1. Develop more sensitive measures of genetic diversity.

2.2. Increase captive breeders.

2.3. Refine aviculture methods and productivity.

2.3.1. Refine breeding pair management.

2.3.2. Refine incubation procedures.

2.3.3. Refine rearing procedures for reintroductions.

2.3.4. Refine veterinary procedures.

2.3.5. Exchange aviculture information.

2.4. Maintain captive facilities.

3. Establish two additional wild populations.

3.1. Develop release techniques.

3.2. Evaluate and select release sites.

3.3. Establish a non-migratory population.

3.4. Establish a migratory population.

4. Determine N_e for species survival by analyzing banding data to determine the N_e/N ratio for the AWBP.

5. Maintain and expand information/education programs.

5.1. Develop media products.

5.2. Provide viewing opportunities.

5.3. Implement education programs.

NARRATIVE OUTLINE FOR RECOVERY ACTIONS TO ACHIEVE OBJECTIVES

1. Increase the AWBP

Reduce mortality and remove habitat constraints that might limit population recovery. The nesting and winter habitats appear to have potential to support substantially more than the 58 nesting pairs and the associated subadults and young-of-the-year present in 2005 (Johns 1998a, Brian Johns, CWS, pers. comm., Tom Stehn, ANWR, pers. comm.).

For those birds still identifiable by color marking, determine longevity and record movements in response to habitat changes. Identify pairs on summer and winter territories to determine adult survivorship and productivity by recording unison calls and analyzing sonograms as developed by Dr. Bernard Wessling. Measure chick survival in WBNP in relation to food supply, water levels, predation, and weather conditions. Analyze data to estimate population size, amount of habitat, and recruitment needed to achieve recovery goals. Develop management options by comparing mean annual population growth rates with and without egg manipulation practices. Periodically update the Population Viability Assessment as new data and improved models become available.

For the Central Flyway, develop a working group to address issues in the migration corridor. Issues would primarily include migration monitoring, collisions, shootings and other mortality factors, loss of habitat, or any needed recovery actions.

1.1. Monitor population numbers, including annual recruitment and mortality.

Conduct aerial population censuses on nesting and wintering areas to determine status and distribution. Nesting ground surveys will include: numbers of nests, location of territories, and clutch size (May); habitat conditions, nesting success, and chick survival (June); and habitat conditions and fledging (August). Weekly winter surveys will determine population size and number of juveniles, delineate territories, and detect mortality. Annual surveys of nesting and wintering areas should provide a record of each pair's annual productivity.

1.1.1. Conduct aerial surveys in WBNP to determine distribution, productivity, recruitment, and mortality.

Aerial surveys are currently conducted in May to find nests and determine number of eggs laid, in June to find out the number of chicks that hatched, and in August to count chicks that fledge.

1.1.2. Analyze data on egg management and develop a strategy to maximize size of the AWBP. Develop management options regarding egg manipulation.

Controlled scientific studies are needed on the effects of removing one egg from nests in WBNP.

1.1.3. Conduct aerial surveys at ANWR to determine total population numbers, movements, territories, habitat use, and mortality.

Flights are generally conducted weekly, fall to spring, at Aransas.

1.2. Monitor movements in migration.

Continue spring and fall migration monitoring to identify and map migration stopover habitat, and provide opportunities to protect birds from collisions with power lines, disease outbreaks, shooting, and to protect traditional migration stopover sites. Continue the whooping crane reporting network to document sightings. Develop a GIS database depicting all confirmed sightings categorized by state and by county that can be readily distributed to those whose management actions may affect migratory whooping cranes.

1.3. Reduce mortality.

Whooping cranes disappear due to unknown causes during most years. Spring and fall migration periods should receive emphasis to further diminish mortality of fledged birds (Lewis et al. 1992a). However, management actions need to be taken wherever they can effectively reduce mortality, regardless of relative rates of losses. Determine mortality factors, measure impacts, and carry out strategies to reduce losses. Aerial surveys on the nesting and wintering areas help detect losses and their causes. Determine mortality factors in WBNP and ANWR on adults and chicks and develop strategies to increase survival. Utilize satellite telemetry to determine causes of most mortality occurring during migration. Develop methods to address mortality factors not considered in subtasks below.

1.3.1. Prevent shooting.

Federal, provincial, and state wildlife agencies should continue to follow and update contingency plans for protection of whooping cranes that appear in hunt areas or other hazardous situations. Continue to work with provincial and state agencies to minimize conflicts between sport hunting and whooping cranes. Continue education programs, including identification brochures, videos, and DVDs, to increase competency of the public (e.g. hunters) for identifying whooping cranes and their protected status. Create a web site that offers an identification guide for whooping cranes and look-alike species. Continue public outreach programs to prevent shootings and inform the public of the need to report sightings.

1.3.2. Diminish losses to disease.

Develop methods of disease prevention, detection, and treatment for avian tuberculosis, infectious bursal disease (IBD), West Nile virus (WNV), Eastern Equine Encephalitis (EEE), and parasites. When possible, prevent whooping crane use of areas where waterfowl disease outbreaks are underway or have recently occurred. The Contingency Plan for Cooperative Protection of Whooping Cranes updated in 2006 covers response to disease incidents. Response will be directed by the Canadian Cooperative Wildlife Health Centre (CCWHC) in Canada and the National Wildlife Health Center (NWHC) in the United States. Disease research will determine where prevention and control methods should be directed, and whether control will involve site modification, inter-specific separation, individual prophylaxis, or a combination of responses. The Whooping Crane Health Advisory Team (WCHAT) will continue to provide advice and recommendations to the Recovery Team on all health issues. Captive breeding centers should formulate contingency plans using professional standards including quarantines to deal with an

outbreak of H5N1 avian influenza in their nearby vicinity that has spread exponentially in recent years.

1.3.3. Reduce collisions/mortality.

Collisions with power lines and fences are a frequent cause of death or injury. Use telemetry to locate areas receiving high crane use where power lines are a significant problem.

Monitor the placement and design of all new power lines in areas of known crane use. When possible, bury new power lines or route around areas frequently used by whooping cranes making low-level flights. Mark existing problem lines or modify fences to reduce collisions. Remove unnecessary fences and power lines from traditional stopover sites, Critical Habitat, National Wildlife Areas, National Wildlife Refuges, and National Wetland Areas used by cranes. Barbed wire fences should be of no more than 3-strand design. Visibility should be maximized on any existing structures or those, which of necessity, must be constructed in whooping crane use areas or flight routes by following USFWS and/or CWS guidelines to reduce bird strikes.

The USFWS has issued interim guidelines for recommendations on communication tower siting, construction, operation, and decommissioning. If communication equipment cannot be co-located on existing towers and a new tall tower is built requiring guy wires, the wires should have visual markers in place to reduce bird strikes. If possible, towers should be kept less than 61 m in height with a larger tower base and no guy wires. Tower lights for aviation safety should have flashing white strobe lights rather than continuous lighting. If guy wires are unavoidable, the wires should be marked. The Recovery Team should stay in contact with the Avian Power Line Interaction Committee to stay appraised of new developments in collision reduction.

The USFWS proactively should engage with the utility industry to address the potential threat from construction of wind turbines. Until more research is done to assess bird mortality, wind farms should not be constructed within the primary whooping crane migration corridor due to the unknown threat they pose.

1.4. Minimize disturbance from human activities.

Cranes need to be protected from disturbance, especially in migration and on wintering areas. Disturbance can result from activities such as petroleum exploration, mining, hunting, fishing, bird watching, and boat and airplane traffic. The cumulative effect on cranes should be evaluated. Sources and intensity of disturbance are expected to increase in the future. Human activities should be monitored and regulated wherever they cause problems for the cranes.

1.4.1. Coordinate construction projects with periods when cranes are absent.

Conduct seismic exploration, drilling, pipeline activity, dredging, and other development or construction activities within or near migration and wintering habitat only when cranes are absent. Accomplish scheduling through federal, provincial, and state permitting procedures and by agreement with the company or agency involved.

1.4.2. Restrict aircraft altitude in sensitive areas.

An altitude restriction of 610 m minimum, required by Canadian and U.S. regulations over nesting and winter habitat, is particularly important in regulating helicopter flights. Biological survey flights, research, and emergency situations, including unusual weather conditions, should be the only exceptions to these restrictions.

1.4.3. Restrict other disturbance.

Human activities in crane areas on the wintering grounds include bird watching, hunting fishing, commercial crabbing, and boat traffic. Levels of activity need to be monitored and controlled when found to be detrimental to the cranes.

1.5. Identify, protect, manage, and create habitat.

Determine availability of suitable habitat for breeding, staging, migrating, and wintering, including spatial needs and territories of an expanding population.

1.5.1. Identify essential habitat.

Suitable breeding habitat that is currently unoccupied by whooping cranes should be identified. Complete the mapping of these habitats using available satellite imagery. Evaluate the potential of Northwest Territories and Alberta summer habitats to support a population of 1,000 birds.

Additional study is needed to delineate areas that are important to migrating whooping cranes. Utilize satellite telemetry to identify additional stopover sites. Describe the unique characteristics of such habitat. Solicit reports and record sightings of whooping cranes by qualified observers. Identify food and water requirements of an expanding crane population in nesting, migration, and winter habitats. Investigate spatial needs of nesting and wintering adult pairs, family groups, and subadult groups to understand territorial defense behaviors that influence habitat requirements.

1.5.2. Measure food resources in summer, winter, and during migration.

The food base for cranes on sites utilized by cranes and areas not utilized should be sampled. Describe the food complex that seems attractive and supports crane needs. Relate this information to the evaluation of the ability of summer and winter habitats to support 1,000 whooping cranes. Obtain more information on blue crab populations in the crane marshes at Aransas. The food needs and energetics of whooping cranes during migration should be studied.

1.5.2.1. Monitor habitat in WBNP, including water levels and crane foods.

Expand the surface-water monitoring network to measure water level fluctuations and their effect on nesting success. Define specific factors that impact cranes in relation to water levels in WBNP.

1.5.2.2. Monitor food resources and salinities at Aransas and relate to energy budgets of the cranes and winter mortality.

Availability of food should be studied and related to crane behavior and energetics at Aransas. Hire a technician to carry out this task.

1.5.2.3 Complete studies of availability of migration stopover habitat and monitor changes over time.

A project to quantify suitable stopover habitat needs to be completed for the entire migration corridor and changes monitored over time.

1.5.3. Protect habitat.

The majority (90%) of the whooping crane population nests within WBNP. In 2005 six pairs of whooping cranes nested outside the boundaries of WBNP. As the population grows, more birds will begin to nest outside the park. Identify, map, and protect additional breeding habitat adjacent to WBNP.

Ensure long-term protection of migration stopovers sites, including staging areas in southern Saskatchewan and traditional stopovers along the Platte River, Nebraska. Ninety-five percent of the stopover sites in Canada are in private ownership (Johns et al. 1997). Work with landowners to ensure that habitat remains suitable for cranes. Several traditional stopover areas along the migration route in the United States have been designated as critical habitat. Identify, map, and protect additional important migration stopover areas. Pursue needed protection of stopover sites, including obtaining stewardship agreements and/or conservation easements. Conservation of stopover habitat should primarily focus on providing wetland mosaics (Richert et al. *In press*). Complete analysis of whooping crane habitat availability in Kansas and Texas.

Protection is also needed for winter habitat required to accommodate an expanding crane population on public and private lands. The threat of increasing human population growth, activities, and development that may be detrimental to the cranes and their habitat should be lessened or alleviated in these areas. In most instances, protection would not significantly alter current uses. Where non-refuge lands are involved, work with landowners/managers to ensure that habitat remains suitable for cranes. When necessary purchase fee title or conservation easements from voluntary sellers all essential marshes used by whooping cranes during winter. Study range expansion at ANWR and provide protection, including conservation easements, on areas that a larger whooping crane population will occupy. Complete protection for 100 hectares of salt marsh and adjacent uplands on the Johnson Ranch located on Lamar Peninsula. The area used historically for wintering along the Texas coast, including ANWR and Matagorda Island, has been declared critical habitat under the ESA. With the population wintering in a larger area, 8 crane territories were located outside critical habitat in the 2004-05 winter. With full public input, evaluate the need to expand critical habitat boundaries at ANWR and in the migration corridor to ensure protection of all important U.S. whooping crane habitats.

1.5.3.1. Maintain WBNP.

Effective management and research is needed on the wintering grounds to maintain the quality of crane habitat at WBNP. Long-term studies are needed to detect and address any detrimental changes from climate change or other causes.

1.5.3.2. Ensure long-term protection of migration stopover sites.

Work with landowners to ensure migration habitat remains suitable for cranes. Pursue stewardship agreements and conservation easements when needed, focusing on providing wetland mosaics.

1.5.3.3. Maintain ANWR.

Effective management and research is needed on the wintering grounds to maintain the quality of crane habitat at Aransas. Issues including freshwater inflows, development, and sea level rise all threaten the long-term suitability of coastal ecosystems.

1.5.3.4. Prevent contamination of habitat.

Preventive measures range from efforts to minimize existing damage to the long-range efforts to reduce the potential for contamination of habitat. Work with resource agencies in Texas to ensure that pollution is minimized during the rapid population and industrial growth that is occurring. Work with the Coast Guard and marine transportation industry to reduce the risk of chemical spills. Whooping crane protection should be specified explicitly in contaminant spill contingency plans which involve state, federal, and provincial agencies, along with local oil spill control groups, in efforts to contain and clean up leaks and spills which could impact whooping crane habitat. Ensure that response personnel are sufficiently trained and equipped.

The USFWS should coordinate with the appropriate regulatory agencies in all aspects of the oil and gas industry within whooping crane habitat. Encourage responsible agencies to inspect facilities to see that they conform to regulations and, if needed, to modify regulations to provide protection for cranes. For example, Quivira NWR is an important stopover site for migrating whooping cranes. The refuge contains numerous oil and gas wells where spills could occur. However, each production site is surrounded by a containment levee to ensure site protection if an accident occurs.

Screening for the presence of contaminants in habitats used by whooping cranes including known food items should be carried out periodically. More research is needed on the potential indirect or sublethal effects of pesticides on whooping cranes.

1.5.3.5. Prevent erosion of winter habitat at Aransas.

Erosion structures need to be monitored and maintained to remain effective. Other winter crane use areas need to be monitored for erosion.

1.5.3.6. Better manage deposition of dredge material.

Permit applications for dredging projects should be reviewed carefully and modified if they are incompatible with whooping crane management objectives. Solutions include

re-use of existing disposal sites, by removal of dredged material after it dries, and barging or pumping of dredged material to sites away from the marsh. Continue experiments to create new crane marsh habitat with dredged materials. Implement the USACE 50-year Dredge Material Plan, which calls for creation of 654 ha of marsh at 11 sites. Continue research as part of the plan and modify as needed to maximize benefits to whooping cranes.

1.5.3.7. Maintain freshwater inflows.

Human withdrawal of water from the Guadalupe and San Antonio Rivers and the Edwards Aquifer threatens productivity of marshes and bays at Aransas. Through consultation and management, agencies must ensure that stream flows are maintained to continue productivity of the Texas bay systems used by whooping cranes. Inflows on the Mission/Aransas watershed also potentially affect critical habitat. Future expansion of the flock northwards could make inflows critical on the Lavaca/Navidad Rivers.

1.5.3.8. Maintain appropriate in-stream flow.

Maintain suitable stopover habitat on the Platte River, Nebraska, and the South Saskatchewan River, Saskatchewan, and on other rivers used by migrating cranes, by ensuring adequate flows that provide quality roosting riverine and wet meadow habitats. These flows are necessary for scouring invading cottonwoods and willow from the riverbed. Purchase or lease of lands bordering key roosts may be necessary to protect the sites from human disturbance and to provide wet meadow habitat that supplies an important source of protein for whooping cranes.

1.5.3.9. Monitor global warming.

The potential for sea level rise and climate change related to global warming should be monitored to address possible impacts to whooping crane habitat. Research and appropriate management response will be needed to protect coastal ecosystems and nesting habitat.

1.5.4. Manage habitat.

First priority should be given to habitats designated as critical or essential. Essential habitat is that used by and important to an endangered species, but not given any special protection or designation by law. Evaluate and improve management practices on NWR, NWA, Waterfowl Production Area, federal, provincial, and state wildlife areas important to whooping cranes to develop and maintain habitat. Acquire or develop cooperative agreements on private lands. Review management practices systematically to determine benefit or detriment to whooping cranes.

1.5.4.1. Fire management

The effect of fire on nesting and wintering habitat is thought to be beneficial. Parks Canada Agency should continue to review fire management in WBNP and carefully manage fire suppression activities that would be detrimental to the crane summering area (Timoney 1999). Better define the role of fire in maintaining suitable nesting habitat. Maintain upland prairie savannah habitat used by the cranes at ANWR using prescribed fire and attract cranes to the uplands by making additional foods available.

1.5.4.2. Maintain upland water sources.

Maintain freshwater ponds and/or create new ponds on the wintering grounds to ensure a supply of freshwater for the cranes and to optimize distribution of upland use by cranes. Human activities on upland areas need to be controlled to minimize disturbance to cranes at freshwater sources.

1.5.4.3. Manage vegetation.

Manage vegetation in essential or critical roosting habitat on the migration route. This may require mechanical or chemical removal of established trees or other vegetation that may be discouraging use by cranes (i.e., the degraded Platte River, Nebraska). Cranes make significant use of uplands in winter when relatively open feeding conditions are maintained. Mowing, roller chopping, and prescribed burning can provide such areas. Control the exotic Chinese tallow tree (*Sapium sebiferum*) that invades wetland swales at ANWR with an aggressive herbicide application program. Continue to develop other habitat management practices that increase the habitat base available in wintering areas. These techniques should emphasize use in areas that are most protected from human encroachment.

1.5.5. Create wetland habitat.

On the migration route, wetland restoration may be needed in areas where there has been extensive loss of crane habitat. On and near the ANWR wintering grounds, enhance the whooping crane wintering habitat to provide for an expanding crane population. Increase management activities to provide better use of existing protected areas. Create new habitat to help compensate for habitat losses and increase the carrying capacity of the wintering area. Saltwater marsh can be created in open water areas using dredged material. Lowering of some areas mechanically, to allow flooding by high tides and collection of runoff, should promote development of salt or brackish marsh areas.

2. Develop and maintain captive populations.

Maintain 45 breeder pairs of whooping cranes at PWRC (15), ICF (12), CZ (10), SSC (5), and SAZ (3). Birds unable to reproduce can be used for parent-rearing, role models, or education programs.

2.1. Develop appropriate measures of genetic diversity.

Develop a thorough pedigree history for each producing pair in the captive flocks, outlining production histories and difficulties encountered, and analyze for genetic inheritance of deficiencies. Enter data annually into the flock studbook. Identify ways to separate family lines by exploring the use of anonymous fragment length polymorphisms (AFLP) or other techniques. Convene a genetics workshop to develop specific genetic plans for the FP and EMP.

Based on the above actions, research would extend to captive crane populations to: (1) obtain genetic representatives of as many wild pairs as possible; (2) retain in captivity those birds that are especially valuable because of their genetic background; and (3) give careful attention to genetic and demographic considerations to ensure health of the captive population. The

genetics flock manager(s) of the captive population should make annual analyses of the genetics and demographics of captive and reintroduced populations. Results of these analyses could be used to guide selection of eggs for transfer from the wild, selection of individuals for pairing and maintenance of appropriate population demography. Before additional eggs are picked up from the wild, a large-scale genetic study is needed in WBNP since information on the composition of nesting pairs has been lost with the cessation of color-banding in 1988. Frozen semen banks should be maintained to prevent loss of founder lines. A national serum bank should be set up to serve as a repository of genetic material for the species.

2.2. Increase the number of captive breeders.

The small captive population of the past placed constraints on productivity and reduced the potential to form socially and genetically compatible pairs. As more pairs begin egg production, there will be an increase in offspring available for reintroduction efforts and an opportunity to enhance the behavioral, demographic, and genetic management of the captive population.

2.3 Refine aviculture methods and productivity.

Captive breeding centers should optimize the production of whooping cranes in captivity through the application of proven aviculture techniques described in the Crane Propagation Manual (Ellis et al. 1996). Research is needed in the fields of reproductive physiology, genetics, behavior, and veterinary science.

2.3.1. Refine breeding pair management.

Develop and/or refine various procedures used in captive propagation of whooping cranes, particularly behavioral and physiological management, to maximize productivity of captive populations. Use research surrogates to accomplish biological research and develop techniques. Determine optimum techniques for handling, pairing, and inducing crane reproduction at captive breeding centers. Foster whooping crane production at an earlier age comparable to that of wild cranes.

2.3.2. Refine incubation procedures.

Whooping crane eggs have greater hatching success when incubated naturally for at least two weeks. Determine conditions involved in successful artificial and natural incubation to enhance overall egg hatchability and flock productivity. Sandhill cranes and other cranes are available and desirable for natural incubation. Improve mechanical incubation to allow reduction in the numbers of captive cranes used for incubation, resulting in a savings in costs and pen space.

2.3.3. Refine rearing procedures for reintroductions.

Focus captive rearing techniques and procedures on conditioning the birds for release into the wild. Birds destined for release into the wild should either be parent-reared by whooping cranes or isolation-reared using live whooping cranes as models. Whooping cranes should not be reared by other species. Birds reared for captive breeding would initially be parent-reared or exposed to proper imprint cues to assure reproduction. When

possible, expose captive-reared birds to conditions and situations in captivity that they will encounter in the wild.

2.3.4. Refine veterinary procedures.

Long-term survival and productivity of the captive populations will require healthy flocks. Proposed protocols are described in the report entitled *Whooping Crane Health Management Workshop* (Anonymous 1992). Another workshop is needed and tentatively planned for 2006. Conduct research at the captive centers, the NWHC, and other partner centers on the diagnosis, treatment, and prophylaxis of ailments in whooping cranes and other cranes in order to ensure flock health and minimize mortality. Monitor routine health practices at all times, and modify as necessary. Record health and provide postmortem findings and the long-term storage of preserved tissues in a centralized facility. Captive health research needs include investigation of orthopedic problems, chick developmental problems, parasite control, drug and vaccine use, emerging infectious diseases such as WNV, and salmonella pathogenicity.

2.3.5. Exchange aviculture information.

Staff of captive centers should exchange information including annual progress reports on propagation activities. Propagation and veterinary personnel should meet periodically to exchange information, jointly address similar problems, and develop implementation plans and protocols. Cooperation and exchange between captive centers is needed to train new staff.

2.4. Maintain captive facilities.

All aspects of Task 2 require adequate facilities for the captive whooping crane populations and surrogate species. All facilities should be maintained in conditions suitable for the cranes' health, safety, and productivity so that recovery and research objectives can be achieved. Captive sites will conform to national animal care guidelines. Once established at a site, captive pairs should not be moved to another captive facility, as transporting can cause stress and mortality, and disrupt and/or permanently hinder production (Mirande et al. 1997b).

3. Establish two additional wild populations.

The USFWS and CWS should coordinate their research and management efforts to establish at least two discrete, self-sustaining populations, each consisting of a minimum of 25 nesting pairs by year 2035. As long as they meet recovery criteria, these new populations can be either migratory or non-migratory. Plans call for all releases to be in the eastern U.S., at least through 2010.

It is important to note that much of what is known about the life history, behavior, and ecology of whooping cranes is based on the small, remnant AWBP. New behaviors or selection of new habitats may be exhibited by new populations, depending on reintroduction techniques employed, and/or changes to the current environment, which differs drastically from that of historical times. These ecological nuances should become evident through time and research.

3.1. Develop release techniques.

Test techniques for establishing migratory and non-migratory populations. Research and establish protocols for age of released birds, rearing methods, time of year, pre-release conditioning procedures, methods for teaching suitable migration behavior, and predator avoidance training. The number of released birds and post-release monitoring should be adequate to ensure proper evaluation.

3.2. Evaluate and select release sites.

Evaluate proposed potential release sites based on the biological needs of the whooping crane, the likelihood of establishing discrete, self-sustaining populations, and the impact of such an introduction on other resources and programs. Select proposed sites and rank them according to their biological suitability. Examine proposed release sites and other habitats to be used by released cranes to determine potential conflicting management problems, e.g., land and water resource development, habitat degradation, impact on other wildlife species, distribution of power lines, towers, and fences, disease, predators, and hunting of look-alike species. Conduct research studies on the suitability of release sites at Marsh Island and White Lake, Louisiana.

3.3. Establish a non-migratory population.

Continue to test the soft release of whooping cranes, isolation-reared or parent-reared in captivity, as a means of establishing a non-migratory population in Florida or elsewhere. Monitor the released birds to gather data on habitat use, movements, mortality factors, nesting success, and other data crucial to success of a reintroduction. Conduct an ongoing evaluation of release success. Implement management techniques throughout the range of the new wild population to increase project success. Management should be designed to minimize unnecessary conflict with other land and resource uses. If survival and productivity data indicate a reasonable chance for attaining a self-sustaining population, supplement the Florida population until it attains 25 nesting pairs.

3.4. Establish a migratory population.

Continue to test various means of teaching captive-produced birds to migrate and survive in the wild. Supplement this population until 25 nesting pairs are reached. Monitor the released birds to gather data on habitat use, movements, mortality factors, nesting success, and other data crucial to success of the reintroduction. Conduct an ongoing evaluation of release success. Techniques worth investigating include leading birds behind an ultralight or model aircraft, stage-by-stage migration by truck, or allowing released cranes to follow wild cranes in migration. Write a management plan for the EMP. Implement management techniques throughout the range of the new wild population to increase project success. Management should be designed to minimize unnecessary conflict with other land and resource uses.

4. Determine N_e for species survival by analyzing banding data to determine the N_e/N ratio for the AWBP.

Determine a minimum population size needed to ensure survival of the whooping crane through stochastic and catastrophic events while maintaining genetic diversity. Use knowledge from advances in the conservation biology of small populations, population viability theory, experience with long-term survival of endangered populations and genetic information to determine N_e and revise recovery criteria as warranted. An analysis of banding data collected

from the AWBP from 1977 – 1988 would provide an estimate of productive pairs vs. total population size.

5. Maintain and expand information/education programs.

Implement information and education programs to further recovery of the whooping crane. Issue press releases for December population counts at ANWR; spring departure from ANWR, arrival in Saskatchewan and requests for reports of migration sightings; number of nesting pairs in WBNP; number of chicks surviving to autumn in and near WBNP; and autumn arrival in Saskatchewan and other provinces. Events to publicize for reintroduced populations could include similar significant events including population census estimates, nesting successes, migration departures, arrivals, and general locations of birds, and requests for migration sightings. Provide outreach opportunistically at meetings and festivals.

5.1. Develop media products.

Develop and distribute printed and audio-visual media regarding recovery efforts. Target important segments of the public and specific needs of the recovery program. Encourage collaboration between the various agencies and organizations that have specific responsibilities or interests in whooping crane recovery.

5.2. Provide viewing opportunities.

Provide opportunities for the public to view whooping cranes near major use areas wherever such viewing does not interfere with recovery of the cranes. Provide live whooping cranes when available for educational displays at zoos. Provide specimen mounts for museums and educational institutions to further public education and research.

5.3 Implement education programs.

Work with educators to tell the story of whooping crane recovery and promote whooping crane conservation. Develop appropriate web sites and other methods for providing information.

INFORMATION NEEDS

Survey Requirements

Aerial population surveys on nesting and winter areas are a continuing need. There remains a need to identify unoccupied but potential nesting and winter habitat to identify any limitations on population growth. Some of these habitats may require protection by purchase, lease, or legal action. Water level surveys and monitoring of food resources are a necessity in WBNP to fully understand ecological changes and their impact on population trends. Surveys of coastal water salinity levels, freshwater inflows, and crane food resources will continue to be necessary on the winter area at Aransas to identify ecological trends. Migration activities must be monitored to ensure safety of the cranes and evaluate changes in conditions faced on the long semi-annual journey.

Biological/Ecological Research Requirements

Causes of mortality in wild and captive cranes should continue to be identified and addressed. Frequent monitoring of the birds will be required to detect losses. Such monitoring will require radio tracking or satellite tracking of wild birds in some instances. Further understanding of migration stopover habitat is needed to refine the effectiveness of habitat augmentation and management on the Platte River and elsewhere. Additional research is necessary to refine methods of creating marsh habitat with dredged sediments to ensure long-term benefits to whooping cranes. For captive populations, research needs include refining means of disease prevention, prevention of toe, leg, and wing injuries, gaining knowledge on pairing and promoting early breeding, improvements in use of artificial incubators, improving natural fertility, genetic management, nutrition of captive birds, and behavioral training to promote wildness in birds destined for release in the wild. Research is continuing to refine reintroduction techniques for establishing a second migratory population to promote appropriate migratory behavior and survival. In 2001 the Whooping Crane Health Advisory Team (WCHAT) identified the high priority research needs in captivity as: (1) the effect of West Nile virus on cranes and development of a vaccine; (2) developing a more effective TB test for screening whooping cranes; and (3) developing a fecal corticosterone test to compare levels of stress associated with various management techniques in captivity. Research is also needed on IBD in cranes.

Threat Clarification Research Requirements

Research already identified is needed to further define potential threats. For example, the impact that anticipated reduced freshwater inflows at ANWR will have on salinity, winter food resources, and population survival needs to be quantified. Continued research on mortality in reintroduced populations is another example. Such losses threaten the success of the reintroductions. Research is also needed to derive techniques to separate family lines so management of the captive flock can be improved to preserve and increase the genetic diversity of the flock.

FUTURE CONSIDERATIONS

Additional methodologies for re-establishing a migratory population need to be developed. Although the ultralight method appears to work well, it is labor intensive, expensive, and not practical for releasing hundreds of cranes. Also, it is unknown if cranes trained to follow an ultralight will have subsequent normal breeding behavior. Techniques for releasing juvenile captive-bred whooping cranes into migratory flocks of whooping or sandhill cranes should be explored.

The suitability of habitat in Florida is an area of concern. High mortality continues to hinder the reintroduction of non-migratory whooping cranes in Florida. Two of the 7 ultralight whooping cranes that followed an ultralight during migration were later killed by bobcats at CNWR in Florida in the 2001-02 winter. In 2002, the remaining 5 completed a successful migration in both the spring and fall and summered in the core release area of central Wisconsin. The 5 cranes returned to Florida but most did not remain in salt marsh habitat. Apparently the ultralight-trained whooping cranes will prefer other habitats over salt marsh habitat in Florida and may possibly associate with the non-migratory whooping cranes in central Florida.

Several sites, within the former range of the species, have been evaluated for their potential as reintroduction sites, including areas in Saskatchewan (Lyon et al. 2005a,b) and Manitoba (Sommerfeld and Scarth 1998, de Sobrino 1998), and the eastern United States (Cannon 1998, 1999). In 1999, the Canada/United States Whooping Crane Recovery Team agreed that further refinement of reintroduction techniques is needed prior to placing an experimental flock in proximity to the existing AWBP. With that in mind, the recovery team made a recommendation to release whooping cranes in central Wisconsin, with the birds wintering at CNWR in Florida, with future potential expansion into Manitoba and Louisiana.

Current plans call for all whooping crane releases to take place in the eastern U.S., at least through 2010. If either of the two eastern populations is not successful, and/or if the habitat in Florida is not suitable for whooping cranes, then the Recovery Team recommends consideration of reintroduction sites in Louisiana. In 2001, a committee was formed in Louisiana to investigate the potential for reintroducing whooping cranes to that state. At least two possible sites have been identified. Studies done by Cannon (1998) found winter habitat at Marsh Island, Louisiana, to be highly suitable for whooping cranes. There is also interest in restoring non-migratory whooping cranes to the vicinity of White Lake, Louisiana, where until 1950, a non-migratory flock existed. In July, 2002, BP American Production Company donated the 71,130-acre White Lake Preserve to the State of Louisiana. It is currently being managed by the Louisiana Department of Wildlife and Fisheries (LDWF). Returning whooping cranes to this site has been discussed with LDWF. Based on their historical presence in the state, Louisiana seems to be a good site for whooping crane reintroduction.

Although the Recovery Team is interested in the idea of establishing a Louisiana population, there are currently not enough whooping cranes produced annually in captivity to support a reintroduction effort in that state. Additionally, much planning and coordination with state and local agencies and other interested parties in Louisiana is required to further these preliminary discussions.

PART III. IMPLEMENTATION SCHEDULE

The implementation schedule outlines and prioritizes recovery tasks over the recovery period. It will be used in the ongoing monitoring of all recovery tasks and will provide the basis for funding of recovery actions. Tasks are identified under general categories, and all headings are derived from Part II's Narrative Outline for Recovery Actions to Achieve Objectives. The schedule ranks objectives and tasks, identifies respective responsible agencies, defines schedules, and estimates costs in terms of financial resources and person-years for the recovery period. Tasks must be continually revised as plans move from implementation to completion as a result of monitoring results and updating information. Each revision will identify additional actions and studies that will be needed during the recovery period.

Recovery priorities are defined as follows:

Priority 1: An action that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population or habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery (or reclassification) of the species.

- IMPLEMENTATION SCHEDULE -

Action	Task #	Priority	Responsible Party	Program	Cooperator	Duration	Cost ($ x 1000) Year 1	Year 2-5	Year 6-10	Year 11-30
Conduct Aerial Surveys in WBNP	111	1	CWS, WBNP	CWS	WBNP	Continuous	25	100	125	600
Analyze Data on Egg Management	112	3	CWS	CWS	WCRT	Continuous	5	-	-	-
Conduct Aerial Surveys at ANWR	113	1	USFWS-2	ES, RW	-	Continuous	20	80	100	400
Monitor Movements in Migration	12	2	CWS, USFWS-2,6	CWS, ES	RW, A, M, S	Continuous	125	500	625	2500
Prevent Shooting	131	2	CWS, USFWS	CWS, USFWS-2,3,4,6	ES, RW, A, M, S	Continuous	5	25	32	150
Diminish Disease Losses	132	2	CWS, USFWS	NWHC	WCRT, PWRC, CCWHC	Continuous	20	90	115	450
Diminish Collisions	133	1	CWS, USFWS	CWS, ES	FCC	Continuous	2	13	180*	60
Restrict Construction Periods	141	2	CWS, USFWS-2	ES	A, M, S, RW, WBNP	Continuous	5	20	25	100
Restrict Aircraft Altitude	142	2	CWS, PCA, USFWS-2	WBNP, RW	FAA, TC	Continuous	2	5	5	10
Restrict other disturbance	143	2	CWS, PCA, USFWS-2	WBNP, RW	FAA, TC	Continuous	18	75	95	490
Identify Essential Habitat	151	2	CWS, PCA	CWS, USFWS-2,6	WBNP	Continuous	30	140	312*	100
Monitor Habitat in WBNP	1521	2	WBNP	WBNP	CWS	Continuous	40	160	75	250
Monitor Foods and Salinities at ANWR	1522	2	USFWS-2	RW, ES	-	Continuous	30	110	125	450
Measure stopover habitat	1523	3	CWS, USFWS	USFWS-2,6	PRT	Continuous	10	50	-	-
Maintain WBNP	1531	2	WBNP	WBNP	CWS	Continuous	100	380	485	25
Protect migration habitat	1532	2	CWS, USFWS	CWS, USFWS-2,6	States	Continuous	100	400	500	2000
Maintain ANWR and other NWR	1533	2	USFWS	USFWS-2,6	PRT	Continuous	290	1140	1465	75
Prevent Contamination	1534	2	CWS, USFWS-2	ES, CG	TNRCC,USACE	Continuous	1	4	5	20

Prevent Erosion of Habitat	1535	2	USFWS-2	USACE	RW, ES	Continuous	1	4	5	20
Manage Dredge Material	1536	2	USFWS-2	USACE	ES, RW	Continuous	1	4	5	20
Maintain Freshwater Inflows	1537	1	USFWS-2,6	ES, RW	TNRCC,TPWD, USACE	Continuous	40	160	200	2000
Maintain Instream Flows	1538	2	USFWS-6	ES, PRT	NAS	Continuous	100	400	500	2000
Monitor Global Warming	1539	2	CWS, PCA, USFWS-2,	RW, ES	CWS, WBNP,ES	Continuous	2	5	10	20
Fire Management	1541	2	PCA, USFWS	RW, ES	PRT, NAS WBNP	Continuous	20	80	100	400
Maintain Upland Water Sources	1542	2	USFWS-2	RW		Continuous	2	8	10	40
Manage Vegetation	1543	2	USFWS-2,6	RW	PRT, NAS	Continuous	300	1200	1500	6000
Create Wetland Habitat	155	2	USFWS-2,6	ES, USACE	RW	Continuous	200	800	1000	4000
Develop More Sensitive Measures of Genetic Diversity	21	2	USGS	-	ICF, PWRC, NGO, NWHC	Continuous	60	240	60	100
Increase Captive Breeders	22	1	CWS, USGS, USFWS-2,9	ES	all captive centers	Continuous	1400	5600	7000	300
Refine Breeding Pair Management	231	2	USGS, all captive centers	-	all captive centers	Continuous	50	200	50	100
Refine Incubation Procedures	232	3	ICF, PWRC	-	all captive centers	5 years	10	40	40	20
Refine Rearing Procedures for Reintroductions	233	2	PWRC, ICF, OM	-	all captive centers	10 years	10	40	40	100
Refine Veterinary Procedures	234	3	all captive centers, NWHC	-	-	Continuous	20	80	80	100
Exchange Avicultural Information	235	3	WCCMT	-	all captive centers	Continuous	5	20	25	40
Maintain Captive Facilities	24	3	USGS, USFWS-9	-	all captive centers	Continuous	150	600	750	3000
Develop Release Techniques	31	2	PWRC, ICF, USFWS-3,4	-	FL, OM, WCRT	10 years	750	3000	3750	400

Select Release Sites	32	2	CWS, USFWS-2,3,4	-	WCRT	Do when needed	-	50	75	100
Establish a Non-Migratory Population	33	2	USFWS-4,9, FL	-	-	10 years	280	1120	1400	-
Establish Migratory Population	34	2	USFWS-3,4, WI, PWRC,ICF, OM	-	States	20 years	2000	8000	10000	40000
Determine *Ne* for Species Survival	4	3	CWS, USFWS, PWRC	-	-	Continuous	-	30	10	10
Develop Media Products	51	3	CWS, USFWS-2,3,4,6,9	PA	ICF,PRT PWRC, WCCA	Continuous	5	20	25	40
Provide Viewing Opportunities	52	3	CWS, FL, WI USFWS-2,3,4,6	ES, RW	OM	Continuous	5	20	25	40
Implement Education Programs	53	3	CWS,USFWS-2,3,4,6,9		WCEP,WCCA	Continuous	5	20	25	40

* Includes 162K for satellite telemetry

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Canadian migration staging/stopover areas; contact Brian Johns, Canadian Wildlife Service, address listed above.

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AWBP wintering area along the Texas Gulf Coast; contact Tom Stehn, Aransas NWR, address listed above.

Florida non-migratory population; contact Marty Folk, address listed above.

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DATE COMPLETED: July 19, 2006.

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APPENDICES

APPENDIX A: MINIMUM VIABLE POPULATION AND GENETICS

Minimum Viable Population

Extinction in small populations has led to the theory of minimum viable population size, defined as the smallest number of individuals necessary to give a population a high probability of surviving over a specified time (Primack 1993). Small populations are subject to rapid decline due to 3 main causes: (1) genetic fluctuations (e.g., genetic drift, inbreeding); (2) demographic fluctuations (e.g., variations in birth and death rates); (3) environmental fluctuations in predation, disease, competition, food supply, and natural catastrophes. As the population increases, the threat of extinction due to stochastic events diminishes, and loss of genetic diversity slows, thereby increasing species security.

Shaffer (1981) provided a specific technique for determining the minimum viable population (MVP):

> "A minimum viable population for any given species in any given habitat is the smallest isolated population having a 99% chance of remaining extant for 1,000 years despite the foreseeable effects of demographic, environmental, and genetic stochasticity, and natural catastrophes,"

(e.g., the smallest population size that can be predicted to have a very high chance of persisting for the next 1,000 years). In this case, the probability for remaining extant could be set at 95% or 99%, and the time frame could be adjusted to 100 or 500 years. The theory of MVP is simply a guide to aid in the preservation of a species.

Opinions vary widely as to the population sizes necessary to achieve a minimum viable population. One rule of thumb is to protect 1,000 individuals of a vertebrate species, because this number seems adequate to preserve genetic diversity (Shaffer 1981, Salwasser et al. 1984). Others suggest that an effective population size of 5,000 individuals is needed to retain evolutionary potential (Lande 1995). More recently, Reed et al. (2003) used population viability analysis to estimate MVP for a variety of vertebrate species. Their definition of MVP is a population that has a 99% probability of persistence for 40 generations. Their results indicate that the lack of long-term studies for endangered species may lead to an underestimation in the extinction rates for the species. They recommend that recovery/conservation programs should be designed to support a population of up to 7,000 adults to ensure long-term survival.

Downlisting Based on MVP Criteria

Population sizes sufficient to be referred to as a minimum viable population depend highly on the effective population size (N_e). The effective population size is the size of a population that maintains heterozygosity at the same rate of the entire species' population and is a function of mating behavior, mutation rate, gene flow, demographics, and population size, among other factors. As not all breeding adults pass on their genetic material equally and randomly, there is a difference between the number of breeders and effective population size. When defining the population size sufficient for downlisting, criteria must account for the difference between the total population and the breeding population size (i.e., the N_e/N ratio). For the wild whooping

crane population, breeders comprise approximately 50% of the population. However, as the effective population will always be less than the number of breeders, proper estimates for N_e will need to be obtained before the minimum viable population for whooping cranes can be determined.

Given the data to date, this plan recognizes growth of the AWBP to 1,000 individuals and 250 productive pairs as criteria for downlisting. The Memorandum of Understanding on Conservation of Whooping Cranes, approved by Canadian and U.S. federal officials, recognizes a goal of 1,000 individuals in the AWBP population. If two additional self-sustaining populations can be established in the wild, each with 25 nesting pairs, and with the AWBP projected to reach 125 nesting pairs by the year 2020, a figure approaching a population of 1,000 whooping cranes may be obtained from these three populations. However due to the uncertainty surrounding the exact figure required, with suggested values ranging between 1,000 and 7,000, this Plan does not set a delisting goal for the whooping crane. If additional research into the exact calculation of a *Ne*/*N* ratio for the wild whooping crane population and additional research with other conservation programs can provide more assurances of the N_e required, a delisting goal will be set prior to the anticipated downlisting in 2035.

Population Growth and Retention of Genetic Material

A Conservation Viability Assessment (CVA) workshop held in 1991 for the whooping crane was funded by the USFWS as a cooperative endeavor with CWS, U.S. Whooping Crane Recovery Team, Canadian Whooping Crane Recovery Team, ICF, The Captive Breeding Specialist Group, and Species Survival Commission of the International Union for Conservation of Nature. The final report includes priorities for research and management of the wild and captive populations as a meta-population to maximize retention of genetic heterozygosity and minimize the risk of extinction (Mirande et al. 1993). The CVA developed stochastic simulation models to estimate rates of genetic loss for the wild and captive whooping crane populations. As a consequence of the 1941 population bottleneck, the current population is derived from an estimated 6 or 8 founders (Mirande et al. 1993, Glenn et al. 1999), with an estimated genetic loss of 66% (Glenn et al. 1999). Mirande et al. (1993) showed that a loss of 6% to 8% of gene diversity would have resulted in the first generation following the bottleneck, where generation time is 12 years. It was estimated that about 87% of the gene diversity that survived the bottleneck has persisted from 1938 to 1990. In contrast, the captive-hatched descendants have retained about 96% of the gene diversity present in the post-bottleneck wild flock. As continued loss of genetic material could lead to inbreeding and declining productivity, the AWBP must increase to the level where creation of new alleles will offset the loss of genetic diversity.

Several other population viability analysis packages have been tested using whooping crane data (Mirande et al. 1997a, Brook et al. 1999). Modeling of the AWBP showed the population large enough to sustain a fairly steady annual growth rate of 0.046 (SD=0.081) over the last 50 years (Mirande et al. 1997a). The standard deviation is about double the mean growth rate so in many years the population will decline temporarily even though long-term growth may be good. If this rate continues, the population will reach 500 birds in 17 years (about 2020) and 1,000 in 33 years (2035). The population is projected to have a very low probability of extinction over the next 100 years (less than 1%).

Given the current genetic analyses based on captive pedigrees, an estimated 153 whooping cranes (21 productive pairs) are needed in captivity to retain 90% of genetic material for 100 years (Jones and Lacy 2003). This Plan recommends having 50 captive breeder pairs of whooping cranes by 2010, including 15 pairs at PWRC, 12 at ICF, 10 at CZ, 10 at SSC, and 3 at the SAZ. Production from these five facilities will be the principal source of birds for release to the wild. However, sources of release birds should be based on the optimal genetic mix to ensure long-term population viability.

Loss of Genetic Diversity and Estimates of Relatedness

For most of the 1940's, the AWBP teetered on the brink of extinction. Mitochondrial DNA from museum specimens collected before and after 1941, when the AWBP declined to 15 birds, showed a 66% reduction in haplotypes post-bottleneck, with the rarest haplotype before 1940 now the most common (Glenn et al. 1999). Although we lack pre-bottleneck diversity estimates for nuclear DNA, we realize that similar declines for this genome must have also occurred (Jones et al. 2002). This is evident from AWBP's lack of genetic diversity as compared to other cranes. Compared with a subset of other cranes, an electrophoretic study of blood proteins showed that whooping crane diversity was less than that known from out-bred populations of Sandhill Cranes, and greater than that of the Mississippi Sandhill which was known to have undergone a similar genetic bottleneck (Dessauer et al. 1992). When diversity was compared across other markers, the whooping cranes were shown to be below average in band sharing of DNA fingerprints (Longmire et al. 1992), average in polymorphism of the major histocompatibility complex (Jarvi et al. 1992), and less than average in microsatellite DNA diversity (Jones et al. 2002, Jones 2003). From these studies, it is evident that the extant whooping cranes show an overall reduction in genetic diversity compared to their pre-bottleneck ancestors and to that of out-bred cranes. This known diversity reduction, along with the fact that generations of captivity increase inbreeding and decrease genetic diversity (Woodworth et al. 2002), indicates that genetic changes within the population threaten to reduce vitality before the population is large enough for mutation to offset losses in diversity from genetic drift (Frankel and Soule 1981, Ballou et al. 1995).

In addition to the knowledge of genetic diversity, understanding relatedness among individuals within the captive whooping crane populations is important to adequately manage the captive population and to establish viable wild populations (Jones et al. 2002). In addition to pedigree management, there have been various molecular genetic techniques used in relatedness estimation. These studies have resolved unknown paternities (Longmire et al. 1992; Jones and Nicolich 2001), developed a species-specific probe for the whooping crane (Love and Deininger 1992), and identified inter-relatednesses within the captive founder lines (Jones et al. 2002). A recently developed technique that could provide additional insights into the whooping crane population is Amplified Fragment Length Polymorphisms (AFLP). Because of the relative paucity of information in birds in general, and cranes in particular, the usefulness of this technique in cranes is currently unknown. An AFLP study currently underway at PWRC will include samples from other crane populations with robust populations and those of reduced diversity. This comparison across crane species should provide additional understanding of crane diversity in general and the relative state of genetic diversity of the whooping crane.

APPENDIX B: SOCIAL AND ECONOMIC CONSIDERATIONS

Numerous books, magazine articles, television programs, and nature documentary films have been produced about this magnificent bird. Corporations have funded whooping crane research and recovery efforts and also have used whooping cranes in promoting their environmental concern. The WCCA, a nonprofit organization, was formed in 1961 to promote conservation of whooping cranes and to educate the public. Other organizations, such as the NAS and NWF, have participated in whooping crane research, conservation, and education. The Platte River Whooping Crane Habitat Maintenance Trust (PRT) was established in 1978 as a nonprofit conservation organization to protect and enhance habitat for migratory birds in Nebraska, along the Platte and North Platte rivers, and especially to protect and maintain whooping crane habitat.

Appreciation of whooping cranes also can be expressed in monetary terms. Each year 70,000 to 80,000 people visit ANWR, most during the winter, and spend significant amounts locally on lodging, gasoline, and supplies (Ellen Michaels, ANWR, pers. comm.). Starting in 1964, 1 tour boat named the "Whooping Crane" offered weekend day-trips from Rockport, Texas, to view the cranes along the Gulf Intracoastal Waterway that runs through ANWR. By 1990, 5 boats offered this opportunity, spanning every day of the week. During 1990-1991, approximately 17,000 people took these tours, paying an average of $20 per ticket, for total seasonal expenditures of $340,000 (Ellen Michaels, ANWR, pers. comm.). In 2004-05, an estimated 8,500 people rode commercial tour boats, paying an average of $35 per adult (Bernice Jackson, ANWR, pers. comm.). The Rockport Chamber of Commerce estimates that whooping crane-related activities result in annual gross economic benefits of $6 million to the local economy. Port Aransas, Texas, holds an annual event in February entitled "Festival of Whooping Cranes and Other Birds".

An understanding is needed of the secondary socio-economic benefits that Canadians derive from Canada's biological resources today while providing for the perpetuation of these resources for future generations. The $11.7 billion spent by Canadian residents and U.S. tourists on nature-related activities in Canada represents a significant outlay which has important impacts on the Canadian economy (Filion et al. 1994).

In Calgary, Alberta, in 2003, 1.2 million people visited the Calgary Zoo, where a whooping crane pair in a wetland exhibit is on display. Entry fees to the zoo are $15.00 for adults and $7.50 for children (in 2003). Operation Migration, an organization involved in the introduction of whooping cranes to eastern North America, has an annual budget of $420,000 entirely directed toward the recovery of the whooping crane. WBNP receives over 1,400 visitors each year, and many of them come there to see the habitat of whooping cranes and for a possible chance to see the birds themselves. A recent land transfer to the Salt River First Nation in Fort Smith has provided the First Nation with the unique opportunity of having Whooping Cranes nesting on their lands. The First Nation is entertaining the idea of establishing a remote viewing area that may provide an opportunity for visitors to view whooping cranes. In addition, each autumn, visitors descend on Saskatchewan in search of whooping cranes. Many of these visitors stay for several days and a large portion of them are with various tour groups.

In 2001, annual fall whooping crane festivals were started in Tennessee and in central Wisconsin. In Baraboo, Wisconsin in 2004, 25,092 people paid an entry fee of $8.50 for adults and $7.00 for seniors to visit ICF where a whooping crane breeding pair in a wetland exhibit is

among the crane species on display (ICF Education Department, pers. comm.). In several areas where large numbers of sandhill cranes are viewed by tourists, an additional attraction for observers is the possibility of sighting whooping cranes. Approximately 80,000 people visit the Platte River area of Nebraska each year during the peak of spring crane migrations, expending approximately $15 million (Lingle 1992).

Although whooping cranes no longer occur in the Rocky Mountains, interest in crane festivals that the whooping cranes played a role in starting remains high. Approximately 160,000 people annually pay a $3 per vehicle entrance fee to visit Bosque del Apache NWR, New Mexico, mostly in winter when the sandhill cranes are present (Maggie O'Connell, USFWS, pers. comm., 2005). The refuge and Socorro Chamber of Commerce also sponsor a 6-day "Festival of the Cranes" in the fall to promote tourism. The presence of whooping cranes in the past heightened interest in the crane migration at the Alamosa/Monte Vista NWR in Colorado. Approximately 10,000 people visit the refuge during the peak migration periods, many of these during the spring Monte Vista Crane Festival. This 4-day festival is estimated to generate about $10,000 per day in revenue to the local economies (Ann Morekill, Alamosa/Monte Vista NWR, pers. comm., 1993).

The total value for most endangered species is intangible and difficult to quantify; however, in recent years economists have developed methods to approximate the value of nonmarket resources such as endangered species. These methods measure: (1) the value people place on seeing an endangered species (use value); (2) the value they place on continued existence of the species for potential future observation value (option value); and (3) the value of simply knowing the species exists (existence value) (Randall and Stoll 1983). One method of estimating these values, the contingent valuation method, asks individuals to express their willingness to pay for nonmarket goods (Stoll 1983). Individuals are asked to estimate their willingness to pay for observing (use value) or preserving (option and existence value) the species.

Contingent valuation methodologies have been used to estimate the value of whooping cranes. In written surveys distributed in 1982-83 at ANWR, refuge visitors indicated willingness to pay an average of $4.47 for an annual permit to visit the refuge and an average of $16.33 per year to support a private foundation that would be responsible for conservation of whooping cranes. A mail survey to 4 metropolitan areas outside of Texas indicated that respondents were willing to contribute an average of $7.13 per year to the same hypothetical foundation. Allowing for sampling error and non-response bias, the total value of the whooping crane to United States' residents appears to range between 0.5 billion to 1.5 billion dollars per year (Stoll and Johnson 1984).

Three conclusions can be drawn from this evidence of the economic value of whooping cranes. First, local economies can realize significant economic benefit from the presence of an endangered species; these localities need assistance in identifying and capturing these economic benefits. Second, values for endangered species appear to be directly associated with the public's knowledge and awareness of the species. Value for the whooping crane derives not only from its aesthetic qualities and rarity, but probably more directly from its identity as a symbol of the effort to save species from extinction. This value would not have been realized without extensive education efforts. Finally, increasing interest in this endangered species, which brings economic benefits, has raised concerns about the effects of these appreciative uses upon the well being of the species. The issue of disturbance management is discussed elsewhere in this Plan.

APPENDIX C: ACTIONS ALREADY COMPLETED OR UNDERWAY

Breeding Grounds Management and Research

Management of Wood Buffalo National Park

Management of WBNP and the crane breeding grounds is not nearly as complex an operation as management of the increasingly active wintering grounds at ANWR in regards to whooping crane issues. The breeding range of the AWBP flock is secure from human-induced changes such as forestry or conversion to agricultural land, because approximately 90% of the nesting occurs within WBNP. To afford the highest level of protection, the breeding habitat is designated as a Zone 1 Special Preservation area. The Special Preservation designation establishes that within that area, there are to be no manmade facilities (except Hwy 5), and human access is prohibited from April 15 through October, except for park staff and scientists involved in whooping crane research. Under normal circumstances, habitat manipulation is not permitted in a Canadian national park. Policy would allow for manipulation of natural processes only if feasible, beneficial, and urgent to achieve recovery goals. Issues such as global warming, which may dry out the marshes, and acid rain, are external concerns that may affect the population and require habitat intervention.

Egg Collection

The management activity that has had the most profound effect on the recovery program has been the collection of eggs from the wild. These eggs when hatched would form a captive breeding and release program. The idea of a captive flock of whooping cranes dates back about 50 years (Lynch 1956). Lynch recommended capturing young cranes to serve as a nucleus of breeders, producing offspring to release back into the wild. This proposal, although passed by the participants of the Twentieth Federal-Provincial Wildlife Conference, was very controversial.

In an effort to move the captive propagation proposal along, Erickson (1961) analyzed the Aransas winter population counts from 1938-1960. This analysis revealed 3 important characteristics of the wild population that were later confirmed by Novakowski (1966): (1) principal production was apparently derived from a fairly stable cohort of long-lived adults; (2) among birds returning to Canada, mortality was highest in the subadult cohort; and (3) because subadult mortality was apparently limiting recruitment into the breeding population, the population would remain insecure until this mortality was reduced. Based on these findings, Erickson reiterated Lynch's proposal to bolster the wild population through captive propagation and the release of captive-produced stock. However, he cautioned that before stock was obtained from the wild, safe and effective procedures should be developed using sandhill cranes as research surrogates.

Research results indicated that egg collection was the best method of obtaining wild stock. These experiments also indicated that nest desertion was negligible and population productivity was relatively unaffected when single eggs were removed from 2-egg clutches. Others noted that cranes normally lay 2 eggs but rarely fledge 2 chicks. Observations on the breeding grounds by Novakowski (1966) confirmed that whooping cranes generally follow this pattern. It appeared that a single egg could be removed from each 2-egg clutch with the same favorable

results experienced with sandhill cranes.

The whooping crane population has been artificially augmented through translocation and captive rearing of wild eggs. The total number of cranes (wild plus captive) was increased by taking 1 egg from a clutch of 2 and rearing it in captivity (Erickson 1975).

The CWS and the USFWS obtained eggs from nests in WBNP from 1967 to 1971 and in 1974 to further augment the PWRC population, and in 1975 through 1988 to provide 215 eggs for the Grays Lake cross-fostering experiment (Table 2). Egg transfers to PWRC were resumed in 1982-1989 and 1991-1996. Egg transfers to ICF began in 1990 and resumed in 1992-1996. Eggs were shipped to Calgary in 1994 and 1998 and a chick was transferred from WBNP in 1999. The transfer of eggs between nests ended with the last scheduled pickup of eggs in 1996. Between 1967 and 1998, 242 eggs were taken from WBNP to the captive sites. The transfers in the 1990s were designed to increase the size and genetic diversity of the captive flock. Chicks raised from these eggs currently form the nucleus of the breeding flocks being maintained at PWRC, ICF, and CZ. Egg collections and subsequent propagation efforts have been described elsewhere (Ellis et al. 1996, Kepler 1976, Kuyt l976a).

Viability testing of eggs during collection was initiated in 1985 with the objective of leaving at least 1 viable egg in each nest visited. In nests with 2 viable eggs, 1 egg was removed and placed in nests that contained nonviable eggs or transported to the captive facilities. As a result of this procedure, the hatching success of tested known live eggs left in nests was 11.7-15.5% over those of undisturbed nests from 1985-1988 (Kuyt 1993b). However, some of the lower hatching success among undisturbed eggs/nests probably existed because they were primarily those of younger, less experienced pairs.

The results of egg collection on the growth rate and overall fitness of the wild AWBP population are unknown. Erickson (1976) and Kuyt (1976a, 198la, 198lb) noted that egg removals have not adversely affected the productivity of the wild population. Between 1967 and 1996, the era of egg pickups, the AWBP increased from 48 to 160, and the number of nesting pairs increased from 5 to 45. Cannon et al. (2001) agree that although total numbers of whooping cranes, both captive and wild, can be increased by egg pickup, total numbers of chicks reaching Aransas are less when eggs are picked up compared to when no eggs are removed. Ellis and Gee (2001) further noted the potential benefits of removing the second fertile egg from nests. After reviewing studies by Cannon et al. (2001) and Ellis and Gee (2001), Lewis (2001) concluded that the data as presented did not support the views of Cannon et al. (2001) and determined that a re-analysis of the existing egg collection data was warranted.

Because of these differing opinions, B. Johns reviewed the data pair by pair and extracted as much information as possible from original reports and solicited the expertise of Dr. Mark Boyce, University of Alberta, for the analysis. Mark Bradley (WBNP, pers. comm.) advises that the data set used has biases, including: non-random nest selection; lack of a control group; not testing eggs for viability in the early years of collection; limited samples in certain years; and potential inaccuracies in chick surveys.

Table 2. Known number of nesting pairs, productivity, and distribution of eggs removed from Aransas Wood Buffalo Population, 1966-2005.

Year	No. of known nesting pairs[a]	No. of juveniles[b]	Max. no. of nonbreeders[c] (including juveniles)	Destination of eggs removed from WBNP			
				PWRC[d]	Grays Lake	ICF[e]	CZ[f]
1966	5[g]	5	-[h]	0	0	0	0
1967	9[g]	9	-[h]	6	0	0	0
1968	10	6	30	10	0	0	0
1969	12	8	32	10(3)[i]	0	0	0
1970	15	6	27	0	0	0	0
1971	13	5	33	11(2)	0	0	0
1972	16	5	19	0	0	0	0
1973	14	2	21	0	0	0	0
1974	15	2	19	13	0	0	0
1975	16	8	25	0	14(3)	0	0
1976	16	12	37	0	15	0	0
1977	17	10	38	0	16	0	0
1978	15	7	45	0	13(2)	0	0
1979	19	6	38	0	19(3)	0	0
1980	19	6	40	0	12(2)	0	0
1981	17	2	39	0	12(2)	0	0
1982	17	6	39	2	14(1)	0	0
1983	24	7	27	2	16	0	0
1984	29	15	28	3(2)	22	0	0
1985	28	16	41	4(3)	23(3)	0	0
1986	29	21	52	12(10)	15(2)	0	0
1987	32	25	70	12(5)	12	0	0
1988	31	19	76	14[j](6)	12	0	0
1989	31	20	84	15(9)	0	0	0
1990	32	13	82	0	0	12(1)	0
1991	33	8	66	16(10)	0	0	0
1992	41	15	56	10(1)	0	11(1)	0
1993	45	16	57	16(1)	0	10(2)	0
1994	28	8	77	0	0	9	4
1995	49	28	60	14(2)	0	10	0
1996	45	16	70	8(1)	0	6	0
1997	51	30	84	0	0	0	0
1998	50	18	83	0	0	0	2[k]
1999	48	17	92	0	0	0	0
2000	50	9	80	0	0	0	0
2001	52	15	72	0	0	0	0
2002	50	16	73	0	0	0	0
2003	61	25	72	0	0	0	0
2004	54	34	109	0	0	0	0
2005	58	30		0	0	0	0
			TOTALS	178	215	58	6

[a] Nesting pairs. (Canadian Wildlife Service, Brian Johns, pers. comm.)
[b] Fall arrivals, ANWR and area (U.S. Fish & Wildlife Service 1994; Refuge Manager, ANWR, pers. comm.).
[c] Calculated as following winter's peak population minus number of breeding adults.
[d] Patuxent Wildlife Research Center**,** Laurel, Maryland.
[e] International Crane Foundation, Baraboo, Wisconsin.
[f] Calgary Zoo
[g] Data incomplete.
[h] Cannot be calculated, as data on number of known nesting pairs are incomplete.
[i] Numbers in parenthesis indicate nonviable eggs or eggs that failed as a result of embryonic death (1975-1988 data from R.C. Drewien).
[j] Excluding one sandhill crane egg.
[k] Two eggs from an abandoned nest were picked up opportunistically in May, 1998.

Boyce et al. (2005) analyzed colt recruitment in WBNP in relation to egg removal activities between 1987-1996. The egg collection was never intended to be established with an experimental design suitable for testing its effect on the population. As such there are inherent biases associated with the data set, including a bias towards experienced, productive pairs. The results of the analysis indicated that recruitment of young into the population was higher when eggs were removed than when eggs were not removed: theta=0.498$\pm$0.0012 with removal, theta=0.355$\pm$0.0013 without removal, showing a 25% reduction in survival of chicks without removal. This advantage of increased recruitment from 1-egg nests is counterbalanced by occasional survival of both chicks from 2-egg nests.

Boyce and Miller (1985) found a 10-year cycle in whooping crane counts, which held true through 2002 (Boyce et al 2005). This trend parallels counts of predators (based on lynx fur returns) in the area (Boyce et al. 2005). There was a strong negative effect between egg collection and lynx populations, such that collection of eggs during a crashing lynx population may not be detrimental to the AWBP. This would provide additional offspring for recovery efforts elsewhere. During years that egg removal did not occur, 10% of recruits were from sets of twins. One interpretation is that periodically there are very good years and the whooping cranes can actually raise twins. The analysis revealed that there were no negative consequences from egg removal, even with the twinning effect.

Boyce et al. (2005) also evaluated egg substitution effects and found that they did not improve nest success over nests that had no substitutions. This could be due to the nest being situated in a poor habitat or because the pair was inexperienced.

The recovery team recognizes that collection of eggs has benefited the whooping crane recovery program by providing stock to establish the captive flocks and providing offspring for release, thus increasing the total number of whooping cranes and helping to preserve the genetics of the species. The recovery team believes that data analyses to date do not indicate that egg collection would increase recruitment in the AWBP over the long term, but could increase recruitment in selected years. The recovery team would like to document the rate of twinning until 2006 without any egg collection in order to observe the population dynamics through a full 10-year cycle (1997-2006).

The genetic master plan indicates that the genetic diversity of the AWBP is well represented in the captive flocks, hence there would be little to be gained genetically in the captive flocks by removing additional eggs from WBNP at this time. However, certain pairs in captivity are not breeding, so it may become important to obtain additional genetic material from WBNP similar to those pairs. A large-scale study of the genetics of the nesting pairs may have to be undertaken first since information has been lost on the composition of nesting pairs with the cessation of the color-banding program in 1988. There may be demographic benefits to egg collections (i.e. more chicks available for reintroductions), but the recovery team believes that production from the captive flocks is sufficient to support reintroductions at the present time. The current captive facilities are at peak manpower and pen capacity for raising existing chicks and would be strained to handle additional eggs at present. The issue of egg collection should be reevaluated in 2006 at the completion of 10 years with no collection.

Color Banding

Flightless young whooping cranes were captured and marked with colored plastic leg bands in WBNP from 1977 through 1988 (Kuyt 1978a, 1979a, Drewien and Kuyt 1979). Banding whooping cranes in WBNP was halted after 1988, since much information had already been obtained and the objectives of the original banding program had been met. Also, capturing the chicks can cause some mortality. Over the 12 years of the banding program, 134 birds were captured and 2 chicks died (1.5%). As of winter, 2004-2005, 25 of the 217 birds (i.e. 11.5%) in the AWBP were still individually identifiable by their bands (Tom Stehn, ANWR, pers. comm.).

This marking program provided a wealth of information on whooping crane biology, including the summering locations of subadults, the dynamics and habitat use of wintering subadult flocks, age specific survivorship, the age of initial pairing and breeding, juvenile and adult philopatry and the identification of stopover sites, and wintering and breeding territories used by specific pairs (Kuyt 1979b, 1981a, 1981b, Bishop and Blankinship 1982, Bishop 1984, Stehn and Johnson 1987, Johns et al. *In press*). Other information gained from the banding studies included the ability to develop a studbook on a fairly large segment of the wild population, tracing the reproductive histories of many of the birds including mate switches and probable deaths. These data provide valuable insight into the relatedness and genetic diversity of the wild flock and may be of assistance in evaluating potential inbreeding effects in the future.

Migration Monitoring

Whooping cranes spend approximately 3 months annually in migration. Although a number of migration sightings have been reported and compiled over the years (Allen 1952, Sutton 1967, Walkinshaw 1973, Archibald et al. 1976, Stephen 1979, Asherin and Drewien 1987, Johns 1987, Asherin et al. 1992), few were confirmed. In order to protect migrating whooping cranes from disease outbreaks and other potential hazards, and to compile information on the characteristics and locations of stopover sites, the USFWS initiated the Cooperative Whooping Crane Tracking Project in 1975. The CWS started a similar program in 1977. This program alerts key personnel about sightings so that reports can be verified, stopover sites described, and the birds kept under protective surveillance by State, Provincial, and Federal personnel. This monitoring program is coordinated with reporting networks of wildlife agencies along the migration corridor. Whooping crane sightings compiled within the U.S. portion of the migration corridor by the USFWS (1,352 confirmed sightings, 1943-99) were summarized by Austin and Richert (2001).

Whooping crane sightings compiled within the Canadian portion of the migration corridor were summarized by Johns (1992) and Johns et al. (1997) The presence of marked birds from the banding program conducted in WBNP provided more precise information on migration chronology, and yielded information on several events that would have otherwise gone undetected (Stehn 1992a,c).

Radiotelemetry techniques were first tested on cross-fostered whooping cranes in the RMP (Drewien and Bizeau 1981). Beginning in 1979, flightless young were captured and marked with plastic leg bands to which miniature radio transmitters (45-60 g) were attached. Local movements of the radio-tagged birds were monitored on summering and wintering areas, and several individuals were followed during their fall migration between Grays Lake NWR in southeastern Idaho and Monte Vista NWR in south-central Colorado. No adverse effects were noted from capturing, banding, and radio-tagging young whooping cranes (Drewien and Bizeau 1981).

On the basis of these preliminary studies, a cooperative USFWS-CWS-NAS radio tracking program was initiated for birds in the AWBP to determine various aspects of migration ecology, including habitat characteristics, behavior, and sources of mortality. During each summer 1981-1983, small solar-powered transmitters were placed on several prefledged whooping cranes captured during the color-banding operation in WBNP (Kuyt 1979a, 1979b, 1992). Data were obtained on 3 southbound and 2 northbound migrations. Most information involved the individuals or family groups actually being followed, but data also were accumulated on other migrating whooping cranes encountered during the project.

This successful tracking project resulted in important information concerning migration routes, migration timing, flight methods and speed, stopover locations and staging areas, habitat use, social behavior, activity budgets, predator/disturbance reactions, and sources of mortality (Howe 1989, Kuyt 1992). Perhaps the most important result obtained from this tracking project has been documenting mortalities on the breeding grounds (wolf predation) (Kuyt et al. 1981), during migration (power line collisions), and on the wintering grounds (predation and disease). Similar valuable information has been acquired on migration and behavior of whooping cranes in the RMP (Drewien and Bizeau 1981, Asherin and Drewien 1987, Drewien et al. 1989) and the EMP (Urbanek et al. *In press*{b}).

Migration Habitat Management and Research

Suitable stopover habitat is necessary for the birds to complete their migration in good condition. There has been considerable alteration and destruction of natural wetlands, rivers, and streams, some of which had served as potential roosting and feeding sites for migrating cranes. There may be additional areas along the migration route that need to be delineated and protected.

South central Saskatchewan has been referred to as a traditional fall staging area for whooping cranes (Johns 1992). Habitats used by cranes, in the staging area, were characterized by Johns et al. (1997). Choice of wetland types for roosting was influenced by a variety of landscape features both natural and manmade. Roosting wetlands varied in size and type, depending on the season, in areas of higher than average wetland density. The staging area is in a highly modified environment with the majority of crane roosts (96% spring, 85% fall) being on private land. Foraging area use exhibited a similar trend (Johns et al. 1997). Once the cranes leave the fall

staging area, the remainder of their migration is rapid and stopovers are of shorter duration (Kuyt 1992). There is no equivalent spring staging area.

The USFWS has funded studies of availability of suitable migration stopover habitat within the AWBP migration pathway in the United States (Stahlecker 1988, 1992, 1997a, 1997b). National Wetland Inventory (NWI) maps, used in conjunction with aerial photo maps and suitability criteria (Armbruster 1990), were poor predictors (33% correct) of suitable roosts in Oklahoma, but good predictors (97% correct) of unsuitability (Stahlecker 1992). NWI map review in Nebraska was a good predictor of both suitability (63% correct) and unsuitability (73% correct). Wetlands suitable for overnight roost sites for migrating whooping cranes were available throughout the migration corridor in the Dakotas and Nebraska (Stahlecker 1997a, 1997b), but may be limited in Oklahoma (Stahlecker 1992). Similar sampling to evaluate roost availability in Kansas and Texas should be conducted.

Richert (1999) used Geographic Information Systems (GIS) and remote sensing technologies to evaluate whooping crane stopover habitat in Nebraska. Confirmed whooping crane sightings, when compared with habitat selection, suggest that whooping cranes select roost habitat by recognizing local and larger-scale land cover composition. Habitat selection was influenced by social group, season, and landscape pattern (Richert 1999).

Based upon recommendations from the Recovery Team, the USFWS initiated a project in 1977 to conduct site evaluations at sites in the U.S. used by whooping cranes during migration. The site evaluation data base, containing 1,060 evaluations completed between 1977 and 2000, was summarized by Austin and Richert (2001). Results revealed some new insight into whooping crane habitat use during migration (e.g., roosting and feeding site characterization).

Based on the large number of sightings along the central Platte River in Nebraska during 1820-1948, Allen (1952) believed that whooping cranes made that area a major stopover, remaining in the area for some days. In 1978, the USFWS designated an 88 km portion of the Platte River in central Nebraska as critical habitat. The National Research Council of the National Academies of Science (NRC) (2005) reviewed and affirmed the scientific validity of that critical habitat designation, and the importance of the Platte River to the survival and recovery of the whooping crane population.

Currently, an average of about 7% of the AWBP population use the central Platte River during migration, although there is substantial fluctuation in that percentage from year to year (NRC 2005). Additionally, the average duration of stopovers (as reflected by crane use-days) and the number of confirmed sightings along the central Platte River have increased more than can be explained by the increase in size of the AWBP (NRC 2005).

The NRC (2005) concluded that "…current habitat conditions along the central Platte River adversely affect the likelihood of survival and recovery of the whooping crane population." (p. 183). As a result of reduced channel width, loss of adjacent wet meadows, and encroachment of the channel by woody vegetation brought on by diversion and storage of water for irrigation and power generation (USFWS 1981), 128 km of Platte River channel habitat has been lost. In the remaining 120 km of the Platte River channel that crosses the breadth of the migration path, there has been a 58 to 87% reduction in channel area due to encroachment of woody vegetation and approximately 70% loss in the average annual flow since 1930. As much as 97% of suitable

crane roosting habitat has been lost in some river segments. Woody vegetation is still expanding and channel width declining on the Platte River (Currier 1997). Over 73% of native grasslands and wetlands adjacent to the river channel have been lost due to declines in river flows, construction of drainage systems, and conversion to cropland (Currier et al. 1985). The need to prevent further deterioration of habitat along the Platte River has been identified (USFWS 1981, NRC 2005).

A river management plan was prepared by the Biology Workgroup of the Platte River Management Joint Study, a group of representatives from the USFWS, Bureau of Reclamation, Corps of Engineers, States of Wyoming, Colorado, and Nebraska, water development interests, and environmental groups. The plan identified management alternatives that could be implemented in the Platte River basin as an aid to future management (Platte River Management Joint Study 1990). Currier et al. (1985) and Strom (1987) described management programs to preserve, rehabilitate, and restore river habitat. Other research conducted along the Platte River (Hurr 1983, Wesche et al. 1990, Henszey and Wesche 1993) indicates river discharge and stage are dominant factors affecting groundwater levels in wet meadow grasslands. Areas for whooping cranes should be managed to prevent further channel shrinkage and encroachment by woody vegetation. Reasonable in-stream flows are required to maintain the wet meadows used by cranes.

The USFWS recommended target flows for the central Platte River, Nebraska, to the Federal Energy Regulatory Commission (FERC). These recommendations are designed to rehabilitate and maintain the structure, patterns, processes, and habitat of the central Platte River ecosystem. Flow recommendations are generally prioritized by time period in the following order: a) pulse flows during late spring (May and June) and late winter (February and March); b) summer; c) spring migration; and d) fall migration.

Multiple organizations and agencies continue to be involved in habitat restoration and management for whooping cranes on the Platte. These include the USFWS, the Nebraska Game and Parks Commission, the Platte River Whooping Crane Habitat Maintenance Trust (PRT), the Platte River Bird Observatory at Crane Meadows, the Audubon Society's Rowe Sanctuary, the Nature Conservancy, and the National Wildlife Federation. Beginning in the 1980s, restoration activities have focused on clearing and maintaining river roost sites free of trees and shrubs and restoring and rehabilitating wetland meadows and marshes adjacent to the river channel. Other efforts include habitat management done by the Nebraska Public Power District and the Central Nebraska Public Power and Irrigation District pursuant to conditions of their FERC licenses. The Nebraska Game and Parks Commission and the Central Platte Natural Resource District hold instream flow rights that may help provide river roosting habitat during migration periods.

Additional actions intended to improve habitat conditions on the Platte River are currently being pursued by the states of Wyoming, Colorado, and Nebraska, and the U.S. Department of the Interior. In 1997 they signed a *Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitats Along the Central Platte River, Nebraska* (Derby and Strickland 2001). The cooperators agreed to implement certain management activities for four target endangered or threatened species, including the whooping crane and its federally designated critical habitat. Currently, intensive aerial and ground monitoring for whooping crane use of the Platte River is being done pursuant to the Cooperative Agreement, at a cost of more than $100,000 per year.

The signatories of the Cooperative Agreement are planning to implement a basin-wide Platte River Recovery Implementation Program (Program) to restore the river to assist in the conservation and recovery of the target species. Although the signatories anticipated development and implementation of the Program by the year 2000, negotiation of Program details are ongoing. Program implementation currently is expected in 2006, following appropriate environmental reviews. One objective of the Program is to protect or restore 4,047 ha in the first 10-13 years and, ultimately, protect 11,736 ha of Platte River habitat for the whooping crane, least tern, and piping plover (Derby et al. 2000). It is important that actions taken reverse the ongoing degradation of the river and loss of crane habitat as described in the NAS report (National Research Council 2005).

Along the Platte River, roosting habitat suitability criteria (Ward and Anderson 1987, Armbruster 1990), combined with hydraulic simulations of Instream Flow Incremental Methodology (IFIM), have been used to identify the relationship between river discharge and roosting habitat (Platte River Management Joint Study 1990, Ziewitz 1992, Platte River Management Joint Study 1993). The IFIM consists of a collection of computer models, including the Physical Habitat Simulation Model and analytical procedures, designed to predict incremental changes of habitat resulting from incremental changes in river discharge.

Farmer et al. (2004) reviewed the C4R version of the Whooping Crane Habitat Suitability Model and suggested some improvements. Their suggestions will be considered by the USFWS, along with recommendations of the NRC (2005) regarding water management using normative flows, and information collected during the Program and from other sources, to evaluate current USFWS instream flow recommendations for the central Platte River.

Wintering Grounds Management and Research

Despite intensive studies of whooping cranes on the wintering grounds by Allen in the late 1940s, some important questions remained unanswered. More detailed information was needed on food habits, food availability in relation to climatic conditions, spatial requirements and territorial behavior in an expanding population, and on the effects of increasing human activities in and around the cranes' habitat. With more of this information available, better management planning and evaluation would be possible.

Potential whooping crane food organisms and related physical factors were studied in 1963 and 1964 by Bill Van Tries and Gordon Folzenlogen of the USFWS. In1970, the NAS assigned David Blankinship to conduct research on wintering whooping cranes at ANWR and adjacent areas. Findings on territorial behavior, subadult flocks, adult-young relationships, feeding ecology, parasites, and other aspects of wintering ecology have been published (Blankinship 1976, Forrester et al. 1978, Bishop and Blankinship 1982, Bishop 1984, Blankinship 1987).

Hunt (1987) studied upland habitats at ANWR to identify environmental conditions associated with crane use, the effect of management on uplands, and the importance of food items consumed there. Whooping cranes used portions of upland pastures that were open, close to the wetland edge, and away from sources of human disturbance. Periodic upland burning increased visual openness of habitat, oak stem density, and availability of acorns (Hunt 1987).

Winter territories of whooping cranes on the Texas coast place the birds in close proximity to several human-induced disturbance factors. These factors included whooping crane tour boats, boat and barge traffic along the GIWW, recreation and commercial traffic (including hunting, angling, crabbing, and oystering), photographers, and aerial overflights. In the winter of 1985-86, Mabie et al. (1989) examined the response of 4 whooping crane family groups on Matagorda Island to several staged hunting and boating activities. Cranes are somewhat tolerant of people in carefully operated boats and land vehicles. Direct harassment by airboat caused the only significant difference in behavior pattern (percent of time alert) when compared to control observations. The cranes responded to disturbances at distances ranging from 25 to 550 m. Response ranged from alert posture to walking away to flying away for a maximum distance of 2,150 m. Whooping crane response was generally short-term, with a return to normal behavior patterns by the second hour of observation. Irby (1990) observed whooping cranes on Welder Flats for 365 hours, using scan sampling and focal bird sampling techniques, and noted all events that caused disturbance. Of the 365 hours of observation, cranes spent 47 minutes responding to non-observer human-induced disturbance. Irby (1990) made several recommendations resulting from his observations. Barge mooring may represent a dangerous threat. A coordinated plan needs to be developed to protect the area from pollution, and to designate safe barge mooring areas. In a study done in the winters of 1989-90 and 1990-91, whooping cranes on the ANWR responded with a negative reaction to 40% of all disturbances, were disturbed for 17 minutes for each hour observed, and moved an average of 525 m from human disturbances, and were displaced most often from open bay and wet marsh habitats (T. Lewis In prep). Airboats, low-altitude aircraft, and especially helicopters were more disturbing, and cranes were particularly sensitive to humans on foot (Lewis and Slack 1992). The extent to which whooping cranes were exposed to disturbance varied among the different use localities. The most recent disturbance study being done by Kristen LaFever and Dr. Doug Slack of Texas A & M University is scheduled for completion in 2006.

It is difficult to assess the total impacts of disturbance upon whooping cranes in terms of fitness, productivity, and survival. Crane displacement results in short-term or long-term loss of habitat, social disruption of the flock, and limits the ability to obtain food resources and thus impacts fitness (T. Lewis In prep). Refuge and coastal wetland users should be encouraged to minimize disturbance to whooping cranes. Damage caused to submerged vegetation by boating activities should be reduced. Support of private landowners in minimizing disturbance and maximizing protection should be recognized and encouraged. As the AWBP continues to expand, a decrease in territory sizes and expansion into new wintering areas is likely to continue. The effects of increased population density and/or exposure to disturbances could be compounded by an increase in frequency or severity of disturbance. Levels of disturbance should be monitored on the wintering grounds and steps taken to minimize detrimental activities.

Management of ANWR is a sizeable and complex operation (Johnson 1976). Prime habitat is limited and natural foods may be in short supply at times. Two 40-ha fenced enclosures were developed during 1964-1968, in which various cereal and root crops were grown. Some whooping cranes used these fields but sandhill cranes and Canada geese (*Branta canadensis*) ate most of the food (Shields and Benham 1969). Another management strategy was the diking of a 28-ha impoundment equipped with a high volume, low-lift pump designed to bring large quantities of saline water and marine life into the basin; the exit of live food items was prevented by screens at spillway outlets. Limited use by whooping cranes was achieved during 1 winter

when they were attracted to the site by "bait" grains, but in subsequent years whooping cranes did not use the artificial impoundment.

During the mid-1960s, whooping cranes were attracted to grains spread for their use. Such supplemental food has since been avoided because concentrating the birds increases the potential for a disease outbreak or the spread of parasites, and changes the distribution of the cranes. Supplemental feeding could be attempted to attract cranes from the tidal areas in certain emergency situations, such as during oil or chemical spills, or periods of food scarcity.

Chavez-Ramirez (1996) analyzed whooping crane winter foods during the 1992-93 and 1993-94 winters. He evaluated standing biomass of blue crabs, clams, and wolfberries and human and wildlife competition for these principal foods. The nutritive composition of winter foods was compared to the commercial rations used for the captive flocks (Nelson 1995, Chavez-Ramirez et al. 1997).

Prescribed burning is used to reduce height and density of grasses, remove brush, and modify plant composition on uplands to make them more attractive to whooping cranes. Management in the past included mechanical cutting and grazing by livestock. Whooping cranes almost immediately use the burned areas (Hunt 1987). Currently, 15 prescribed burn units averaging 322 ha are located in the crane area at ANWR, with the units burned on a 3-year rotation. Additional burning is done on Matagorda Island, as well as on private lands on San Jose Island and Welder Flats.

About 30 freshwater ponds are present on ANWR and Matagorda Island near areas used by cranes. Cranes drink at upland freshwater ponds where surrounding vegetation is kept low to the ground and aquatic emergent or floating vegetation is sparse or absent. Such ponds provide a source of fresh water when coastal waters are highly saline above 23 parts per thousand and may encourage cranes to utilize upland food resources.

The most complete census of the AWBP is made during winter. Aerial censuses are made weekly from the time the first whooping cranes appear, approximately twice a month during mid-winter, and again weekly until the last cranes depart. Flights provide information on mortality, habitat use, pair formation, territory establishment, and population age structure by identifying all color-banded birds present. These flights serve to alert the refuge staff to hazards or harassment of cranes resulting from human activity. If a crane is determined to be "missing," then a ground search may be initiated to locate the carcass.

Whooping cranes use marshes bordering Matagorda Island, a barrier island 60.8 km long by 1.2 to 7.2 km wide. In 1942, the Federal government purchased approximately 7,700 ha of Island uplands, and leased 2,400 ha from the State of Texas, to establish an airbase and bombing range. In 1971, a Memorandum of Agreement with the USFWS established the Matagorda Island Unit of ANWR. The upland area was declared excess property by the Air Force in 1975. The property was transferred to the USFWS as part of the NWR system in 1978. In 1988, the USFWS and Texas General Land Office exchanged easements and signed a management agreement that established Matagorda Island State Park and Wildlife Management Area. In 1988, the USFWS purchased 2,232 ha on the south end of the Island. A new agreement between the USFWS and the State of Texas enabling joint management of the entire island was signed in 1994 and is reviewed every 5 years. It established the Matagorda Island NWR and State Park

and includes a separation of duties. The USFWS has the lead for wildlife and habitat management, and Texas Parks and Wildlife Department manage public use.

Additional protection of some winter habitat has been provided by NAS's leasing of Ayres, Roddy, and a portion of Rattlesnake islands from the State of Texas. The leasing arrangement substantially reduces the potential for disturbing or harassing cranes wintering in these areas.

Construction of the GIWW in the early 1940s through the heart of marshes on ANWR, subsequent erosion by wind and boat wakes, and deposition of dredged material, resulted in loss of 11% of wintering habitat (Sherrod and Medina 1992). In 1983-1984, shoreline erosion along the GIWW was measured at a loss of 1 m per year, amounting to destruction of 0.8 ha of whooping crane habitat along 13.6 km of critical habitat shoreline (Stehn 1987). In 1985, the USACE formed an interagency committee to study the impacts of the GIWW on critical habitat of whooping cranes. Boats and barges plying the GIWW create wakes and surges that erode marsh bordering the channel (U.S. Army Corps of Engineers 1988). Ponds and sloughs in the marsh are destroyed as erosion breaches their margins.

Between 1989-1992, volunteers built walls using more than 57,000 sacks of cement to protect 2,652 m of shoreline. In 1992, USACE used 610 m of interlocking cement mats to stop erosion. USACE agreed in 1993 to armor approximately 4.8 km of the most critically eroding shoreline, and to continue to armor 610 m annually until all areas were adequately protected. The USACE's Section 216 Study provided a permanent solution to the habitat erosion problem. In 1998-2000, the USACE used flexible cement mats to protect 25.6 km of shoreline at ANWR and 8.3 km at Welder Flats. They also protected 471 m at Welder Flats using geotubes, and purchased equipment stored on the refuge to respond to an oil spill. Total project costs were $15.43 million.

Deposition of dredged material from periodic maintenance dredging of the channel has destroyed additional marsh and, accidentally, created some new marsh. Dredged material disposal sites along the GIWW have been nearly fully utilized. The problem of future disposal of dredged material is critical.

In the summer of 1991, Mitchell Energy created a dike around 5 ha of open shallow bay and filled the area with dredge material. Vegetation was planted in the created shallows and the first whooping crane use was documented in January 1992. Mitchell Energy constructed additional marsh acreage in 1993 and 1995 totaling 8 ha. The USACE has evaluated beneficial uses of dredge material to create new coastal marsh habitat for whooping cranes. In 1995, the USACE created 2 wetland areas using dredged material totaling 18 ha (Evans and Stehn 1997). The USACE's new dredge material disposal plan calls for the creation of 654 ha of marsh habitat over the next 50 years. The USACE is working cooperatively with other agencies on the design and location of these new marshes.

Several studies have characterized whooping crane winter habitat. Darnell et al. (1997) studied influence of landscape features on bird use of marsh habitat created for whooping cranes. Although the created marshes were successful in providing avian habitat, design modifications were suggested to increase the similarity of created and natural marshes (Darnell et al. 1997). Bonds (2000), using GIS and remote sensing, characterized whooping crane territories from 1992-1997. Bonds (2000) recommended land-cover composition of whooping crane areas to be

50% salt marsh (5-6.5 patches/ha), 30-40% salt marsh open water (10-16 patches/ha), and up to 10% grasslands (8.9 patches/ha).

Vocalizations of whooping cranes have been studied by several researchers. Initial vocal analysis of alarm calls was not sufficiently accurate (64.4%) to identify individual birds (Carlson 1991), but recordings of unison calls allows for identification of individuals (Bernhard Wessling, pers. comm.). Wessling (2000) recorded the unison calls for 27 pairs on winter territories at ANWR in winter 1999-2000. In the summer of 2000, Brian Johns recorded unison calls of 9 pairs on the breeding grounds. Additional calls were recorded in subsequent summers and winters. From the comparisons, it was possible to identify several of the nesting pairs on their winter territories (Brian Johns, CWS, pers. comm.).

Health Management

A whooping crane health management workshop was organized in 1992 by the NWHC and ICF. Participants included the veterinary and wildlife disease specialists working with whooping cranes. Uniform health management protocols were established for disease monitoring of captive and wild flocks, and for pre-release and pre-transfer disease screening. Unpublished information was collated on disease research. Research needs were identified and prioritized including avian tuberculosis, EEE, and crane herpes. A centralized, computerized database on whooping crane mortality was initiated. WCHAT was established with clinical and research veterinarians identified to coordinate input and serve as official advisors to the recovery team. This Team continues to meet periodically to evaluate progress and address needs. It has regularly updated the health management protocols, developed plans for a centralized serum/tissue bank, and provided advice to the recovery team on issues such as new release site disease assessments, monitoring and control of emerging disease including EEE and West Nile virus, and selection of new captive facilities.

Captive Propagation

Whooping cranes are propagated to save the genetic material of the species and to establish additional wild populations. In 1998, the Recovery Team adopted the following allocation of captive-produced chicks listed in order of priority: maintenance of captive flocks; Florida releases; Wisconsin/Manitoba releases; off-corridor experiments considered essential to Florida, Wisconsin, or propagation; education; other approved populations; and other experiments.

<u>Research and Propagation at Patuxent Wildlife Research Center</u>

Before research was carried out at PWRC, successful attempts to propagate whooping cranes involved only 4 birds - 2 females (Josephine and Rosie) and 2 males (Crip and Pete) (McNulty 1966, Doughty 1989) (Fig. 6). Josephine, who in 1941 was captured and placed in captivity at Audubon Park Zoo in New Orleans, Louisiana, became the last survivor of the non-migratory, southwestern Louisiana population. Crip, Pete, and Rosie, flightless due to injuries, were from the migratory population (McNulty 1966, Maroldo 1980). Three other birds in poor health (1 from Louisiana and 2 from ANWR) were rescued from the wild but all died soon after capture.

Josephine, in captivity from 1941 to 1965, produced 13 chicks. Four lived for more than a decade but left no survivors and the genetics of the Louisiana non-migratory flock was lost. Pete

lived for 13 years in captivity but also left no survivors. In 1949, Pete and Josephine nested unsuccessfully in an enclosure at ANWR. After Pete died at ANWR in 1949, Josephine was re-paired with Crip. The pair hatched one chick in 1950 at ANWR but a predator took it a few days after hatch. After nesting unsuccessfully in 1951, Crip and Josephine were transferred to Audubon Park Zoo. Josephine died in 1965 and Rosie was paired with Crip. After an unsuccessful nesting attempt in 1966, they were moved to the San Antonio Zoo in Texas. Rosie, in captivity from 1956 to 1971, produced 1 line with Crip that survives today (Gee Whiz). Crip, in captivity from 1949 to 1979, produced 13 chicks with Josephine, 3 with Rosie, and 1 with Ektu. Ektu, hatched and reared at PWRC from an egg taken from WBNP in 1967, died in 1984, and produced 1 chick with Crip that died the same year (Fig. 6).

Experimentation with bringing sandhill cranes into captivity began in 1961. Immature lesser and greater sandhill cranes were captured in 1961 and 1962, respectively, and greater sandhill crane eggs and downy chicks were collected in 1962. These cranes were housed in temporary facilities at Monte Vista NWR, Colorado. Initial results of this research indicated that egg collecting was the safest and most convenient method of obtaining and transporting wild stock (McNulty 1966, Doughty 1989). In subsequent years, only eggs were taken from the wild at Malheur NWR, Oregon, and Grays Lake NWR, Idaho, several locations in peninsular Florida, Jackson County, Mississippi, and central Wisconsin.

A male whooping crane named CAN-US, captured as a chick in WBNP in 1964 with an injured wing (Novakowski 1965), was the only whooper in the flock. In 1966, U.S. Senator Karl Mundt sponsored a supplemental appropriation to establish the Endangered Wildlife Research Program and to develop permanent facilities at the PWRC in Laurel, Maryland. The WCCA was influential in acquiring the first project funding at PWRC (Erickson 1968). The single whooping crane, sandhill cranes, and Aleutian Canada geese were transferred to Maryland in spring 1966.

Although some propagation techniques developed for sandhill cranes can be applied to whooping cranes, the latter have required certain procedural modifications. Whooping cranes are more difficult to rear than sandhills, and most mortality has occurred within one month of hatching as a result of bacterial infections, coccidiosis, congenital abnormalities, and leg disorders resulting from rapid growth (Kepler 1978). All mortalities in the captive flock have been summarized from 1967 to 1981 (Carpenter and Derrickson 1982) and from 1982 to 1995 (Olsen et al. 1997).

Whooping crane eggs were first produced at PWRC in 1975 when 1 female laid 3 eggs. Although 2 females produced eggs when they were 5 years old, most captive females have not laid until they were 7-10 years old (Table 3). At CZ, 1 female produced eggs when she was 4 years old (Dwight Knapik, CZ, pers. comm.) and 2 females when 5 years old. ICF had 2 females produce eggs at 4 years of age (Mike Putnam, ICF, pers. comm.).

Possible factors responsible for delaying reproduction in the captive flock include photoperiod, rainfall, rearing conditions, dominance relationships, age of separation of potential pairs from a bachelor flock, sexual compatibility, inadequate pen size, lack of access to ponds, and stress associated with handling and disturbance (Kepler 1976, 1978, Derrickson and Carpenter 1982, Ellis et al. 1996, Mirande et al. 1996). Besides delayed sexual maturity, other factors reduce reproductive potential in the captive flock. Most birds, after they start, lay eggs every year. Some pairs lay every other year, some more occasionally, and some lay small or misshapen eggs. Between 1975 and 2005, the captive flock at PWRC produced 957 eggs (Table 4).

Figure 6. Whooping crane captive propagation, 1941-1979.

Table 3. Age of captive whooping cranes when they first produced eggs, Patuxent Wildlife Research Center, 1975-1993.

Age (years)	Females[ab]	Producing Females[c]	Percent Producing
5	28	5	17
6	22	8	36
7	15	8	53
8	13	10	76
9	10	9	90
10	9	9	100

[a] Does not include birds transferred between centers before maturation. Transfers delayed egg production.
[b] Females reaching or passing through that age class by 1993.
[c] Females producing eggs in that age class.

Breeding pair numbers and egg fertility have been the primary factors limiting annual production in captivity (Gee and Temple 1978). Successful natural copulations were not observed until 1991 when a full-winged pair laid a fertile egg (Nicolich et al. 2001).

There has been no difference in the number of eggs produced by naturally fertile pairs and artificially inseminated birds at PWRC. From 1991 to 1999, 8 pairs produced chicks by natural breeding, but egg fertility (54%) was less than from females artificially inseminated (76%). Natural fertility, which reduces the risk of injury due to handling, is good in some pairs but overall is less than in pairs artificially inseminated. Some pairs, although they copulate, fail to lay a high percentage of fertile eggs or do not reliably lay fertile eggs every year. In these pairs, artificial insemination before they lay the first egg may increase natural fertility and increase total fertile production in the captive flock (Bakst 1988). To get fertile eggs from badly imprinted or handicapped individuals, the females have been artificially inseminated using the massage technique (Gee and Mirande 1996). To condition pairs to this procedure, collection of semen from males and the handling of females begin well before laying. After their pubic bones begin to spread, females are inseminated 3 times weekly and after each oviposition until laying ceases.

From 1975 through 2005 at PWRC, fertility of eggs (256 of 376) from whooping cranes artificially inseminated averaged 68%. From 1991, when the whooping cranes began natural breeding, through 2005, fertility through natural breeding was 64% (268 of 421). In 1999, PWRC began doing supplemental artificial insemination on a few naturally breeding birds to increase their rate of fertility. Fertility of eggs produced by these pairs in 1999-2005 was 81% (43 of 53). From 1975 through 2005, the PWRC flock produced 967 eggs of which 503 were fertile (52%). Through 2005, from these 503 fertile eggs, PWRC fledged 350 birds (70%). In addition, between 1975 through 1996, PWRC received 90 fertile whooping crane eggs from WBNP and from those eggs, 61 chicks fledged (68%).

Table 4. Size and productivity of the captive whooping crane flock at Patuxent Wildlife Research Center, 1975-2005.

					Eggs retained at PWRC			
Year	AHY[a] Birds 31 Dec.	HY[b] Birds 31 Dec.	Females Laying	Total Eggs[c]	No.	Fertile	Hatched	Chicks Fledged
1975	20	0	1	3	3	2	1	0
1976	18	1	2	5	3	1	1	1
1977	19	2	4	22	8	4	3	2
1978[d]	19	3	3	23	8	8	7	3
1979[e]	22	4	4	21	16	10	8	4
1980	22	0	2	6	4	1	0	0
1981	19	1	2	11	11	5	3	1
1982	19	7	5	28	15	12	9	6
1983	25	10	5	34	22	18	14	8
1984	27	5	5	31	21	16	12	4
1985	31	7	3	13	13	8	7	6
1986[f]	36	2	0	0	0	0	0	0
1987	35	6	5	7	7	3	2	1
1988	37	9	6	15	15	8	7	3
1989	30	2	5	19	19	14	9	8
1990	32	3	4	14	14	5	4	3
1991	35	5	5	21	21	9	5	2
1992	36	13	8	48	48[g]	11	9	8
1993	37	19	8	35	35	16	15	10
1994	40	16	9	48	48	29	21	18
1995	37	35	8	48	48	35	31	26
1996	39	21	8	44	44	27	25	18
1997	42	18	8	55	55	30	29	18[h]
1998	40	27	10	55	55	35	30	27
1999	44	30	8	52	52	32	29	26
2000	47	25	8	51	51	35	35	32
2001	53	15	10	52	52	31	29	25[h]
2002	50	7	10	43	43	27	22	20[h]
2003	51	8	10	51	51	30	27	26[h]
2004	50	4	13	54	54	23	21	19[h]
2005	53	2	13	58	53	18	18	17[h]
			TOTALS	967	889	503	433	350

[a] AHY = After Hatch Year
[b] HY = Hatch Year
[c] Includes 73 eggs transferred to Grays Lake National Wildlife Refuge in 1976-1984. Fertility determined for unhatched eggs by examination of egg contents. Examination occurred after full-term incubation and eggs containing no detectable embryo were considered infertile, therefore, the number of fertile eggs listed is considered a minimum estimate.
[d] All eggs retained at PWRC were incubated and hatched under sandhill cranes and chicks were "foster-parent" reared. All eggs transferred to GL were artificially incubated until transfer.
[e] All eggs retained at PWRC were incubated under sandhill cranes and chicks were hand-reared or foster parent-reared by sandhill cranes. All eggs transferred to GL were incubated under captive pairs of sandhill cranes at Patuxent until transfer this year and subsequent years.
[f] No eggs were produced in 1986. Breeding birds were moved temporarily to pens in summer 1985 during construction of new pens. The birds were moved into the new pens in November 1985. These movements were believed to be the disturbance that disrupted the 1986 breeding cycle.
[g] Six new pairs broke the 19 eggs they produced.
[h] In 1997 and 2001-2005, the number of chicks fledged also includes chicks that were shipped to their release site prior to fledging.

From 1993 to 2005, 368 of 641 eggs (63%) from the PWRC flock were fertile. From these 368 eggs, 282 (77%) were fledged or were shipped prior to fledging. Of these, 177 (plus 14 produced from WBNP origin eggs) were sent to the Florida reintroduction. In addition, 7 chicks (plus 1 of ICF origin) were sent to Idaho and 75 (plus 13 eggs from other institutions) were sent to Wisconsin for release through ultralight migration reintroduction projects. PWRC avoids imprinting problems by parent-rearing chicks or hand-rearing them in visual and auditory contact with a subadult whooping crane imprint model.

Seventy-three whooping crane eggs were transferred from PWRC to Grays Lake between 1976 and 1984. PWRC shipped 22 birds to ICF in 1989 and 11 birds to Calgary in 1992 and 1993 to help establish other captive flocks. The flock was split several times to reduce the risk of disease outbreaks decimating the entire captive population.

Hatchability of whooping crane eggs incubated by cranes exceeds that of eggs placed in incubators, probably because of less than optimum incubation regimes. In 1978, hatchability of the 8 eggs retained at PWRC and incubated under sandhill cranes was 88%, while only 5 of 11 fertile eggs incubated artificially before their transfer to GL hatched. As a result, since 1979 all whooping crane eggs at PWRC have been incubated under sandhill cranes or whooping cranes. Since these modifications were undertaken, hatchability and chick survival (Table 4) has equaled that observed in eggs and chicks from the AWBP.

A study of the pedigree effect on survival in captivity and in Florida found that some families do not produce eggs or fertile eggs. Some produce many chicks but few survive well in captivity and after wild release, some fledge many chicks and they survive well in captivity and after wild release, and some families carry genetic defects (e.g. scoliosis) (George Gee, PWRC, pers. comm.).

Infection with coccidia (*Eimeria* spp.) has been a major morbidity and mortality factor for chicks at PWRC, in some years resulting in up to 20% mortality of the hatched chicks (Carpenter et. al 1980). Control programs, including better pen design, improved pen husbandry, pen rotation, and development and use of new coccidiostats in the feed, have now reduced the mortality to zero.

A disease outbreak can cause a serious setback to the captive breeding program. In the fall of 1984, 7 whooping cranes in the captive flock at PWRC died from EEE, of which 5 were females. The January 1985 sex ratio in the surviving adult captive population was 10 males to 4 females. Sandhill cranes at PWRC also were exposed to the virus, but no mortality occurred (Carpenter et al. 1987). Whooping cranes appear especially susceptible to EEE; consequently the potential impact of this disease will be considered when selecting any site for additional whooping crane populations.

Thirteen of the 32 whooping cranes at PWRC were exposed naturally to the EEE virus and all developed antibody titers. Ongoing unpublished research has shown that use of an EEE vaccine protects against infection and should reduce the risk of this disease in the future. Actions taken in 1985 and continued annually to prevent another outbreak of EEE at PWRC include: (1) a surveillance and control program for the principal mosquito (*Culiseta melanura*), vector of the disease; (2) testing EEE vaccines and developing a more effective vaccine for whooping cranes; and (3) continuing serological monitoring of the captive flock for antibody titers. Now that the etiology of the whooping crane deaths at PWRC is known, the disease threat can be minimized in captivity by initiating appropriate mosquito control measures and the use of EEE vaccines. However, the long-term efficacy of the vaccine is unknown and annual booster shots are required. The WCHAT recommended that the breeder cranes at all captive facilities in EEE geographic areas, including ICF and PWRC, be vaccinated. EEE vaccination research is also being done to test its usefulness when whooping cranes are released into EEE areas like Florida. As part of an experimental strategy, chicks transported from PWRC to Florida for release are vaccinated, but those coming from ICF and other northern captive centers are usually not vaccinated.

In September-October 1987, a mycotoxin in commercially prepared crane feed poisoned about 240 of the 300 captive cranes at PWRC. Fifteen cranes died (5% of the flock), including 3 whooping cranes. Laboratories found a trichothecene in the feed that may have been the toxic agent (Valente 1992). A small sample of each commercial food shipment is now fed to bobwhites (*Colinus virginianus*) before being offered to cranes. Food consumption, body weight changes, and mortality in the quail are used to detect toxins in the feed.

WNV, a form of encephalitis newly arrived from Africa and first detected in the New York area in 1999, has been spreading across the U.S. and Canada. An outbreak of WNV at SSC in August 2002 resulted in the death of 7 out of 18 sandhill crane chicks and the serious illness of one staff person. The adult whooping cranes were apparently not affected. WNV may pose a threat, which needs to be assessed, to the cranes at PWRC and to all the whooping crane populations (Robert McLean, NWHC, pers. comm.). Young chicks with undeveloped immune systems may be particularly vulnerable. Research on WNV and the efficacy of vaccination in sandhill cranes was carried out by PWRC and NWHC in 2002. Preliminary results show that sandhill cranes didn't die or develop obvious clinical signs when challenged with WNV, but they did have a

subclinical infection. Vaccination appears to be particularly effective in protecting sandhill cranes, reducing virus shedding.

Recent significant studies at PWRC include: use of monensin and vaccine as an improved treatment for disseminated visceral coccidiosis; estimates of diversity in the major histocompatibility complex; methods to establish migratory crane populations using trucks, ultralight aircraft, and other techniques; ingested metal treatment (Olsen and Wise 2001), blood studies (Olsen et al. 2001), experiments involving fertilization timing of artificially inseminated cranes (Jones and Nicolich 2001; Jones et al. *In prep*), and comparisons between individual crane behaviors and survival in Florida (Kreger et al. 2001, Gee et al. 2001). An adaptive management study of the Florida population is currently underway.

The pen facilities at PWRC were modernized in the early 1990s, but major maintenance and replacement needs exist at present. These new facilities should help establish breeder pairs on a territory without the disturbances associated with pen maintenance experienced in earlier complexes.

Propagation at International Crane Foundation

The ICF is a non-profit conservation organization that works worldwide to conserve cranes and the wetland, grassland, and other ecosystems on which they depend. The ICF is dedicated to providing experience, knowledge, and inspiration to involve people in resolving threats to these ecosystems.

Captive propagation expertise was developed during the 1970s with several crane species, including whooping cranes (Doughty 1989). ICF employs 30 full-time staff members and 10 additional people on project funding. The Crane Conservation Department, which manages the whooping crane flock and also assists with the eastern migratory reintroduction, consists of 6 employees. In addition, a veterinarian and veterinary technician provide clinical care to the captive flock.

In 1989, the U.S. Whooping Crane Recovery Team decided to split the captive flock to reduce the risk of disease. The ICF received 22 whooping cranes from PWRC and an injured adult male from the RMP. Two cranes died shortly after their arrival. Two experienced pairs failed to lay in 1990, probably due to the disruption caused by the move. Cranes, especially whooping cranes, are sensitive to disturbance and pen changes (Mirande et al. 1997b). Three females laid 9 eggs in 1991, and 1 chick was parent-reared, the start of captive whooping crane production at ICF. From 1991-2005, the flock at ICF has laid 349 eggs, of which 183 were fertile, 135 hatched, and 108 fledged (Table 5). Fifty-five have been sent to Florida for reintroduction. Twenty-three were kept at ICF to build the captive flock and for genetic management.

Eggs were also harvested from wild nests in Canada and shipped to ICF to build up the size of the captive flock or to support reintroductions. In May of 1990, 12 eggs were transferred from WBNP and 8 fledged to increase the size of the captive flock at ICF to 30. Between 1990 and 1996, 58 eggs from WBNP were transported to ICF, 49 hatched and 41 fledged (Table 6). Eighteen were sent to Florida for reintroduction, 4 to Idaho, 3 to Calgary, and 16 retained in captivity for genetic management.

Table 5. Size and productivity of the captive whooping crane flock at International Crane Foundation, 1989-2005.

Year	All Birds, Jan. 1	Females Laying	Eggs	Fertile Eggs	Chicks Hatched	Chicks Fledged	Chicks Sent to Florida
1989	23[a]	-	-	-	-	-	-
1990	21	0	0	0	0	0	0
1991	30	3	9	2	2	1	0
1992	28	3	16	8	6	6	1
1993	37	3	9	5	5	5	2
1994	28	5	14	6	6	6	4
1995	34	5	21	10	8	5	2
1996	34	6	23	15	12	10	10
1997	32	5	23[b]	13	8[c]	7	7
1998	30	6	22	13	11	7	6
1999	30	4	20	9	8	7	6
2000	28	7	26	12	5	5	4
2001	28	5	21	6	5	2	1
2002	28	7	33	16[b]	13[c]	11[d]	4
2003	32	8	31	17	14	12	8
2004	35	8	40	21	11	7	4
2005	35	8	41	30	21[e]	16	0
TOTALS			349	183 (52.4%)	135 (73.8%)	107 (79.2%)	59

[a] 22 birds arrived at ICF in fall of '89
[b] 3 of these eggs sent to PWRC.
[c] 3 eggs hatched at PWRC.
[d] 3 chicks hatched at PWRC and fledged at NNWR.
[e] 9 hatched at PWRC and 2 at SAZ

At ICF, chicks have been parent-reared, hand-reared, or costume-reared. In costume-rearing, cranes are exposed to the human form only during negative, stressful situations and remain wary of people. From the time of hatching, costume-reared whooping cranes are exposed to live whooping crane role models in adjacent pens to avoid imprinting problems.

Significant morbidity and mortality factors for captive whooping cranes at ICF have been orthopedic problems and metal foreign body ingestion (Langenberg, unpubl. reports to the Recovery Team). Developmental wing and leg deformities, and handling-associated leg fractures and joint injuries in chicks have contributed to low fledging or release rates at the ICF in some years, especially in the early 1990s when production first started (Hartup et al. 2001a). Changes in handling protocols, information exchange with PWRC and other centers, and increased experience have decreased the impacts of these chick problems. The ICF flock has been free of significant infectious disease problems, probably the result of intensive husbandry practices and regular health monitoring. As the captive whooping crane population ages, the

incidence of geriatric problems (such as leg joint arthritis) is increasing, and can be a particular problem in the captive facilities in colder regions, such as the ICF.

Beginning in 1990, closed circuit television proved to be an effective tool for monitoring and supervising the socialization of new pairs as well as for monitoring pairs that break their eggs. Through video monitoring, an egg could be retrieved within minutes of being laid. Currently the ICF has 17 cameras. At least 17 crane pens are wired and ready for cameras, allowing staff to move cameras as needed. The ICF has acquired software for analysis and storage-retrieval of its growing collection of video materials.

The number of laying females at the ICF has increased to 8 starting in 2003. The ICF has facilities to house 12 breeder pairs. Research is ongoing to improve reproduction, rearing procedures, behavioral management, health care, and other topics that may directly benefit management and recovery (Gerencser 1997, 1998, Langenberg and Donoghue 1997, Langenberg et al. 1998, Hartup et al. 2001b, Bowman et al. 2002).

Water and exposure to the wetland environment is incorporated into the rearing of the crane chicks for release. Pairs that raise young are provided with flooded areas. Isolation-reared chicks are also provided with pools and flooded areas in their exercise yard. When the cohorts are formed and the youngest crane is thermo-regulating well, they are moved to larger enclosures. These pens have ponds approximately 20 by 30 feet in size where the chicks are encouraged to roost in the ponds overnight.

As part of the ICF's efforts to improve crane management, work was started on a new isolation rearing facility on a secluded portion of the property. This new facility moves the cranes from an area adjacent to the main office complex where it is difficult to isolate chicks from human sounds, to a low disturbance area. Wetlands in the new facility will allow the cranes access to a larger area providing wide open vistas with fewer human artifacts. Currently the new isolation-rearing facility can house 10 chicks and will eventually house 20 chicks when completed. To enhance public education efforts, fiber optic cable delivers real time video images from a camera in the rearing facility to a public display screen.

Since 1989, the ICF has received support from Region 2 of the USFWS to cover costs of maintaining and breeding its captive whooping cranes. Beginning in 2001, these funds have been appropriated from the Washington Office of the USFWS. The ICF raises additional funds from the private sector to support whooping crane conservation, over $300,000 in each of the last two years. Aside from research and crane management efforts, the ICF emphasizes public education about cranes, their habitats, and conservation. Roughly 25,000 visitors come to the ICF each year, where they can see a pair of whooping cranes in a natural wetland setting. In 2005 for the first time, the pair on public exhibit was given a whooping crane chick to hatch and rear, providing great public viewing opportunities. ICF staff members engage in outreach activities along the Wisconsin-to-Florida flyway, in Texas, and in other key crane areas, involving use of crane posters, audio-visual presentations, and Crane Trunks (boxes shipped on temporary loan to schools and containing a variety of crane artifacts and educational activities). The ICF also has a school curriculum on crane migration available through registration on its website.

Table 6. Hatching and fledging rates of AWBP eggs transferred to International Crane Foundation, 1990-1996.

Year	Eggs Received	Eggs Fertile	Eggs Hatched	Chicks Fledged	Chicks Sent to Florida
1990	12	11	11	8	0
1991	0	0	0	0	0
1992	11	10	10	7	6
1993	10	9	8[a]	7	0
1994	9	5	5	5	4
1995	10	10	10	9[b]	8
1996	6[c]	5	5	5[d]	0
TOTALS	58	50	49	41	18

[a] Four chicks sent to Grays Lake, Idaho; 2 chicks sent to Calgary Zoo.
[b] One chick sent to the Calgary Zoo.
[c] One egg arrived with a hole in it, late dead embryo.
[d] All chicks retained at ICF for genetic management.

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Propagation at Calgary Zoo

The Calgary Zoological Society is a non-profit, charitable organization that operates the Calgary Botanical Gardens and Prehistoric Park in Calgary, Alberta, Canada. The Society houses a wide variety of living animals and plants, and participates in many threatened and endangered species breeding programs. In 1988, the CWS called for bids from suitable organizations to manage a captive breeding flock of whooping cranes. In 1989, Calgary was chosen, and the Calgary Zoological Society signed an agreement with CWS to serve as the Canadian captive breeding center.

In 1991, zoo staff visited the ICF for training in captive husbandry. Funding was obtained from the Nat Christie Foundation in Calgary to build breeding enclosures, a chick-rearing building, and incubation facility. In November 1992, the first 2 whooping cranes arrived from ICF, with 11 sent from PWRC in 1993. In 1994, the first chick was hatched from a wild egg from WBNP. In 1995, Hope and Chinook produced the first eggs at Calgary. Chinook, at age 4 years and 14 days, was the youngest female to lay an egg in captivity. In 1996, the same pair produced the first fertile eggs laid at Calgary. Three chicks were reared to fledging, and were the first released to the wild at Kissimmee Prairie, Florida, from this facility (Table 7). Between 1996 and 2005, 17 chicks reared at Calgary, all from Hope and Chinook, were shipped to Florida.

From 1995 to 2005, 183 whooping crane eggs have been laid at Calgary; 56 were fertile, 32 hatched, and 24 fledged (Table 7). Four eggs were received from WBNP in 1994 and 2 in 1996, from which 2 chicks hatched in 1994 and 1 in 1996. From those AWBP eggs, 1 chick fledged each year. Through 2004, all fertile eggs have been produced by natural fertilization. Artificial

Table 7. Size and productivity of the captive whooping crane flock at Calgary Zoo, 1992-2005.

Year	All Birds	Females Laying	Eggs	Fertile Eggs	Chicks Hatched	Chicks Fledged	Chicks Sent to Florida
1992	2	0	0	0	0	0	0
1993	13	0	0	0	0	0	0
1994	16	0	0	0	0	0	0
1995	18	2	5	0	0	0	0
1996	18	1	5	5	5	3	3
1997	20	2	12	1	1	0	0
1998	21	2	10	2	2	2	2
1999	21	3	13	6	2	2	2
2000	20	4	21	11	6	3	2
2001	20	6	28	5	5	3	3
2002	19	6	24	6	2	2	2
2003	17	4	21	8	3	2	1
2004	19	6	22	7	3	3	2
2005	19	7	21	9	6	4	0
TOTAL			183	56	32	24	17

insemination methods were started in 2003 to increase production with successful fertilization first achieved in 2005. Eggs are incubated using a combination of natural and artificial methods. Chicks are reared by parents or by costumed caretakers.

Propagation at San Antonio Zoo

Since April 1956 when an injured whooping crane was received for rehabilitation, the SAZ has maintained this species in their collection and has successfully bred them in captivity (Lauver 1992). The SAZ is the closest facility to ANWR with expertise in cranes and has taken in cranes captured from the wild that have been sick or injured. The Recovery Plan calls for 3 breeder pairs to be kept at the SAZ. They currently hold 5 adult cranes that have produced off-spring for reintroduction programs. In 2005, SAZ hatched 3 genetically valuable eggs sent to them from other facilities. The public exhibit that holds one breeding pair was remodeled in 2000 and includes a stream running through the enclosure. The other whooping cranes are kept off-exhibit. The SAZ has worked in close cooperation with the Recovery Team and provides its own funding for whooping crane propagation activities.

Propagation at Freeport McMoran Audubon Species Survival Center

The Freeport McMoran Audubon Species Survival Center (SSC), a major propagation facility for the endangered Mississippi sandhill crane located in Belle Chasse, Louisiana, was approved by the Recovery Team in 1998 to propagate whooping cranes. The facility is needed primarily as a breeding facility to support ongoing whooping crane reintroduction programs, as well as

increase capacity of the captive flock to reach the objective of 153 birds, the size recommended for conservation of flock genetics. The Recovery Plan calls for 10 breeder pairs to be kept at the SSC.

The SSC received their first whooping cranes in 1998, had their first eggs laid in 2003, shipped fertile eggs to PWRC for the EMP reintroduction program in 2005, and in March, 2005 held 9 birds. In 2002, a review done to balance the needs of the Mississippi sandhill crane and whooping crane propagation programs recommended that a new facility be built for whooping crane propagation. Initial funding was received and land cleared in 2004 with construction getting underway in 2005. The new facility will have larger pens with ponds to promote breeding at an earlier age. More funding will have to be obtained to expand the facility to hold 10 breeder pairs. The facility hopes to eventually produce chicks for a whooping crane reintroduction in Louisiana and do research on propagation issues.

The Audubon Zoo in New Orleans had whooping cranes on exhibit from 1941-1975, including the female "Josephine" from the non-migratory Louisiana flock who hatched the first whooping crane chick in captivity in 1956. In November, 2001, a whooping crane shipped to the Audubon Zoo marked the historic return of the species to the zoo. A new whooping crane exhibit was dedicated in September, 2004, with a pair on display featured prominently near the zoo entrance. This is currently a genetically over-represented pair and is slated for display purposes only.

Cross-fostering, Translocation, and Guide-bird Studies at Grays Lake NWR, Idaho

Survival prospects for the whooping crane would be greatly enhanced by establishing additional, separate populations. The first technique tried was cross-fostering whooping cranes to sandhill crane foster parents. Whooping crane eggs from the wild or from captive breeders were placed in sandhill crane nests, and the sandhill cranes incubated, hatched, reared, and introduced the whooping crane chicks into the wild.

Cross-fostering was tested at Grays Lake NWR (GL) in Idaho, on the western edge of the recent historical range of the whooping crane, where studies on the greater sandhill crane had been in progress (Fig. 7)(Drewien 1973, Drewien and Bizeau 1974). From 1975 through 1988, 216 whooping crane eggs were transferred to GL from WBNP, and 73 from PWRC, and placed under pairs of sandhill cranes. Two hundred and ten eggs hatched and 84 chicks fledged (Table 8) (Drewien et al. 1989, Ellis et al. 1992b). The whooper chicks adapted to dietary and habitat differences and, in subsequent years, repeated the migration pattern of their foster parents.

High chick mortality was attributed to inclement weather at the time of hatching, poor habitat and food conditions during some years, and coyote predation (Drewien and Bizeau 1978, Drewien et al. 1985). Subadult and adult mortality rates were also high; birds were lost to fence and power line collisions (Brown et al. 1987, Brown and Drewien 1995), disease (Snyder et al. 1987, 1992, Stroud et al. 1986), predation (Windingstad et al. 1981, Drewien et al. 1989), and other causes. High mortality and the absence of breeding resulted in a relatively small population that peaked at 33 individuals in winter 1985.

Higher mortality rates among females apparently were the basis for unequal sex ratios among cross-fostered adults. In research in other locations, it had been documented that wild cranes can successfully pair with tame or captive individuals (Hyde 1968, Longley 1970, Nesbitt 1979).

Figure 7. Summer and winter ranges and migration route of the reintroduced Rocky Mountain whooping crane population. As of 2002, this population ceased to exist, except for 1 bird in captivity at ICF.

Table 8. Eggs transplanted, hatched and chicks fledged at Grays Lake, Idaho, 1975-1988.

Year	Origin of Eggs	No. eggs transplanted	No. eggs Hatched	No. chicks Fledged
1975	Canada	14[a]	9	5
1976	Canada	15[b]	11	4
	PWRC	2	0	0
1977	Canada	16	15	4
	PWRC	14[c]	5	0
1978	Canada	13	9	3
	PWRC	15[d]	5	0
1979	Canada	19	12	6
	PWRC[e]	5	4	2
1980	Canada	13	10	4
	PWRC	2	2	1
1981	Canada	12	5	0
1982	Canada	14	8	3
	PWRC	13	11	4
1983	Canada	16[f]	15	11
	PWRC	12[f]	11	8
1984	Canada	22[g]	19	10
	PWRC	10[f]	6	2
1985	Canada	23[h]	20	11
1986	Canada	15[i]	11	2
1987	Canada	12	12	2
1988	Canada	12	10	2
Subtotal	Canada	216	166	67
	PWRC	73	44	17
	Total	289	210	84

[a] Two of 14 eggs lost to predators.
[b] Four of 15 eggs lost to predators.
[c] Three eggs deserted after a snowstorm, one egg lost to a predator.
[d] Examination of 10 eggs that did not hatch revealed that 4 were infertile, 2 contained early-dead embryos, and 4 contained late-dead embryos.
[e] Poor hatchability of PWRC eggs during the period 1976-1978 was due largely to egg infertility (11 eggs) and artificial incubation (20 eggs). After 1978, only eggs containing viable embryos (as determined by flotation) were transferred and all eggs were incubated under sandhill cranes at PWRC before their transfer.
[f] One egg lost to a predator before hatching.
[g] Three eggs lost to predators before hatching.
[h] Three eggs believed to be infertile or to contain early dead embryos at the time of transfer.
[i] Two eggs were eaten by predators and two failed to hatch.

Experimentation was started to simultaneously augment the wild cross-fostered population at Grays Lake NWR with captive-reared individuals, rectify the male-skewed sex ratio, and hasten the onset of breeding in the wild population. In June 1981, a captive, 3-year-old, parent-reared female whooping crane was transferred from PWRC to GL and placed on a male whooper's territory (Drewien et al. 1989). Although the female rapidly adjusted to the wild and associated periodically with the male, a pair bond was never established. Successful migration seemed unlikely, so the female was captured and returned to PWRC in October (Drewien and Clegg 1992). The experiment was repeated in 1982. The same female quickly adapted to the wild and her presence stimulated increased territorial activities by the male (Drewien et al. 1989). Unfortunately, the male died after becoming entangled in a barbed wire fence. The female was recaptured and returned to PWRC.

The experiment was repeated in 1989, but in May rather than June. A captive 6-year-old female from PWRC was placed in a pen on a male's territory at GL. The male exhibited much interest in the female and after 1 week she was released from the pen. Pairing behavior included unison calling and copulations. No nesting attempt was made, perhaps because it was somewhat late in the season. The male molted his flight feathers and secluded himself in the marsh. In early June, the female abandoned the flightless male but was joined by another wild male. The new pair remained together for over 4 months. From October 5-15, the male was observed initiating migratory flights on 5 occasions with the female following. However, the female was unable to keep up with the male and she always returned to the territory with the male following.

On October 15 the male migrated alone. The only other whooper present, a male, immediately joined the female for 2 days until he migrated. Six years in captivity apparently made the female physically incapable of sustaining long flights. Attempts to capture her in late October were unsuccessful and she disappeared. The behavior of the males at GL demonstrated that they were highly responsive to the presence of a conspecific female during the breeding season.

During the 1980s it became apparent that during summer older females did not return to GL or other areas occupied by territorial males. Experiments to enhance pair formation were carried out from 1986 through 1990 whereby 20 whooping cranes (some females were recaptured several times) were moved from isolated summer sites and released at GL near male whooping

cranes (Drewien et al. 1989). Five (2 males, 3 females) were held for 1 to 4 months in a pen before being released. These experiments contributed to numerous associations and interactions between both sexes, but no permanent pair bonds developed. The longest associations lasted 2 to 4 months before males and females separated. The cross-fostered females exhibited minimal response to the presence of males. These results suggested that imprinting problems possibly existed in whooping cranes raised by sandhill cranes.

Dr. Edward 0. Garton, biometrician at the University of Idaho, modeled the cross-fostered population to predict when it might become self-sustaining. The model assumed (1) cross-fostered females would be breeding at the same rate as the females in Canada and (2) survival of birds in their first year would be similar to that of first year birds in Canada. Despite these optimistic and unrealized assumptions, with the future transfer of 30 eggs per year, the population would only reach 6 nesting pairs after 50 years (Garton et al. 1989). "It is obvious from all scenarios modeled that egg transplants of less than 30 eggs per year will not suffice to establish a self-sustaining population in a reasonable period of time. Natural breeding will be essential to establish a self-sustaining population" (Garton et al. 1989).

At the 1989 meeting of the U.S. WCRT, the team recommended the cross-fostering be discontinued. Other research continued at GL until 1992, but cross-fostered females appeared incapable of normal breeding behavior. The average whooping crane at WBNP begins egg production in its 4th year (Ernie Kuyt, CWS, pers. comm., 1991). By the fall of 1992, cross-fostered adult female whooping cranes of ages 4 through 12 years had passed through a nesting season on 34 occasions without pairing.

In 1992, a wild cross-fostered male whooping crane paired with a female sandhill crane to produce a hybrid chick. The hybrid wild chick provided additional evidence that cross-fostering may break down behavioral barriers that normally discourage pairing between the 2 species. However, isolated cranes from one species may hybridize with the more common species found in the same area. The hybrid summered in Yellowstone National Park. It never produced offspring and was believed sterile. It was last seen in spring 1999 and is believed dead.

Sexual imprinting of a foster-reared species on the foster-parent species had already been confirmed in foster-reared raptors, waterfowl, gulls, finches, and gallinaceous birds (Immelmann 1972, Bird et al. 1985). An investigation of the potential imprinting problem in cranes occurred at the ICF where sandhill cranes were foster-reared by red-crowned cranes (sample of 1), white-naped cranes (sample of 2), and Siberian cranes (sample of 1). When given a choice the cross-fostered sandhill cranes socialized more with the foster species than with conspecifics. The 2 foster-reared females showed a stronger preference for the foster species than did the 2 foster-reared males (Mahan and Simmers 1992) lending further support to the theory of improper sexual imprinting, particularly in female cranes, being the reason for failure of pairing in the cross-fostered whooping cranes at GL.

In 1993, 4 males (9-17 yr old) and 4 females (7-13 yr old) remained in the Rocky Mountains. A variety of observations suggested that these adults might adopt and rear whooping crane chicks. Cross-fostered males had built nests, intermittently incubated an empty nest and sandhill eggs placed in that nest, and assisted neighboring sandhill pairs in raising sandhill and whooper chicks. Penned male and female whoopers fed and temporarily reared sandhill crane chicks.

In 1993 and 1994, an experiment was designed to determine if the cross-fostered adults would adopt and raise whooping crane chicks and teach them migration (Drewien et al. 1997). If successful, this procedure would overcome the imprinting problems that had prevented appropriate pairing. Four whooping crane chicks or eggs were provided to the project each year. Although parent-chick bonds appeared to develop in captivity, adults did not remain with the chicks after release to the wild. The chicks did not permanently remain with any cranes nor migrate. Field research was ended after 1994.

In 1997, the remnant Rocky Mountain whooping crane population was designated experimental nonessential and 4 areas removed from designation as critical habitat to allow greater management flexibility and to permit crane research to be conducted using ultralight aircraft. In fall 1997, Kent Clegg flew a mixed flock of 8 sandhills and 4 whooping cranes behind an ultralight aircraft between Grace, Idaho, and Bosque del Apache NWR, New Mexico. The trip covered 1,140 km in 9 days. Two of the whooping cranes were lost to predators on the wintering grounds, and two migrated north in the spring. The cross-fostered population in the Rockies declined to a single survivor in year 2000 along with one crane from the ultralight experiment. Both were dead by spring 2002.

Reintroducing a Non-migratory Population in Florida

A November 21, 1975, letter to members of the WCRT from the Florida Game and Fresh Water Fish Commission suggested the possibility of re-establishing a non-migratory whooping crane population in the eastern United States. No pure genetic representative of the non-migratory Louisiana flock remained in captivity. The letter proposed that Florida sandhill cranes might be used as surrogate parents to instill non-migratory behavior into cross-fostered whooping cranes with the goal of restoring a non-migratory flock in the Southeast.

In 1977, John Allender (Audubon Park Zoological Garden) and George Archibald (ICF) submitted a proposal to reintroduce whooping cranes to Louisiana. The proposal was tabled by USFWS because they did not wish to endorse other reintroduction efforts until the cross-fostering project was fully evaluated (letter from Lynn Greenwalt, Director, USFWS, to Regional Directors, May 1978). Louisiana Wildlife agency personnel were concerned that critical habitat might be designated within the State as a consequence of a release, a designation that might place unfavorable constraints on land and hunting management (March 1978 letter of J. Burton Angelle, Secretary, Louisiana Wildlife and Fisheries Commission to George Archibald). Resource agency personnel in Louisiana were also concerned that restrictions on hunting of geese and ducks might be imposed as a consequence of the presence of an endangered species (Gomez 1992). Federal concerns included the belief that local residents might not be instilled with a conservation ethic sufficient to permit success of the reintroduction (letter from D. L. Hall, Special Agent In Charge, USFWS, April 1978).

In 1979, the U.S. Whooping Crane Recovery Team contacted the Florida Commission to ask if they were still interested in evaluating the feasibility of establishing a non-migratory flock of whooping cranes. Research was needed to determine whether a migratory crane species, when reared by non-migratory Florida sandhill crane foster parents, would also be non-migratory. Any cranes cross-fostered in Florida would potentially be in association with migratory greater sandhill cranes that nest in the Great Lakes region but winter in southern Georgia and Florida. Such an association at the time of spring migration might trigger some inherent tendency to

migrate. Research to address the question began in 1980. One member of each of several established pairs of Florida sandhill cranes was captured and instrumented with a radio transmitter. When nesting began, eggs of greater sandhill cranes, obtained from PWRC or from the wild in Wisconsin or Idaho, were substituted for the pair's natural clutch. Hatching and rearing of the young were monitored until the resultant chick/chicks were 55 to 60 days old. The young were then captured, radio-tagged, and plastic leg bands attached. Movements were monitored through 1 or 2 spring migrations following separation from their parents.

Thirty-four greater sandhill crane eggs were transferred into 23 Florida sandhill crane nests between 1982 and 1987. From these transfers, 5 young were produced which survived to the age at which they separated from their parents. Twenty-seven captive-reared young were released (4 cohorts) during 1986 and 1987. They were radio-instrumented and distinctly color banded. Eighteen survived through at least 1 spring migration and 2 fall migrations. Only southerly movements by some individuals (60 to 120 km) exceeded normal dispersal of subadult Florida sandhill cranes. In the 1 instance of the 120 km movement south, the birds returned within 6 weeks to the general vicinity of release. The movements of the dispersing experimental birds did not differ significantly ($P > 0.05$), either in direction or date of movement from that of a control group (Nesbitt and Carpenter 1993). Research results all indicated that migration in sandhill cranes was learned from their parents and not genetically programmed.

By the mid-1980s, questions began to arise concerning the lack of pairing behavior of whooping cranes cross-fostered by sandhill cranes. It was desirable to test an alternative reintroduction technique. Thus, in 1986, releases of captive-reared sandhill cranes began. Four cohorts of captive-reared greater sandhill cranes were soft-released in Florida during late winter or early spring (Nesbitt and Carpenter 1993). Concurrently a group of Florida sandhill cranes (1- or 2-year-olds) from known natal sites were captured, radio-instrumented, and monitored as a control to compare dispersal.

In 1983, the U.S. WCRT met to select sites to evaluate for another wild population. Eastern sites were proposed because they would be discrete from the other wild populations, a requirement of endangered species re-introductions in the United States. Coastal Louisiana, where whooping cranes survived as a non-migratory population in the 1940s (McIlhenny 1943), was not considered due to its proximity to Texas wintering sites and potential conflicts with Louisiana's extensive hunting of waterfowl.

Sites selected for evaluation were Seney NWR and adjacent areas in the Upper Peninsula of Michigan and Ontario, Okefenokee NWR in southern Georgia, and 3 sites in Florida (Lewis and Cooch 1992). Three-year research projects began in 1984 and final reports on the eastern study sites were submitted in 1987-88 (Bennett and Bennett 1987, McMillen 1987, Bishop 1988, Nesbitt 1988). In summer, 1988, the U.S. WCRT recommended that the next reintroduction establish a non-migratory population in the Kissimmee Prairie of Florida. Reasons the Team chose to establish a non-migratory population included (1) failure of the cross-fostering technique in Idaho and (2) lack of any proven technique to establish a migratory population. Some Florida habitats are similar to habitats historically used in Louisiana. Florida has no goose or crane hunting so hunting conflicts were unlikely. The Canadian Recovery Team endorsed the Kissimmee Prairie site in fall 1988. The Director of the USFWS and the Director General of CWS approved the project in 1989.

Considerable progress had been made in developing reliable methods for reintroducing captive-produced cranes to the wild. Releases of isolation-reared sandhill cranes resulted in high post-release survival both in migratory and non-migratory situations (Ellis et al. 1992a). Isolation-rearing refers to rearing the birds separated from visual contact with humans. Ethologist Dr. Robert Horwich at the ICF developed costume-rearing, and the release of such birds into flocks of wild cranes, in 1986. These first experimental releases used captive-reared sandhill cranes (Nesbitt 1979, Drewien et al. 1981, Zwank and Derrickson 1981, Horwich 1986, Bizeau et al. 1987, Leach 1987, Zwank and Wilson 1987, Nesbitt 1988, Horwich 1989, Archibald and Archibald 1992, Ellis et al. 1992b, Horwich et al. 1992, Urbanek and Bookhout 1992, 1994, Nesbitt and Carpenter 1993) to test the techniques. Some were soft or gentle releases involving a gradual transition from life in captivity to the wild. The cranes were placed in large predator-proof enclosures containing food and water. Their wings were brailed to prevent flight (Ellis and Dein 1991). After an acclimation period of 1-2 weeks, the brails were removed and the cranes could fly from the pen. Urbanek and Bookhout (1992) noted the need for similar studies on captive-reared whooping cranes.

The Florida release site, Kissimmee Prairie, consists of approximately 2,000 square kilometers of flat, open palmetto prairie interspersed with shallow wetlands and lakes (Fig. 8). On private ranch lands, much of the prairie has been converted to improved pasture. Land ownership includes 8 large ranches totaling 82,200 ha. Large private holdings range from 2,700 ha to 42,500 ha. Public lands range from 2,955 ha to 43,300 ha. Three Lakes WMA (22,450 ha) was identified by Bishop (1988) as the preferred release site with the best habitat lying between lakes Jackson and Kissimmee.

The whooping crane population in Florida was designated experimental nonessential to increase flexibility of management (Lewis and Finger 1993). Release pens like those used successfully in releases of the endangered Mississippi sandhill crane (*Grus c. pulla*), at the Mississippi Sandhill Crane NWR, were built near Lake Jackson and Lake Marian. In January 1993, the first group of 14 juvenile whooping cranes was transferred to Florida in a soft-release, managed like previous sandhill crane releases in Mississippi (Ellis et al. 1992b) and Florida. The objective of the first release was to evaluate release techniques and response of whooping cranes to the Florida habitat. At regular intervals released birds were recaptured and samples taken to evaluate exposure to disease and parasites.

Whooping cranes were released in Florida habitats similar to those used by Florida sandhill cranes (Nesbitt and Williams 1990). Shallow palustrine wetlands were used for roosting, foraging, loafing, and nesting. They also frequented upland habitats for foraging. Open grassy fields, usually grazed by livestock and/or used for sod production, provided abundant invertebrate and vertebrate food items. Live oaks and laurel oaks (*Quercus spp.*) provided seasonally abundant acorns. Marsh/pasture ecotones and lake edges provided a diversity of aquatic, semiaquatic, and upland food resources.

Upon arrival and prior to release from the pens, whooping cranes were examined and treated with antihelmenthics to reduce the chance for introduction of exotic parasites. Most were vaccinated for eastern equine encephalitis (EEE) and provided feed containing a coccidiostat. Three exotic parasites were found in early releases (Spalding et al. 1996), but their occurrence declined with additional antihelmentic treatment in Florida of subsequent releases.

Figure 8. The Florida peninsula, showing the primary range of the Florida non-migratory population.

Two diseases, EEE and disseminated visceral coccidiosis (DVC) are of particular concern for the recovery of whooping cranes in Florida. Released whooping cranes are partly protected from these diseases by the current release protocol. DVC is caused by infection with a protozoan, *Eimeria* spp., transmitted by fecal contamination of food. This disease is very prevalent in local sandhill cranes but illness and mortality are rarely observed in this species. Whooping cranes are given feed containing a coccidiostat during the time that they are in the pens and while they continue to use the pen area. Although disseminated granulomatous lesions are frequently found in whooping cranes killed by bobcats, severe lesions have only been recorded a few times. In two cases, DVC may have caused mortality, or predisposed birds to predation. Exposure of chicks to DVC is expected to be high, and research to determine its impact on chicks is needed.

EEE virus is endemic in central Florida, although more common in the panhandle. Transmission is by mosquitoes but varies greatly from year to year, being more common in wet years. Most whooping cranes released in central Florida are vaccinated prior to release. The vaccine titer wanes after about 6 months. Several cranes are believed to have been temporarily ill from EEE virus and have recovered when given supportive care. Exposure of newly hatched chicks is likely in years with high transmission. Maternal antibodies may provide some protection in chicks but more research is needed to elucidate risk factors. The drought in Florida from 1998-2002 reduced transmission of the disease and also the ability to study it.

From 1993-2005, 289 whooping cranes were released in Florida, mostly as juveniles, and 60 have survived as of August, 2005 (Table 9). Predation by bobcats has been the primary mortality factor (Nesbitt et al. 1997). Other mortality factors, roughly in order of importance are: wasting syndrome associated with IBD virus infection (Julie Langenburg, Wisconsin DNR, pers. comm.), power line collision and electrocution, alligator predation, and ingestion of metal and other objects (Spalding et al. 1997, Folk et al. 2001).

Egg production started in 1999, with 41 pairs producing eggs through 2005. The first chick was fledged in 2002. Wetlands in Florida experienced a drought during 1998-2002, reducing the potential for suitable nesting conditions.

The drought is believed to have increased the dispersal range in recent years. The birds have ranged over much of peninsular Florida from near the Georgia border (Baker County) to the latitude of Lake Okeechobee (Palm Beach County) (Nesbitt et al. 2001) (Fig. 8). One pair spent the summer and fall of 2000 in Michigan, and 1 subadult spent nearly 2 months in Virginia in 2001. Eight other birds (in 2 groups) dispersed from the state in 2000 and 4 were never seen again. Five subadults were observed in South Carolina in May, 2005. Efforts to track them down shortly after the initial confirmed report were unsuccessful. One of the 5 was back in Florida in early September.

The Florida reintroduction has entered an assessment phase, with no additional introductions planned for 2005. Results of the adaptive management study being conducted by PWRC along with 2005 production and mortality data will be used in 2006 to determine goals and objectives for the FP. The WCRT will continue to evaluate the project's potential for establishing a self-sustaining population.

Table 9. Number of birds released and surviving in the Florida non-migratory population, 1993–2005.

Year	Number Released	Age	Year end Population	Number Pairs	Nesting Pairs	Chicks Hatched	Chicks Fledged
1993	14	all < 1year	8	0	0	0	0
1994	19	all < 1year	16	0	0	0	0
1995	19	all < 1year	25	0	0	0	0
1996	47	5=1.5y, 43=<1y	56	1	0	0	0
1997	28	all < 1year	60	1	0	0	0
1998	22	all < 1year	57	7	0	0	0
1999	28	all < 1year	65	10	2	0	0
2000	30	all < 1year	82	15	3	2	0
2001	21	all < 1year	86	15	2	0	0
2002	27	8=1.5y, 19=<1y	85	16	7	2	1[a]
2003	13	all < 1year	87	18	7	8	2
2004	16	all < 1year	71	15	12	4	1
2005	5	all < 1year	59	15	8	1	0
TOTAL	289				41	17	4

[a] First chick to fledge in the U.S. since 1939 in Louisiana.

Research on Reintroducing Migratory Populations

After cross-fostering proved unsuitable as a technique for reintroducing migratory populations of whooping cranes, the Whooping Crane Recovery Team identified the need for testing other techniques (U.S. Fish and Wildlife Service 1994). Since then, various modifications of leading captive-reared cranes with trucks and ultralight aircraft, and coordinated releases with migratory sandhill populations, have been tested (Nagendran 1992, Urbanek and Bookhout 1994, Nagendran et al. 1996, Ellis et al. 1997, 2001a, Lewis 1999, Duff et al. 2001a, Urbanek et al. *In press*{a}). Some projects utilized isolation-rearing with caretakers in crane costumes and another project (Clegg et al. 1997, Clegg and Lewis 2001) used group rearing of chicks to promote proper imprinting. Formerly, aggression was thought to be so severe as to prevent group rearing.

Cranes can be led long distances behind motorized craft (air and ground), and those led over most or the entire route will return north in spring and south in fall to and from the general area of training (Ellis et al. 1997, Ellis et al. 2001b, Duff et al. 2001b, Mummert et al. 2001). However, they may follow their own route. Groups transported south and only flown at intervals may not migrate. Trained birds will not home on a captive site where they hatched but rather will return to the site where they were flown free and began their migration. Cranes can also be expected to return to the same (or nearby) wintering area the following fall. All birds need not follow the entire route south to return north if flock mates know the route.

If cranes are field-reared and are to be introduced into a wild flock, costumes may not be necessary and cranes quickly learn to avoid humans (Clegg et al. 1997). Crane decoys can be used to hold cranes at roost sites before and during migration and at the release site after migration. The threat of losses to predators can be reduced with these decoys by influencing the cranes selection of roost sites and feeding locations (Clegg et al. 1997, Clegg and Lewis 2001).

If certain protocol restrictions are followed, it is possible to make the costume-reared cranes exhibit some wild behavior. The most efficient way to make trained cranes wild (e.g., not approach humans) is to release them after migration with wild cranes.

In the western United States, golden eagle (*Aquila chrysaetos*) attacks were a problem (Ellis et al. 1999) both for ultralight-led and for truck-led migrations. Collisions with power lines were a major problem in the trucking migrations. During the 2 trucking migrations, 3 cranes died and about 15 non-lethal collisions were observed. However, techniques were developed to diminish or eliminate these hazards (Ellis et al. 1997).

It appears possible to restore or supplement wild migratory populations of cranes by first leading small groups from chosen northern to southern sites. Abruptly releasing cranes after migration results in good survival if they are released individually or released as a group into a large wild flock (Ellis et al. 2001c, Clegg et al. 1997, Clegg and Lewis 2001).

Proposed Migratory Reintroductions

In 1996, the WCRT decided to investigate the potential for another reintroduction site in the eastern United States with the intent of establishing an additional migratory population. Separation between a new flock and the AWBP was an important safeguard against a catastrophic event impacting both populations, to avoid transmission of disease, crossbreeding between the 2 populations, and the behavioral influence that cranes reintroduced from captivity could have on the wild flock (U.S. Fish and Wildlife Service 2001). Also, under Section 10(j) of the ESA, reintroductions of experimental nonessential populations must essentially be kept separate from endangered populations.

After a study of potential wintering sites (Cannon 1998), the Team selected the CNWR/St. Martin's Marsh Aquatic Preserve near Crystal River, Florida, as the top wintering site for a new migratory flock. Although the habitat at Marsh Island, Louisiana, appeared to be excellent, its location closer to the AWBP migration corridor was a key negative factor resulting in the selection of a site in Florida.

Based on concerns that a reintroduced population in Saskatchewan or Manitoba might mix with the wild AWBP (Melvin and Temple 1980, Melvin et al. 1990, May 1992, Lyon et al. 1995a,b, Burke 1996, Hjertaas et al. 1997, deSobrino 1998, Sommerfeld and Scarth 1998), the Team considered summering areas further to the east of the AWBP migration corridor and requested the investigation of suitable sites in Wisconsin.

From the beginning, Wisconsin and other eastern flyway States have been and remain extremely supportive of establishing the EMP. After a list of potential areas was compiled, studies evaluated 3 potential release sites: Crex Meadows State Wildlife Management Area; central Wisconsin, including NNWR and several Wisconsin WMAs; and Horicon NWR (HNWR) (Cannon 1999). The WCRT in September, 1999, recommended that releases start in central

Wisconsin (Fig. 9). This recommendation was based on the presence of suitable habitat, food resources, and favorable local attitudes.

A partnership of 9 founder organizations comprised of public agencies and private nonprofit organizations was formed and referred to as the Whooping Crane Eastern Partnership (WCEP). Founding members (alphabetically) include:
* International Crane Foundation
* International Whooping Crane Recovery Team
* National Fish and Wildlife Foundation
* Natural Resources Foundation of Wisconsin
* Operation Migration, Inc.
* US Fish and Wildlife Service
* USGS National Wildlife Health Center
* USGS Patuxent Wildlife Research Center
* Wisconsin Department of Natural Resources

The partnership extends beyond the list above. The huge scope of this migration requires united efforts spanning twenty states, seven of which lie in the migration corridor. WCEP was divided into sub-teams of Bird, Budget, Outreach, Regulatory, and Flyway teams. A Project Direction team with key representatives from each agency serves as the final decision making body. Federal environmental documents were prepared and after publication in the Federal Register in June, 2001, the eastern migratory population of whooping cranes was declared experimental non-essential under section 10(j) of the ESA. This action provides for greater management flexibility and reduces the regulatory requirements.

The plan is to release annually 10 to 25 juvenile, captive-reared whooping cranes in central Wisconsin (U.S. Fish and Wildlife Service 2001). Cranes will be captive-reared to 20-40 days of age at PWRC or the ICF, before transfer to facilities at the Wisconsin release site, where they will be conditioned for wild release to increase post-release survival (Ellis et al. 1992b) and adaptability to wild foods. They will be radio-tagged at release and monitored to discern movements, habitat use, behavior, and survival. They will be released in the fall and taught to migrate. Several strategies may be used to teach migration including: (1) leading them by ultralight aircraft to the chosen wintering site in Florida (Clegg et al. 1997, Lishman et al. 1997, Clegg and Lewis 2001); (2) releasing them with migrating wild whooping cranes or sandhill cranes, or (3) some combining of these or other techniques. If initial results are favorable, the releases would continue for at least 10 years. Experience with the RMP and FP provides insight that a minimum of 20 years may be needed for attaining self-sustaining populations. Thus, a 20-year project duration is listed in the Implementation Schedule.

In fall 2001, 8 cranes started the migration behind an ultralight from NNWR in central Wisconsin (Table 10). One bird would not follow well enough and was placed daily in a crate and trucked to the next roost site. The migration included 26 stops, covered 1,987 kilometers, and took 50 days. The longest flight day covered 154 km, and the longest flight lasted 2.15 hours. The shortest migration leg only lasted 38 minutes. Total flight time of the birds between Wisconsin and Florida was 35.8 hours. One crane died in Wisconsin hitting a power line at night after a severe storm blew the pen down and the birds escaped. Bobcats killed two cranes during the winter at CNWR. The remaining five migrated back on their own to central Wisconsin in

Figure 9. Eastern United States experimental nonessential population area, with 2001 migration route.

spring, 2002. Four summered right at or near Necedah NWR, and one female summered about 80 miles to the southeast at HNWR.

In 2002, 17 whooping cranes raised at PWRC were shipped to Wisconsin and trained to follow ultralight aircraft. One of the young cranes died from injuries received colliding with the ultralight in migration; the remaining 16 were led to Florida (Table 10). In the fall of 2002, the 5 surviving whooping cranes reintroduced in 2001 migrated south on their own. One spent a considerable time at Hiwassee Wildlife Refuge in Tennessee before joining another ultralight whooping crane in Florida, whereas the other 4 returned initially to CNWR. In December 2002, one had joined the 16 juveniles wintering at the release pen at CNWR, 2 were together with sandhills about 125 miles northeast of CNWR, and 2 were about 30 miles southeast of the refuge.

In 2003, 17 whooping cranes raised at PWRC were shipped to Wisconsin and trained to follow ultralight aircraft. One of the young cranes died from injuries received colliding with the ultralight during a training flight. Sixteen were led 1,191 miles to Florida in a journey of 54 days, utilizing 20 stopovers. All 21 whooping cranes in the EMP migrated north on their own in the spring, 2003. One crane got off track but was captured in Ohio and released in Wisconsin. One crane stopped short and summered in Northern Illinois, and one crane summered in southeastern Minnesota. Three cranes moved through Wisconsin and just across the border into South Dakota where they by law stop being classified as experimental nonessential and become endangered. At the request of the Central Flyway Council, the trio was captured and returned to Wisconsin. One of the three suffered capture myopathy and was the only mortality of the summer.

In the spring of 2004, 6 cranes migrated too far to the east and summered in Michigan. Five were blocked from continuing by Lake Michigan. The other 30 cranes in the EMP returned to Wisconsin. In fall 2004, 14 juveniles migrated behind the ultralight to Florida, with 13 arriving safely. One bird died of EEE at the final migration stop. One bird in the fall was direct-released into a group of older whooping cranes in Wisconsin and successfully migrated to Florida. This reintroduction technique will be tried with a larger sample size in 2005. In the winter of 2004-05, the EMP whooping cranes were more scattered. Nineteen older birds wintered in Florida, but 3 wintered in North Carolina, 7 in South Carolina, and 4 in Tennessee. Two of the older cranes died in the fall migration, and 2 died at CNWR. Two pairs nested in central Wisconsin in spring of 2005, but eggs were predated. In fall 2005, 19 juveniles migrated behind the ultralight to Florida. Four birds in the fall were direct-released into a group of older whooping cranes in Wisconsin and successfully migrated, with 2 wintering in Tennessee and 2 making it to Florida. In the 2004-05 and 2005-06 winters, a total of 4 of the WCEP cranes spent time in the vicinity of or closely associated with non-migratory Florida whooping cranes. These associations broke up and some mixing between the two flocks is not considered to be a problem. In February, 2006, the EMP consisted of 64 whooping cranes. Releases are planned to continue through at least 2010 until the population reaches a minimum of 100.

Two unanticipated events have occurred during the EMP reintroduction. The release site selected by the WCRT at CNWR is apparently not suitable whooping crane habitat, but it is an excellent release site (Urbanek et al. *In press*{b}). Secondly, older birds returning to the CNWR

release site may stay if they find pelleted food being given to the juvenile ultralight cranes. These older birds will disrupt the juveniles which, if not intensively managed, can increase mortality. As expected, not every crane will summer in central Wisconsin and return to Florida to winter, although a high percentage has done so.

Table 10. Number of birds released and surviving in the eastern population, 2001–2005.

Year	# Eggs Hatched	# Young Sent to Wisconsin	# Fledged	# Starting Migration	# Finishing Migration	# Surviving Winter	Year End Total
2001	11	10	8	8	7	5	5
2002	18	17	17	17	16	16	21
2003	19	17	17	16	16	16	36
2004	21	17	16	15	14	13	47
2005	33	26	25	24	23	23	64
Total	102	87	83	80	76	73	

APPENDIX D. SUMMARY OF COMMENTS ON DRAFT RECOVERY PLAN AND USFWS RESPONSES

On January 11, 2005, the USFWS released the Draft Revised International Whooping Crane Recovery Plan for a 60-day review and comment period ending on March 11, 2005. Availability of the plan was announced in the Federal Register (70 FR:1902-1903) and via a news release to media contacts throughout the species' U.S. range. Electronic versions of the plan, notice of its availability, press release, fact sheet, and a questions and answers document were posted on the USFWS's national and Region 2 web sites.

In accordance with USFWS policy, an earlier draft was sent out for peer review, and comments were incorporated into the agency draft. Initial peer review was conducted by Dr. M. Bishop, Cordova, Alaska. Revisions made to the January, 2005, public draft were peer reviewed at a meeting held at the 10th North American Crane Workshop in February, 2006. Reviewers were LeeAnn Linam of TPWD, Walter Sturgeon of WCCA, Kelley Tucker of ICF, and Marty Folk of FL. Their comments are briefly described at the end of Appendix D, with many items incorporated into the final plan.

Nearly 600 people were notified via email about the availability of the draft plan. Additionally, approximately 30 copies and/or CDs of the Draft Recovery Plan were distributed to affected agencies, organizations, and interested individuals during the comment period.

Twenty-four comment letters and/or emails were received during the official comment period. All comments, including those of the peer reviewer are on file at the Aransas National Wildlife Refuge, P.O. Box 100, Austwell, TX 77950.

Some commenters raised similar issues. Most expressed strong support for the conservation of the species as described in the Recovery Plan. Four were quite critical of specific portions of the plan.

Many of the comments were incorporated into the approved recovery plan. Information and comments not incorporated into the approved plan were considered and noted. A synopsis of comments received is presented below.

COMMENTS AND USFWS RESPONSE

COMMENTS ON PART I – BACKGROUND INFORMATION

1. <u>Comments about updating crane numbers:</u>

Several reviewers wanted numbers to be up-to-date as possible.

<u>USFWS Response:</u> Numbers were not up-to-date because of time elapsed between writing the Draft Plan and receiving final approval of the document. Population numbers in the Final Plan were updated through February, 2006.

2. <u>Comment about variability in AWBP numbers over time:</u>

One reviewer analyzed recruitment rates and noted that although recruitment rates since 1970 are lower than those between 1938-69, rates have been relatively stable since 1970 and are much less variable than in earlier times. They noted that the AWBP continues to grow, but at a more constant, less stochastic rate, whereas the draft text on pp. 25-27 conveyed somewhat of a concern for population growth.

USFWS Response: The text referred to does not express concern about the continued growth of the population except for the unexplained drop in recruitment rates. The text states that the AWBP is likely to continue to grow with a low probability of extinction over the next 100 years. Other sections of the plan do express concern about the future population because of looming threats and unprecedented global changes and expanding human pressures on wildlife species throughout North America.

3. Comment that the impact of egg collection should be assessed:

USFWS Response: The Recovery Team has discussed a study to determine the impact of egg pickup on the growth rate of the AWBP, but is waiting to collect data through 2006 before making any decisions involving egg pickup (see p. C-6).

4. Comments about down-listing criteria and lack of de-listing criteria:

Two comments were made supporting the down-listing criteria, including specifically the level of 250 pairs in the AWBP. Two comments thought the down-listing criteria did not set levels high enough. One comment thought there should be more than 3 populations established. Four comments were received saying the species should not be downlisted at the present time. One comment specifically supported not having any delisting criteria at the present time.

USFWS Response: A misleading news story that ran in south Texas made people think the USFWS was contemplating downlisting the species in the near future. This definitely is not the case – the Draft Plan states that the expected date to reach downlisting criteria is approximately 2035. The downlisting criteria are primarily an indicator that the species is making significant progress towards recovery. Downlisting would not remove legal protections from the species, as it would then be listed as threatened. Thus, the population targets set to recommend downlisting seem reasonable.

5. Comments about Critical Habitat:

Three comments addressed Critical Habitat (CH). The Canadian Wildlife Service (CWS) modified the previous section on CH to reflect a refinement of their definition of CH that came out after the draft plan was distributed. Another reviewer asked if the areas listed that "may be considered critical at some time in the future" referred to areas in Canada only. A third comment cautioned that private landowners affected should be a part of any discussion involving changes in CH.

USFWS Response: All revisions from the CWS were incorporated. Areas that may be considered critical sometime in the future refer to Canadian areas only. This was clarified by separating the discussion of CH for Canada and the U.S. The Narrative Outline (Section 1.5.2)

calls for evaluation of the need to expand CH boundaries at ANWR and in the migration corridor to ensure protection of all important U.S. whooping crane habitats. It may seem logical to add additional CH areas in the U.S, especially at ANWR where multiple whooping crane territories are now located outside the CH boundary. However, in 30 years of implementing the Act, the USFWS has found that the designation of statutory CH provides little additional protection to most listed species, while consuming significant amounts of available conservation resources. The USFWS's present system for designating CH has evolved since its original statutory prescription into a process that provides little real conservation benefit, is driven by litigation and the courts rather than biology, limits our ability to fully evaluate the science involved, consumes enormous agency resources, and imposes huge social and economic costs. The USFWS believes that additional agency discretion would allow its focus to return to those actions that provide the greatest benefit to the species most in need of protection. If the USFWS receives a petition to amend CH for the whooping crane, it will go through a public rule-making process with full public involvement.

6. <u>Comments about inadequate recovery cost estimates:</u>

Two reviewers involved with Platte River issues commented on the inadequacy of the recovery costs in the Draft Plan. Expenditures for specific management programs along the Platte River alone exceed the Plan's anticipated costs for those same programs for the entire flyway.

<u>USFWS Response:</u> Costs in the Draft Plan were incorrectly based primarily on anticipated Federal dollar expenditures. Cost estimates were revised to reflect total estimated costs for recovery, including the amounts forecasted to be needed for recovery actions on the Platte River.

7. <u>Comment about funding shortfalls for Recovery Actions that are needed.</u>

One comment was received about the inadequacy of funding made available for recovery.

<u>USFWS Response:</u> Recovery actions implemented by federal agencies are dependent on budget appropriations. The USFWS can only accomplish its goals for recovery with the assistance and participation of its many partners.

COMMENTS ABOUT THREATS TO THE SPECIES

8. <u>Comments about freshwater inflows in Texas:</u>

Five comments mentioned the importance of freshwater inflows in Texas to wintering whooping cranes.

<u>USFWS Response:</u> Comments received were incorporated to provide more details on freshwater inflow and water rights issues in Texas (see p. 22-23). The Draft Plan was updated to include relevant issues that had occurred in the past two years that potentially impact Guadalupe River flows and spring flows that feed the Guadalupe. More emphasis was placed on the difficulties faced by the estuary during drought years, and information from a recent report (National Wildlife Federation) 2004 was incorporated.

9. <u>Comments about shootings:</u>

Three comments addressed the issue of hunting. Much input from the States was received on the issue of shootings (see pages 23-24). Although hunting was a major factor in the decline of the whooping crane in the 1800s and early 1900s, reviewers felt that losses today are mostly acts of vandalism and that the term "shooting" should be used instead. One comment was received stating that hunting was causing the demise of far too many species.

USFWS Response: The term "shooting" in many places was substituted for "hunting", including the heading in the Table of Contents. The USFWS agrees that the use of "shootings" is a more inclusive term since many of the shootings of whooping cranes that have taken place were separate from sport hunting programs, or were done illegally in connection with sport hunting actions. Shootings of whooping cranes only occur occasionally and many are acts of vandalism not connected with sport hunting. The final plan carefully tries to differentiate between the historical role of hunting in the decline in whooping crane numbers versus the occasional shootings that occur at present. More emphasis was placed on the crucial role that sportsmen and other conservationists have played in helping whooping cranes (see Conservation Measures – page 31).

10. Comments about the positive role in conservation of hunters and private landowners:

One comment mentioned the positive way hunters and private landowners help whooping cranes. Positive hunter actions include hunters turning in sighting reports, dispersing waterfowl concentrations, thus decreasing the threat of disease, and also reducing crop depredation.

USFWS Response: A paragraph was added to the first page of the Introduction to emphasize the role of private citizens, including sportsmen and sportswomen, in saving the whooping crane. A paragraph was added under the heading *Conservation Measures* referred to in the *Shootings* section to mention positive aspects of sports hunting for whooping crane recovery.

The sections on hunting were carefully edited to remove any unintended negative slant towards hunting. However, up to 4 whooping cranes have been shot in the last 2 years, an unacceptable level of take, so the Plan continues to address strongly the issue of shootings.

11. Comments about unexplained losses:

Two reviewers commented on statements in the draft made about mortality with no known cause. They cautioned about making implications about these unexplained losses, and especially attributing them to shooting.

USFWS Response: It is reasonable to take the known causes of mortality and hypothetically project them in an equal percentage for carcasses that are not recovered (unexplained losses). However, caution has to be exercised in doing so since there could be many other unknown factors affecting the population, and detectability of the various causes of mortality could vary greatly. Thus, wording was changed to reduce speculation involving shooting. A sentence was added on p. 24 (See Shooting) stating that it is not known what percentage of unexplained losses can be attributed to shooting.

12. <u>Comments about genetic issues:</u>

One comment questioned the evidence that limited genetic diversity is hurting the AWBP. Another pointed out an incorrect use of the term "genetic drift".

<u>USFWS Response:</u> It is well established that limited genetic diversity is likely to affect productivity of avian populations. Data are starting to show a trend towards reduced productivity in the AWBP, but other factors could be involved and the exact role that genetics is playing is unknown. The text was clarified on pages 27, 36, 38, and 42 and an explanation given in Appendix A to more clearly differentiate between "genetic drift" and "genetic mutations".

13. <u>Comments about power line issues:</u>

One reviewer mentioned that there was no consideration of the economic or technical feasibility of some of the recommendations made in the plan about reducing the threat of cranes colliding with power lines. They felt stakeholders were not involved enough in formulating recommended recovery actions in the Plan.

<u>USFWS Response:</u> The USFWS has worked extensively with electric utility companies on the issue of avian mortality. A product of this collaboration was the 1994 publication, *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994*, which is referenced in the Plan. The USFWS agrees that more participation by the electric power industry in whooping crane recovery is needed and is welcomed, and that the USFWS should work hard to facilitate such interactions.

14. <u>Comments about the threat of wind farms:</u>

Two comments stated the expected growth of wind farms in the migration corridor could be a major threat to the species. Not only are there unknowns associated with cranes being able to avoid wind turbines, it is known that construction of transmission lines associated with wind farms will be hazardous.

<u>USFWS Response:</u> Material was added to the Plan about growing concerns about wind farms in the section dealing with Threats (See p. 29 - *Collisions with Power Lines, Fences and Other Structures*).

15. <u>Comments about migration mortality and the need for another telemetry study:</u>

Three comments dealt with the desire to learn more about mortality that occurs in migration and location of sites used in migration. A radiotelemetry study could provide data on both topics.

<u>USFWS Response:</u> The Recovery Team has discussed the need for a telemetry study similar to the one carried out from 1981-1985. The Recovery Team feels that much of the data obtained from a telemetry study would be very similar to the previous data set. Mortality of approximately 1% can be anticipated when capturing juveniles to put radios on them, so significant value would have to be expected from the study to justify expected losses. Without significant funding sources at present to conduct a telemetry study, there are currently no plans to

carry out such a study. However, the Recovery Plan leaves open the possibility of future telemetry studies. The Recovery Team has stated that more data on mortality is needed.

16. Comment about forming working groups to promote interactions among states within flyways to work on whooping crane issues (2 such comments):

USFWS Response: This comment is similar to an idea previously expressed by the Platte River Trust to form a working group for the AWBP to deal primarily with migration issues. The Recovery Team is supportive of such an action and it was added to the Plan's Task 1 in the *Narrative Outline of Recovery Actions to Achieve Objectives*.

17. Comments about the migration corridor map for the AWBP:

One reviewer thought the map depicting the migration corridor (Figure 2) should be re-drawn from the sighting database using a GIS system.

USFWS Response: This process utilizing a GIS data base has been completed for Texas and started for the state of Kansas, but has not been completed for the entire flyway. There is currently inadequate staff and funding to complete this task. An updated map showing confirmed sightings done by graduate student Tom Wassenich was incorporated as Figure 2 in the Final Plan.

18. Comments about treatment of Platte River issues:

Two critical comments stated that too much emphasis was put on Platte River issues in the draft plan since less than 3% of the AWBP stops on the Platte in any single migration. Both pointed out the apparent inconsistency with the Plan's mentioning the socioeconomic value of birdwatchers traveling to see whooping cranes, and yet human disturbance is an issue of concern to the species. Both mentioned that the Recovery Team should re-evaluate management actions for the Platte River to ensure they will benefit the population.

USFWS Response: The Platte River serves as a model of river flow requirements for the species throughout the flyway. Because of the long history of management disputes on the Platte and the documented degradation of crane critical habitat on the Platte, the plan cannot minimize treatment of these important issues. The Recovery Team believes that whooping crane use of the Platte will increase if more habitat is restored as has been documented by whooping cranes that have utilized cleared portions of the river channel. The recent National Academy of Science study of the Platte confirmed the general degradation of the riverine ecosystem and the importance of the Platte River to the species, and tied management efforts providing habitat along the river with helping the species. That study, which explains the importance of the Platte River to whooping cranes, was added as a key reference to the Recovery Plan. Bird watching can be compatible with whooping crane recovery if the public is educated to remain at an adequate distance from cranes.

19. Comments that the management efforts of many groups along the Platte River should be recognized:

USFWS Response: In response to the comments received, additional organizations involved with Platte River restoration efforts were mentioned in a new paragraph added on page C-9.

20. Comment about inadequate evaluation of impacts to other species along the Platte River:

Two comments mentioned that recovery actions on the Platte River to help whooping cranes can end up hurting other wildlife; specifically woodland obligate bird species along the Platte. They felt the Plan failed to adequately take into account the loss to other species that habitat modification and enhancement for the whooping crane will cause.

USFWS Response: All wildlife management practices impact species differently. The conservation of wetlands used by cranes throughout the Flyway, including the Platte River, will help numerous wetland obligate birds complete their annual migrations. Restoration of the Platte River ecosystem is consistent with sound ecological principles. The NAS study re-confirmed the importance of the Platte River to endangered species and the Cooperative Agreement needs to be carried out in good faith and in a timely fashion to meet obligations of the ESA. Members of the Platte River Cooperative agreement should assess impacts to all species of concern and formulate management plans accordingly to counterbalance negative impacts that may occur to other key species.

21. Comments about the value of whooping cranes:

Two comments expressed that the value of a whooping crane as described in Appendix B was overstated and failed the common sense test of what people are willing to pay to protect endangered species. They also felt the number of visitors that actually visit the Platte River to view sandhills is overstated.

USFWS Response: Information presented on species value is from published scientific literature based on accepted methodology of estimating values. What people perceive as the value of something and what they actually would pay are very different. The number of visitors to the Platte River that view sandhills is taken from peer-reviewed scientific literature. The option to write and publish a rebuttal or conduct a study challenging these results is open to anyone.

22. Comment about re-organizing Part II so that the section on *Reduction or Alleviation of Threats* either followed *Downlisting Criteria* or preceded *Recovery Actions*:

USFWS Response: Part II was re-organized extensively with the section on "*Reduction or Alleviation of Threats*" put before "*Recovery Actions*".

COMMENTS ON REINTRODUCED POPULATIONS

23. Comments on Reintroduced Populations:

Three comments suggested putting more emphasis on and/or incorporating more information on reintroduced populations. One mentioned that life history information is based on the AWBP, but in the future may have to reflect differences of behavior and habitat use found in the reintroduced populations. One comment felt it desirable that recovery actions such as habitat

management and education efforts should specifically address those actions needed in reintroduced populations as well as the AWBP.

USFWS Response: Information on reintroduced populations is covered primarily in Appendix C. A statement that there may be nuances of behavior and habitat use for reintroduced populations different from the AWBP was added to the Narrative Outline (Section 3.0, p. 54). An effort to develop a Wisconsin management plan for the EMP is currently underway that will provide management guidelines for that reintroduced population. Portions of that management plan can be incorporated into future revisions of the Recovery Plan.

24. Comments about experimental nonessential whooping cranes that move into the central flyway should remain designated as "experimental nonessential":

One commenter strongly supported establishing populations distinct from the AWBP. However, they felt reintroduced whooping cranes designated as experimental nonessential should not automatically be re-classified as "endangered" if they stray into the central flyway.

USFWS Response: This issue is beyond the scope of the Recovery Plan. At the present time, legal interpretations of the ESA, including court rulings (January 31, 2005; U.S. District Court in Portland, Oregon), don't allow for the kind of flexibility discussed in the comment. The States could ask the USFWS to work on a more flexible approach. Reintroduced birds classified as experimental nonessential in some instances can be expected to stray long distances.

25. Comments about the Florida population (FP):

Two comments were made that high mortality rates and continued human development make it unlikely the non-migratory FP can be successfully reintroduced into Florida.

USFWS Response: The Recovery Team is currently assessing the future of the FP.

26. Several comments supporting the Eastern Migratory Population (EMP):

USFWS Response: The reintroduction of the EMP shows great promise and is currently receiving great emphasis.

27. Comments of final peer reviewers made February 7, 2006.

The 4 reviewers all felt the plan was very good, comprehensive, and well written. They felt that threats to the species were adequately portrayed and quite complete. However, their primary criticism was that in the Recovery Criteria for downlisting to occur, there was no alternative to growth of the AWBP to 1,000 individuals if two additional populations cannot be reintroduced. They felt a middle ground was needed, especially given the difficulties currently faced by the non-migratory population in Florida. In response to this, an additional alternative criterion (1A) was added to the plan. This alternative provides for downlisting if the AWBP grows to 100 pairs (400 individuals) and one reintroduced population reaches a goal of 30 nesting pairs (120 individuals). This criterion of 520 individuals in two populations is a middle ground between having 360 individuals in 3 populations and 1,000 individuals in only one population. The

numbers follow the principal that more individuals are needed for downlisting to occur if they are in fewer populations where a single threat may have a greater impact.

The reviewers mentioned numerous items they felt were not adequately covered in the plan. These included indirect and sublethal impacts of pesticides, positive benefits of human interactions with whooping cranes, the global spread of the H5N1 bird flu and potential threat particularly to captive crane populations, some inadequate regulatory mechanisms to protect the species and additional genetic reasons for egg collection. Corresponding sections of the plan were modified to meet these concerns. In addition, crane numbers were updated in the final draft to make them as current as possible.

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March 2007

Front cover, Whooping crane.
Photgraph by Tiffany Smith, FWS
Rear Cover, Male and female whooping cranes at Aransas National Wildlife Refuge, Texas.
Photograph by Steve Sykes, FWS