Recovery Planning for the Whooping Crane

Workshop 4:
Final Recovery Planning Workshop

8 – 10 October, 2019
Baraboo, WI, USA

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Workshop Report

Workshop Organization:
International Whooping Crane Recovery Team
Canadian Wildlife Service
United States Fish and Wildlife Service

Workshop Design and Facilitation:
IUCN / SSC Conservation Planning Specialist Group

Workshop Support:
Coastal Bend Bays & Estuaries Program
International Crane Foundation

Photos: Klause Nigge / Parks Canada-Wood Buffalo National Park.

A contribution of the IUCN/SSC Conservation Planning Specialist Group, in collaboration with the Whooping Crane International Recovery Team, the United States Fish and Wildlife Service, the Canadian Wildlife Service, and workshop participants.

Workshop support provided by Coastal Bend Bays & Estuaries Program, and the International Crane Foundation.

IUCN encourage meetings, workshops and other forums for the consideration and analysis of issues related to conservation, and believe that reports of these meetings are most useful when broadly disseminated. The opinions and recommendations expressed in this report reflect the issues discussed and ideas expressed by the participants in the workshop and do not necessarily reflect the formal policies IUCN, its Commissions, its Secretariat or its members.

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Workshop Report

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Whooping Crane Recovery Planning Workshop
International Crane Foundation, Baraboo, WI
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Executive Summary

The Whooping Crane (*Grus americana*) was officially declared Endangered in North America in 1967, and the original Recovery Plan was completed in 1980 with the last revision occurring in 2007. Recovery planning activities mandated by the Endangered Species Act (ESA; USA) and the Species at Risk Act (SARA; Canada) are carried out by the U.S. Fish and Wildlife Service (USFWS) and the Canadian Wildlife Service (CWS), and these agencies are advised by an International Recovery Team (IRT) established under an international agreement governing co-operation among and signed by both countries. As it has already been several years since the last International Recovery Plan (IRP) was completed, the IRT wishes to update the Plan to incorporate new information and techniques, with the overall goal of downlisting and eventually fully recovering the species using efficient and effective strategies.

To initiate and inform this effort, the IRT began collaborating in 2015 with the Conservation Breeding Specialist Group (CBSG) (now the Conservation Planning Specialist Group, CPSG), part of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN), to hold population viability analysis (PVA) and population and habitat viability assessment (PHVA) workshops with members of the IRT and other invited specialists to produce information to be included in an upcoming version of the International Recovery Plan. To begin this process, a PVA workshop was held 1 – 3 December 2015 in Calgary, Alberta Canada and was generously hosted by the Calgary Zoo. Twenty-one participants with expertise in Whooping Crane biology and management and endangered species conservation planning attended the meeting, which was facilitated by CBSG staff. This first workshop was important for building the conceptual and mechanistic foundation for the quantitative risk assessment that forms the basis of the PVA. As a follow-up to this meeting, a second Species Conservation Planning (SCP) workshop was held 29 November – 1 December 2016, again located in Calgary and once again hosted by the Calgary Zoo. Twenty-five specialists in the biology and management of Whooping Cranes and other North American species gathered to learn about the state of the developing PVA modeling effort, and to begin the process of generating detailed modeling scenarios representing a variety of management alternatives for the species and the habitat on which it depends.

The third workshop in this project was to be the final gathering of the group, and was designed to discuss the final results of the PVA, to review existing International Recovery Plan recovery criteria and consider revising these criteria if warranted in light of the PVA results, to discuss proposed management recommendations targeting both wild and captive populations, and to consider revisions to the International Recovery Plan in the context of the new information brought to light by these deliberations. The workshop was once again generously hosted by the Calgary Zoo and took place on 4 – 5 December 2018. Approximately twenty representatives from wild and captive population management entities were scheduled to attend the workshop. Unfortunately, political events in the United States led to the prohibition of travel for all US government employees for the scheduled workshop days. As a result, the workshop was reduced to just two days from the original three, and with a much reduced set of participants. The primary outcome from this meeting was a draft vision for Whooping Crane conservation, and a draft outline for a new Recovery Plan document that would address specific elements of the recovery process in both Canada and the United States.

This fourth and final workshop, graciously hosted by the International Crane Foundation at their headquarters in Baraboo, Wisconsin in October 2019, was designed to generate a set of actions that management authorities could undertake to improve the status of the species in the wild, and to enhance the role that the existing captive population plays in support of that recovery. Thirteen experts from Canada and the United States attended the meeting. Key outputs from this gathering include:

1. A revised conservation vision statement for the species across its current distribution;
2. Revised recovery objectives, originally taken from the 2007 International Recovery Plan, that featured more precise definitions of important concepts such as viability, sustainability, genetic stability, etc.;
3. An assessment of the status of the full set of actions laid out in the 2007 Recovery Plan, identifying the extent to which those actions had been completed by the end of 2019; and
4. A new set of recovery actions, including where feasible details on responsible parties, timelines, etc.

Whooping Crane Recovery Planning Workshop
International Crane Foundation, Baraboo, WI
8 – 10 October, 2019

Workshop Overview

Approximately 15 experts in Whooping Crane biology and conservation gathered together at the International Crane Foundation in Baraboo, WI (USA) in early October 2019 for the final workshop in a series of meetings designed to address recovery planning needs for this North American endangered species. The three-day meeting was designed to utilize information and insights from a comprehensive population viability analysis (PVA) that was completed in 2019 to assess the utility of current recovery objectives and criteria. Moreover, a primary workshop objective was to come up with a set of short-term (five-year) actions that would effectively move forward Whooping Crane recovery as US and Canadian officials revised the current species Recovery Plan.

The overall project was a collaboration between the United States Fish and Wildlife Service, the Canadian Wildlife Service, and the IUCN-SSC Conservation Planning Specialist Group (CPSG). Previous workshops leading up to the October 2019 meeting included:

- Workshop I: Population Viability Analysis (PVA) workshop – December 2015
- Workshop II: Species Conservation Planning Workshop – November 2016
- Workshop III: Preliminary Recovery Planning Discussions Workshop – December 2018

CPSG staff was responsible for conducting the PVA risk assessment process, and for designing (in collaboration with US and Canadian federal management authorities) and facilitating each of the workshops. Experts in both *in situ* (wild population) and *ex situ* (captive population) management participated throughout the recovery planning process, providing both quantitative data for the PVA and a diverse range of perspectives for the more broad tasks that defined species recovery planning.

The workshop began with a brief overview of the population viability analysis results, particularly in the context of their implications for recovery planning. Following this background presentation, the group collectively discussed the key elements of a long-term, aspirational conservation vision for Whooping Cranes. Core ideas and themes emerged from this discussion, with a draft vision ultimately constructed and agreed upon midway through the workshop. This concise expression of an ideal future for Whooping Cranes on the North American landscape is meant to serve as a guiding principle for the more detailed conservation planning that was to follow.

Next, workshop participants addressed the existing recovery objectives as laid out in the current (2007) Revised Recovery Plan. Explicit consideration of the "3 R's" of recovery as laid out by international conservation standards – resiliency, redundancy and representation – formed the foundation of these conversations. In the end, the group made important revisions to the wording of the primary biological recovery objectives, and drafted explicit operational definitions of various words and phrases – "viable", "self-sustaining", "genetically stable", and others – that make up these objectives. These revisions and definitions now greatly improve the specificity and intent of the proposed recovery objectives, and can therefore facilitate similar discussions intended to revise current recovery criteria as laid out in the 2007 Plan.

Participants then moved on to assessing the status of the full set of actions laid out in the 2007 Recovery Plan, identifying the extent to which those actions had been completed by the end of 2019. This can help

to inform decisions around the utility of including those actions that are considered ongoing or perhaps, in light of the current conservation situation for the species, no longer relevant for including in a revised Recovery Plan. With this information in hand, the full body of workshop participants split into two working groups to develop new actions that could inform the evolving Recovery Plan. These two groups were: Aransas – Wood Buffalo Wild Population, and Captive Population & Reintroduction. The groups were asked to develop clear and complete action steps, with as much detailed specification as possible of the important characteristics for those actions – those responsible for moving the actions forward, estimated timelines and cost, measurable outcome of the action, important collaborators, perceived obstacles to completing the action, etc.

The following material in this report represents a written record of these discussions, analyses and decisions.

Vision for Whooping Crane Conservation

Wild whooping crane populations are viable, widely distributed, and able to adapt to environmental changes. Whooping cranes are a valued part of people's lives.

Whooping Crane Conservation Mission

- Establishes or preserves populations of whooping cranes within the historic range of the species,
- includes both migratory and non-migratory habit, and
- involves various interested publics in planning these activities.

Revised Whooping Crane Recovery Objectives

Objective 1.

Original statement:

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

Revised statement:

Establish and maintain large and wide-ranging, self-sustaining populations of Whooping Cranes in the wild that are, as a result, genetically stable and resilient to stochastic environmental events.

- Explicitly incorporating conceptual elements of resiliency, redundancy and representation
- Self-sustaining: Mean population growth rate (λ) $\geq$ 1.0 over a period of 20 years in the absence of releasing individuals on the landscape (T = 13 years)
- Genetically stable: Gene diversity (expected heterozygosity) retention $\geq$ 90% of today's level over a period of 100 years
- Resilient to stochastic events: Sufficiently low risk (<10%?) of a population falling below a critical abundance threshold (quasi-extinction) or declining to abundance of 0 (extinction) over a given timeframe (100 years?)

Objective 2.

Original statement:

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

Revised statement:

Maintain a genetically stable managed captive population to ensure against extinction of the species serving one or more roles that collectively contribute to species recovery in the wild.

- Original objective referred to an insurance population, while the original criterion described a source population for use in reintroduction / augmentation efforts.
- Captive population roles defined by IUCN's 2014 *Guidelines on the Use of Ex-Situ Management for Species Conservation*

Draft Whooping Crane Recovery Criteria

The following recovery criteria were drafted by a subset of workshop participants as a way to begin thinking about how to revise existing criteria (as laid out in the 2006 Whooping Crane Recovery Plan) in light of the revised recovery objectives and their definitions that are presented earlier in this report.

Note that these draft criteria have not yet been fully vetted by the United States Fish and Wildlife Service or the Canadian Wildlife Service. Therefore, the draft criteria may not currently represent the final wording that will be included in a finalized Recovery Plan for the species.

Current Recovery Criteria

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 reestablished, 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 reestablishment 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.

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.

Proposed Revised Criteria

Downlisting Criteria

Canada:
The breeding and wintering grounds for the population are each at least 5,000 km^2, OR there are at least five populations and more than 250 mature individuals (i.e., approximately 500 total individuals).

The populations identified above must be considered to be not vulnerable to a single threatening event.

United States:
At least one self-sustaining population of 600 – 700 individuals, AND at least one additional population of 200 individuals that may be supported by a functioning ex situ (SSP) population.

The abundance values cited above are considered to be sufficient to meet a genetic diversity management goal of 90% gene diversity retention over 100 years.

Moreover, the additional population required for downlisting should be located in order to increase the ecological representation of the species across its historic range.

Delisting Criteria

Canada:
The breeding and wintering grounds for the population are each at least 20,000 km^2, OR there are at least ten populations and more than 1,000 mature individuals (i.e., approximately 2,000 total individuals).

The populations identified above must be considered to be not vulnerable to a single threatening event.

United States:
At least three self-sustaining populations of at least 1,500 total individuals, sufficient to meet a genetic diversity management goal of 90% gene diversity retention over 100 years. The populations must encompass both migratory and non-migratory behavioral conditions over a broad representation of the species' historic range.

Outline of Existing Recovery Actions to Achieve Objectives

See Whooping Crane Recovery Plan 2007, pg 43

The outline below reproduces the recovery actions listed in the 2007 International Recovery Plan (Third Revision) for the Whooping Crane. Workshop participants were asked to review the recovery actions, to suggest revisions to the wording of the actions where applicable, and to insert updates on the stats of achieving the actions. The action items outlined below include those revisions and status updates.

AWBP Population

1. Increase the AWBP

    1.1. Monitor population numbers, including annual recruitment and mortality.
        1.1.1. Conduct surveys in WBNP to determine distribution, productivity, recruitment and mortality.
        [*Ongoing and maintained*]
        1.1.2. Analyze data on egg management and develop a strategy to maximize size of the AWBP. Develop management options regarding egg manipulation.
        [*Fits with PVA. Predominately not started. Needs to be re-worded*]
        1.1.3. Conduct aerial surveys at ANWR to determine total population numbers and habitat use.
        [*Ongoing*]

    1.2. Monitor movements in migration.
        [*Ongoing. Needs to be re-evaluated in its utility and mechanism*]

    1.3. Maintain mortality. (Recommendation out of PVA)
        1.3.1. Prevent shooting.
        [*Ongoing. Re-evaluated to expand out to look at age class mortality*]
        1.3.2. Monitor for disease associated mortality.
        [*Not shown to be an issue*]
        1.3.3. Reduce collisions/mortality.
        [*Ongoing. Actively working to reduce this*]

    1.4. Reduce indirect human harassment / Evaluate impact of and mitigate human harassment. Anthropogenic impact.
        1.4.1. Construction periods.
        1.4.2. Aircraft altitude.
        1.4.3. Other disturbance.

    1.5. Identify, protect, manage, and create habitat
        1.5.1. Identify essential habitat.
        [*Ongoing*]
        1.5.2. Measure food resources in summer, winter, and during migration.
        [*Not done on breeding grounds/do not want to conduct. Breeding grounds - no longer relevant*]

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.

[*Needs re-wording. Essential core of this is good. Ongoing*]

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.
[*Needs re-wording. Essential core of this is good. Ongoing*]

1.5.2.3. Complete measurement of availability of migration stopover habitat and monitor changes over time.
[*Modeling of habitat has not been done during migration. Ongoing*]

1.5.3. Protect habitat.

1.5.3.1. Maintain WBNP.
[*Check! What does this mean? Maintain habitat? Its existence is not an issue, but level of protection is of severe debate. Ongoing. Re-word this/use language from the Action Plan.*]

1.5.3.2. Ensure long-term protection of migration stopover sites.
[*Ongoing. Re-word*]

1.5.3.3. Maintain ANWR and other NWRs.
[*Ongoing. Re-word*]

1.5.3.4. Prevent contamination of habitat.
[*Ongoing. Re-word*]

1.5.3.5. Prevent erosion of winter habitat at Aransas.
[*Ongoing*]

1.5.3.6. Better manage deposition of dredge material.
[*Ongoing*]

1.5.3.7. Maintain freshwater inflows.
[*Not started*]

1.5.3.8. Maintain appropriate in-stream flow.
[*Not started*]

1.5.3.9. Monitor global warming.
[*Assessing potential effects of GB. Re-word*]

1.5.4. Manage habitat.
[*Ongoing*]

1.5.4.1. Manage fire.
[*Ongoing*]

1.5.4.2. Maintain upland water sources
[*Combine with a broader wetland action*]

1.5.4.3. Manage vegetation.
[*Ongoing*]

1.5.5. Create wetland habitat.
[*Ongoing*]

Captive Populations

2. Develop and maintain captive populations.

   2.1. Utilize more sensitive measures of genetic diversity.
   [*Ongoing. Re-word*]

   2.2. Increase captive breeders
   [*Not clear – does this mean # of facilities or # of individuals? Re-word – for example: "Improve reproductive success of certain breeding pairs. Implement the SSP."*]

   2.3. Refine aviculture methods and productivity.
   [*Ongoing. Re-word*]

   2.3.1. Refine breeding pair management.
   [*Ongoing. Re-word*]

   2.3.2. Refine incubation procedures.
   [*Ongoing. Re-word*]

   2.3.3. Refine rearing procedures for reintroductions.
   [*Ongoing. Re-word*]

   2.3.4. Refine veterinary procedures.
   [*Ongoing. Re-word*]

   2.3.5. Exchange aviculture information.
   [*Ongoing. Re-word. SSP*]

   2.4. Maintain captive facilities.
   [*Ongoing. Re-word. SSP*]

3. Establish additional wild populations.

   3.1. Develop release techniques.
   [*Ongoing. Re-word. Complete. Refine these techniques.*]

   3.2. Evaluate and select release sites.
   [*Ongoing*]

   3.3. Establish a non-migratory population.
   [*Ongoing. Complete. How do we define "establish"? Re-word. Maintain non-migratory population*]

   3.4. Establish a migratory population.
   [*Ongoing. Re-word*]

4. Determine Ne for species survival by analyzing banding data to determine the Ne/N ratio for the AWBP.
   [*Not started yet. May no longer be relevant*]

5. Maintain and expand information/education programs.

   5.1. Develop media products.
   [*Ongoing*]

   5.2. Provide viewing opportunities.
   [*Ongoing*]

   5.3. Implement education programs.
   [*Ongoing*]

Draft Conservation Actions

Captive Population Management / Reintroduction Working Group

Captive Populations. Relates to Objective 2 in the RP.

2. Develop and maintain captive populations as determined by the AZA Species Survival Plan (SSP) for the purpose to maintain a demographic and genetically viable productive captive population. In addition, provide demographic and genetic supplementation of reintroduced populations.

2.1 Utilize the best available practices through the SSP to maintain and continue to monitor the genetic diversity of the captive population.

Responsible Party:	AZA WHCR SSP Coordinator and AZA WHCR Stud Book Keeper
Cost:	SSP master planning occurs every 3 years/annual updates to stud book Medium Cost: under 50K/year
Timeline:	Long term/ongoing
Outcome:	Objective 2 in RP. Continue to monitor the pop
Collaborators:	AZA WHCR SSP/AZA Gruiformes TAG/holding institutions
Obstacles:	People effort/volunteer positions – no dedicated long term positions or institutional support
Data Gaps:	Need to know paternity, reproductive challenges of the birds

2.2. Utilize the best available practices from the AZA WHCR SSP/WCHAT through husbandry and veterinary methods to maintain and improve the productivity of the captive population.

Responsible Party:	AZA WHCR SSP Coordinator/AZA WHCR Stud Book Keeper/WCHAT Chair
Cost:	SSP master planning occurs every 3 years/annual updates to stud book Medium Cost: under 100K/year
Timeline:	Long term/ongoing
Outcome:	Producing enough chicks to satisfy the needs for the reintroduction and captive populations
Collaborators:	AZA WHCR SSP/AZA Gruiformes TAG/holding institutions/ WCHAT
Obstacles:	Obtaining dollars/fundraising/institutional support, AI training/staff, incubation management
Data Gaps:	Communication between holding institutions, reproductive physiology, management of captive environment to promote breeding, egg transport/incubation management

2.3. Maintain number of qualified captive breeding facilities that are part of the AZA WHCR SSP that meet the goals of both Canada and the U.S. for the captive and reintroduction populations.

Responsible Party:	AZA WHCR SSP Coordinator/WHCR IRT/qualified SSP partners
Cost:	High Cost: over 100K/year
Timeline:	Long term/ongoing
Outcome:	Currently there is adequate capacity of partners to produce the number of chicks needed to maintain goals of the captive and reintroduction populations
Collaborators:	AZA WHCR SSP/AZA Gruiformes TAG/holding institutions/WCHAT/WHCR IRT/AZA Accreditation Commission
Obstacles:	Ongoing institutional support, need to have additional dollars/fundraising/institutional support, update/maintain/renovate/expand infrastructure at level required, loss of staff knowledge/training
Data Gaps:	Best facility design for goals, financial constraint for what is best for WHCRs and management

Re-introduced Populations. Relates to Objective 1 in the Recovery Plan:

3. Establish and develop additional wild populations across a representative portion of the species range.

3.1. Develop/refine/implement rearing and release techniques that maximize survival, encourage natural behaviors, and lead to the successful reproduction of the released birds.

3.1.1. Develop a research project to examine possible impacts of captive effect using a mix of AWB eggs and captive eggs in the existing reintroduction populations.

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term
Outcome:	Birds are breeding successfully, survival is comparable to natural population
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time, agreement to egg collect, sample size, transport
Data Gaps:	Impacts of captive effect on reintroduction success

3.1.2. Develop research to investigate factors contributing to lack of colt survival

3.1.3. Develop research to investigate factors contributing to nest success

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term/ongoing
Outcome:	Birds are breeding successfully, survival is comparable to natural population
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	Impacts of captive effect on reintroduction success, reasons for lack of fitness

3.2. Encourage birds to establish breeding territories in a variety of natural areas. *(needs further development)*

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Long term/ongoing
Outcome:	Birds are breeding successfully, survival is comparable to natural population
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	Evaluate habitat components of successful breeding, release, migration and wintering sites

3.3. Establish and maintain migratory and non-migratory populations.

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Long term/ongoing
Outcome:	Birds are breeding successfully, survival is comparable to natural population
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	Impacts of captive adaptation on reintroduction success, continue to investigate lack of colt survival and factors contributing to nest success

3.3.1. Determine elements of success and failure targets. *What are we measuring to determine success or failure? Timelines? If we do not reach X by X year – is that failure? For example, (1) for success lambda is above 1 for 8 out of 10 years, (2) we have F2 breeding in X years.*

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term
Outcome:	An informed decision based on species natural history and biology and recovery needs and goals
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	Impacts of captive adaptation on reintroduction success, continue to investigate lack of colt survival and factors contributing to nest success

3.3.2. Develop guidelines for when to start new reintroduction, translocation, head-starting projects.

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term
Outcome:	An informed decision based on species natural history and biology and recovery needs and goals
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	*Need to add*

3.3.3. Refine monitoring plans to gather the most important information (*to be decided*) and to maximize resources.

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term
Outcome:	An informed decision based on species natural history and biology and recovery needs and goals
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	*Need to add*

3.4. Refine release cohorts to maximize resources and efficiency to meet designated goals for the targeted population (s).

Responsible Party:	Federal agency, Reintroduction Implementation Team, Recovery Team
Cost:	Initial costs - 100K and over
Timeline:	Short term/ongoing
Outcome:	Shortest path to self-sustaining and the population target population number
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	*Need to add*

3.5. Removal plan to manage non-breeding/forced removed birds from reintroduction programs.

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term
Outcome:	Remove risks from reintroduced populations and maximize bird welfare and contribution. Have a process for removal from population and disposition
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	*Need to add*

3.6. Plan to monitor and address widely dispersed birds from reintroduction programs.

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term/ongoing
Outcome:	Maximize/support opportunities for a bird to find good habitat and to be successful
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	*Need to add*

[Stopped here: 4.0 and 5.0 need revisions. All sections herein need RP, Cost, Outcome, Collaborators, Obstacles, Data Gaps re-checked.]

4. Determine N_e for species survival by analyzing banding data to determine the N_e/N ratio for the AWBP. [*Not started yet. May no longer be relevant*]

Responsible Party:	Federal agency, SSP institutions, Reintroduction Implementation Team
Cost:	Initial costs - 100K and over
Timeline:	Short term/ongoing
Outcome:	Birds are breeding successfully, survival is comparable to natural population
Collaborators:	State and Provincial Agencies
Obstacles:	Funding and staff time
Data Gaps:	Impacts of captive adaptation on reintroduction success, continue to investigate lack of colt survival and factors contributing to nest success

5. Maintain and expand information/education programs.

5.1. Develop media products.
5.2. Provide viewing opportunities.
5.3. Implement education programs.

Aransas / Wood Buffalo Population Management Working Group

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

RP Objective 1 (Revised): Establish and maintain large and wide-ranging, self-sustaining populations of Whooping Cranes in the wild that are, as a result, genetically stable and resilient to stochastic environmental events.

1. Increase the AWBP
    1.1. Monitor population characteristics including size and distribution, and conduct periodic assessments of demographic rates such as, recruitment and mortality.
        1.1.1. On breeding grounds, conduct annual surveys in areas used for breeding to determine size, distribution and productivity of the breeding population and conduct periodic or opportunistic assessments of demographic rates, health status, etc.
        1.1.2. On wintering grounds, conduct annual surveys in areas used for wintering to determine age-specific size, distribution and recruitment of the entire population and conduct periodic or opportunistic assessments of demographic rates, health status, etc.
        1.1.3. During migration conduct annual monitoring to determine distribution and phenology, and collect additional information to conduct periodic or opportunistic assessments of demographic rates, health status, etc.
        1.1.4. In all areas, conduct periodic assessments of quantity and quality of suitable habitat (e.g., salinity at ANWR, food resources, water levels, etc.).
        1.1.5. Conduct periodic assessments of all operational and analytical aspects of monitoring activities.
            - Responsible Party: US and CA Recovery Coordinators
            - Cost:
            - Timeline: Short term/immediate/annual/ongoing
            - Outcome: Objective 1 in RP. Continue to monitor the pop
            - Collaborators: Parks Canada, USGS, Citizen Science
            - Obstacles:
            - Data Gaps:
            - Resiliency and Redundancy and Representation
    1.2. Maintain contemporary population growth until recovery is reached.
        1.2.1. Maintain or increase recruitment (e.g., egg management/manipulation, head-starting)
        1.2.2. Maintain or decrease direct mortality (e.g., collisions, shootings, etc.)
        1.2.3. Maintain or decrease sub-lethal effects of anthropogenic disturbances across the AWBP range (e.g., construction, aircraft altitude, etc.).

1.3. Identify, protect, manage and restore habitat.

1.3.1. Identify suitable habitat.

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

1.3.1.2. Complete measurement of availability of winter habitat and monitor changes over time.

1.3.1.3. Complete measurement of availability of breeding habitat and monitor changes over time.

- Responsible Party: US and CA recovery coordinators, US refuge staff, Parks Canada staff
- Cost:
- Timeline: 2022/ongoing
- Outcome: Objective 1 in RP.
- Collaborators: NGO's, Private landowners, Universities, Local and/or federal agencies
- Obstacles:
- Data Gaps:

1.3.2. Protect habitat.

1.3.2.1. Identify breeding and migratory Critical Habitat (Canada)

- Responsible Party: CA recovery coordinator and Parks Canada staff
- Cost:
- Timeline: 2023/ongoing
- Outcome: Objective 1 in RP.
- Collaborators:
- Obstacles:
- Data Gaps:

1.3.2.2. Establish and maintain effective protections in breeding marshes in areas identified as Critical Habitat in and outside of WBNP. (e.g., maintain protection of WBNP, work with other governments to protect areas outside of WBNP)

1.3.2.3. Establish and maintain effective protections in identified migration stopover sites in migratory Critical Habitat in Canada, Platte River, Quivira NWR, Salt Plains NWR or other identified habitat. (e.g., prevent contamination, maintain quality and quantity of water).

1.3.2.4. Establish and maintain effective protections in wintering salt marsh and other habitat in Aransas NWR, other Texas coastal NWRs, and adjacent areas. (e.g., maintain protections in protected areas, prevent erosion and contamination, and freshwater and in-stream flows).

- Responsible Party: US and CA recovery coordinators, Parks Canada Staff, US Refuge staff and Partners biologists
- Cost:
- Timeline: Long-term/ongoing [Action Plan 2023 Parks Canada]
- Outcome: Objective 1 in RP.
- Collaborators: NGO's, Private landowners, Local and/or federal agencies, indigenous partners, GNWT, Northern Bio?
- Obstacles:

1.3.3. Manage and restore habitat.

1.3.3.1. Manage breeding habitat. (e.g., invasive species control, regulate human and aircraft activity)

1.3.3.2. Manage migration habitat. (e.g., water and vegetation management, riparian and wetland restoration, invasive species control)

1.3.3.3. Manage winter habitat. (e.g., water and vegetation management, riparian and wetland restoration, invasive species control, prescribed fire, management of deposition of dredge material and upland water sources)

- Responsible Party: US and CA recovery coordinators, Parks Canada Staff, US Refuge staff Cost:
- Timeline: Long-term/ongoing
- Outcome: Objective 1 in RP.
- Collaborators: NGO's, Private landowners, Local and/or federal governments
- Obstacles:
- Data Gaps:

2. Conduct Research

2.1 Demographics

2.1.1. Increase understanding of factors limiting survival from egg to fledge, such as climate and predation. Conduct research on recovery actions that could increase survival during this period, such as headstarting and nest management;

2.1.2. Increase understanding of cause-specific and seasonal mortality rates at other life stages, including how these are influenced by anthropogenic and natural factors. Conduct research on recovery actions that could reduce mortality rates.

2.2. Habitat

2.2.1. Increase understanding of habitat availability, requirements and use across the range, including during breeding, migration and wintering.

2.2.2. Conduct research on management actions that could promote protection or restoration of existing habitat or use of alternative habitat, given anticipated future population growth, anthropogenic pressures and climate change.

- Responsible Party: US and CA recovery coordinators, Parks Canada Staff, US Refuge staff
- Timeline/Cost: Long-term/ongoing
- Outcome: Objective 1 in RP.
- Collaborators: NGO's, Private landowners, Local and/or federal governments
- Obstacles:
- Data Gaps:

3. Deliver education and outreach programs

   3.1 Implement programs to educate members of the public about threats to whooping cranes and how the public can participate in conservation efforts.

   3.2 Coordinate with media to communicate results of monitoring, research, recovery actions, etc. to the public through appropriate public outlets.

- Responsible party: US Regional EA staff and Refuges staff, Parks Canada staff, GNWT
- Timeline/Cost: Long-term Ongoing
- Outcome:
- Collaborators: State and Provincial Agencies, NGO's, landowners/managers
- Obstacles:
- Data Gaps:

Appendix I: Workshop Agenda

Recovery Planning for Whooping Crane
Workshop IV: Species Recovery Planning

8 - 10 October, 2019
International Crane Foundation
Baraboo, WI, USA

DRAFT WORKSHOP AGENDA

DAY ONE: Tuesday, 8 October

9:00 Welcome and workshop opening
(*ICF Representative; Wade Harrell, USFWS; Mark Bidwell, CWS)*

Participant introductions

Review of abbreviated December 2018 workshop (*Phil Miller, CPSG*)

Overview of important results from PVA in the context of recovery planning and development of recovery objectives (*Kathy Traylor-Holzer, CPSG*)

Coffee / tea break

Preliminary discussion of Whooping Crane recovery objectives: operational definitions of objective components, etc.

12:30 Lunch

13:30 Continued discussion of Whooping Crane recovery objectives

Introduction to high-level discussion of recovery objectives

Agreement on revisions to recovery objectives, etc.

Coffee / tea break

Begin review of 2007 recovery actions

17:30 Adjourn

DAY TWO: Wednesday, 9 October

8:30 Reflections on Day 1

Begin development of recovery actions and studies needed

Coffee / tea break

12:30 Lunch

Continue development of recovery actions and studies needed

Coffee / tea break

Revew and revision of 2007 recovery actions (continued)

17:30 Adjourn

DAY THREE: Thursday, 10 October

8:30 Reflections on Day 2

Discussion of remaining needs for IRP, Canadian recovery strategy documents

Coffee / tea break

Next steps

12:00 Workshop Closing

12:15 Lunch

13:00 IRT Meeting (Tentative: may begin over lunch and end by 14:00)

Appendix II: Workshop Participants

Recovery Planning for Whooping Crane
Workshop IV: Recovery Planning Discussions

8 – 10 October, 2019
International Crane Foundation
Baraboo, WI, USA

WORKSHOP PARTICIPANTS

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Appendix III: Workshop Briefing on Genetic Considerations for Recovery

Evaluation of Genetic Considerations Used in Deriving Downlisting Criteria for Whooping Cranes

Phil Miller, PhD
IUCN-SSC Conservation Planning Specialist Group
19 November, 2018

Introduction

The Third Revision of the International Recovery Plan for the Whooping Crane (*Grus americana*), published in 2007, lays out a set of alternative downlisting criteria for the species. These alternative criteria differ fundamentally in the number of populations distributed across the species' historic, with associated modifications to the abundance targets depending on the presence of one, two or three populations on the landscape (with the Aransas – Wood Buffalo population included as a core component of each alternative).

In the Recovery Plan's description of downlisting criteria (pages 37-38), genetic considerations are presented as seemingly primary justification for specific quantitative population abundance targets. However, careful reading of this material reveals some questionable logic in the application of population genetics principles to the identification of viable abundance targets. This document is an attempt to point out some of these issues, and is meant to stimulate additional discussion at the December 2018 Recovery Planning Workshop, to be held in Calgary, AB.

Downlisting Criterion 1

The text for downlisting Criterion 1 from the Recovery Plan states the following:

> Maintain a minimum of 40 productive pairs in the AWBP [Aransas – Wood Buffalo Population] 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.

The Plan goes on in this subsection to state,

> 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).

Appendix A, titled "Minimum Viable Populations and Genetics", includes a set of subsections that discuss both demographic and genetic considerations in the estimation of minimum viable population abundance for endangered species. Demographic considerations are based largely on extinction risk thresholds, with target population abundances in the range of 1,000 – 5,000 or perhaps greater that are consistent with a low risk of extinction over ecologically functional timeframes (e.g., 1% risk over 1000 years). More plausible risk thresholds – say, 5% risk of extinction over 100 years – would logically yield smaller abundance targets, perhaps 1,000 or less. Regardless of the risk tolerance that is adopted, the target population abundance based on general demographic principles is likely to be larger than the 360 total birds that makes up this downlisting criterion.

A separate subsection of Appendix A, titled "Population Growth and Retention of Genetic Material", appears to form the basis for the target abundances defining Criterion 1. Analysis of data from the captive population, based on a 2003 Masterplan for the captive population (Jones and Lacy 2003), suggests that an abundance of 153 cranes (equivalent to about 21 productive pairs) is needed to retain 90% of the genetic variability present in that captive population at the time of analysis over a period of 100 years. This appears to be the basis of setting 100 to 160 birds (with a total of 360) as the population-specific target abundances under this Criterion. The captive population target abundance, however, is based on careful management of breeding in order to minimize the rate of loss of genetic variability (heterozygosity) to the extent possible in the captive environment. This is accomplished by detailed maintenance of pedigree records documenting the ancestry of each bird so that breeding recommendations can be made with the purpose of minimizing inbreeding and loss of genetic diversity. These opportunities are not possible in wild population management; as a result, genetic diversity is lost more rapidly in the wild through random breeding, higher rates of inbreeding, higher chick mortality, etc.

Therefore, it seems problematic to set target abundances for wild population viability that are based on genetic management principles that underlie intensive management practices for captive populations. It may be feasible to set a broad genetic objective around minimizing the rate of genetic diversity loss in the wild population relative to the existing level in the wild, and then deriving a target abundance for the wild population(s) consistent with that objective. The magnitude of that target abundance may be influenced by the extent to which the wild population(s) interact through translocation with the highly-managed *ex situ* population, which can infuse genetic material not currently present in the wild population.

Downlisting Alternative Criterion 1A

The text for downlisting Criterion 1A from the Recovery Plan states the following:

> If only one additional wild self-sustaining population is reestablished, 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 reestablishment 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.

Given the reliance on Criterion 1 stated here, it follows that the same issues pertaining to the logic underlying the earlier downlisting criterion are relevant in the derivation of this criterion.

Downlisting Alternative Criterion 1B

The text for downlisting Criterion 1B from the Recovery Plan states the following:

> 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 Plan goes on in this subsection to state,

> 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.

This criterion seems to rely rather heavily on the assumption that new genetic material can be generated in a population through mutation, and that this rate of mutation will offset the loss of genetic variability when the breeding population of cranes is at least 500 individuals (i.e., 250 pairs). The conceptual foundation of this logic is unclear after reading the text in this section, or in Appendix A. We must infer, therefore, the basis on which this target was identified.
Technically, the roots of this argument can be traced to the "neutral theory of molecular evolution" that is an important topic in conservation genetics. In general terms, this theory states that specific neutral loci in the genome (those loci that are not subject to natural selection) undergo mutation at a constant rate that is independent of population size, and that the gradual loss of genetic diversity (heterozygosity) at those neutral loci is governed by the process of random genetic drift. Population genetics theory tells us that the rate of loss of genetic diversity at a neutral genetic locus through drift is proportional to the effective population size, N_e, which simply speaking is roughly equivalent to the breeding component of the population. Specifically, populations lose diversity at a rate of $(1/[2N_e])$ per generation; it therefore follows that smaller populations lose diversity through drift more rapidly than their larger counterparts.

Returning to the Whooping Crane criterion: If the target AWBP abundance is 250 breeding pairs, we may optimistically assume that the effective population size N_e is 500 individuals. Therefore, genetic diversity is expected to be lost through drift in this population at a rate of (1/[2*500]) = 0.001 = 0.1% per generation. Therefore, it follows that if the goal is to gain back that lost diversity through mutation, the rate of mutation at that neutral locus, creating new genetic variants that contribute to expressions of genetic diversity, would have to be at least 0.001 or more per generation.

To assess the validity of the above rate, we need to understand the average mutation rate of neutral loci in the average genome. Estimates of neutral mutation rate are difficult to obtain experimentally and highly complex to estimate theoretically, but in general a typical neutral locus mutation rate estimate is on the order of 10^{-5} per generation – or about 100 times slower than the rate of genetic diversity loss through drift in our Crane population. Mutation rates for loci that determine fitness in an organism are even lower (10^{-7} per generation) because most of these mutations are going to be deleterious and therefore rapidly eliminated from the genome through selection.

Because neutral mutation rates are independent of population size, the only way that loss of diversity through drift can be replaced by mutation is for this rate of loss to be minimized by maintaining a larger population size. The actual abundance needed to satisfy this condition is, once again, difficult to estimate – dependent on the actual average heterozygosity at typical neutral loci in the existing population, etc. However, the concepts discussed here tell us unequivocally that the required abundance is far larger than 250 breeding pairs, and is at least 1-2 orders of magnitude larger. In other words, for the Aransas – Wood Buffalo population to gain genetic variation through mutation at a rate equivalent to or larger than the rate of loss through genetic drift, the effective size of the population would need to be on the order of at least 5,000 – 10,000 breeding birds.

The information presented above argues against using drift – mutation balance as a valid consideration for developing a downlisting criterion for Whooping Cranes. If it is desirable to include a genetic argument for establishing this criterion, it would be more reasonable to adopt an approach based on minimizing the rate of genetic diversity loss instead of relying on natural mutation to offset that loss. This approach would be similar to that described above for Criterion 1: setting a threshold for the acceptable level of loss of genetic diversity relative to a given starting point (e.g., 90% of current genetic diversity over 100 years), and then identifying the maintenance population abundance required to achieve that objective.

Conclusion

The current population viability analysis conducted by the Conservation Planning Specialist Group for this planning process is a valuable tool for evaluating the genetic structure of wild populations in response to alternative management scenarios. In particular, the level of retention of genetic diversity over the simulation period, relative to the diversity considered to be present at the start of the simulation, can be reported for each population. This metric is in keeping with the type of meaningful downlisting criterion discussed in the previous sections.