Comparative studies on recovery histories and conservation strategy for *Grus japonensis* and *Grus americana*

タンチョウおよびアメリカ・シロヅルの回復史と保全戦略に関する比較研究

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Abstract

Southeast Texas/northern Alberta and southeast Hokkaido, Japan are homes to populations of two extremely similar species of cranes with similar conservation stories. The whooping crane of North America, specifically the Aransas-Wood Buffalo (AWB) migratory flock, and the red-crowned crane of Hokkaido were both pushed to the brink of extinction, with surviving populations numbering 21 and 33 individuals, respectively, in 1952 (Butler et al. 2022; Japan Red-Crowned Crane Conservancy 2022). Both species have been subjects of focused rehabilitation efforts led by advanced national governments. While both governments' conservation authorities relied on a variety of conservation methods throughout their programs' histories, the United States Fish and Wildlife Service (FWS) focuses mainly on habitat management, while in Japan the Ministry of the Environment (MOE) and its predecessors lean most heavily on a direct population management strategy via a long-standing winter artificial feeding program. The recovery histories of these two remarkably similar species provide a unique opportunity for comparing and contrasting the relative efficacy of two primary endangered species management approaches: habitat management vs. direct population management through artificial and supplemental feeding. These case studies also afford opportunities to explore, better appreciate, and better understand the legacy of the now 50-year-old United States Endangered Species Act, the historical underpinnings behind Japan's unique approaches to wildlife conservation, and the ongoing and emerging threats to the recoveries of both crane species.

An initial review of these two case studies strongly indicates that supplemental

feeding in periods of lean food availability likely resulted in much faster overall population recovery in Japan, with the red-crowned crane population expanding at a rate roughly 20 percent faster than the AWB whooping crane population over the 70-year period reviewed in this study. Today, Japan's resident red-crowned crane population numbers more than triple that of North America's AWB whooping crane population: about 1,800 red-crowned cranes by 2022 according to the Red-Crowned Crane Conservancy (RCCC) vs. 543 AWB whooping cranes as of 2022 per FWS. These results suggest Japanese conservationists may have uncovered a method for ensuring faster population recovery in an endangered species: sustained long-term artificial feeding during times of least forage availability (in this case, the height of winter). Evidence in the academic literature further points to supplemental or artificial feeding's net positive effect on avian species' rates of reproduction and population growth. For purposes of this study, an ecological definition of "population growth" is given as a net positive increase in the numbers of individuals of a species as recorded in that species' primary habitat in the wild, thus excluding increases in the number of individuals of a species held in captivity.

While other factors that may explain the variance in red-crowned crane vs. AWB whooping crane population recovery, there is no convincing evidence that the AWB whooping crane population has been experiencing higher mortality rates, and a careful review of these other factors leaves the winter-feeding program as the strongest factor and the one that best explains the population growth different outcomes. Prior research has also found that the winter supplemental feeding campaign is principal driving force behind Hokkaido red-crowned crane population growth. This author's study now goes

farther by analyzing red-crowned crane population recovery against that of its cousin species, the AWB whooping crane.

This study lays out in detail how the supplemental winter-feeding campaign in Japan best explains the faster rate of population growth (or net positive increase in the numbers of individuals of a species as recorded in that species' primary habitat in the wild) witnessed in Hokkaido's red-crowned crane population. Evidence from the academic literature is drawn to support this conclusion. Furthermore, a detailed assessment of habitat management efforts in Japan is offered to assess Japan's options for managing and protecting the large Hokkaido population of red-crowned cranes moving forward.

Finally, this study compares and contrasts international endangered species laws, including Japan's landmark endangered species statute, against the 50-year-old US Endangered Species to highlight the legacy of the Endangered Species Act and how the respective histories of crane conservation in the US and Japan influenced modern endangered species laws and management practices. This exercise revealed important philosophical and culture differences between approaches to endangered species conservation in the US and Japan, differences that can be interpreted through the lens of these two endangered crane species conservation initiatives.

Chapter 1

Introduction

On opposite sides of the world, two endangered crane species conservation projects find themselves at a crossroads.

In the United States, a rehabilitation effort to conserve the whooping crane, North America's largest bird, is seeing improvement in the form of possibly accelerating whooping crane population growth, with the largest targeted conservation initiative recording 543 members of that species by winter 2022 according to data by the United States Fish and Wildlife Service (Butler et al., 2022). In Japan, managers of the famous red-crowned crane, the "dancing crane" prized by wildlife photographers, can be proud of their work to save this species from the endangered list as the Hokkaido resident population now numbers at least 1,800 according to 2022 data published by the Red-Crowned Crane Conservancy (RCCC 2022), and possibly as high as 2,000 individuals according to assessments by management at the Akan International Crane Center provided verbally to this study's author. For purposes of this study, an ecological definition of "population growth" is given as a net positive increase in the numbers of individuals of a species as recorded in that species' primary habitat in the wild, thus excluding increases in the number of individuals of a species held in captivity.

The red-crowned crane of southeast Hokkaido and the whooping crane of the Aransas National Wildlife Reserve in Texas and Wood Buffalo National Park in Canada (the Aransas-Wood Buffalo or AWB whooping crane population) are so similar in biology and physiology that they are placed in the same genus: *Grus*. *Grus japonensis* and *Grus americana* show similar histories, as well. Both species were nearly driven to extinction

by the 1940s, with both species' populations numbering as few as 20 or 30 birds by the 1950s (USFWS, RCCC, Ministry of the Environment, Japan). Both species have also been subjects of robust government-led rehabilitation efforts beginning in the 1950s (USFWS, RCCC, Ministry of the Environment, Japan). For most of these decades the Japanese initiative has proven to be a runaway success story. For example, by 2017 the red-crowned crane population in Japan had risen to over 1,500 birds (RCCC 2022). In contrast, AWB whooping crane numbers were recorded as mired in the 350-400 population range for many years (FWS 2012).

FWS officials with the Aransas National Wildlife Refuge reported in 2022 that at least 543 whooping cranes returned from Canada to winter in Texas (Butler et al. 2022). RCCC authorities put the red-crowned crane population at around 1,800 individual birds in 2022 (RCCC 2022), more than triple the size of the AWB whooping crane population despite both efforts having begun from similar population baselines in the early 1950s.

This study is a comprehensive assessment of these two crane conservation programs, the two species' primary habitats and threats facing them, and how the histories of these crane conservation initiatives reverberate in endangered species management regimes today. As a launching point, this study sought to explain why eastern Hokkaido's red-crowned crane population expanded at a greater rate compared to the AWB whooping crane, even as both species exhibit similar breeding patterns, survival strategies, biology, and conservation histories. After conducting fields visits, interviews, population data assessments, a basic geospatial assessment, and a review of the publicly available academic literature, research lasting three years, this study concludes that the winter-feeding program launched by local citizens in eastern Hokkaido in 1950 and maintained

by Japan's Ministry of the Environment best explains Japan's success in red-crowned crane recovery compared to AWB whooping crane population. This author argues that the comparative case studies of the whooping crane and red-crowned crane adds to a growing body of evidence in the academic literature, made apparent through a literature review, showing that supplemental or artificial feeding of wild endangered species, especially avian species, not only facilities greater individual and group survival but also elicits faster reproduction and population growth in that targeted species. In other words, there is emerging evidence in academic research that endangered species supported by sustained artificial feeding, even operating only part of the year, will likely exhibit higher rates of reproduction and faster population growth than in the absence of such a strategy. These findings are in accordance with the findings of other similar published studies. Prior research conducted in Hokkaido agrees with this author's conclusion that the winter supplemental feeding campaign is the main factor responsible for the strong recovery in the east Hokkaido red-crowned crane population (Masatomi 1991, Masatomi et al. 2007, Inoue et al. 2013).

Japan's winter-feeding program began in the Akan, a village near Kushiro Marsh National Park in eastern Hokkaido in 1950 (Akan International Crane Center website). Japan's government is now pushing forward a new conservation experiment. Starting in 2014, the Ministry of the Environment ordered winter feeding cut by 10 percent annually (MOE 2018). The volume of feed supplied to whooping cranes during the high winter months is now down by approximately 50 percent of historic levels (MOE 2018). The aim is to gradually wean red-crowned cranes off the eastern Hokkaido winter-feeding centers to encourage them to migrate to other parts of Japan (MOE 2018). The red-

crowned crane has expanded its range in eastern Hokkaido, but that crane population continues to mainly stick to eastern Hokkaido's wetlands rather than migrate further west and south in numbers beyond just a few individuals (RCCC 2022).

Kushiro Marsh National Park is a large national park east of Akan that holds more than 60 percent of Japan's total wetland area (Amano et al. 2006). The wetland area comprising Kushiro Marsh National Park, habitat best suited for the red-crowned crane, has contracted over decades as observed and reported by MOE research and independent studies (Hanioka et al. 2018), meaning the red-crowned crane of Hokkaido has been gradually losing some of its best habitat during the same period that its population recovered strongly.

For AWB whooping cranes, their area of protected habitat in Texas is now expanding dramatically. The Texas Parks and Wildlife Department (TWPD) acquired the 7,000-hectare Powderhorn Ranch near the southeast Texas city of Port O'Connor thanks to an infusion of cash from the settlement over the 2010 Gulf of Mexico Oil Spill park (Texas Parks and Wildlife Department 2018). Over 6,000 hectares of the former ranch are now the state's newest wildlife management area, while the remaining 800 hectares are slated to be developed into a new state park (TPWD 2018). A site visit to Powderhorn Ranch conducted by this author and a study undertaken by a research team at the University of Texas at Austin both revealed that Powderhorn Ranch contains ideal habitat for AWB whooping cranes wintering in the nearby national wildlife refuge (Paine et al. 2018). The Nature Conservancy held this land in trust before it was turned over to Texas parks management (TPWD 2018). There are some non-native species of Asiatic deer found on the property as witnessed by this author. An official with the Nature

Conservancy told the author that these exotic deer species were added to the land by the land's former owners but these invasive species are not deemed a threat to the whooping crane's recovery by the Nature Conservancy, State of Texas, and the University of Texas at Austin research team. A thorough independent ecological survey of Powderhorn Ranch also concluded that the presence of exotic Asiatic deer on the property poses no threat to AWB whooping cranes (Paine et al. 2018).

There is no convincing evidence that the AWB whooping crane population has been suffering from higher rates or mortality compared to the Hokkaido red-crowned crane over the 70-year history reviewed. None of the research papers reviewed by this author indicated elevated levels of mortality for the AWB whooping crane in the earlier years of FWS-directed conservation. The AWB whooping crane recovery initiative has experienced only two serious setbacks in the past during periods of intense drought conditions in Texas. A harsh 2011 Texas drought resulted in a 12 percent decline in the AWB whooping crane population (FWS 2012). FWS reported that fatalities during this event rose mainly by starvation as the drought lowered the fresh water flow into the wildlife refuge, reducing the population of blue crabs that whooping cranes have come to rely upon at the refuge (FWS 2012).

Among the largest wetland birds in the world, AWB whooping cranes and Hokkaido red-crowned cranes are very similar biologically (International Union for Conservation of Nature 2020, IUCN 2022), but not necessarily culturally. In the United States, the whooping crane is regarded as another endangered species competing with numerous others for funding and attention. This is unfortunate, as this author finds that the US government's experience with managing the AWB whooping crane population

likely played an immense role in influencing the drafting of the 1973 US Endangered Species Act, and in turn much of the world's legalistic and philosophical approaches to endangered species management. These influences are explained in Chapter 5. In Japan, the red-crowned crane is a cultural icon and the subject of art and folklore. Thousands of photographers gather in eastern Hokkaido every winter to take pictures of the cranes conducting their elaborate courtship dances in snowy backdrops. Tourism to the Aransas National Wildlife also increases every winter following the whooping cranes' return from breeding grounds in central Canada. As with the AWB whooping crane, Japan's experience with managing and saving the Hokkaido red-crowned crane population from extinction also likely played an immense role in influencing the drafting of Japan's federal endangered species law, influences that are also explained and explored in detail in Chapter 5.

These two crane species are very closely related, a relationship determined not only by their very similar physical appearance. Both species exhibit similar lifespans—Japanese legend has the red-crowned crane living for 1,000 years but the actual life span for this species in the wild is closer to 30 years, similar to the 24-year lifespan estimated for whooping cranes (RCCC, FWS). Both species demonstrate slow reproductive cycles, both species are omnivorous, and both species prefer wetland habitat and are considered primarily wetland birds (International Union for Conservation of Nature, RCCC, FWS).

The scale of the red-crowned crane winter-feeding regime in northern Japan is slated to continue its contraction should MOE maintain its stated policy of eventually eliminating winter feeding entirely (MOE 2018). Meanwhile, AWB whooping crane winter territory is expanding as managers gradually incorporate Powderhorn Ranch into

the area of formally designated protected habitat (TPWD 2018). MOE's push for zero winter feeding has already invited political backlash from communities in Akan and Tsurui where the red-crowned cranes are a mainstay of the tourism industry (MOE 2019). Responding to this, MOE decided to slow down the pace of feeding volume reduction in official policy adjustments announced in 2022 (MOE 2022).

This author can find no evidence that higher-than-average rates of mortality or any other factors have held back AWB whooping crane population growth over the 70-year period reviewed in this study. This is demonstrated quantitatively in the population growth data—with the exception of minor fluctuations, AWB whooping cranes have generally returned to Texas from Canada in higher numbers—and qualitatively per the records and testimony provided by the US Fish and Wildlife Service, which states that the only serious mortality events recorded for the AWB whooping crane occurred in Texas during two severe drought years. Likewise, this author can find no other explanation for the Hokkaido red-crowned crane's faster-than-average population growth witnessed and recorded over the same 70-year period. As noted, prior research agrees that the winter artificial feeding campaign has permitted the Hokkaido red-crowned crane population to expand at a rate faster than what would have normally occurred under conditions without artificial feeding (Masatomi 1991, Masatomi et al. 2007, Inoue et al. 2013).

This study is divided into three segments, each segment supporting and reinforcing the central conclusions of the others. First, this exercise sought to prove a central hypothesis: that a thorough assessment of the case studies of the AWB whooping crane and Hokkaido red-crowned crane add further evidence (as is found in the existing and prevailing academic literature) that artificial or supplementary feeding may elicit

higher rates of species reproduction, and thus, the winter artificial feeding campaign begun in 1950 in Akan best explains the dramatic divergence in population growth witnessed in the case studies of the AWB whooping crane and Hokkaido red-crowned crane. The author achieved this conclusion by ruling out other factors that could explain the huge divergence in red-crowned crane vs. whooping crane population growth. This author expanded upon his investigation into the recovery histories of these two species, their habitats, and existing or emerging threats to their recoveries through a review of the academic literature concerning artificial feeding and its effects on endangered species reproduction, undercovering the existing evidence that supplemental feeding likely elicits faster population growth in a target endangered species. This very study adds to this body of evidence contained in the academic literature.

Second, as indicated earlier, this study did not limit itself to only a narrow focus on the impact of supplemental or artificial feeding on animal reproductive rates. Rather, a deeper review was undertaken to determine the past, present, and future of these two crane conservation initiatives and the marks that both of these case studies have left on global endangered species management and protection policy, marks stemming from the US and Japan's experiences with saving these two crane species from extinction. In other words, this author has discovered that the case studies of the AWB whooping crane and Hokkaido red-crowned crane not only add to the body of emerging evidence of a net positive population growth effect stemming from artificial feeding, but these case studies also reveal how American and Japanese governments' experiences with endangered crane species management helped influence the world's existing endangered species laws. In short, the histories of endangered crane species management in Hokkaido and Texas

reveals details regarding the history of endangered species legislation globally and why many endangered species laws have taken the shape that they have today.

This author carefully analysed the national laws governing endangered species management in the United States, Japan, and other countries. Japanese and US endangered species legislations entered into force well after the AWB whooping crane and Hokkaido red-crowned crane protection regimes were established, a central point worth emphasizing. This exercise was designed to explore how AWB whooping crane conservation and Hokkaido red-crowned crane protection practices and experiences may have influenced conservation policies and philosophies in the US, Japan, and beyond. The result of this side investigation led the author to conclude that the United States Endangered Species Act of 1973 has had a profound influence on endangered species conservation theory and practice in much of the world, though in Japan's case there are clear differences in approach and philosophy most likely influenced in part by the red-crowned crane conservation history. As explained in Chapter 5, there are clear signs that the landmark endangered species laws of Japan and the US strongly reflect the experiences of wildlife managers in saving the Hokkaido red-crowned crane and AWB whooping crane, demonstrating the critical importance of these two conservation histories, a degree of importance that has been overlooked up to now. The author also finds strong cultural elements and differences influencing how endangered species management is approached and conducted in Japan vs. the US, cultural differences that are also reflected in the respective countries' endangered species laws today.

Third, this study also includes an exploration of the future. Incorporated into this broader review is an in-depth analysis of the problems threatening Hokkaido red-crowned

crane habitat availability in Kushiro Marsh National Park and how wetland losses there might be alleviated to ensure the future survival of that species (Amano et al. 2006). The focus here is on red-crowned crane habitat as the region of Kushiro Marsh is deemed vulnerable to further wetland loss; thus, future conditions there matter greatly for the future of the red-crowned crane (Amano et al. 2006). No similar threat exists for the AWB whooping crane; on the contrary, AWB whooping crane protected habitat is expanding considerably (TPWD 2018). This portion of this study, detailed in Chapter 4, is important to include as wildlife managers need to understand what future trends threaten the viability of the large Hokkaido red-crowned crane population in considering both the impact the winter artificial feeding program has had on past red-crowned crane population growth, how changes to the program ordered by the Ministry of the Environment might impact population growth and propagation moving forward, and what ongoing threats to wetland habitat in eastern Hokkaido mean for these evolving dynamics.

Figure 1 (below) is a flow chart illustrating the structure of this dissertation.

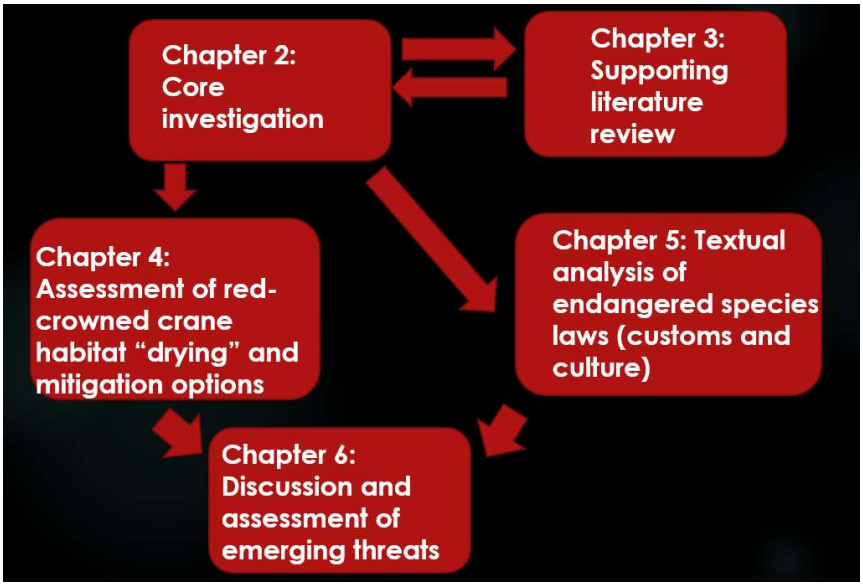


Figure 1: Study workflow and design.

The rest of this dissertation is divided into five chapters, in addition to this introductory chapter, with each chapter representing a separate segment of research conducted in the course of this investigation. Following this introductory chapter, Chapter 2 explains the initial research effort, Chapter 3 is the literature review that supports and is supported by the findings revealed in Chapter 2, while Chapter 4 explores ongoing threats to Hokkaido red-crowned crane habitat and how managers can mitigate against these threats. Chapter 5 uncovers the historical legacy of these two crane conservation initiatives, while Chapter 6 provides a summary and general conclusions.

A more detailed chapter-by-chapter explanation follows.

Chapter 2, this study's main chapter and research paper, details the hypothesis underpinning this study, the author's research methodologies, findings, and conclusions. To reiterate, this author finds that the case studies of the AWB whooping crane and Hokkaido red-crowned crane add to an emerging body of evidence in academic research that supplemental or artificial feeding will likely elicit faster population growth in a targeted endangered species.

Chapter 3 details the evidence supporting this author's hypothesis as found in the existing academic literature concerning the impact of supplemental or artificial feeding on endangered species reproduction patterns and population growth trends. As will be shown, there are strong indications emerging from research on the impact of supplemental or artificial feeding that these interventions are likely to result in a greater rate of population expansion in a targeted species, including managed endangered species. The evidence for a net positive impact of supplemental feeding is likely greater for avian species, but studies of other non-avian species revealed (albeit weaker) signs of a similar

net positive population growth effect. These chapters cover the past and present: Chapters 2 and 3 help explain the current status of the two endangered crane populations and why their population numbers differ so drastically as they do today.

Chapter 4 examines the future of crane conservation in Hokkaido. It presents research involving the author's separate investigation into the causes and consequences of wetland habitat contraction in Kushiro Marsh National Park, the red-crowned crane's principal habitat. This chapter explores options either pursued or proposed to mitigate against wetland losses while proposing an additional measure that could be taken by conservation authorities to further mitigate against the wetland "drying" phenomenon and hardwood incursions occurring in Kushiro Marsh National Park. Again, the focus here is on Hokkaido red-crowned crane habitat as no similar threats exist to the main protected habitat of the AWB whooping crane population (although potential direct threats to the AWB whooping crane are considered later on.)

Chapter 5 demonstrates how the American and Japanese governments' experiences with endangered crane species protections helped influence the architecture of endangered species laws and management approaches worldwide. This chapter includes a critical look at the cultural foundations underpinning endangered species management and key cultural differences between the way the US and Japan approach species conservation. This exercise was undertaken on the advice of a faculty member of Hokkaido University's Graduate School of Environmental Science, utilizing a methodology designed to allow for as an objective assessment as possible. In short, the author researched the legacy and impact of the US Endangered Species Act of 1973 and how AWB whooping crane conservation practices may have influenced the drafting of

that landmark endangered species law through a detailed textual analysis of multiple national and provincial endangered species laws. This chapter reveals how the Endangered Species Act may have influenced Japan's endangered species management approaches, while also uncovering important differences in endangered species management approaches best explained by Japan's different and unique history with Hokkaido red-crowned crane management.

Chapter 6 brings this entire analysis together while inviting readers to consider ongoing approaches to endangered crane species management in Hokkaido and Texas. This chapter summarizes this study's overall findings while also exploring and considering other emerging threats to AWB whooping crane and Hokkaido red-crowned crane conservation that authorities in Japan, the United States, and Canada must consider moving forward.

As you will see, the case studies of the AWB whooping crane and Hokkaido red-crowned crane offer valuable clues into the past, present, and future of endangered species management efforts across the world. The different population growth outcomes seen in these two case studies offer a compelling picture of the differences inherent in direct population management approaches vs. an emphasis on habitat management, while adding to emerging evidence of a net positive population growth effect of supplemental feeding of endangered wildlife. These case studies tell the story of how the endangered species laws of multiple countries have taken the form that they have today; how experiences with endangered crane species conservation in Japan and the United States influenced endangered species legislations globally. These case studies also underscore factors that endangered wildlife managers everywhere must consider as they continue

their efforts to save species from extinction while adjusting approaches and management strategies toward the greater goal of preserving the world's biodiversity for future generations.

Chapter 2

Comparative Conservation Strategy Efficacy for *Grus japonensis* and *Grus americana*: A Post-Policy Implementation Assessment

2.1 Abstract

Southeastern Texas/northern Alberta and northeastern Japan are homes to populations of two extremely similar species of cranes with similar conservation histories. The whooping crane of North America, specifically the Aransas-Wood Buffalo (AWB) migratory flock, and the red-crowned crane of Hokkaido were both pushed to the brink of extinction with surviving populations numbering 21 and 33 individuals, respectively, in 1952 (US Fish and Wildlife Service; Japan Red-Crowned Crane Conservancy). Both species have been subjects of focused rehabilitation efforts led by national governments. While both governments relied on a variety of conservation methods throughout their programs' histories, the United States Fish and Wildlife Service (FWS) focused mainly on habitat management, while Japan's Ministry of the Environment (MoE) and its predecessors leaned most heavily on a direct population management strategy via a long-standing winter artificial feeding program. The recovery histories of these two similar species provide a unique opportunity for comparing the relative efficacy of two primary endangered species management approaches: habitat management vs. direct population management through artificial feeding. An initial review of these two case studies reveals indications that artificial feeding in periods of lean food availability resulted in much faster overall crane population recovery in Japan, with the red-crowned crane population expanding at a rate up to 20 percent faster than the AWB whooping crane population over

a 70-year period reviewed in this study. Today, Japan's red-crowned crane population numbers more than triple that of North America's AWB whooping crane population: 1,800 red-crowned cranes by 2022 according to the Red-Crowned Crane Conservancy (RCCC) vs. 543 AWB whooping cranes as of 2022 per FWS. Additional research may be warranted to further eliminate other variables that could explain these vastly different population growth outcomes, but a post-policy implementation assessment points to the artificial feeding campaign in Japan as the main reason for the differences in historical population recovery.

2.2 Introduction

The red-crowned crane (*Grus japonensis)* of eastern Hokkaido and the whooping crane (*Grus americana)* of the Aransas National Wildlife Refuge in southeastern Texas and Wood Buffalo National Park in Alberta, Canada (AWB) belong to the same genus, *Grus*, and have similar to nearly identical sizes, appearances, diets, and reproductive cycles (International Union for Conservation of Nature, US Fish and Wildlife Service, Ministry of the Environment, Japan). These two iconic crane species have even more in common: both were nearly driven to extinction by the early 1950s, with populations numbering 21 and 33 birds in 1952, respectively, according to data compiled by the US Fish and Wildlife Service (FWS) and Japan's Red-Crowned Crane Conservancy (RCCC). Both species are subjects of legal protections and intensive government-led rehabilitation efforts lasting more than 70 years. In the United States, the AWB whooping crane population status is increasing according to assessments by the International Union for Conservation of Nature (IUCN) and the outlook for recovery is positive (IUCN Red List of Threatened Species 2020). In Japan, managers of the famous "dancing cranes" prized

by photographers have helped that species rebound strongly with the population more than triple the size of the AWB whooping crane population (RCCC 2022). IUCN and Japanese authorities no longer consider the red-crowned crane of Hokkaido to be an "endangered" species per se; instead, Japan now classifies the species as "vulnerable" per the Japanese government's own Red List tracking system (Ministry of the Environment, Japan 2020, IUCN Red List of Threatened Species 2021).

The Japanese initiative has seen greater success in endangered crane species population recovery (see Figure 9). For purposes of this study "population growth" is ecologically defined as a net positive increase in the numbers of individuals of a species as recorded in that species' primary habitat in the wild, thus excluding increases in the number of individuals of a species held in captivity. The gap in population growth rates is quite wide even though these two interventions began at about the same time and with crane numbers at comparable levels—21 AWB whooping cranes versus 33 Japanese red-crowned cranes in 1952 (FWS; RCCC). By 2022, the red-crowned crane population in Japan was estimated to have risen to at least 1,800 birds (RCCC, see Figure 9). The most recent population count for AWB whooping cranes conducted in 2022 shows 543 individual cranes (FWS, see Figure 9).

This paper describes research to determine the reasons for these different population growth outcomes, beginning with a basic initial post-policy implementation assessment. This inquiry into the likely factors accounting for the vastly different population growth outcomes strongly suggests that Japan's greater success with red-crowned crane recovery is due to a winter artificial feeding program that began in the village of Akan in the 1950s and expanded to the village of Tsurui, with three feeding

stations formally established by conservation authorities in Japan and operated every year since during three peak winter months (December, January, and February).

Throughout the histories of both endangered species rehabilitation efforts, a variety of strategies have been practiced, including legal protections for the two species, protection of critical habitat, critical habitat management (including artificial changes to vegetation), captive breeding, and artificial feeding. The whooping crane is among the first species listed for protection by the US Endangered Species Act of 1973, and was afforded earlier legal protections under the Endangered Species Preservation Act of 1966 and Endangered Species Conservation Act of 1969. For the lifetime of AWB whooping crane recovery efforts, the US federal government and FWS have emphasized habitat management and habitat expansion where possible. This remains true today—in October 2018 the Texas Parks and Wildlife Department acquired the 7,000-hectare Powderhorn Ranch near the community of Port O'Connor and adjacent to the federal Aransas National Wildlife Refuge thanks to an infusion of cash from the settlement over the 2010 Gulf of Mexico oil spill (TPWD 2018). Over 6,000 hectares of the former ranch is now designated as Texas' newest wildlife management area, while approximately 800 hectares are slated to be developed into a new Texas state park (TPWD 2018). This expansion of legally protected habitat marks the biggest change to US whooping crane conservation in decades.

In eastern Hokkaido, the red-crowned crane's habitat is centered at Kushiro Marsh National Park, a large peat bog wetland that makes up more than 60 percent of Japan's total wetland area (Kushiro Nature Conservation Office 2017). The area in and near Kushiro Marsh is home to the largest concentration of the species (other concentrations can be found in marshes and wetlands further east, north, and west). Kushiro Marsh was

first designated a Ramsar Convention Wetland of International Significance in 1980, and then a national park in 1987 (Kushiro Nature Conservation Office 2017).

From January 1950, residents in the area began feeding the wild red-crowned cranes at land that eventually became the Akan International Crane Center as they feared for the species' survival (Akan International Crane Center website). Japanese government conservation authorities at the Environmental Agency and the Ministry of the Environment (MOE), which was formally designated a cabinet-level ministry in 2001, later assumed oversight of three artificial feeding stations: Akan International Crane Center, Tsurui-Itoh Tancho Sanctuary, and Tsurumidai (Akan International Crane Center website). Artificial feeding has been conducted every year since, and the program continues to this day, running mainly during December, January, and February with corn-based feed distributed to red-crowned cranes at these three official feeding stations.

Beginning in 2015, MOE began curbing artificial feeding by 10 percent of food volume (measured in weight) annually (MOE 2013). By 2019, feeding was down by 40 percent, and was scheduled to reach 50 percent of historical levels starting with winter of 2020-2021 (MOE 2013). The stated reason for the annual reduction in feeding is to encourage the red-crowned cranes to migrate to other parts of Hokkaido and northern Japan (MOE 2013). MOE's initial 2013 draft plan was to see artificial feeding ending by 2025, though this is strongly opposed by neighboring communities heavily reliant on red-crowned crane-focused tourism (MOE 2019). This phased reduction in artificial feedings marks the biggest change to Japanese red-crowned crane conservation since the 1950s.

As noted above, a recent winter population census by FWS puts the AWB whooping crane population at 543 (FWS 2022). Smaller flocks exist in Louisiana, Wisconsin, and Florida. The Canadian Wildlife Service has announced a goal of achieving

an AWB population of 1,000 individual cranes by 2030 (Environment and Climate Change Canada 2007). RCCC's winter 2022 population census gives an estimated total population figure of 1,800 red-crowned cranes in eastern Hokkaido (RCCC 2022).

2.3 Methodology

This paper describes research seeking to uncover the likeliest explanation for the vastly different endangered species population recovery outcomes for these two similar crane species. Population census data compiled from FWS and RCCC spanning 1952 to 2022 were analyzed to determine average annual population growth rates over this 70-year timespan. Average annual population growth rates were calculated by running an online exponential growth calculator (www.rapidtables.com) in reverse. The histories and present state of affairs of the Japanese and US crane conservation initiatives were assessed through site visits, reviews of current and historical academic literature, and reviews of historical and recent government reporting. Data collection was severely hindered by the 2020-2021 COVID-19 pandemic, but this deficit was offset by a review of academic literature relating to the migratory path AWB whooping.

A spatial analysis of the area of agricultural land adjacent to legally protected habitats in Japan and Texas was also conducted to provide a clearer picture of the effectively available foraging habitat for the two species, as both species are known to forage on farmland, a fact confirmed visually by this author during past field visits. This spatial analysis was conducted using publicly available Google Earth GIS software which incorporates satellite imagery along with spatial analysis tools that the author used to augment his own first-hand knowledge of the areas based on site visits. The area of agricultural lands adjacent to the officially protected habitats of both crane species in

Texas and Hokkaido was measured using Google Earth's ruler and area measurement tools. This area measurement was restricted to an approximately 5-to-10-kilometer buffer zone extending from the official boundaries of the Aransas National Wildlife Refuge and Kushiro Marsh National Park according to GIS shapefiles made publicly available by the US Fish and Wildlife Service and Japan's Ministry of the Environment. Through this analysis, this author was able to confirm that the AWB whooping crane has far more available foraging habitat compared to Japan's red-crowned crane in terms of both public and private lands (i.e., adjacent agricultural lands both crane species utilize for foraging).

Possible alternative explanations for the differences in population recovery were considered and explored. Three alternative factors were considered: potential elevated AWB whooping crane mortality due to human influences along the AWB whooping crane migration corridor; inclement weather in Texas, in particular past droughts determined responsible for sharp declines in the AWB whooping crane population; and the availability of effectively additional habitat in terms of adjacent agricultural lands. The author defines effectively additional habitat as agricultural land adjacent to Kushiro Marsh and Aransas National Wildlife Refuge where the author has observed both species foraging for food, and where both species are known to regularly forage for food. The author spent time at the AWB whooping crane's winter habitat at the Aransas National Wildlife Refuge in 2017 and 2018, and toured the Powderhorn Ranch in March 2018. Portions of AWB whooping crane migratory corridor were visited and assessed in 2022. Red-crowned crane conservation zones and feeding stations at Akan and Tsurui, Hokkaido were visited in the winters of 2019-2020 and 2020-2021. GIS and remote sensing assessments using Google Earth, further data collection, and reviews of recent academic literature occurred in 2021, 2022, and 2023.

2.4 Red-crowned crane habitat in eastern Hokkaido, Japan

Kushiro Marsh National Park is a protected zone encompassing some 28,800 hectares located in the southeastern corner of the island of Hokkaido (Kushiro Nature Conservation Office 2017). Registered under the Ramsar Convention on Wetlands of International Importance, Kushiro Marsh contains unique habitat for more than 2,000 species of wildlife (Ministry of Land, Infrastructure, and Transport 2007). Its most iconic resident is the red-crowned crane, a large wetland bird famous for elaborate winter courtship dances in the snowy backdrops of eastern Hokkaido.

Though pristine and relatively undisturbed in much of its expanse, Kushiro Marsh National Park is surrounded on almost all sides by urban and agricultural development. In the south, most of the original coastal wetland habitat has been overtaken by the city of Kushiro, which was built atop the wetlands to develop a continually ice-free port for fishing, cutting most of Kushiro Marsh off from the sea. To the west, north, and east Kushiro Marsh is boxed in by agriculture, mainly dairy farming operations and fields for raising hay used to feed dairy cattle. Research on the potential for abandoned farmland in the region becoming additional habitat for the red-crowned crane is ongoing, though initial results suggest lands adjacent to Kushiro Marsh that are no longer under cultivation are not expansive enough to make up for historical wetland losses (Hanioka et al. 2018).

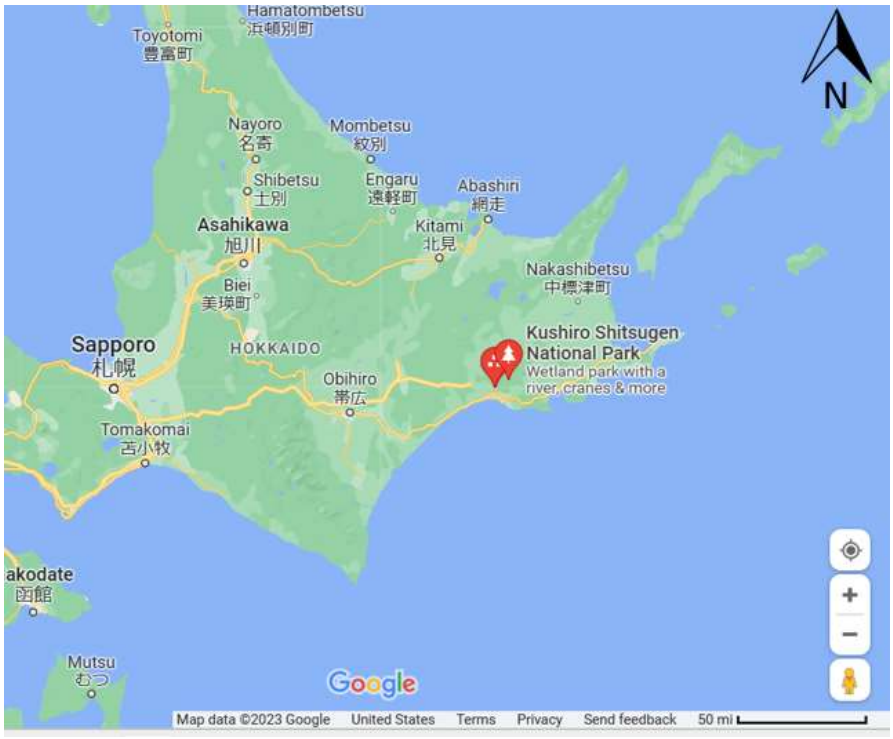


Figure 2: Location of Hokkaido red-crowned crane habitat in northern Japan, southeastern Hokkaido (Google Maps).

While the Marsh itself has long been protected, extensive redevelopment has occurred on the waterways in the north beyond park boundaries and without regard to the potential negative impacts on downstream ecosystems. The biggest land use impact occurred following work to straighten rivers and streams north of the Marsh. Work was performed in the 1970s and 1980s to re-channel and straighten portions of the Kuchoro River that drains into Kushiro Marsh intending to prevent upland flooding damage to dairy operations (Nakamura 1996). Of the 45 kilometers of the river's main channel length, 10 kilometers of the river just outside the park's boundaries were straightened (Nakamura 1996). Several studies conducted since have confirmed that this work resulted in a major influx of sediment into Kushiro Marsh, effectively "drying" significant portions of the

wetland (Nakamura 1996). The straightening of upland rivers and streams, especially the Kuchoro River, resulted in a 0.1 percent to 0.2 percent steeper gradient to the river system thereby increasing the energy of the river (Mizugaki 2006). Research has found that over the past two decades the steeper, faster run of the Kuchoro River resulted in the river cutting itself deeper into the riverbed, ultimately carrying and depositing larger volumes of sediment further downstream when waters reached lower elevations at Kushiro Marsh (Nakamura et al. 2003). Additional sedimentation provides a more stable soil environment for hardwood plant species to take hold (Mizugaki 2006). Dendrogeomorphological sampling and radionuclide testing of sediment deposits have linked the added drier soil layers to specific major flooding events that occurred shortly after work to straighten portions of the Kuchoro River was completed (Mizugaki 2006). Studies have found that within a year hardwood species, especially Japanese alder, established roots systems in these new sediment layers (Mizugaki 2006).

Thus, during the red-crowned crane's population recovery the species has been losing available foraging habitat in the officially protected zone of Kushiro Marsh National Park. By the late 1990s, the original wetland expanse within Kushiro Marsh National Park was estimated to have declined by about 20 percent while Japanese alder forest cover increased from 8.6 percent to 36.7 percent (Nakamura 2004). Over the past 100 years, Hokkaido has lost some 70 percent of its original wetland area to agriculture or urban development, but mostly from the direct conversion of wetlands to farmlands (Fujita 1997). The situation in Kushiro Marsh has since apparently stabilized, thanks in part to intervention efforts. Tree cutting and strand removal of Japanese alder by Kushiro Marsh National Park managers have been found to be effective means to both protect surviving wetland areas and to promote the restoration and expansion of wetland

vegetation (Ministry of Land, Infrastructure and Transport 2007). A 2012 field experiment found that Japanese alder removal encouraged the recovery of natural wetland hydro-dynamics, which then promoted the growth of more common native wetland vegetation such as grasses and reeds more favorable to the red-crowned crane and other iconic Kushiro Marsh species (Nakagawa et al. 2012). Other mitigation efforts in eastern Hokkaido include engineering projects aimed at "re-winding" portions of artificially straightened rivers in the higher elevations to prevent further downstream sediment loading (Ministry of Land, Infrastructure and Transport 2007).

Investigators have turned their attention to the potential for abandoned farmlands in the region to eventually become incorporated into existing wetland expanses to offset habitat lost to the Japanese alder intrusion (Yamanaka et al. 2017). In particular, researchers have delved into the question of whether or not wetland animals are beginning to colonize abandoned farmland adjacent to Kushiro Marsh, beginning with the lowest order species down the food chain (Yamanaka et al. 2017). One study focused on the propagation of wetland ground beetles into abandoned farming regions, setting out to determine whether occurrences of these species in abandoned farms represented merely occasional wanderings away from the beetles' home habitat in Kushiro Marsh or if these beetles were establishing themselves permanently in these newly available spaces (Yamanaka et al. 2017). The study concluded that the presence of wetland ground beetles in abandoned farms in and near Kushiro Marsh represents permanent establishment and colonization, thus an expansion of the beetle's habitat in the region (Yamanaka et al. 2017). The study concludes that an increase in the soil moisture content in these lands left abandoned by agriculture results in ecosystem conditions more closely resembling the beetles' preferred natural Kushiro Marsh wetland habitat, raising hopes that the resident

red-crowned cranes may one day find these tracts appealing as well (Yamanaka et al. 2017).

Figure 3: Extent of Kushiro Marsh National Park, Hokkaido, Japan (Google Earth, Ministry of the Environment, Japan, scale bar enhanced for greater visibility).

2.5 Red-crowned crane direct population management

Red-crowned cranes are known to exist in two main populations: flocks migrating from northeastern China and parts of the Korean Peninsula to grounds in eastern Siberia, and the non-migrating flock located in eastern Hokkaido, Japan (IUCN Red List of Threatened Species 2021). The population in Hokkaido has expanded rapidly, while populations in China and Siberia are reported to be in decline (Su and Zou 2012, IUCN Red List of Threatened Species 2021). Conservation efforts targeting red-crowned cranes on the Asian mainland are less well defined and developed than in Japan and have a shorter history (Su and Zou 2012). For instance, a study in South Korea noted that a local government only recently became interested in advancing ecotourism centered on cranes

but had no plans to protect or manage the habitat, thus likely harming the wintering population there (Kim et al. 2016). In parts of China and Russia migrating flocks have suffered population declines of 50 percent or more due to hunting, poisoning, and habitat loss (Su and Zou 2012). By contrast, the red-crowned crane population on Hokkaido has shown consistently strong population growth over a 70-year history (RCCC 2022) This despite the fact that the Japanese red-crowned crane in Japan was nearly wiped out entirely by habitat loss and over-hunting, the same pressures pushing red-crowned crane numbers lower on the Asian mainland (Akan International Crane Center website). In fact, authorities in Japan in the early 20th Century assumed that the species no longer existed on the Japanese islands (Akan International Crane Center website).

Historical accounts by RCCC and MOE state that in 1924, a Japanese government survey team discovered a small flock of some 20 red-crowned cranes surviving in Kushiro Marsh in eastern Hokkaido (Akan International Crane Center website). Other survivors were soon discovered in smaller numbers, and the estimated number of surviving cranes rose (Akan International Crane Center website). RCCC data shows 33 red-crowned cranes in Hokkaido in 1952 (RCCC 2022). Winter artificial feeding of Hokkaido red-crowned cranes began at the present site of the Akan International Crane Center in 1950 (Akan International Crane Center website). Two more stations were later added in the village of Tsurui: at the Tsurui-Ito Tancho Crane Sanctuary and Tusrumidai (Akan International Crane Center website).

The available data shows the red-crowned crane population expanded exponentially in the early decades of the organized winter artificial feeding program (Masatomi et al. 2007). By 2008, the Hokkaido crane population was estimated to be about 1,241 birds despite a harsh winter experienced that year (Tancho Conservation

Research Group 2008). RCCC data puts the 2014 population at over 1,400 (RCCC 2022). A recent 2022 winter census counts 1,800 red-crowned cranes in Hokkaido, up from 33 in 1952 (RCCC 2022). The population of red-crowned cranes in eastern Hokkaido today exceeds a theoretical carrying capacity of approximately 1,659 individual cranes as estimated in modeling undertaken as part of a 2007 study (Masatomi et al. 2007). That the population today exceeds the estimated natural carrying capacity of the available habitat is a strong indication that artificial feeding in winter has been the prime factor driving population recovery in the Hokkaido red-crowned crane population.

The red-crowned crane looms large in Japanese culture, art, and literature. Today, the red-crowned crane is a celebrated symbol of eastern Hokkaido and one of the region's top tourist attractions. The species is especially famous for its winter courtship dance. The main regional airport in Kushiro is named for the crane (Tancho Kushiro Airport; "tancho" meaning "red crown") and the regional ice hockey team is called the Cranes. The three feeding stations at Akan, Tsurui, and Tsuruimidai are top draws for nature photographers while tourists also flock to see cranes at rehabilitation centers at Kushiro Zoo and the Red-Crowned Crane Natural Park near the airport. Red-crowned crane-themed souvenirs are popular with millions of visitors passing through the region every year. The red-crowned crane's historical, cultural, and economic significance for eastern Hokkaido cannot be overlooked in any discussion of the species.

Since its establishment, the winter artificial feeding program has been the prime vehicle for red-crowned crane population management and recovery policy in Japan (Akan International Crane Center website). Habitat conservation has played a key role as well, in particular the designation of Kushiro Marsh as a federally-protected national park in 1987 (Kushiro Nature Conservation Office 2017). But because conservation managers

have little control over land management decisions outside the park, and due to constraints on expanding the park's boundaries, artificial feeding and direct population management has been the focus of red-crowned crane conservation initiatives for decades. MOE has its writ limited to the national park's boundaries and the feeding stations located outside Kushiro Marsh National Park. Efforts to "re-wind" the Kuchoro River and other upland waterways in an attempt to protect Kushiro Marsh from further excessive sediment loading are overseen by the Ministry of Land, Infrastructure, Transport, and Tourism (Ministry of Land, Infrastructure, and Transport 2007).

Feeding operations at the three winter feeding stations in eastern Hokkaido consist of grinding corn cobs and scattering the ground kernels atop the snow and ice. During a site visit by this author to the Itoh Tancho Crane Sanctuary in the village of Tsurui, feeding occurred at approximately 1:00 p.m. with a single sanctuary official hauling a cart filled with feed using a large scoop to collect and scatter the corn at the feet of the visiting cranes. The official moved through the sanctuary and scattered the feed as widely as possible until the cart was empty. As witnessed by this author, the red-crowned cranes appeared habituated to the human presence and the feeding routine. A few cranes waited immediately outside the door to the sanctuary storehouse in anticipation of feeding. Once the corn was scattered the sanctuary official returned indoors and left the wild cranes unsupervised. The cranes ate their rations and paid no attention to the 50-odd photographers gathered to document the spectacle. The winter artificial feeding program is managed and overseen by MOE's regional office in Kushiro (Kushiro Nature Conservation Office 2017). MOE is now seeking to eventually to end winter feeding in an effort to encourage the eastern Hokkaido population to expand its range and begin settling and breeding in other parts of Japan, though recent adjustments to the phased

decrease in artificial feeding have been implemented (MOE 2019). Though the Kushiro and east Hokkaido regional population is decidedly non-migratory, the Japanese red-crowned cranes have retained their natural ability to fly long distances as their cousins on the Asian mainland do (Akan International Crane Center website).

The plan to wean red-crowned cranes off winter feeding was finalized in early 2013 and implementation began in earnest in 2015 (MOE 2013). The initiative was reviewed by the Ministry in 2018 (MOE 2019). The strategy calls for the three feeding stations in Tsurui and Akan to lower the volume of feed disbursed to the cranes by approximately 10 percent annually, with adjustments anticipated as necessary, continuing until eventually winter feeding is halted entirely (MOE 2013). Authorities agreed to periodically evaluate progress and allowed for potential adjustments to the program as they may deem necessary (MOE 2013). A 2018 audit of the plan found the three feeding stations to be largely in compliance (MOE 2018). The volume of food disbursed to cranes at the Itoh-Tancho Crane Sanctuary fell from a record high mark of 5,250 kilograms to 3,960 kg; from 5,250 kg to 3,370 kg at the Tsurumidai station; and from 7,740 kg to a volume of 3,800 kg at the Akan International Crane Center (MOE 2018). In total, the Ministry's 2018 review found that combined winter feeding had fallen from 18,240 kg to 11,130 kg, a decline of approximately 38.9 percent (MOE 2018). 2020-2021 winter seasonal feeding was scheduled to fall to at least 50 percent of historical high volumes according to the existing plan. The latest population census data issued by RCCC shows the Hokkaido red-crowned crane population is stable, but no population growth has been recorded since 2020 (RCCC 2022). This author believes it is too early to tell whether the phased decline in artificial feeding is having an impact on Hokkaido red-crowned crane population growth rates, but the available data shows that a noticeable slowdown in red-

crowned crane population growth at least correlates with MOE's implementation of reductions in artificial winter feeding.

2.6 Whooping crane habitat and habitat management

The Aransas National Wildlife Refuge covers approximately 46,300 hectares of coastal wetland, estuary, and salt marsh along the Gulf of Mexico coastline in southeast Texas (United States Fish & Wildlife Service Aransas National Wildlife Refuge 2012). The refuge is not contiguous but divided into four sections in the same geographic region: the main area encompassing a large peninsula extending into the surrounding bays, a smaller section of the Lamar Peninsula to the west, the coastal barrier island of Matagorda Island, and a sub-section of the refuge found farther to the east adjacent to the ghost town of Indianola. The refuge is the main wintering grounds for the only wild migrating flock of whooping cranes in North America, the AWB population.

AWB whooping cranes arrive at the Aransas National Wildlife Refuge in southeast Texas every year in early winter to forage, feeding mainly on blue crabs and the fruit of wolfberry plants (FWS Aransas National Wildlife Refuge 2012). At the start of spring, AWB whooping cranes begin departing Aransas, taking several weeks to migrate through central North America until arriving in the northern section of Wood Buffalo National Park, Canada's largest national park, where breeding primarily occurs (FWS Aransas National Wildlife Refuge 2012). The Aransas National Wildlife Refuge was established by presidential executive order in 1937 and developed partly by the Civilian Conservation Corps (FWS Aransas National Wildlife Refuge website). By the mid-1940s, the AWB whooping crane population was said to have fallen to as few as 16 individuals, putting the species on the brink of extinction (FWS website). Federal conservation efforts began

in earnest around this period. In 1966 the US Congress passed the Endangered Species Preservation Act (ESPA), and the whooping crane was among the first species to be listed for protection in 1967 with the population numbering 48 individual cranes at the time (FWS 2022). The cranes' listing was maintained as ESPA gave way to the Endangered Species Act of 1973 (ESA). The AWB whooping crane population began rising steadily since federal protections were enhanced under ESA (FWS 2022). Canadian authorities designated the whooping crane as an endangered species in 2000 (Tischendorf 2003).

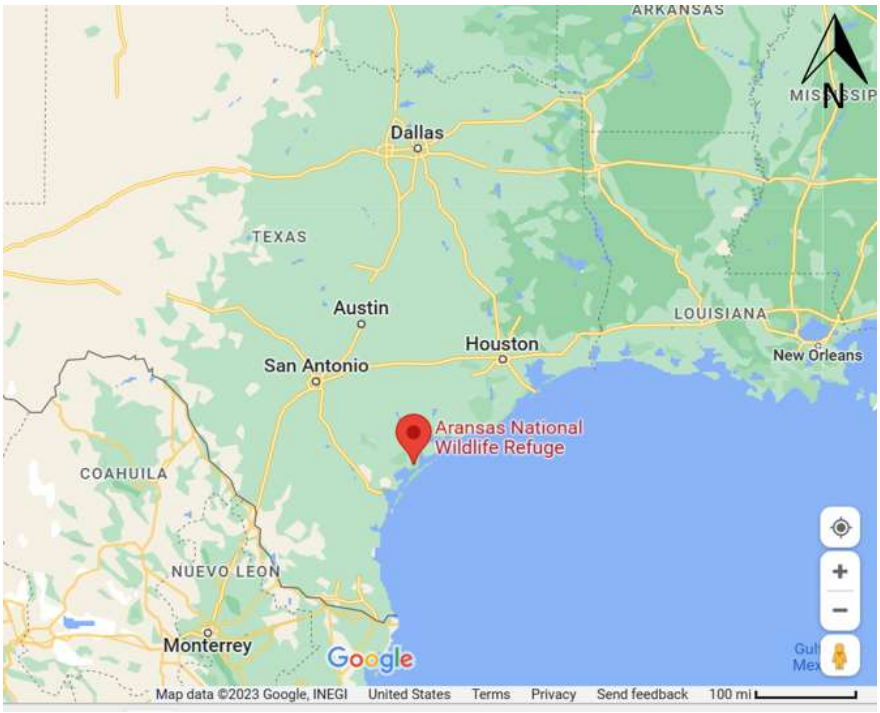


Figure 4: Location of whooping crane wintering habitat at the Aransas National Wildlife Refuge in Texas, United States (Google Maps).

Throughout whooping crane conservation history, habitat management has been the main method used by FWS for AWB whooping crane conservation (FWS Aransas National Wildlife Refuge website). However, habitat management has not been the only

method experimented with. Limited captive breeding was used to enhance the AWB's population in earlier years, and in the 1960s FWS briefly experimented with artificial feeding as well (Davis 1998). But for the majority of the refuge's history, the prime conservation method has been land management. Aransas National Wildlife Refuge managers undertake prescribed burning and other interventions, including deliberately planting wolfberry, to increase winter food availability for AWB whooping cranes (FWS Aransas National Wildlife Refuge website).

Unlike Kushiro Marsh National Park, now land-locked due to the development of the city of Kushiro and dominated by freshwater river hydrology, the ecology of the Aransas National Wildlife Refuge is influenced by freshwater inflows, coastal tidal saltwater intrusion, and the fine balance between both forces that determine the seasonal abundance of blue crabs, the main source of winter protein for AWB whooping cranes (FWS Aransas National Wildlife Refuge 2012). When river and stream levels are low the influence of ocean tides on Aransas' coastal hydrology increases (Slack et al. 2009). Reduced freshwater inflow into San Antonio Bay is known to result in a higher salinity of the brackish waters that are the main breeding grounds for blue crabs (Slack et al. 2009). Conservation groups report that this has the effect of reducing marsh blue crab production, and thus lowering the availability of winter protein needed for AWB whooping cranes to restore energy reserves following their long migration from Canada (Slack et al. 2009). Periods of low rainfall and lower river levels can lead to much of the coastal marsh drying out completely, negatively impacting the development of sufficient forage for the AWB whooping cranes particularly in periods of extreme drought (Slack et al. 2009).

Studies support the view that drought conditions can negatively impact the AWB whooping crane population (Butler et al. 2014). The sensitivity of the Aransas National

Wildlife Refuge to drought resulted in the AWB whooping crane population becoming the subject of a lawsuit filed by a coalition of conservation groups called The Aransas Project (TAP) against the Texas Commission on Environmental Quality (Guadalupe-Blanco River Authority and The Aransas Project 2018).

The only significant AWB whooping crane mortality events that have ever been recorded occurred during two droughts recorded in Texas at the time of AWB whooping crane winter layovers at the Aransas National Wildlife Refuge. During a drought that occurred in 2008-2009, FWS estimates that the AWB whooping crane population at the refuge fell by 21.4 percent (FWS 2012). FWS also saw a steep AWB whooping crane population decline in 2011-2012 to a harsh one-year drought that hit Texas in 2011 (FWS 2012). That 2011 drought has been blamed for reducing AWB whooping crane numbers from 279 to an estimated 245 birds, a decline of about 12 percent (FWS 2012). In *TAP vs. Shaw* lawsuit, plaintiffs called for TCEQ to revoke permits issued to the Guadalupe-Blanco River Authority, accusing GBRA of failing to ensure sufficient inflow of freshwater to the Aransas National Wildlife Refuge during the drought and thereby causing excessive mortality in the AWB whooping crane flock (Guadalupe-Blanco River Authority and The Aransas Project 2018). GBRA intervened in the lawsuit as a defendant. TAP lost in court and appeals, and failed to convince the United States Supreme Court to review the case, thus ending the case in 2015 (GBRA-TAP 2018). TAP and GBRA have agreed to jointly research the links between changes in freshwater inflow to San Antonio Bay and conditions that may prove beneficial or harmful to AWB whooping cranes wintering at the adjacent Aransas National Wildlife Refuge (GBRA-TAP 2018).

Though shown to be susceptible to harm from droughts, the Aransas National Wildlife Refuge has proven remarkably resilient to extreme weather, tested most recently

by Hurricane Harvey in August 2017 which made landfall at the coast at San Jose Island very close to the refuge. The eye of that storm passed directly over portions of the wildlife refuge and caused flooding and damage to infrastructure. The wildlife refuge was closed to the public for several days following the storm event, but later FWS reported that the Aransas National Wildlife Refuge sustained relatively mild levels of damage compared to other protected areas impacted by Harvey (FWS website). Furthermore, Hurricane Harvey made its pass over the region in August and many months before the whooping cranes began their annual arrival from Canada, thus FWS said the AWB whooping crane population was unaffected by that storm.

Figure 5: Extent of the Aransas National Wildlife Refuge in southeast Texas, United States (Google Earth, US Fish and Wildlife Service, scale bar enhanced for visibility).

The whooping crane was one of the first federally listed protected endangered species in the United States. Its recovery has been deemed successful, though far from over. One study suggests that the AWB whooping crane population needs to reach a

number of at least 1,000 individuals before wildlife managers can gain more confidence in the species' ability to survive and thrive on its own (Stratton 2010). A recovery plan in accordance with Canada's Species at Risk Act aims to see 1,000 AWB whooping cranes breeding in Wood Buffalo National Park by 2035 (Environment and Climate Change Canada 2007). With 543 individuals last counted, this suggests that management efforts are halfway to meeting that population goal. Parks Canada estimates that a whooping crane breeding pair requires anywhere from 400 hectares to 1,000 hectares to successfully breed and thrive (Environment and Climate Change Canada 2007). These conditions have been met in Canada—Wood Buffalo National Park is Canada's largest national park and a Ramsar Convention-listed Wetland of International Significance, home to a vast wooded expanse but also massive inland deltas and wetlands (Environment and Climate Change Canada 2007). Efforts to acquire additional whooping crane habitat in Texas were constrained for decades until current efforts to incorporate Powderhorn Ranch land near the Aransas refuge as additional AWB whooping crane habitat (TPWD 2018).

Formerly private land, the 7,000-hectare Powderhorn Ranch is a relatively undisturbed expanse of southeast Texas coastal prairie and wetlands located in Calhoun County adjacent to the community of Port O'Connor, taking its name from Powderhorn Lake (TPWD 2018). It was purchased by The Nature Conservancy and held in trust and managed for years by a coalition of conservation agencies led by the Texas Parks and Wildlife Foundation (TPWD 2018). Acquired in a deal estimated to be worth $37.7 million, the land was transferred completely to the Texas Parks and Wildlife Department in late 2018 (TPWD 2018). The majority of the land acquisition cost, $34.5 million, was made possible by funding to the National Fish and Wildlife Foundation's Gulf Environmental Benefit Fund, which is money paid by BP plc and Transocean Ltd per a

settlement for the 2010 Deepwater Horizon offshore rig explosion and subsequent Gulf of Mexico oil spill (TPWD 2018). With the incorporation of Powderhorn Ranch, the area of legally protected habitat available to wintering AWB whooping cranes in southeast Texas expands by approximately 13 percent. The land is located across from Powderhorn Lake next to the easternmost small subsection of the Aransas National Wildlife Refuge, thus greatly expanding the amount of legally set aside habitat for AWB whooping cranes in the region of Indianola and Port O'Connor.

The majority of Powderhorn Ranch is now a Texas state wildlife management area, with a smaller section slated to be developed into a publicly accessible state park at some point in the near future. The author toured all of Powderhorn Ranch in March 2018 with access provided by Richard Kostecke, associate director at the Austin, TX office of The Nature Conservancy. The site visit revealed that the land holds great conservation potential for the AWB whooping cranes. A separate site survey conducted by the Bureau of Economic Geology, University of Texas at Austin determined Powderhorn Ranch is of "immense" ecological value and contains ideal habitat suitable for AWB whooping cranes (Paine et al. 2018). That separate independent study noted that the 7,000-hectare property, though smaller than the Aransas National Wildlife Refuge, contains within it "18 kilometers of bay frontage, tallgrass prairies, fresh and saltwater wetlands, and live oak woodlands established on a Pleistocene barrier island complex" (Paine et al. 2018). There is evidence that AWB whooping cranes are poised to expand their range to this newly protected ground, as adult whooping cranes were spotted by this author foraging near the ranch. The site visit conducted by this author confirmed that the ranch holds an abundance of marsh terrain that is well suited for waterfowl like the AWB whooping cranes, and

coastal portions of Powderhorn Ranch are virtually indistinguishable from what one finds at large coastal sections of the Aransas National Wildlife Refuge.

The incorporation of Powderhorn Ranch as the newest major addition to a broader Texas coastal conservation initiative should ensure that state agencies and non-profit groups will invest a substantial amount of time and resources to further enhancing the ecosystem there. As noted above, only a small portion of the ranch will be developed as a recreational state park open to the public, while the majority of the land will remain a state wildlife management area, essentially a state-controlled wildlife refuge where public access is restricted and regulated (TPWD 2018). The Powderhorn Ranch and adjacent region are also covered by an existing coastal protection plan pursued by the US Army Corps of Engineers, which aims to invest in land restoration, marsh restoration, breakwater development, and erosion control along an 11-kilometer stretch of the Matagorda Bay shoreline which acts as coastal storm defense for the Powderhorn Lake estuary (US Army Corps of Engineers Galveston District 2018).

2.7 Results

An assessment relying on population estimates, site visits, conversations with government conservation officials, literature reviews, and a GIS spatial assessment was conducted to help determine the likeliest explanation for the differing population recovery trajectories for the AWB whooping crane and Japanese red-crowned crane. This author concludes that the annual winter artificial feeding program in Japan best explains the differences in these endangered species' population recovery rates over the past 70 years.

AWB whooping cranes and Japanese red-crowned cranes are morphologically very similar. They differ mainly in plumage color, with the adult red-crowned crane

developing more black plumage at the neck, wings, and tail feathers, while adults of both species are adorned with a "red crown" at the top of their heads (see Figure 10). Both species practice courtship "dancing" although the red-crowned crane is generally more famous for this courtship dancing behavior and for exhibiting more elaborate choreography. Both species experience relatively long lifespans in the wild, approximately 24 to 30 years (FWS, RCCC, IUCN). Both species breed slowly, and their nesting and breeding patterns are similar—both species typically hatch two eggs per cycle, but only one juvenile generally reaches adulthood (FWS, RCCC, IUCN). Both species are omnivorous, and both forage at wetlands and agricultural lands (FWS, RCCC, IUCN).

In 1952, the US Fish and Wildlife Service estimated the AWB whooping crane population to be 21 individuals (FWS 2022), while data by the Red-Crowned Crane Conservancy shows 33 red-crowned cranes living in eastern Hokkaido at that time (RCCC 2022). Today, FWS puts the AWB whooping crane population at 543 (FWS 2022), while RCCC gives a red-crowned crane population estimate of 1,800 (RCCC 2022). The IUCN no longer considers the Hokkaido red-crowned crane to be an endangered species and instead lists the species as "vulnerable" (IUCN Red List of Threatened Species 2021). The population growth trends for both species are described in greater detail below.

Calculations based on FWS data show the AWB whooping crane population growth rate averaged 4.76 percent annually over a 70-year period, expanding in total by 2,486 percent (1952 to 2022). Based on RCCC data, over the same 70-year period (1952 to 2022) the Hokkaido red-crowned crane population expanded at an average annual rate of increase of approximately 5.9 percent, with a total population expansion of 5,355 percent. Thus, the most recent population counts for both species show that the Hokkaido red-crowned crane population has expanded at an average annual rate that's

approximately 20 percent faster than the rate of AWB whooping crane population growth since 1952. All these estimates are based on the author's own calculations utilizing the population data made available by RCCC and FWS.

RCCC's red-crowned crane population data in the first two decades under review appears inconsistent and may be incorrect. For instance, RCCC shows that the Japanese red-crowned crane population grew from 33 individuals in 1952 to 167 individuals by 1960, for a total expansion of 406.06 percent in just 8 years. These figures suggest that this crane population expanded at an average annual rate of approximately 22.47 percent in the first 8 years of data collection. RCCC data then shows a total decline in the Hokkaido red-crowned crane population of 3.59 percent from 1960 to 1970. Again, these estimates are based on the author's own calculations utilizing the population data made available by RCCC. This author considers this early population history from 1952-1970 to be suspect given that from 1970 onwards red-crowned crane population expansion data shows a more regular pace of growth more comparable to AWB whooping crane population growth rates. However, even after factoring out those earliest decades, the data shows that the red-crowned crane population in Japan has been rising at a rate at least 11 percent faster than the AWB whooping crane from 1970 to 2020, with red-crowned crane population growth averaging 5.06 percent growth per year compared to an average 4.56 percent annual population growth rate for the AWB whooping crane over that time period. This 11 percent difference in growth rates is still significant, especially given the time horizon reviewed.

Going by the population data collected over the entire 70-yar period, if the Japanese red-crowned crane population had risen at the same rate of growth as the AWB whooping crane from 1952 to 2022 (a 4.76 percent annual average rate of growth), then

RCCC and MOE data should be showing a total Hokkaido population of around 855 red-crowned cranes today, and not the 1,800 discovered in the most recent count. Conversely, had the AWB whooping crane population risen at the same rate as that of the red-crowned crane from 1952 to 2022 (a 5.9 percent average annual rate of increase) then FWS figures could be expected to be showing an AWB whooping crane population size of approximately 1,161 AWB whooping cranes instead of the 543 individuals counted. These estimates are also based on the author's own calculations utilizing the population data made available by RCCC and FWS.

Both the Aransas National Wildlife Refuge and Kushiro Marsh National Park are protected, Ramsar-designated wetlands important for the survival of thousands of species, including these two species of cranes. Nevertheless, the AWB whooping crane population has far more protected and effective habitat already available to it in Texas alone compared to the Japanese red-crowned crane. The Aransas refuge is approximately 46,300 hectares in size (FWS 2012), while Kushiro Marsh is comprised of 28,800 ha of protected area (Kushiro Nature Conservation Office 2017). At both Aransas and in its migratory corridor the AWB whooping crane demonstrates a preference for open spaces with good lines of sight for resting to allow individual cranes to spot potential threats from a distance, coupled with grassy, shallow marshes for hunting (Baasch et al. 2019). The Aransas refuge was observed by this author to enjoy these features in abundance, in particular along coastal areas. The AWB whooping crane has also been deemed to be remarkably resilient to predation and other natural threats during its migrations, with no noticeable higher mortality rates witnessed or recorded (Baasch et al. 2019). By comparison, Kushiro Marsh as seen by this author is more heavily forested on its

perimeter and in patches found throughout the wetland's expanse. This is a consequence of historical sedimentation loading and hardwood encroachment (Mizugaki et al. 2006).

Both crane species also forage on agricultural lands adjacent to these preserves as witnessed by this author, thus these adjacent agricultural lands can be considered effectively available additional foraging habitat. A basic spatial analysis was conducted using publicly available Google Earth GIS software which incorporates satellite imagery along with spatial analysis tools that the author used to augment his own knowledge of the area based on site visits and on-the-ground assessments. The area of agricultural lands adjacent to the officially protected habitats of both crane species in Texas and Hokkaido was measured using Google Earth's ruler and area measurement tools. This area measurement was restricted to an approximately 5-to-10-kilometer buffer zone extending from the official boundaries of the Aransas National Wildlife Refuge and Kushiro Marsh National Park according to GIS shapefiles made publicly available by the US Fish and Wildlife Service and Japan's Ministry of the Environment.

Through this analysis, this author was able to confirm that the AWB whooping crane has far more available foraging habitat compared to the Hokkaido red-crowned crane in terms of both public and private lands (i.e., adjacent agricultural lands both crane species utilize for foraging). Thus, the area of both official protected habitat and effectively available for foraging habitat is far greater in southeastern Texas compared to eastern Hokkaido, a fact that should prove more advantageous for AWB whooping crane population growth. The author's analysis using Google Earth spatial analysis tools and the GIS shapefile data provided by MOE and FWS showed the AWB whooping crane could potentially forage on at least 58,800 ha of farmland next to the Aransas National Wildlife Refuge. By contrast, Japanese red-crowned cranes were frequently spotted

foraging on farms next to Kushiro Marsh by this author, but only about 32,700 ha of adjacent farmland is available for red-crowned crane foraging in the immediate vicinity based on the author's GIS assessment. Figure 8 summarizes the data acquired from the adjacent agricultural land measurements. It should be noted that agricultural lands in southeast Hokkaido and southeast Texas are used differently though in no significant way that could explain the vastly different population growth outcomes for these two species. Farms around the Aransas National Wildlife Refuge are used to grow corn and other crops, but the area is most famous for rice cultivation. In southeastern Hokkaido, meanwhile, a variety of crops are also grown, including corn, but the region is known for cultivating hay meant to feed cattle for the region's many dairy farms.

Figure 6: Measuring the area of agricultural lands adjacent to the Aransas National Wildlife Refuge, Texas, United States (Google Earth, USFWS, scale bar enhanced on bottom image for greater visibility).

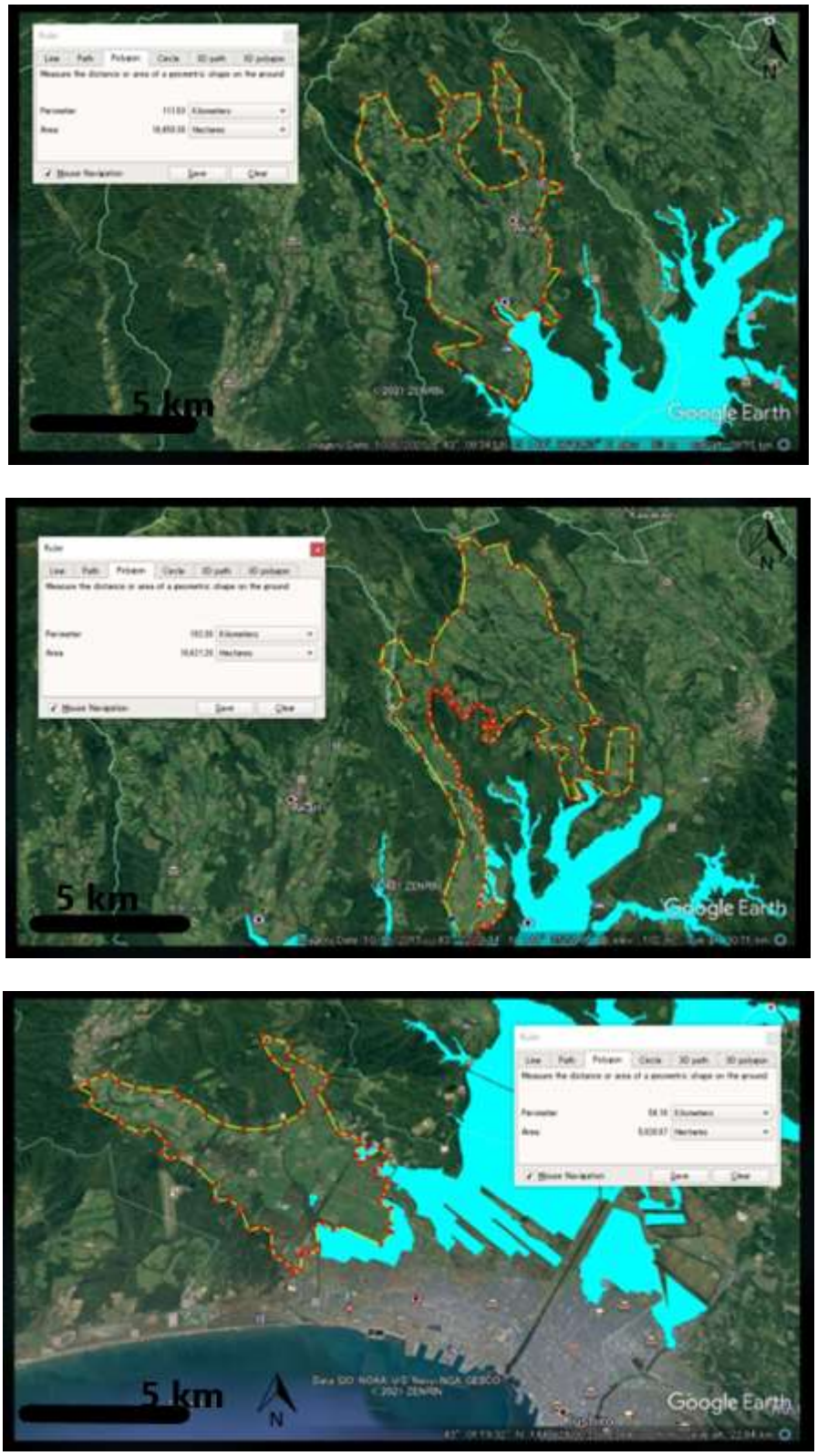


Figure 7: Measuring area of agricultural lands adjacent to Kushiro Marsh National Park, Hokkaido (Google Earth, Ministry of the Environment, Japan, scale bars enhanced).

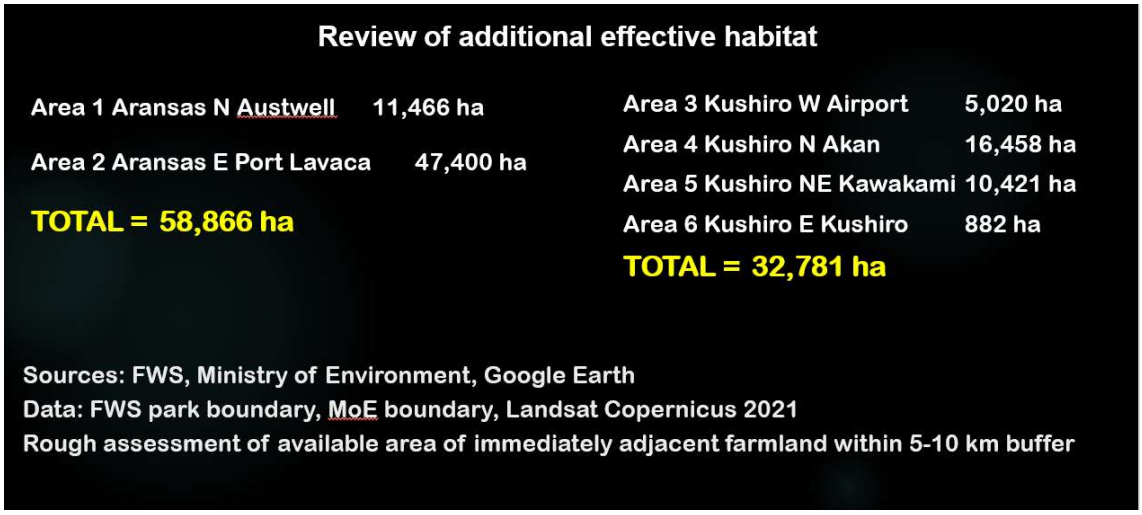


Figure 8: Data results from a general spatial analysis of available effective habitat (agricultural lands available for foraging) adjacent to the Aransas National Wildlife Refuge and Kushiro Marsh National Park. The data shows that there is far more foraging area accessible to the AWB whooping crane vs. Hokkaido red-crowned crane.

It's worth repeating here that the encroachment of Japanese alder into Kushiro Marsh National Park means the area of that park still considered as true wetland vs. hardwood strands has contracted by about 20 percent (Nakamura 2004). Total protected habitat afforded to the AWB whooping crane in Texas has now expanded by about 7,000 ha due to the addition of Powderhorn Ranch (TPWD 2018). The existence of vastly more officially protected and foraging habitat available for the AWB whooping crane population should provide an advantage to the AWB whooping crane in terms of historical population growth compared to the Hokkaido red-crowned crane population which has been losing ideal wetland habitat. Instead, the data clearly shows that Hokkaido red-crowned crane population growth has far outstripped AWB whooping crane population

growth for the past 70 years. An on-site review and a more detailed survey conducted by the Bureau of Economic Geology, University of Texas at Austin confirmed that Powderhorn Ranch is rich with habitat ideal for the AWB whooping crane. This author concludes that habitat availability has not been an impediment to AWB whooping crane population recovery in Texas, despite the more robust rate of recovery seen for the red-crowned crane population of Hokkaido, and that differences in habitat availability cannot explain the differences in population outcomes. The AWB whooping crane's 4.76 percent average annual rate of population growth from 1952 to 2022 appears robust, even accounting for major population setbacks acknowledged by FWS, including a reported 21.4 percent decline in the AWB flock from 2008 to 2009 (FWS, 2012).

Differences in migratory behavior might explain the different population recovery outcomes, but site visits and a review of the available academic literature shows this is unlikely (Pearse et al. 2018). The AWB whooping cranes displays extreme migratory behavior, completing a journey of over 2,500 kilometers from their summer breeding grounds in Canada to wintering grounds in Texas twice a year (FWS 2012). The Hokkaido red-crowned is considered non-migratory, though this could be changing. An individual red-crowned crane was spotted in northwestern Hokkaido and a breeding pair with offspring were confirmed nesting in southwestern Hokkaido near the city of Tomakomai during summer 2021 (Asahi Shimbun July 12, 2021). Still, the vast majority of the Japanese red-crowned crane flock shows no inclination to migrate much beyond a 50-kilometer radius surrounding the species' primary habitat in Kushiro Marsh National Park.

There is no convincing evidence that the AWB whooping crane population has been experiencing higher rates of mortality compared to the Hokkaido red-crowned crane (Baasch et al. 2019). Studies of AWB whooping crane behavior along the species'

migratory corridor conclude that this species is resilient to threats from predators during its long migration (Baasch et al. 2019). The only significant mortality events ever recorded for the AWB whooping crane occurred during two periods of extreme drought in Texas (FWS 2012). There is also a noticeable lack of evidence of elevated AWB whooping crane mortality occurring during the species' migrations between Canada and Texas in the available academic literature; more research on this question is warranted, but investigations into AWB whooping crane behavior during its migration shows the population is successfully avoiding natural threats (Baasch et al. 2019). Furthermore, research has shown that large-scale wind power projects built in the AWB whooping crane migration corridor have not negatively impacted the flock either (Pearse et al. 2021). Again, a 4.76 percent average annual rate of growth is deemed by this author to be fairly robust. However, AWB population growth has not been nearly as strong as that seen for the Hokkaido red-crowned crane. This despite the enormous advantage existing for the AWB whooping crane population in terms of protected and effective habitat availability, the cautious nature of this species and AWB whooping cranes' tendency to avoid human infrastructure and human influences, and despite the lack of any historical record of elevated mortality incidents aside from the two drought episodes in Texas, events that occurred recently enough that they do not explain the massive historical differences in population outcomes between these two species. Factoring out habitat area differences and the long AWB whooping crane migration, that leaves the Japanese red-crowned crane winter artificial feeding program as the one remaining variable that best explains the differences in these endangered species' population recovery histories.

Prior studies have already concluded that the winter artificial feeding campaign has been the critical factor in the recovery of the Hokkaido red-crowned crane population

(Masatomi 1991, Masatomi et al. 2007, Inoue et al. 2013). For instance, research published in 2013 states categorically that above-natural strong population recovery of the Hokkaido red-crowned crane population occurred “as a consequence of human-provided food in winter” (Inoue et al. 2013). Mortality in the red-crowned crane population was not assessed thoroughly by this author as the purpose of this study is to determine if any other factors can account for the slower rate of AWB population growth compared with that of the red-crowned crane. Research undertaken on the physical parameters of the Hokkaido red-crowned crane population indicates consistently strong population expansion correlating with the winter-feeding campaign, with the exception of a single period of temporary population growth stagnation attributed to cranes colliding with power lines before mitigation efforts were undertaken to prevent this (Inoue et al. 2013).

A population viability assessment conducted in 2007 concluded that the carrying capacity of southeast Hokkaido’s red-crowned crane habitat would be about 1,659 individual cranes (Masatomi et al. 2007). The Hokkaido red-crowned crane population was recorded to be about 1,200 cranes in 2007, the year of this population viability assessment (RCCC 2022). The theoretical carrying capacity was reached between 2015 and 2016, and the red-crowned crane population continued is expansion well beyond the theoretical carrying limit (RCCC 2022). These facts present strong evidence that the winter artificial feeding program has been the prime factor driving red-crowned crane population growth and that the winter feeding operation best explains the vast difference compared to historical AWB whooping crane population growth. In other words, not only was winter feeding a critical factor in the survival of the Hokkaido red-crowned crane, but this management strategy also yielded a much higher rate of population growth for

that species compared to the quasi-control example provided by the case study of the AWB whooping crane of southeastern Texas.

2.8 Discussion

Of the eight species of cranes in the genus *Grus, Grus americana* and *Grus japonensis* are the most visibly similar to one another. The AWB whooping crane and Hokkaido red-crowned crane are both large wetland birds with omnivorous diets, similar coupling behaviors, and similarly slow breeding cycles (FWS, RCCC, IUCN). Both were nearly driven to extinction by the 1940s-50s due to hunting and habitat losses (FWS, MOE). Both species are legally protected and subjects of active government-led recovery efforts. Nevertheless, there are important differences between these two species that can't be ignored but rather should be highlighted in a review of these two conservation stories. Any case studies comparison between species, similar or no, should be approached with caution given that the differences between these two species could be just as important as their similarities in terms of best ascertaining how and why the Japanese red-crowned crane and AWB whooping crane populations recovered at different rates. However, as will be shown below, these differences have not affected the vastly different population outcomes for these two species. Rather, historical data, foraging habitat area assessments conducted by the author, and the academic literature strongly suggests that the AWB whooping crane should have been more advantaged in terms of potential population growth over the 70-year period reviewed, yet it was the Hokkaido red-crowned crane population that demonstrated much faster population growth.

Four key differences between these two species are discussed below.

First, the AWB whooping crane is a fair-weather bird—it summers in Canada and winters in Texas. By contrast, the red-crowned cranes of Hokkaido are clearly adapted to colder and more extreme climates. The annual mean temperature at Kushiro Marsh National Park is just 6 degrees Celsius according to MOE, and temperatures there routinely drop below minus 20 degrees Celsius during winter nights (Kushiro Nature Conservation Office 2017). The Hokkaido resident red-crowned crane population remains in the same region year-round where winter conditions can become extremely frigid. The region does receive less annual snowfall than other parts of Hokkaido, but heavy snows do occur. This hard winter existence is ameliorated partly by geothermal activity in Kushiro Marsh, where natural hot springs keep parts of Kushiro River and other smaller tributaries ice-free year-round (Kushiro Nature Conservation Office 2017) The Hokkaido red-crowned cranes generally cannot escape bitter cold conditions for several months of the year, and yet they have been thriving in terms of population size and growth compared to the AWB whooping crane.

Second, the AWB whooping crane displays extreme migratory behavior, completing a journey of some 2,500 kilometers from their summer breeding grounds in Canada to wintering grounds in Texas twice a year (FWS 2012). The vast majority of Hokkaido red-crowned cranes keep to their primary habitat in and near Kushiro Marsh National Park. The greater energy requirements for the AWB whooping crane to make such an epic journey every year might be seen as one factor limiting AWB whooping crane population growth, however, there is no evidence of markedly higher mortality rates in the AWB whooping crane population aside from the two drought events that occurred in Texas. The existing academic literature has also so far determined that the long migration has not been negatively impacting the AWB whooping crane population.

The time required for the AWB whooping cranes to complete their migration also means that the whooping cranes spend a significant amount of time outside areas staffed by conservation authorities, and thus outside the protection of wildlife managers. In Japan, MOE has the advantage of being able to intervene as they see fit at any time of year as most Hokkaido red-crown cranes spend the entire year at either government reserves or protected feeding stations. Thus, MOE officials can conduct interventions and care activities year-round, whereas officials at the Aransas National Wildlife Refuge have a window of about four months to conduct population health monitoring activity.

Third, the AWB whooping crane is notoriously shy of humans. The best way for visitors to see AWB whooping cranes at the Aransas refuge is through boat tours departing from a dock in the community of Rockport, but even this doesn't guarantee that one will necessarily get close enough to take a clear picture. This author participated in one such boat tour after failing to approach AWB whooping cranes by land close enough to allow for photography. The situation is quite the opposite at Hokkaido red-crowned crane winter artificial feeding stations. During winter feeding sessions, Japanese red-crowned cranes have been seen by this author to be extremely habituated to the human presence. The cranes are still careful to not get too close to humans, and a red-crowned crane will begin to escape if a human attempts to approach it, but they are much less shy and skittish around people compared to AWB whooping cranes.

During feeding the author observed at the Itoh Tancho Crane Sanctuary, red-crowned cranes were seen standing within 10 meters of a crowd of photographers, some occasionally awing the crowd by flying directly overhead, casting long shadows over the visitors and their vehicles. Japanese red-crowned cranes routinely disrupt automobile traffic in and around Kushiro Marsh while crossing roads. Red-crowned cranes are also

not shy about invading human infrastructure, even when humans are present and working. A penchant for avoiding humans and human infrastructure, including massive new wind energy arrays built in the AWB whooping crane migration corridor (Pearse et al. 2021) should afford AWB whooping cranes better chances of survival compared to Hokkaido red-crowned cranes willing to dodge traffic and play chicken with farm equipment.

Lastly, Hokkaido red-crowned cranes display more communal behavior. Though they migrate together, AWB whooping crane couples spend their time at the Aransas refuge and in Wood Buffalo National Park spaced far apart from one another (FWS, Environment and Climate Change Canada). By contrast, Japanese red-crowned cranes have been seen by this author gathering in the hundreds to take advantage of winter artificial feeding stations or to hunker down for cold winter nights in hot spring-fed shallow streams. The red-crowned cranes do space themselves farther apart when breeding in the wetlands of eastern Hokkaido in the warmer spring and summer months (Akan International Crane Center website), but not to the extent of the whooping cranes. Here again, one might argue that such circumstances should be more beneficial to AWB whooping crane survival given how excess crowding pressures food availability during the nine months of the year when red-crowned cranes must forage for themselves. Crowding also leaves red-crowned cranes more susceptible to disease outbreaks.

An attraction to warmer climates should ensure more year-round and steady wild food availability for AWB whooping cranes, and this shy species behaves in ways that limits exposure to disease, predators, and humans, precautionary behavior that is no doubt beneficial to its survival. This should be advantageous to AWB whooping crane population growth. The more human-habituated Japanese red-crowned crane takes more chances and consequently should be suffering higher rates of mortality. Moreover, there

is little indication in the academic literature that the extreme migration route taken by AWB whooping cranes likely leads to higher mortality and thus having some negative impact on that population's growth rates (Baasch et al. 2019). Again, the only major mortality incidents ever recorded for the AWB whooping crane occurred in Texas during winter layovers that coincided with droughts (FWS 2012).

Conservation strategy matters, and we can discern patterns or lessons from analyzing these separate approaches to managing these two geographically separated species which are nevertheless extremely close physiologically, biologically, and behaviorally. These two separate management regimes have been undertaken by wealthy governments as well-financed initiatives for approximately the same length of time, decades-long initiatives led by highly trained wildlife managers. These two case studies are an opportunity to examine whether an emphasis on habitat management vs. direct population management via artificial feeding yields faster, more long-lasting endangered species recovery. This author finds that these two case studies indeed add to a growing body of evidence in academic literate that artificial feeding likely yields faster rates of reproduction and population expansion in some wild endangered species and for endangered avian species in particular.

Again, wildlife managers at both the Aransas refuge and Kushiro Marsh do not practice one management strategy exclusively to the complete exclusion of all others. FWS has tried a variety of strategies including population survival intervention, with FWS attempting artificially feeding of AWB whooping cranes at least once early on in the conservation effort's history (Davis 1998). MOE authorities and Hokkaido red-crowned crane feeding station managers have also attempted to manipulate the eastern Hokkaido marsh habitat to render it more hospitable to red-crowned cranes (MOE 2018).

But Japan's managers have overwhelmingly relied on a population management strategy founded on the decades-long winter artificial feeding program while closely monitoring the health and welfare of the red-crowned cranes. AWB whooping crane managers in Texas have spent most of their efforts on preserving and improving AWB whooping crane critical habitat. The additional calories made available to Hokkaido red-crowned cranes during the lean winter months best accounts for the greater success seen in restoring population numbers in Japan as opposed to the Texas initiative.

Japan’s red-crowned crane population has rebounded far more strongly than the North American AWB whooping crane population even though Japan's red-crowned cranes are confined to a much smaller area of protected and effective habitat and survive in an environment of greater temperature extremes. The strong population growth can be attributed to winter artificial feeding, a management strategy lacking with respect to the AWB whooping crane. However, although the winter artificial feeding program in Japan has proven successful, ultimately there is no cost-free policy choice. The changes taking place in Hokkaido red-crowned crane management strategy in Japan are proving more controversial than the expansion of protected AWB whooping crane habitat underway in southeast Texas. Business owners and members of the communities hosting red-crowned crane tourism are concerned that the experiment may threaten their livelihoods, and have informed MOE that they intend to continue with artificial feeding at some volume despite the policy changes (MOE 2019). This author believes that, should the artificial feeding reduction program eventually result in fewer cranes spending time at feeding stations, these opposition voices will grow louder over time.

For AWB whooping crane management in Texas, the current mood appears harmonious. A lawsuit over AWB whooping crane habitat management ended years ago,

and AWB whooping crane Texas habitat is expanding through a public-private partnership that enjoys widespread local community support (TPWD 2018). Yet as indicated through this initial case study review, simply expanding habitat may not ensure better population recovery in AWB whooping cranes in the future. AWB whooping cranes already enjoy access to far more habitat than Hokkaido red-crowned cranes. The Aransas refuge managers' efforts to maintain the refuge to the greatest possible benefit for AWB whooping cranes has ensured the population's survival, but this doesn't seem to have encouraged faster population recovery when compared with the case of Japan's red-crowned cranes. The Hokkaido red-crowned crane has lost much of its prime wetland habitat at Kushiro Marsh over the decades, and yet its numbers rose strongly despite this degradation to their environment.

This examination of these two case studies in crane conservation and population management shows that controlling food availability for an endangered species in times of probable or proven food shortages could improve individual survival and reproduction, thus potentially facilitating faster population growth. This study adds to a growing body of evidence in the academic literature showing a net positive population growth effect from supplemental or artificial feeding.

2.9 Conclusion

The AWB whooping crane of North America and the red-crowned crane of the Japanese island of Hokkaido are similar to virtually identical in size, appearance, diet, and reproductive behavior. Both species were almost lost due to hunting and habitat destruction, numbering just two or three dozen individuals by the early 1950s (FWS, Akan International Crane Center website). Both species have been subjects of

government-driven conservation initiatives sustained for more than 70 years. These case studies share much in common, except in Japan the main intervention strategy has been an annual winter artificial feeding program, while in the United States conservation authorities have relied mainly on habitat protection and enhancement. Today, FWS counts 543 AWB whooping cranes (FWS 2022). The whooping crane is still classified by IUCN as endangered though increasing (IUCN Red List of Threatened Species 2020). RCCC in Japan gives an estimate of 1,800 red-crowned cranes in Hokkaido (RCCC 2022). The IUCN no longer classifies the species as "endangered" (IUCN Red List of Threatened Species 2021).

This analysis of the case studies of these two endangered species recovery programs reveals how the winter artificial feeding campaign in Japan best explains the sharp differences in historical population growth, with the Japanese red-crowned crane population expanding at a rate 20 percent faster than that for the AWB whooping crane population. This study adds to a growing body of evidence in the available academic literature that sustained annual artificial feeding of a critically endangered species will likely result in faster population recovery above and beyond what would occur under policies emphasizing habitat conservation and management. This author hypothesizes that artificial feeding may be relieving red-crowned cranes of the anxiety that comes from difficulties in securing sufficient forage in times of lean food availability, freeing them to focus more on reproduction and offspring survival. Other research has discovered that supplemental feeding has a similar effect on other species (Hejcmanova et al. 2013).

Calculations based on FWS data show the AWB whooping crane population growth rate averaged 4.76 percent annually over a 70-year period, expanding in total by 2,486 percent (1952 to 2022). Based on RCCC data, over the same 70-year period (1952

to 2022) the Hokkaido red-crowned crane population expanded at an average annual rate of increase of approximately 5.9 percent, with a total population expansion of 5,355 percent. Thus, the most recent population counts for both species show that the Hokkaido red-crowned crane population has expanded at an average annual rate that's approximately 20 percent faster than the rate of AWB whooping crane population growth since 1952. All these estimates are based on the author's own calculations utilizing the population data made available by RCCC and FWS.

Going by the population data collected over the entire 70-yar period, if the Japanese red-crowned crane population had risen at the same rate of growth as the AWB whooping crane from 1952 to 2022 (a 4.76 percent annual average rate of growth), then RCCC and MOE data should be showing a total Hokkaido population of around 855 red-crowned cranes today, and not the 1,800 discovered in the most recent count. Conversely, had the AWB whooping crane population risen at the same rate as that of the red-crowned crane from 1952 to 2022 (a 5.9 percent average annual rate of increase) then FWS figures could be expected to be showing an AWB whooping crane population size of approximately 1,161 AWB whooping cranes instead of the 543 individuals counted in 2022. These estimates are also based on the author's own calculations utilizing the population data made available by RCCC and FWS.

The AWB whooping crane population is advantaged by the fact that there is far more protected and privately owned foraging habitat available to it. The author's analysis using Google Earth spatial analysis tools and the GIS data provided by the US Fish and Wildlife Service and Japan's Ministry of the Environment showed the AWB whooping crane could potentially forage on at least 58,800 ha of farmland next to the Aransas National Wildlife Refuge. By contrast, Japanese red-crowned cranes were frequently

spotted foraging on farms next to Kushiro Marsh by this author, but only about 32,700 ha of adjacent farmland is available for red-crowned crane foraging in the immediate vicinity based on this author's basic GIS assessment.

Other researchers have concluded that the winter artificial feeding campaign has been the critical factor in the successful recovery of the Hokkaido red-crowned crane population (Masatomi 1991, Masatomi et al. 2007, Inoue et al. 2013). A population viability assessment conducted in 2007 concluded that the carrying capacity of southeast Hokkaido's red-crowned crane habitat would be about 1,659 individual cranes (Masatomi et al. 2007). The Hokkaido red-crowned crane population was about 1,200 by 2007 (RCCC 2022). The theoretical carrying capacity estimated in the 2017 study was reached between 2015 and 2016, and the red-crowned crane population continued is expansion well beyond that earlier theoretical carrying limit estimate (RCCC 2022). These facts present strong evidence that the winter artificial feeding program has been a prime factor driving red-crowned crane population growth.

The winter artificial feeding campaign best explains the vast differences in population outcomes seen between the AWB whooping crane population and Hokkaido red-crowned crane population. In other words, not only was winter feeding a critical factor in the recovery of the Hokkaido red-crowned crane, but this management strategy also yielded a much higher rate of population growth for that species compared to the quasi-control example of the AWB whooping crane of southeastern Texas. There is also an expanding body of evidence in the academic literature showing a net positive effect on population growth rates from artificial or supplemental feeding. In other words, studies on the impact of supplemental feeding on endangered species are increasingly finding that the supplemental feeding programs have led to faster population growth rates in a

wide variety of managed species. Evidence in the academic literature that artificial feeding leads to higher rates of reproduction and faster population growth is especially strong with respect to avian species.

Habitat availability is not a constraint for the AWB whooping crane population, either in the United States or in Canada. A 2003 review concluded that the species enjoys access to at least 92,700 hectares of useable habitat in Wood Buffalo National Park alone (Tischendorf 2003). Furthermore, there is no evidence in the available academic literature or from population surveys that the AWB whooping crane population has been experiencing higher rates of during its long migration (Baasch et al. 2019, Pearse et al. 2021). The largest mortality incidents ever recorded for the AWB whooping crane population occurred in Texas during two notably strong winter droughts (FWS 2012).

Moving forward, other potential factors that could influence the survival and future expansions of both crane populations could be explored. Potential impacts of future climate change must be factored in. Some studies suggest that global warming could pose a greater potential threat to AWB whooping cranes as rising average global temperatures are believed to be linked to more frequent and severe North American droughts (Williams et al. 2020). However, other researchers have concluded that climate change poses no immediate threat to AWB whooping crane migration (Pearse et al. 2018). Meanwhile, recent research conducted in northern Japan indicates that climate change may be leading to shorter winters and possibly positive changes to biodiversity in Hokkaido, changes that could prove ultimately beneficial to Japanese red-crowned cranes (Hiura et al. 2019).

The fact that the Hokkaido red-crowned crane population is now roughly triple the size of the AWB whooping crane population after 70 years of concerted conservation efforts in both Japan and the United States can be attributed to the fact that wildlife

managers in Japan have been practicing sustained artificial feeding in periods of least wild forage availability during that entire 70-year period, while managers in the US have not. Changes to the artificial feeding regime in Japan leading to a lowering of the volume of feed given to the red-crowned cranes during winter should have an impact on that crane population, but it is too early to determine what the nature of that impact will be. The Ministry of the Environment in Japan hopes it will have a positive impact by encouraging the red-crowned crane to migrate beyond the confines of southeastern Hokkaido. There are some tentative signs that this may be happening, but again, it is too early and there is too little available data to make such a definitive determination.

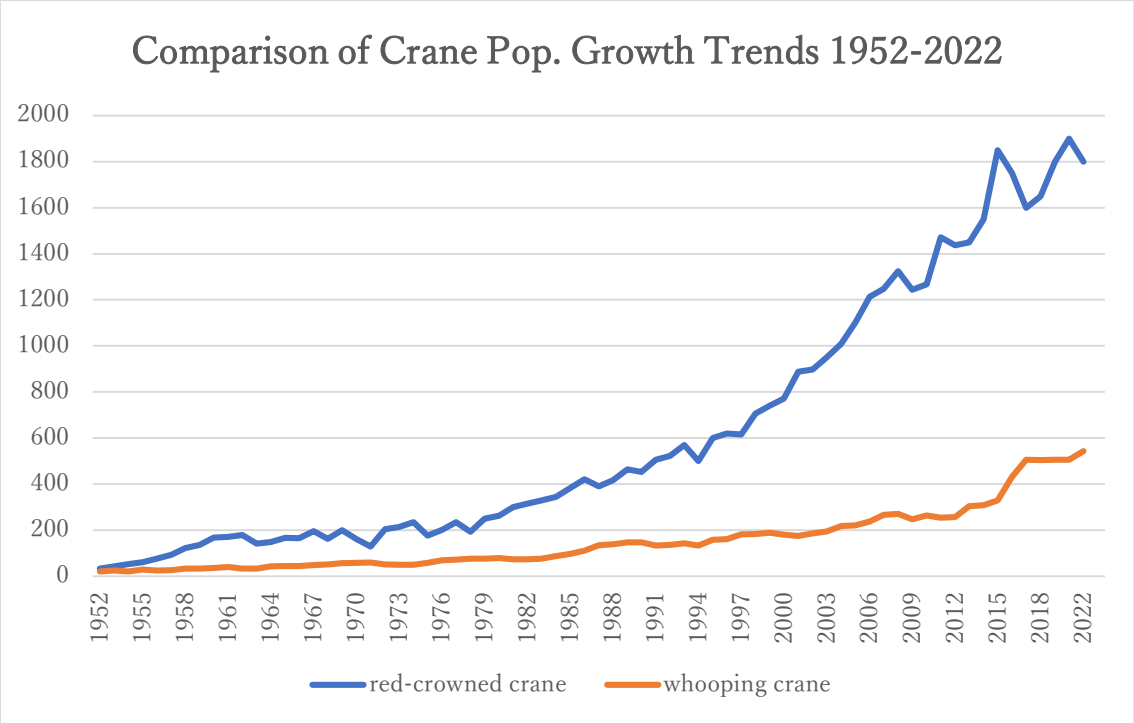


Figure 9: Comparison of AWB whooping crane and Hokkaido red-crowned crane population growth trends, 1952-2022 (USFWS, RCCC data).

Figure 10: Whooping cranes (top) and red-crowned cranes (bottom). Whooping crane photo courtesy of the US Fish and Wildlife Service (Creative Commons license CC BY 2.0). Red-crowned crane photo courtesy of Atsuko Ellie Teramoto (with permission).

Figure 11: Photographs taken at the Aransas National Wildlife Refuge, southeast Texas, United States (Nathanial Gronewold).

Figure 12: Photograph taken at Kushiro Marsh National Park, southeast Hokkaido, Japan (Nathanial Gronewold).

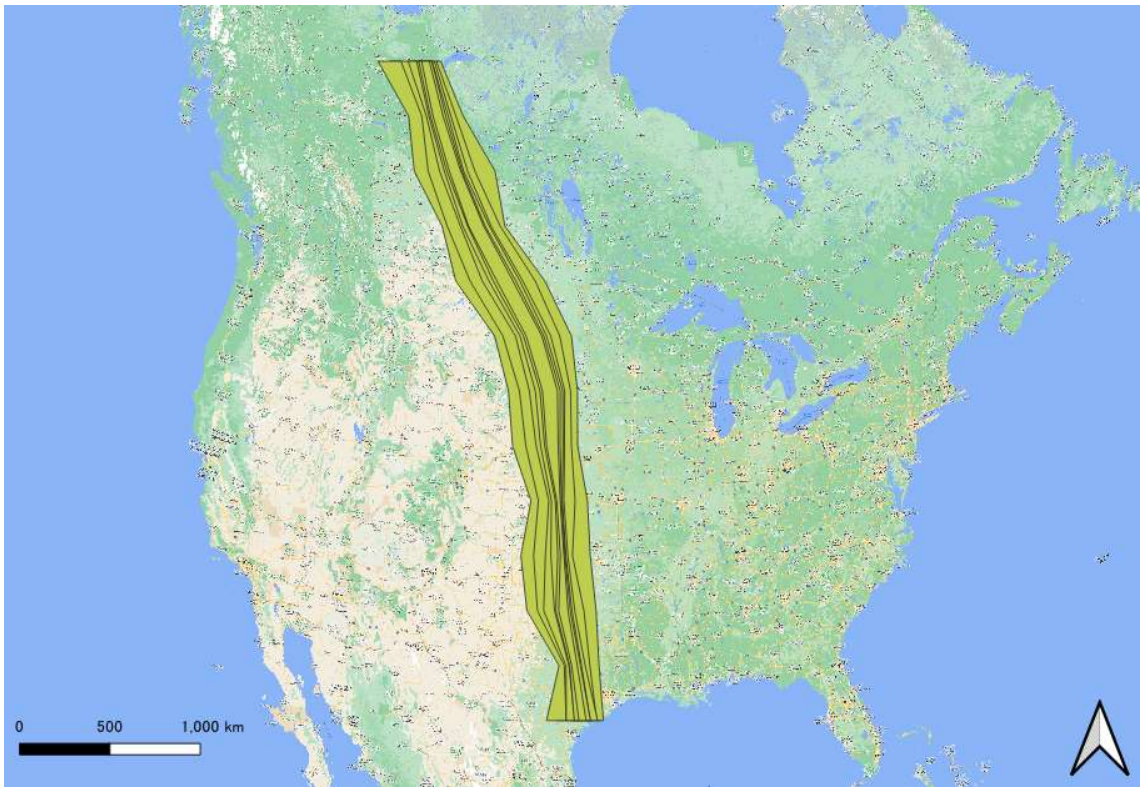


Figure 13: AWB whooping crane migration corridor in North America (Google Maps, QGIS, USFWS).

Chapter 3

Impact of supplemental feeding on endangered species recovery and reproduction: A literature review

3.1 Abstract

It's common knowledge among conservation circles that supplemental feed provided to recovering endangered species in the wild can improve individual animal survival rates. Due to this general understanding, many supplementary feeding campaigns tend to be short-lived and are viewed as temporary emergency measures meant to support animal survival during times of feeding difficulties. Increasingly, various studies looking into effects arising from sustained supplemental feeding of wildlife are discovering a net positive impact on species' rates of reproduction. A review of multiple studies shows that the evidence that supplementary feeding enhances rates of reproduction and thus facilitates faster population growth is especially strong with regard to avian species (for purposes of this study, an ecological definition of "population growth" is given as a net positive increase in the numbers of individuals of a species as recorded in that species' primary habitat in the wild, thus excluding increases in the number of individuals of a species held in captivity).

The following study is a limited literature review assessing some of the evidence that exists in the academic literature concerning the impact of supplement or artificial feeding on managed species. As will be shown, the existing academic literature illustrates that supplementary feeding campaigns likely increase rates of reproduction and facilitate faster population growth in managed species, and thus faster population recovery for managed endangered species. This study first assesses the evidence for this effect as

shown in research involving supplementary feeding of avian species. A brief look at impacts on non-avian species follows, along with a discussion and conclusions.

3.2 Introduction

It's considered common knowledge that supplemental feed provided to recovering endangered species in the wild improves individual animal survival rates. Increasingly, studies looking into other impacts arising from supplemental feeding of wildlife are discovering a net positive effect on species' rates of reproduction and population growth rates (with "population growth" ecologically defined here as a net positive increase in the numbers of individuals of a species as recorded in that species' primary habitat in the wild, thus excluding increases in the number of individuals of a species held in captivity). Evidence for this effect appears strongest for managed avian species.

Caution is in order, as the academic literature on artificial feeding for endangered species recovery is admittedly mixed. Some studies show that this strategy could end up harming a species in certain circumstances (Selva et al. 2014). But there is increasingly compelling evidence emerging from the research community that intervention feeding is likely a powerful tool for recovering endangered avian species. One example appears to be the Hokkaido red-crowned crane in northern Japan, a species that has been afforded supplementary feed during winter months every year since 1950 (Gronewold 2021). A cross-assessment between the recovery histories of the Hokkaido red-crowned crane and North American whooping crane (the Aransas-Wood Buffalo or AWB population) strongly suggests that the supplementary feeding program in Japan best explains the much faster population recovery witnessed for the Japanese red-crowned crane compared to the

AWB whooping crane population in North America (Gronewold 2021). Authorities in Japan may have been among the first to inadvertently discover the effect of supplementary feed on reproductive rates, but researchers across the world are beginning to reach the same conclusion to varying degrees.

First, it's necessary to clarify that intervention feeding of wildlife isn't rare. In most cases, artificial or supplemental feeding of endangered species is seen as a short-term measure enacted only to prevent high rates of mortality during an emergency. In one recent example, the US Fish and Wildlife Service and Florida's state conservation officials joined forces to save manatees from starvation during the winters of 2021–2022 and 2022-2023 by spreading large volumes of lettuce in the manatees' home waters (Davis and Koches 2023). Such interventions are commonly short-term affairs, meaning they are meant to be temporary measures taken only in times of potential emergency.

However, as with the assessment of the red-crowned crane's conservation history, selected academic literature reveals evidence that supplementary feeding likely enhances reproduction and faster population growth in an array of species. The evidence of this effect appears strongest for avian species. The papers chosen for this review were located and selected through online searches utilizing three search engines (Google, DuckDuckGo, Bing) and by queries made directly to authors via the ResearchGate website. Studies were also drawn from the online Public Library of Science (PLOS ONE). 36 papers in total were chosen, providing a small but crucial and relevant sampling of studies on the impacts of artificial feeding on wild species. A plurality of the academic studies selected concerning the impacts of artificial feeding on wild species focused on the impact of supplementary feeding on avian species, providing additional evidence that feeding wild birds likely sees those bird species reproducing at faster rates, leading to an

overall higher rate of population growth in that species. Below is a review of a sampling of academic literature evidence showing strong correlations between supplementary feeding and avian species' population growth.

3.3 Effects of artificial feeding on avian species

Research has uncovered signs that artificial feeding can facilitate faster population growth for a variety of species. Most of the case studies uncovered during the course of this research demonstrate how supplementary feeding likely boosts rates of reproduction in avian species in particular. These studies add further evidence in support of the hypothesis that supplementary feeding can facilitate faster endangered species population recovery by boosting rates of reproduction in a given species.

As this author argues in his study on the red-crowned crane and whooping crane recovery histories in the wild, animals have two goals: survival and reproduction (Gronewold 2021). All things being equal, survival will take precedence and reproduction is secondary in importance to a given species, but if an animal's basic survival needs are satisfied then more energy and effort can be spent on reproduction (Gronewold 2021). As this author theorizes, through artificial feeding, humans likely effectively relieve stress on an animal that must seek food in the wild, and as this source of anxiety is alleviated, this frees individual animals to focus more effort and energy on reproduction and the successful rearing of young (Gronewold 2021). Separate research has shown artificially fed animals resting more, further evidence that artificial feed can lower stress in foraging animals (Hejcmanov et al. 2013). Below is a review of some of the evidence uncovered to date that artificial feeding programs targeting endangered bird species facilitates higher rates of reproduction and faster population growth for those species.

In one study looking at the effects of long-established feeding stations established for the European white stork, researchers uncovered evidence that white storks utilizing feeding stations are reproducing at faster rates compared to white storks that do not make regular use of the feeding stations (Hilgartner et al 2014). The white stork was nearly driven to extinction in Europe, especially after World War II; conservationists and communities in Europe organized campaigns to save this species, beginning with captive breeding and reintroduction programs that were started in the 1950s in some countries, while strong laws were enacted to protect the species (Hilgartner et al 2014). Only 11 breeding pairs could be found in France in 1974, 5 breeding pairs in the Netherlands in 1984, and 6 breeding pairs in Denmark in 1996 (Hilgartner et al. 2014). From the 1950s on, conservationists doubled down on efforts to save the species, including "continuous releases of white storks reared in captivity, installation of nest sites (poles), and supplementary feeding of free flying individuals" (Hilgartner et al. 2014). Today, the white stork population has recovered and is classified as a species of Least Concern by the International Union for Conservation of Nature (IUCN Red List of Threatened Species 2015).

This study on European white storks notes the multiple explanations given for the white stork's recovery. For instance, this species is migratory, with most storks preferring to spend winters in West Africa rather than Europe, so fewer and milder winter droughts are seen as one possible explanation for the species' recovery (Hilgartner et al. 2014). But the authors determined that investigations into the root causes of the stork's recovery were limited and flawed, stating that "to our knowledge, the effect of additional feeding on reproductive success of white storks has never been investigated in detail" (Hilgartner et al. 2014). Taking the initiative to do so, they've concluded that, as with the case of the

red-crowned crane, feeding stations established to aid white stork survival facilitated higher rates of reproduction for this species (Hilgartner et al 2014). The authors focused their investigation on a set of feeding sites established in southwestern Germany near the border with Switzerland to determine if there was any correlation between breeding pair reproductive success and proximity to feeding stations (Hilgartner et al 2014). The data they collected spanned 22 years, from 1990 to 2012, and included 569 breeding events at 80 separate locations; thus, the management history for the white stork in Europe is another example of a sustained artificial feeding campaign focused on one endangered avian species lasting decades, although this study used only two decades' worth of data (Hilgartner et al 2014). The authors reported a net positive effect of the feeding stations on white stork reproduction, noting that "reproductive success was significantly higher in pairs breeding in close distance to the feeding site" (Hilgartner et al. 2014). Specifically, the investigators found that the number of fledglings per nest declined by 8 percent for every kilometer away from a feeding station—in other words, white stork couples living in closer proximity to feeding sites had overall better reproductive success than those breeding pairs nesting further away, leading the authors to conclude that "supplemental feeding of free flying white storks as a conservation measure should therefore compensate for low habitat quality and increase reproductive success of pairs" (Hilgartner et al. 2014).

A positive correlation between supplementary feeding and reproductive rates has also been uncovered at a program dedicated to preserving the endangered Mauritius (or Echo) parakeet (Tollington et al. 2015). The Mauritius parakeet is today is classified as Vulnerable by the IUCN (IUCN Red List of Threatened Species 2019). The species survives thanks to captive breeding programs, reintroduction to the wild, habitat conservation, and supplemental artificial feeding in the wild (Tollington et al. 2015). The

Mauritius parakeet provides another case study in support of artificial feeding as a means to encourage faster rates of reproduction and faster endangered avian species recovery.

University of Kent researchers gathered about 20 years' worth of data on the population of a particular group of parakeets to see how well the birds were recovering (Tollington et al. 2015). They were looking for signs that the feeding stations established to help Mauritius parakeets survive in the wild were detrimental to the parakeets' recovery, conversely causing higher incidence of mortality by making it easier for diseases to spread in a small population of reintroduced birds (Tollington et al. 2015). As they phrased it, "infectious diseases are widely recognized to have a substantial impact on wildlife populations" and "these impacts are sometimes exacerbated in small endangered populations, and therefore, the success of conservation reintroductions to aid the recovery of such species can be seriously threatened by outbreaks of infectious disease" (Tollington et al. 2015). Some association was discovered between supplemental feeding and disease spread in a managed Mauritius parakeet population; in this case, beak and feather disease virus (BFDV)—birds that gathered in groups and relied more on feeding stations tended to show higher incidence of the disease (Tollington et al. 2015). But the difference was reported to be insignificant as BFDV disease outbreaks didn't last long, and whatever negative impact on the population that the diseases may have had on the parakeets was deemed to have been entirely overwhelmed by the positive impact of the artificial feeding regimen on the parakeet's rates of reproduction (Tollington et al. 2015).

The researchers discovered the same general effect that was discovered for the white storks in Germany, namely that "parakeets which took supplemental food generally fledged a higher proportion of chicks than pairs which did not use this resource" (Tollington et al. 2015). The gap in population growth between parakeet groups using

feeding stations and groups that did not was vast. This study tracked 10 breeding pairs inhabiting areas with feed stations against 10 breeding pairs lacking feeding stations beginning in 2003; by 2010, the artificially fed group had expanded to approximately 60 breeding pairs while the non-artificially fed group numbered at just 15 breeding pairs (Tollington et al. 2015). In other words, Mauritius parakeets taking advantage of feeding stations gave birth to and raised more chicks relative to members of the same species on the same island that were not relying on supplemental feed. The study's findings led the researchers to concluded that "supplemental feeding, therefore, appears to be beneficial by (i) enabling breeding pairs to fledge more offspring and (ii) by mitigating the negative effects of fluctuating natural food resources" (Tollington et al. 2015).

Other scientists have found that supplemental feeding seems to facilitate greater survival and reproduction in species of avian scavengers—specifically, vultures and condors. Here, it may be important to reiterate that the practice of disseminating artificial feed to wildlife poses risks. For instances, there are cases in which wildlife managers have found evidence that feeding stations established for particular prey species tend to benefit their predators more—the predators learn to lie in wait for animals visiting feeding stations, making their hunting work easier (Selva et al. 2014). It also seems reasonable to expect that concentrating animals at feeding stations makes it easier for diseases to spread, as the study in Mauritius referenced above revealed (Tollington et al. 2015). Parasites may also spread through a population more easily as individual animals concentrate to take advantage of supplementary feeding stations. The question left to answer is: do the benefits outweigh the risks? In the case of the Mauritius parakeet the answer seems to be that, yes, benefits may outweigh risks in certain circumstances (Tollington et al. 2015). Studies involving other avian species have reached the same conclusion.

Populations of vultures and condors have been hit hard globally by ranching operations pushing out native grazing species. In the wild, buffalo, deer, antelopes, and so on die, and their carcasses stay right where that animal dropped. This is the carrion that avian scavengers rely on for survival, in turn playing an important role in the ecology by breaking these carcasses down and returning their energy and resources to nature. Cows, by contrast, mainly die in slaughterhouses, unless predators take them in the wild. Thus, fewer wild ungulates grazing naturally means less available carrion, and the transition from wild grazing herds to managed ranch herds has consequently decimated populations of flying scavengers. In some instances, conservationists have elected to save wild vultures and condors from extinction by leaving food for them, without fully understanding the implications of doing so. In a 2016 study, researchers reviewed both the pros and cons of artificially feeding avian scavengers in detail (Cortes-Avizanda et al. 2016). Again, artificial feeding regimes for vultures and condors were established primarily to aid the survival of remaining individuals, though some even speculated that artificial feed would save vultures by keeping them away from the carcasses of animals that had been poisoned (Cortes-Avizanda et al. 2016). This 2016 study uncovered evidence that populations of vultures and condors benefitting from artificial feeding interventions enjoy greater reproductive success as well (Cortes-Avizanda et al. 2016).

In a 2014 study, researchers sought to determine how a concentrated artificial feeding program might benefit or harm populations of endangered bearded vultures in Spain (Ferrer et al. 2014). They proposed using supplementary feeding to boost populations of vultures living in suboptimal locations and then introduce extra individual vultures to other regions where the ecosystem was more amenable to survival without human interventions (Ferrer et al. 2014). The authors conclude that through “using food

supplementation in target territories, the expected production of extra young allowed their removal without any effect on the donor population, in either the short or long term" (Ferrer et al. 2014). The best results would come from a sustained effort lasting more than a decade, or "at least 13 years" (Ferrer et al. 2014).

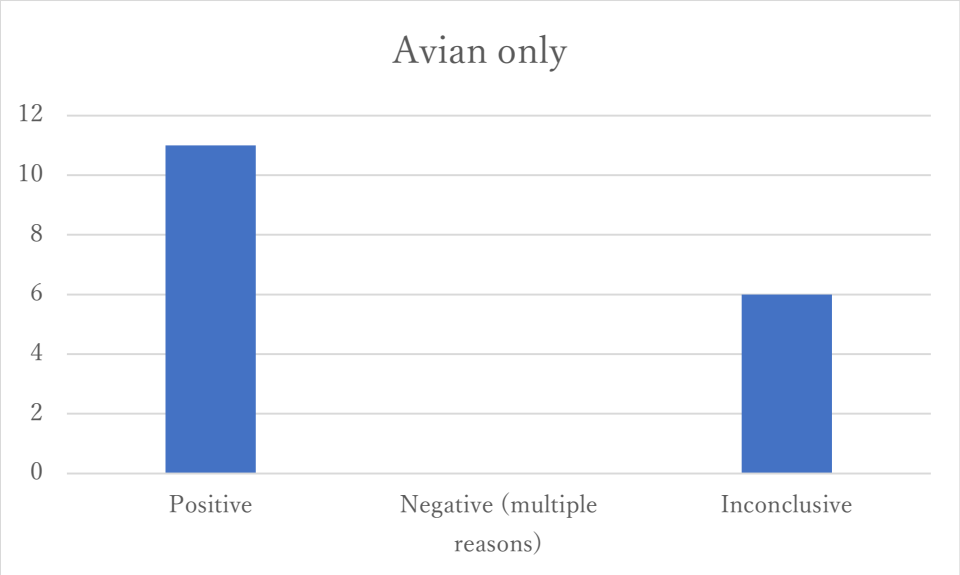
Other studies have concluded that supplementary feeding for avian species not only improves survival rates, but that these programs likely enhance rates of reproduction for these species, as well. Research on programs to save the endangered Hawaiian crow revealed signs that supplementary feeding "may lead to improved physical health, survivorship, and reproduction," while cautioning that "offering predictable food sources could make individuals more conspicuous to predators and less aware of their surroundings" (Lee et al. 2021). Large and sustained efforts involving supplemental feeding of wild birds in Poland were revealed to have "biological consequences, increasing survival and breeding success in the next season" (Chosinska et al. 2012). Research on the impact of artificial feeding during winter on a population of great tits found that "breeding was positively affected by supplementary feeding during winter, as birds breeding in the supplemented area increased their clutch size compared to birds from the control area" (Broggi et al. 2022). Research on San Clemente loggerhead shrike populations in California discovered net positive impacts on reproduction rates when supplemental feed was dispensed to the species during droughts (Hudgens et al. 2009). Findings showed that "from 2001 through 2007, the mean number of independent young produced by supplementally fed shrike pairs was 30 percent higher than for non-supplementally fed pairs," and that "in dry years, supplementally fed pairs initiated breeding an average of 12 days earlier, were nearly a third again as likely to renest after

successfully fledging young, and attempted a third again as many nests as non-fed pairs" (Hudgens et al. 2009).

36 papers in total were chosen for this literature review, providing a small but crucial and relevant sampling of studies on the impacts of artificial feeding on wild species. The papers chosen for this review were located and selected through online searches utilizing three search engines (Google, DuckDuckGo, Bing) and by queries made directly to authors via the ResearchGate website. Some papers were reviewed but otherwise withheld from this literature review for their lack of relevancy to this particular study. Studies were also drawn from the online Public Library of Science (PLOS ONE). It's hypothesized that further investigations into the impact of artificial feeding on avian species should uncover more evidence that this strategy can lead to faster reproduction and population growth given how this effect has been revealed to be acting for a wide variety of different avian species, including cranes, storks, crows, vultures, shrikes, and great tits.

In total, 36 research papers published from 2002 to 2023 covering the impacts of supplemental or artificial feeding on wildlife were reviewed. Of this total, 17 papers looked at impacts on wild avian species only. These papers were categorized into whether they uncovered evidence of net positive effects of feeding on population growth, net negative effects on the species' ecology (meaning any potentially detrimental impacts that could impede a species' population growth or recovery), and research papers where the impacts of feeding on population dynamics were inconclusive (including papers that reported either neutral impacts or research that was too short in timescales to have reasonably uncovered population growth effects). Of the 17 papers reviewed that only explored supplemental or artificial feedings' impact on avian species, 11 of the studies

uncovered net positive impacts on population growth, 0 found net negative effects, and 6 of the studies achieved results that were inconclusive on this question. The breakdown is show in Figure 14.



	Reference	Outcome	Key comments by the author(s)
1	Bordjan D., Soultan A., Jerina K. "Temporal occurrence and species composition of birds on artificial feeding sites maintained for game mammals in the Dinaric Mountains, Slovenia". Ornis Fennica (2023) vol. 100, pp. 1-14.	Inconclusive	"Some species...adapted their presence to the availability of food at the feeding sites, while others were not affected by this"
2	Broggi J., Watson H., Nilsson J., Nilsson J.A. "Carry-over effects on reproduction in food-supplemented wintering great tits". Journal of Avian Biology (2022), vol. 2022, issue 8, pp. 1-8.	Positive	"Breeding was positively affected by supplementary feeding during winter"
3	Cortes-Avizanda A., Blanco G., DeVault T., Markandya A., Virani M., Brandt J., Donázar J. "Supplementary feeding and endangered avian scavengers: benefits, caveats, and controversies". Frontiers in Ecology and the Environment (2016), vol. 14, no. 4, pp. 191-199.	Positive	"Documented increases in survival of long-billed vultures (Gyps indicus) and theirsubsequent slight population recovery have also been attributed to [supplemental feeding stations]"
4	Chosinska K., Dudus L., Jakubiec Z, "Supplemental feeding of birds in human settlements of western Poland". International Studies on Sparrows (2012), vol. 36, pp. 95-102. DOI: 10.1515/isspar-2015-0018.	Positive	"Supplemental feeding of birds has also biological consequences, increasing survival and breeding success in the next season."
5	Doer T., Silvy N. "Effects of supplemental feeding on northern bobwhite populations in south Texas". National Quail Symposium Proceedings (2002), vol. 5 article 51, pp. 233-240.	Inconclusive	"data suggested feeding was not effective when habitat structure was inappropriate, or when food was not limiting."
6	Ferrer F., Newton I., Muriel R., Báguena G., Bustamante J., Martini M., Morandini V. "Using manipulation of density-dependent fecundity to recover an endangered species: The bearded vulture gypaetus barbatus as an example". Journal of Applied Ecology (2014), vol. 51, no. 5, pp. 1255-1263.	Positive	"using food supplementation in target territories, the expected production of extra young allowed their removal without any effect on the donor population"
7	Hilgartner R., Stahl D., Zinner D. "Impact of supplementary feeding on reproductive success of white storks". PLOS ONE (2014), vol. 9(8) e104276.	Positive	"supplementary feeding increases fledgling populations"
8	Hudgens B., Johnston N., Bradley J., Bridges A. "Benefits of supplemental feeding are climate dependent in the San Clemente loggerhead shrike". *Proceedings of the 7th California Islands Symposium* (2009), Institute for Wildlife Studies, Arcata, CA, pp. 315-325.	Positive	"Shrike breeding phenology was affected by both rainfall and supplemental feeding, with the beneficial effects of supplemental feeding most evident in dry years."
9	Lee H., Greggor A., Masuda B., Swaisgood R. "Anti-predator vigilance as an indicator of the costs and benefits of supplemental feeding in newly released 'Alala (Corvus hawaiiensis)." Frontiers in Conservation Science (2021), vol. 2, article 701490, pp. 1-10.	Positive	"Providing additional food resources may lead to improved physical health, survivorship, and reproduction"
10	McLaughlin J., Wiley D., Dabbert C., Terhune T. "Broadcast supplemental feeding and northern bobwhite demographics in Texas". The Journal of Wildlife Management (2019), vol. 83 issue 1, pp. 52-63.	Inconclusive	"Despite the importance of feed during winter, we did not detect differences in bobwhite survival during the spring, summer, and fall seasons."
11	Oro D., Margalida A., Carrete M., Heredia R., Donazar J. "Testing the goodness of supplementary feeding to enhance population viability in an endangered vulture," *PLOS ONE* (2008), vol. 3(12) e4084, pp. 1-10.	Positive	"[artificial feeding sites] can be used as a very specific tool for the recovery of the population in peripheral areas, and to promote the colonization of suitable unoccupied areas outside the Pyrenees."
12	Ricket J., Dey C., Stothart J., O'Connor C., Quinn J., Ji W. "The influence of supplemental feeding on survival, dispersal and competition in translocated brown teal, or pateke (*Anas chlorotis*)". *Emu* (2023), vol. 113, pp. 62-68.	Positive	"supplemental feeding has value as a conservation tool for Brown Teal, particularly during releases in managed areas."
13	Sanders T. "Feeding trial evaluation of supplemental sodium and calcium use by pigeons". Wildlife Society Bulletin (2023) 47, pp. 1-15.	Inconclusive	"it remains unknown if there are benefits to reproductive performance from access to supplemental minerals"
14	Sweikert L., Phillips M. "The effect of supplemental feeding on the known survival of reintroduced aplomado falcons: Implications for recovery". Journal of Raptor Research (2015), vol. 49(4), pp. 389-399.	Positive	"Providing food once daily corresponded with an increase in the known survival of the aplomados... and the establishment of nearby nesting pairs."
15	Vigo-Trauco G., Garcia-Anleu R., Brightsmith D. "Increasing survival of wild macaw chicks using foster parents and supplemental feeding". Diversity (2021), vol. 13(3), 121, pp. 1-27.	Inconclusive	"Our foster parents technique increased the reproductive success of our studied population"
16	Tollington S., Greenwood A., Jones C., Hoeck P., Chowrimootoo A., Smith D., Richards H., Tatayah V., Groombridge J. "Detailed Monitoring of a Small but Recovering Population Reveals Sublethal Effects of Disease and Unexpected Interactions with Supplemental Feeding". Journal of Animal Ecology (2015), vol. 84, pp. 969–77.	Positive	"parakeets which took supplemental food generally fledged a higher proportion of chicks than pairs which did not use this resource."
17	Welcker J., Speakman J., Elliott K., Hatch S., Kitaysky A. "Resting and daily energy expenditures during reproduction are adjusted in opposite directions in free-living birds". Functional Ecology (2015), vol. 29 issue 2, pp. 250-258.	Inconclusive	"Supplemental feeding did not allow [daily energy expenditure] to exceed this apparent limitation."

Figure 14: Distribution of reviewed studies on impacts of supplemental or artificial feeding on avian wildlife species (2002-2023), arranged according to whether researchers found a positive population effect, a negative effect on population dynamics, or inconclusive results.

3.4 Artificial feeding of non-avian species

Thus far, this analysis has focused primarily on bird species. This is in reflection of this author's research on the likely impact of a famous supplementary feeding program on the disparate population recover trajectories for two similar species of crane (Gronewold 2021). Through case study research, this author is convinced that sustained artificial feeding during periods of scarce forage availability likely resulted in much higher rates of reproduction for Hokkaido red-crowned cranes in Japan compared to a the AWB whooping crane population in the United States that has not been managed through a similar long-term supplemental feeding program (Gronewold 2021). Other authors undertaking separate and distinct research projects on different avian species and supplementary feeding interventions are reaching similar conclusions. Research on the impact of feeding stations on European white storks found convincing evidence that white storks using supplemental feeding resources reproduce at much faster rates than white storks that do not (Hilgartner et al. 2014). Researchers concerned about a possible disease outbreak among groups of artificially fed Mauritius parakeets expressed surprise by their discovery that not only do artificially fed Mauritius parakeet populations reproduce at faster rates than parakeets relying entirely on wild forage, but that the availability of supplemental feed equates to a high degree of endangered species population resilience during a recovery period (Tollington et al. 2015). Vultures and condors aided with supplemental food also enjoy better chances of survival and may give birth to more fledglings than might otherwise be possible as other studies have shown, with researchers speculating that this effect could potentially be leveraged to boost avian scavenger populations in other regions (Cortes-Avizanda et al. 2016). In sum, the available evidence

in support of population management through artificial feeding is compelling at least with regards to avian species.

There is similar if tentative evidence pointing to potentially positive impacts of artificial feeding on population growth for non-avian species, as well. As with avian species, studies unveiling net positive reproduction impacts by artificial feeding focused on a wide array of species. Below, research studies discovering this impact for giant elands, caribou, cotton rats, and edible dormice are briefly noted.

A study published in 2013 looked at the impact of artificial feeding on the western giant eland of West Africa (Hejcmanová et al. 2013). It was argued earlier that artificial feeding likely alleviates animals of the stress and anxiety associated with the struggle to survive during lean food periods, enabling them to focus more energy and effort on reproduction and rearing their young (Gronewold 2021). This study on giant elands sees the same or similar forces at work for the eland, and as with the case of the Mauritius parakeet, researchers concluded that risks associated with artificially feeding wild elands may be outweighed by the benefits afforded to this species through such a campaign (Hejcmanová et al. 2013). As the researchers put it, "supplemental food did not induce changes in browsing pattern at the plant species level, probably due to a small individual effect on total nutrient energy intake," but rather "facilitates the animals overcoming unfavorable conditions or alleviates stress with additional rest, and could therefore assist as a conservation intervention to enhance fitness" (Hejcmanová et al. 2013). Eland reproduction and population growth appears to have been positively impacted by the supplemental feed, as well (Hejcmanová et al. 2013).

Heard and Zimmerman undertook research to determine the impact of a supplementary feeding campaign aimed at a population of caribou in British Columbia,

Canada (Heard and Zimmerman 2020). Two separate herds of caribou were evaluated: a Kennedy Siding herd that benefited from both intervention feeding and predator removal beginning in the winter of 2015-2016, and a Quintette herd that also benefited from predator removals that same winter (specifically, wolf removal) but not supplementary feeding (Heard and Zimmerman 2020). They concluded that the herd experiencing supplementary feeding reproduced at a faster rate (Heard and Zimmerman 2020). "Average annual growth rate of the Kennedy Siding herd over the subsequent four years, where both feeding and wolf reduction occurred concurrently, was higher than in the Quintette herd where the only management action in those years was wolf reduction" with an 8 percent increase in population growth attributed to artificial feeding (Heard and Zimmerman 2020).

This effect of supplementary feeding on rates of reproduction has been confirmed for some small mammals, as well. One representative study involved a comprehensive assessment of management efforts directed at the hispid cotton rat feeding (Morris et al. 2011). Three factors affecting the hispid cotton rate population that was the subject of this study were investigated: managed prescribed burning at habitat sites, predator removals, and supplementary feeding (Morris et al. 2011). They determined that supplementary feeding had the greatest impact on reproduction rates and consequent population growth; however, the positive net impact on reproduction wasn't enough in the short-term to overcome the negative impacts of fires feeding (Morris et al. 2011). As they explained, "food supplementation increased survival, transitions to reproductive states, and abundance, but was not sufficient to prevent post-fire declines in any of these parameters" (Morris et al. 2011). Lebl et al. discovered a similar net positive impact on rates of reproduction for edible dormice managed through supplementary feeding (Lebl et al.

2009). As those authors explained, “supplemental feeding caused significant increases in the proportion of reproducing females and reproductively active males…these results suggest that edible dormice may use the occurrence of an energy-rich food resource to predict the autumnal mast situation” (Lebl et al. 2009). In other words, “our data indicate that the decision to reproduce was not the result of an increased body mass due to the consumption of surplus food, but that sufficient seed abundance acts as an environmental signal to which dormice adjust their reproduction” (Lebl et al. 2009).

Again, 36 research papers published from 2002 to 2023 covering the impacts of supplemental or artificial feeding on wildlife were reviewed in total. These published research papers were categorized into whether or not they uncovered evidence of net positive effects of feeding on population growth, net negative impacts on the species’ ecology (meaning any potentially detrimental impacts that could impede a species’ population growth or recovery), and research papers where the impacts of feeding on population dynamics were inconclusive (including papers that reported either neutral impacts or research that was too short in timescales to have reasonably uncovered population growth effects). Of the total 36 research papers reviewed for this chapter, 16 papers found evidence for net positive population effects, 6 discovered potential evidence for net negative impacts on species’ ecology and welfare, and 14 of the papers reached conclusions that are best described as inconclusive. This review shows that there is evidence emerging in the academic literature that supplemental or artificial feeding will likely lead to faster population growth in some species of wildlife, though evidence for this net positive population growth effect is so far stronger for avian species as opposed to non-avian wildlife species. The outcome of this review is summarized in Figure 15.

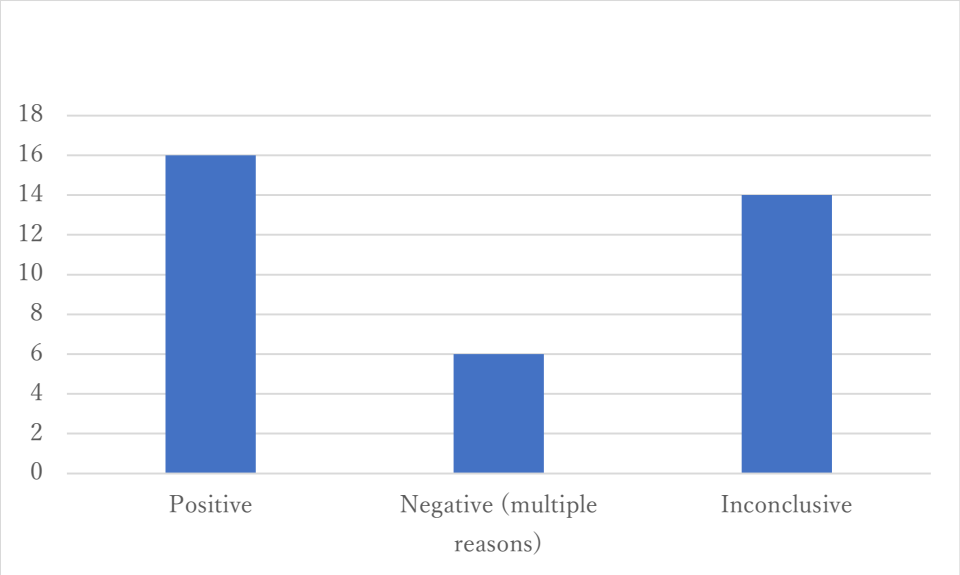


Figure 15: Graph showing the distribution of all reviewed studies (2002-2023) on impacts of supplemental or artificial feeding on wildlife, arranged according to whether researchers found a positive population effect, a negative effect on population dynamics, or inconclusive results.

3.5 Discussion and conclusion

There are risks inherent with pursuing a strategy of supplemental feeding as a wild species management strategy. Some conservation officials are concerned that supplemental feeding may result in accidentally rendering a wild species quasi-domesticated. Wildlife managers in northern Japan have voiced to this author their concerns that the red-crowned cranes of Hokkaido may have become too dependent and expectant of the seasonal winter feeding from the humans; in other words, they've grown worried that the Hokkaido red-crowned cranes may have come to strongly associate humans with food, especially in winter. There are other associated risks we must be cognizant of. Some studies warn that the establishment of feeding stations meant to help

some species could be inadvertently helping those species' predators more as the predator animals learn to wait for their prey to check in at a feeding station (Selva et al. 2014).

However, the existing academic literature indicates that supplementary feeding campaigns likely increase rates of reproduction and facilitate faster population growth in many species, and thus faster population recovery for managed endangered species. The examples illustrated above show how the pros associated with supplementary feeding may outweigh the cons, especially for avian species. The main positive impact illustrated here is an apparent net gain in rates of reproduction and subsequent population expansion.

36 research papers published from 2002 to 2023 covering the impacts of supplemental or artificial feeding on wildlife were reviewed. Of this total, 17 papers looked at impacts on wild avian species only. These papers were categorized into whether they uncovered evidence of net positive effects of feeding on population growth, net negative effects on the species' ecology (meaning any potentially detrimental impacts that could impede a species' population growth or recovery), and research papers where the impacts of feeding on population dynamics were inconclusive (including papers that reported either neutral impacts or research that was too short in timescales to have reasonably uncovered population growth effects). Of the 17 papers reviewed that only explored supplemental or artificial feedings' impact on avian species, 11 of the studies uncovered net positive impacts on population growth, 0 found net negative effects, and 6 of the studies achieved results that were inconclusive on this question. Of the total 36 research papers reviewed for this chapter, 16 papers found evidence for net positive population effects, 6 discovered potential evidence for net negative impacts on species' ecology and welfare, and 14 of the papers reached conclusions that are best described as inconclusive. This literature review shows that there is evidence emerging in the academic

literature that supplemental or artificial feeding will likely lead to faster population growth in some species of wildlife. The evidence for a net positive population growth effect is so far stronger for avian species as opposed to non-avian species. Supplemental feed helps endangered species to survive challenging conditions such as food shortages brought about by harsh winters or droughts. Illustrated above is evidence in the academic literature demonstrating that artificial feeding not only facilitates individual and group animal survival, but it also helps increase a population's rate of reproduction. As this author hypothesizes in Chapter 2, less energy exerted on individual survival means more energy left for other natural imperatives, especially reproduction, at least to the point when an animal population becomes too crowded (Gronewold 2021). Healthy, well-fed adults give birth to healthy offspring. Greater food availability ensures that the offspring survive and thrive, growing big and strong until they create offspring of their own.

Chapter 4

Wetland loss via hardwood forest incursion into red-crowned crane habitat at Kushiro Marsh National Park, Japan

4.1 Abstract

Kushiro Marsh National Park contains Japan's largest wetland, comprising about 60 percent of the nation's total remaining wetland area (Amano et al. 2006). Home to thousands of species including the Hokkaido red-crowned crane, research there has determined that the greater natural wetland expanse has been shrinking, with the effect most pronounced at the northern edges of the park downriver from waterways that had their channels straightened for agriculture many years ago (Nakamura 1996). This re-channelization of streams and rivers in the region exacerbated sedimentation and gave space for the incursion of hardwood species, especially Japanese alder (Nakamura 1996). There is a good understanding of the threat posed by wetland habitat losses to species that would be harmed by the hardwood incursion trend should it continue, as is this case with the red-crowned crane. But there is less certainty concerning how the Japanese alder incursion may be influencing changes in regional watershed dynamics over time through interception and evapotranspiration.

This paper delves more deeply into the ecology and hydrology of Kushiro Marsh National Park, the main home of Japan's resident red-crowned crane population, and explores the potential risks to changes in the natural hydrology of the greater Kushiro Marsh region by the Japanese alder hardwood intrusion into the Marsh, with an emphasis on changes to interception and evapotranspiration that may be anticipated according to

the scientific literature. The focus here is on Hokkaido red-crowned crane habitat in Kushiro Marsh as studies find the area remains at-risk of further wetland loss (Amano et al. 2006). No similar threat exists for a cousin crane species, the Aransas-Wood Buffalo whooping crane population in North America. This includes an exploration of the potential for wetland recovery and restoration in Kushiro Marsh. Current strategies involve brush removal and envision the incorporation of adjacent abandoned farmlands into the Kushiro Marsh ecosystem either via natural processes or by direct human intervention. The paper proposes another approach that would involve deliberately planting native Japanese alder to create vegetated buffer zones to protect the Marsh from excess levels of erosion and sedimentation from adjacent operational farmlands that is most likely occurring. Further research on the impact of active farm operations on Kushiro Marsh's hydrology is warranted, as is a precautionary approach when designing projects to protect and expand the area of wetland habitat that would benefit the long-term survival of the Hokkaido red-crowned crane.

4.2 Introduction

Kushiro Marsh National Park (釧路湿原国立公園) is located in the north of Japan, in the southeast corner of the island of Hokkaido. Registered under the Ramsar Convention on wetlands of international significance, the Marsh contains unique habitat for more than 2,000 species of wildlife (Ministry of Land, Infrastructure, and Transport, 2007). Its most iconic resident is no doubt the Hokkaido red-crowned crane, a large wetland bird famous for its elaborate courtship dances occurring in the snowy backdrops of eastern Hokkaido in wintertime, especially in the month of February. As noted earlier

in this dissertation, the Hokkaido red-crone crane draws thousands of tourists from all over the world to the region every year. Kushiro Marsh is also home to Japan's largest freshwater fish species, the huchen, and the wetlands there provide a way-station and breeding ground for several species of migratory birds of prey, in particular Steller's sea eagle, the largest eagle species in the world by mass (Ministry of Land, Infrastructure, and Transport 2007).

Though pristine and relatively undisturbed in much of its expanses, Kushiro Marsh is surrounded on almost all sides by urban and agricultural development. To the south, most of the original wetland habitat has been overtaken by the city of Kushiro, which was built atop the wetlands here in order to develop a port community for fishing. Construction of the city has effectively cut off the greater wetland expanse from the sea. Aside from adjacent highland areas to the west and east, the Marsh is further boxed in by agriculture, especially dairy farming operations and farms used to grow hay to feed dairy cattle. Recent demographic changes resulting in a dwindling regional human population has seen some prior developed farmland becoming abandoned. In some sections, it's theorized that some of this abandoned farmland could be incorporated into Kushiro Marsh's protected zone (Yamanaka et al. 2017). Research on the potential of this abandoned farmland to provide habitat for Marsh flora and fauna, including the red-crowned crane, is ongoing, though initial findings have been deemed promising (Yamanaka et al. 2017).

While the Marsh itself has been long protected, extensive redevelopment has occurred on the waterways in surrounding regions without regard to the potential negative effects of these changes on the downstream ecosystems. The biggest land use impact

occurred following work to straighten rivers and stream channels north of the Marsh (Nakamura 1996). For example, work was performed in the 1970s and 1980s to re-channel and straighten portions of the Kuchoro River that drains into the Marsh, with the aim of preventing upland flooding negatively impacting the adjacent dairy operations (Nakamura 1996). Of the 45 kilometers of the river's main channel length, 10 kilometers of the river just outside the park's boundaries were straightened (Nakamura 1996). Studies conducted since have confirmed that this work has resulted in a major influx of sediment into Kushiro Marsh (Nakamura 1996). The sediment has covered and buried normally saturated soils, effectively "drying" significant portions of the wetland (Nakamura 1996).

By straightening upland rivers and streams, especially the Kuchoro River, the managers of this watershed have made the run of these rivers and streams steeper, increasing the energy of the flow of the downstream movement of water (Nakamura et al. 2003). As indicated above, research has found that the Kuchoro River was shortened by about 10 kilometers over the years in total, resulting in a 0.1 percent to 0.2 percent steeper gradient to the river (Mizugaki 2006). Nakamura et al. find that over the past two decades the steeper, faster run of the Kuchoro River has resulted in a more energetic flow, resulting in the river cutting itself deeper into the riverbed, ultimately carrying and depositing large volumes of extra sediment load further downstream when the waters reach the lower elevations of Kushiro Marsh (Nakamura et al. 2003). Periods of heavy flooding see the extra sediment spilling over and eventually settling on soft, saturated peatlands formed from the slow decomposition of organic material (Nakamura et al. 2003). The above added layer provides a more stable soil environment for hardwood plant species to more

easily colonize (Nakamura et al. 2003). Dendrogeomorphological sampling and radionuclide testing of sediment deposits links the added drier soil layers to specific major flood events that occurred shortly after work to straighten portions of the Kuchoro River was completed (Mizugaki 2006). Hardwood species, especially Japanese alder, can establish roots systems in these new sediment layers deposited by flooding within a year, studies have found (Mizugaki 2006).

Over the past 100 years, Hokkaido has lost some 70 percent of its original wetland area to agriculture, according to the general assessments of the academic literature and multiple studies (Fujita 1997). In most cases, these losses occurred due to direct urban development or in the conversion of wetlands to farmlands (Fujita 1997). Kushiro Marsh is a special case in that, aside from the construction of Kushiro City, the greater wetland area has declined due to indirect disturbances caused by upriver river channel alterations (Mizugaki 2006). As a consequence, by the late 1990s it was estimated that the original wetland expanse of Kushiro Marsh had declined by about 20 percent and that regional Japanese alder forest cover had increased from 8.6 percent to 36.7 percent (Nakamura 2004).

4.3 Hardwood incursion trends, likely impacts

Japanese alder (*Alnus japonica*) is a deciduous species native to Northeast Asia and commonly found in Japan, Taiwan, Korea, and parts of Russia and China (Orwa 2009). It occurs naturally in wetter soils found on the edges of wetlands and streams, or in soils with a higher water table (Orwa 2009). Like other alder species, Japanese alder has nitrogen-fixing properties and is sometimes deliberately planted for both controlling

erosion and to restore degraded lands (Orwa 2009). It is a cold weather-hardy species well adapted to the climate of Kushiro Marsh, which is known for long hard winters and an annual mean temperature of 6 degrees Celsius (Orwa 2009).

Figure 16: Photograph taken at Kushiro Marsh National Park showing the extent of hardwood incursion into the wetland (Nathanial Gronewold).

Direct observation and on-the-ground investigations have concluded that upland river channel straightening and a resultant excess of sediment load have expanded the extent of ground cover favorable for Japanese alder's deeper expansion into Kushiro Marsh (Mizugaki 2006). Scientific modelling experiments confirming this effect also foresee changes to regional hydrology, including changes caused by possible alteration of evapotranspiration due to the differences between Japanese alder and other marsh vegetation like cattails, marsh grasses, and reeds (Nakayama 2008). However, this author

was unable to locate in the scientific literature any investigations into interception and evapotranspiration rates for Japanese alder specifically, or research on how Japanese alder incursion has impacted watershed hydrology elsewhere due to differences in interception and evapotranspiration that the species brings. Potential changes in hydrological dynamics can be implied, however, via research that has been conducted on other similar species, including other species of alder and based on the general scientific understanding of the influence of leafy hardwood species on ecosystem hydrology due to these species' impact on average interception and evapotranspiration rates in watersheds where they occur (Environment Canada, Ontario Invasive Plant Council 2014).

As land managers know, evapotranspiration is a main component of a watershed's water budget, and losses of available water due to evapotranspiration and interception can be linked to different types of vegetated cover (Akerman 1975). Differences in interception and evapotranspiration rates between moderately sized shrubs and larger leafy hardwood species like alders can be relatively unimportant, but it's been generally found that woodier species do demonstrate a higher propensity for interception and evapotranspiration than grasses or reeds (Akerman 1975). Leaf area is one important and key determinant—broader leaves can capture more water per their greater surface area than grasses or reeds (Akerman 1975). The higher profile of trees like alder also generally exposes this intercepted precipitation to more solar radiation and wind, raising the odds of this water being returned to the atmosphere before having a chance to reach the soil underneath (Akerman 1975). Woodier deciduous plants with leaves seasonally lost also generate more forest bottom leaf litter, effectively covering the soil with a mat of vegetation that can intercept more water, allowing for further water lost to the atmosphere

versus what might occur in the absence of such leaf litter cover (Akerman 1975).

However, research has concluded that total leaf area alone is not enough to determine how evapotranspiration rates may be impacted or increased in a region from the incursion of such leafy plant species (Ewers 2002). For instance, a study on forest hydrology dynamics in parts of Wisconsin, United States operated on the assumption that broader leaf area is associated (positively correlated) with higher levels of precipitation loss due to interception and evapotranspiration; this same investigation found this to be more or less the case, but the study also concluded that other factors must be considered alongside leaf area index, in particular tree sap production volumes (Ewers 2002). Thus, some cautious assessment is in order as *Alnus japonica* is not known to be a particularly sap-heavy species (Orwa 2009), thus its effect on further drying the regional climate via interception and evapotranspiration may be relatively muted compared to other broad-leafed hardwood species.

Other factors unique to Kushiro Marsh are likely to limit any expected increases in interception and evapotranspiration water losses caused by the incursion of Japanese alder forest. For example, the region generally sees relatively high humidity in the summertime, and frequently experiences thick fog banks caused by differences in ocean thermal conditions in the northwest Pacific Ocean. Both the humid air and frequent exposure to fog can be expected to mitigate against the potential for Japanese alder to cause precipitation to be lost more quickly from the Marsh habitat as these conditions make it more difficult for evapotranspiration to operate efficiently.

Still, there are some indications that the Japanese alder intrusion into Kushiro Marsh National Park may have significant impacts on the Marsh and its regional

hydrology in the future via interception and transpiration (Environment Canada, Ontario Invasive Plant Council 2014). Such evidence can be derived from studies conducted into the impacts of invasions by similar species (Environment Canada, Ontario Invasive Plant Council 2014).

Researchers in Ontario, Canada have been closely monitoring the impact of the invasive European black alder, a species of tree that was introduced to North America in the late 1800s by settlers (Environment Canada, Ontario Invasive Plant Council 2014). A winter-hardy, nitrogen-fixing tree, studies have concluded that this particular species as a threat to wetland habitats across eastern Canada and the northeastern United States, as has been found for Japanese alder in southeastern Hokkaido (Environment Canada, Ontario Invasive Plant Council 2014). Studies conducted on European black alder find that the nitrogen fixation into the soil caused by this plant can alter soil chemistry to a degree that makes it difficult for other species to survive or establish themselves (Environment Canada, Ontario Invasive Plant Council 2014). These studies conducted by authorities in Canada also point to interruptions in the natural hydrological cycle that can be expected by the incursion of European black alder into North American wetlands (Environment Canada, Ontario Invasive Plant Council 2014). Less is discussed about the interception and evapotranspiration potential of European black alder, but these investigations put emphasis on the potential for soil water losses via evapotranspiration given the species' leaf size—up to 13 centimeters long and 8 cm wide—and a relatively wide trunk of up to 30 cm in diameter (Environment Canada, Ontario Invasive Plant Council 2014). European black alder has been found to be a heavy consumer of water and a species incapable of controlling its own transpiration rates, likely resulting in large

losses of water from heavy intake through roots and stem systems and evapotranspiration from European black alder's leaves (Environment Canada, Ontario Invasive Plant Council 2014).

Wetland managers and conservationists in Ontario recommend European black alder eradication campaigns as an effective means to both protect surviving wetland areas and to promote the restoration and expansion of North American wetland range (Environment Canada, Ontario Invasive Plant Council 2014). Experiments on tree cutting and strand removal of Japanese alder in Kushiro Marsh National Park have reached the same conclusion (Nakagawa et al. 2012). A 2012 field experiment found that Japanese alder removal encouraged the recovery of natural wetland hydro-dynamics, which then promoted the growth of more common native wetland vegetation such as grasses and reeds more favorable to the red-crowned crane and other iconic Kushiro Marsh species (Nakagawa et al. 2012). As is the case for European black alder in Canada, this particular field experiment concludes that "the cutting of the invasive and/or expanding tree species may be necessary for the restoration of the original vegetation in a wetland ecosystem" (Nakagawa et al. 2012).

4.4 Existing management strategies, proposed new approach

As noted earlier, Kushiro Marsh National Park is by far Japan's largest wetland. Located adjacent to the city of Kushiro in the southeast corner of the island of Hokkaido, Kushiro Marsh alone comprises some 60 percent of Japan's total wetland area (Amano et al. 2006). The national park, among Japan's largest, is home to approximately 2,000 species, including 170 separate bird species, and some 1,150 species of insects and

invertebrates (Kuriyama 2000). Its most famous resident is the Hokkaido red-crowned crane, an iconic species that appears frequently in Japanese art and folklore but one that was nearly driven to extinction by the early 1900s. Prior to the global COVID-19 pandemic, approximately 600,000 people visited Kushiro Marsh National Park every year, including thousands of visitors from abroad (Kuriyama 2000).

Researchers have determined that over the past 50 years, the wetland area encompassing Kushiro Marsh has shrunk by some 20 percent from its original total area, representing a loss of approximately 25,000 hectares (Ministry of the Environment, Japan 2017). Increased sedimentation has been found to be the root cause of the wetland area contraction, as a community or reeds and sage grasses gives way to woodier plant species such as Japanese alder (Amano et al. 2006). This is, in effect, shrinking the area of suitable habitat for the red-crowned crane (Amano et al. 2006). Ongoing wetland habitat loss in the region is a considerable threat to the red-crowned crane's long-term survivable, especially if wildlife managers in Japan fail to entice the species to migrate to and settle other parts of the country. Ministry of the Environment researchers have determined that a dramatic reduction in catchment sedimentation rates is the only way to halt the shrinking of the wetland expanse (Ministry of the Environment 2017). To that effect, the Nature Restoration Council for the Kushiro Mire was established in 2003 per a national Nature Restoration Promotion Law (Kushiro Nature Conservation Office 2017). The Restoration Council is comprised of six sub-committees that plan and operate various restoration projects (Kushiro Nature Conservation Office 2017)). The Council also monitors scientific research.

To date, the Council has proposed or organized three main Marsh restoration

projects: incorporating abandoned farmlands into Hokkaido red-crowned crane habitat (at this stage a proposed project); a reforestation campaign around Takkobu Lake to slow downstream erosion; and the main initiative, a "river rewinding" project that aims to restore the natural riparian processes to the waterways (Ministry of the Environment 2017). The largest active effort undertaken to date involved restoring some two kilometers of the Kushiro River in an area north of the main marshland, in the Kayanuma region, to its natural windy run (Ahn et al. 2008). Though deemed the greatest source of excess siltation, the unnatural channelization of the Kushiro River is not the only source of the problem as "the widespread attenuation of sediment transport and annual floods has led to the encroachment of riparian vegetation onto the former gravel beds along many rivers" (Amano et al. 2006). Various other re-winding and nature restoration projects have occurred "at rivers, moors and tidal flats including Kushiro Shitsugen, based on their respective Grand Designs and Implementation Plans developed by respective Nature Restoration Committees which consists of governments, experts, NPOs, local residents and others related" (Nakajima et al. 2015). River restoration remains the prime goal of the Nature Restoration Committees, with most efforts aiming "to restore the meandering Kushiro River and the habitats there" (Kushiro Nature Conservation Office 2017).

Another proposed strategy involves incorporating tracts of abandoned farmland into Kushiro Marsh National Park, with the hopes that a gradual return of natural hydrology will encourage the expansion of native marsh plants, and thus red-crowned crane habitat (Yamanaka et al. 2017). As of this writing, the author is unaware of any concerted or organized effort to actually do so, either at a grassroots level or by any active government program. Successfully expanding the size of Kushiro Marsh National Park

would likely require the Ministry of the Environment to purchase large areas of land adjacent to the park from landowners. This author deems such land purchases to be unlikely to occur anytime soon given the Japanese government's strained budget resources and other priorities. Missing from the current list of proposed or active Marsh protection or restoration projects is a focus on sedimentation loading caused by erosion from adjacent farmlands and dairy farms not abandoned and still in operation. This author has yet to locate any discussion in the existing research literature of potentially managing or actively altering non-abandoned adjacent agricultural lands for erosion control purposes for the protection of red-crowned crane habitat in Kushiro Marsh, and no serious efforts aimed at managing adjacent lands controlled by dairy operations exists as far as this author is aware.

Satellite imaging confirm that the area surrounding Kushiro Marsh National Park has been altered for agriculture uses right up to the Park's boundaries (see Figure 18). Therefore, in addition to the river rewinding, reforestation projects, Japanese alder eradication, and other red-crowned crane habitat protection and expansion initiatives, an additional project could be introduced with the aim of creating new vegetated buffer zones between farm and cattle pasture lands and the Park's marsh and wetland habitats to control erosion and excess sedimentation. To avoid problems associated with invasive species (already an issue in the wetland), such a project should select native vegetation with which to build these erosion-control buffer zones, either via transportation of adults and plant seedlings from the marsh region, where feasible, or via new planting of vegetation. Other species could be open for consideration, but a main species that might be utilized for the purpose of creating new vegetated buffer zones on active farmland is, ironically, Japanese

alder.

Japanese alder is recognized as a potentially beneficial species. Research in the 1970s found that “atmospheric nitrogen is fixed symbiotically in root nodules of Alnus” (Tarrant, Trappe 1971). Japanese alder leaches nitrogen from roots and nodules into the soil, stimulating both additional plant species growth as well as microbial activity (Tarrant, Trappe 1971). The leaf litter and debris left from alder trees can add nitrogen to soil via surface leaching (Tarrant, Trappe 1971). Though this species is the main culprit behind the hardwood incursions into Kushiro Marsh caused by excessive sedimentation, this author recommends that the Ministry of the Environment and other interested parties consider using Japanese alder for a vegetated buffer zone creation effort focused at the boundaries of the Marsh and dairy farming operations.

Constructing vegetated buffer zones is recognized as a viable method for effectively addressing excess erosion and non-point source pollution (Liu et al. 2007). Options for buffer zone design and placement should be factored in to any planning that would utilize this option for mitigating against the negative impacts of agricultural erosion on downstream wetlands. A detailed review of 80 vegetated buffer zone projects implemented globally found the ideal width of a zone to be approximately 10 meters, and an ideal 9 percent gradient or slope for optimising the trapping of excess sediment that would otherwise make its way downstream (Liu et al. 2007). Steeper slope grades were found to permit sediment to run off too quickly for vegetation to prevent it from escaping into a nearby waterways (Liu et al. 2007).

Global alder species have been identified as an ideal erosion control species due to its root system and nitrogen fixation properties, which enhance biomass in the soil and

binds soils more tightly from added microbial communities and fungi (Tarrant, Trappe 1971). Native alder trees are already being employed in one erosion control program occurring in the vicinity of Kushiro Marsh, at the Takkobu Native Forest Restoration project (Ministry of the Environment 2017). As admitted above, the choice of Japanese alder is somewhat ironic as it is one of the main species deemed most responsible for the loss of wetlands from siltation and drying—the drier, firmer soils introduced by excess sedimentation aid in the spread of alder in the Marsh, to the detriment of wetland reeds and sages (Amano et al. 2006). But Japanese alder is a native species, one shown to thrive in the local climate where the average annual mean temperature is 6 degrees Celsius (Miyamoto et al. 2004). Given alder's proven capacity to alter soil quality and composition through nitrogen fixation and erosion control, the species could be ideal for use in anti-erosion buffer strip creation and would likely grow relatively quickly in the targeted areas.

4.5 Ecosystem recovery via abandoned farms

As mentioned earlier above, demographic changes witnessed throughout Japan are also being felt in eastern Hokkaido and are resulting in a steadily dwindling in the rural population. Japan's agricultural sector has not been left unscathed by demographic trends as fewer children mean fewer heirs to Japan's farming enterprises, and the ongoing influx of population from rural to urban areas also makes it more difficult for Japanese agriculture to recruit new entrants into these professions. As a result, the total area under cultivation in Japan has been in decline for several years as previously productive farmlands are going unused or are becoming abandoned altogether.

Investigations of abandoned farmland around or adjacent to Kushiro Marsh have discovered wetland species colonizing these previously cultivated lands, holding promise that the greater wetland ecosystem may be gradually expanding into these abandoned farmlands (Yamanaka et al. 2017). The trend, should it continue, could offer relief for sections of the Marsh feeling the stress of the Japanese alder hardwood incursion. As noted, up to now restoration efforts in eastern Hokkaido have focused mainly on organizing engineering projects aimed at re-winding portions of straightened river channels in the upland higher elevation areas, to prevent further sediment load intrusions (Kushiro Nature Conservation Office 2017). However, as much of the damage to the Marsh has already been done and probably can't be reversed, evidence is growing that the incorporation of abandoned farmlands in the region may be one viable option for adding new wetland expanses to make up for portions of the Marsh already lost to expanding Japanese alder forest cover (Yamanaka et al. 2017).

Very recently, researchers have delved into the question of whether or not wetland animals are beginning to colonize abandoned farmland adjacent to Kushiro Marsh National Park, beginning with the lowest order species down the food chain (Yamanaka et al. 2017). One such study focused on the propagation of wetland ground beetles into abandoned farming regions, setting out to determine whether occurrences of these species in abandoned farms represented merely occasional wanderings away from the beetles' home habitat in the Marsh, or if these beetles were indeed establishing themselves permanently in these newly available open spaces (Yamanaka et al. 2017). The researchers collected over 15,000 individuals from 37 sampling locations, more than 5,000 of these wetland beetle species, finding that the abundance of wetland beetle species

at abandoned farmland was comparable to abundances discovered at wetlands directly (Yamanaka et al. 2017). This study concluded that the presence of wetland ground beetles at abandoned farms in and near Kushiro Marsh represents permanent establishment and colonization, thus an expansion of wetland beetles' habitat in the region (Yamanaka et al. 2017). This study found that an increase in the soil moisture content in these lands left abandoned by agriculture is resulting in ecosystem conditions that more closely resemble the beetles' preferred natural wetland habitat; thus, the insects are beginning to make their homes in these areas as well (Yamanaka et al. 2017). To date, his study presents the clearest evidence this author has managed to locate suggesting that some portions of abandoned farmlands in the region of Kushiro Marsh are gradually being transformed into additional wetland habitat that might one day be suitable for Hokkaido red-crowned cranes, with higher soil moisture content possibly preventing further alder or other hardwood incursions at these lands.

The Japanese alder incursion into Kushiro Marsh continues to present a challenge to the long-term conservation of the Hokkaido red-crowned crane's core habitat, but it can be managed. Studies elsewhere show that eradication campaigns directed at other alder species where those trees have become persistently invasive and a threat to native wetlands can prove effective (Environment Canada, Ontario Invasive Plant Council 2014). As earlier research shows, there are indications that lands not yet invaded by Japanese alder and abandoned by humans may become gradually subsumed into Kushiro Marsh's wetland expanses (Yamanaka et al. 2017). As species lower down the food chain find new niches in abandoned farms, species that prey upon these insects will inevitably follow (Yamanaka et al. 2017). Gradually higher order species could expand to the regions, as

well, should soil moisture content continue to rise, giving space for common wetland vegetation to establish itself. The authors of the beetle study speculate that humans can help this process along, working to encourage increases in soil moisture content in abandoned farmland in order to speed up the process of seeing these lands incorporated into protected wetland habitat (Yamanaka et al. 2017).

4.6 Discussion and Conclusion

Conservation managers and researchers have thoroughly investigated the causes and consequences of the hardwood Japanese alder incursion into Kushiro Marsh and the subsequent loss of wetland habitat deemed ideal for the red-crowned crane. Blame for the hardwood incursion has been laid mainly on projects to straighten waterways north of the protected zone of Kushiro Marsh National Park (Mizugaki 2006). In turn, projects have been implemented to mitigate against the ecological damage that has already been done. Conservation authorities in Japan are constantly monitoring conditions at the park and assessing the status of the hardwood incursion and the health of wetlands in the park. Upon review, this author finds that past studies and ongoing reviews fail to take into account the probable effects of higher rates of interception and evapotranspiration that will likely come from greater Japanese alder cover. That said, the academic literature evidence and the author's own knowledge of conditions at the park suggest that any impact from interception and evapotranspiration will likely be marginal and of little consequence compared to the larger issue of the wetland "drying" phenomenon. Nevertheless, interception and evapotranspiration should be taken into consideration. Also, park managers should consider other options for preventing or reducing further

erosion and siltation into Kushiro Marsh, in particular mitigation efforts occurring at the surrounding dairy farm lands.

The Japanese alder hardwood incursion into Kushiro Marsh has been found to be both shrinking the total size of the natural wetland expanse and causing harm to iconic species, including the Hokkaido red-crowned crane (Ministry of the Environment 2017). The hardwood incursions have been shrinking the size of ideal red-crowned crane habitat and thus present a significant threat to the species (Ministry of the Environment 2017). Less is known about how the spread of alder forest may influence the greater regional hydrology of Kushiro Marsh in particular and eastern Hokkaido in general; in other words, it is as yet unknown whether this hardwood incursion could cause further drying in the area through higher rates of interception and evapotranspiration in a sort of feedback loop. Studies on other alder species finds that this order of vegetation consumes large volumes of water that can be lost to evapotranspiration, and that the nitrogen fixing properties of alder can alter soil chemistry to the detriment of other plant species (Tarrant, Trappe 1971). Taller hardwood leaf species are known to exhibit much higher rates of interception than wetland grasses and reed, as well (Akerman 1975). Yet the high humidity and frequent fog experienced in Kushiro Marsh witnessed and experienced by this author during his time spent in the region may be mitigating against these effects. More direct research should be conducted on both the actual changes to hydrology that the Japanese alder expansion is delivering and on the potential to mitigate against these hydrological changes and potential water losses through the incorporation of neighboring abandoned farmlands into the Marsh's wetland expanse.

Conservation authorities in eastern Hokkaido should also consider how active

farms and dairy operations may be negatively impacting downstream wetlands as farms and ranches are known to encourage higher rates of erosion and downstream sedimentation and can negatively impact wetland and aquatic habitats (Blann et al. 2009). Though it's the main culprit behind the hardwood incursions into Kushiro Marsh National Park, Japanese alder could be utilized to create erosion-controlling buffer zones at active agricultural lands to protect the Marsh. Still, efforts to restore or incorporate new lands into the wetland area need to be approached with caution and deliberation. A 2010 overview of wetland restoration projects reviewed multiple case studies of wetland restoration projects and reached this conclusion (Moreno-Mateos et al. 2010). From their assessment of the successes and failures of projects identified in their review, the authors identify four areas of consideration as land managers plan and implement wetland recovery or expansion initiatives (Moreno-Mateos et al. 2010).

First, managers should determine what the additional or recovered wetland is needed for, and why (Moreno-Mateos et al. 2010). In the case of Kushiro Marsh, the wetlands there provide not only habitat for wildlife but also recreational opportunities and are a vital component of the regional economy. Second, it's argued that scale of restoration planned should be carefully defined ahead of any project's launch (Moreno-Mateos et al. 2010). As mentioned above, approximately 20 percent of Kushiro Marsh's original wetland expanse has been already lost to the Japanese alder incursion (Ministry of the Environment 2017). The extent of abandoned agricultural land that could be candidates for wetland conversion is unknown to this author, but the abandoned acreages potentially available for conversion, though fairly substantial, likely would not make up entirely for the expanses of wetlands lost. Third, Moreno-Mateos et al. recommend that conflicting

or compatible objectives should be carefully considered (Moreno-Mateos et al. 2010). Is incorporating these new lands into the greater wetland region of Kushiro Marsh really the best future use of these abandoned farming areas? Would the new wetland created truly offer the same or similar ecosystem functions as the native wetland areas? These are just some of the considerations that need to be addressed ahead of project planning in red-crowned crane territory. Finally, it's recommended that a clear restoration strategy be spelled out prior to planning and implementation (Moreno-Mateos et al. 2010). Converting abandoned farmland into wetland raises the question of whether these lands could remain in private hands or be annexed to Kushiro Marsh National Park by the government, and thus, if government agencies are able and willing to assume the extra burden on time and finances. As noted earlier, this author has yet to encounter any plans to use Japanese government funds to purchase abandoned farmlands near Kushiro Marsh for conversion into protected wetlands.

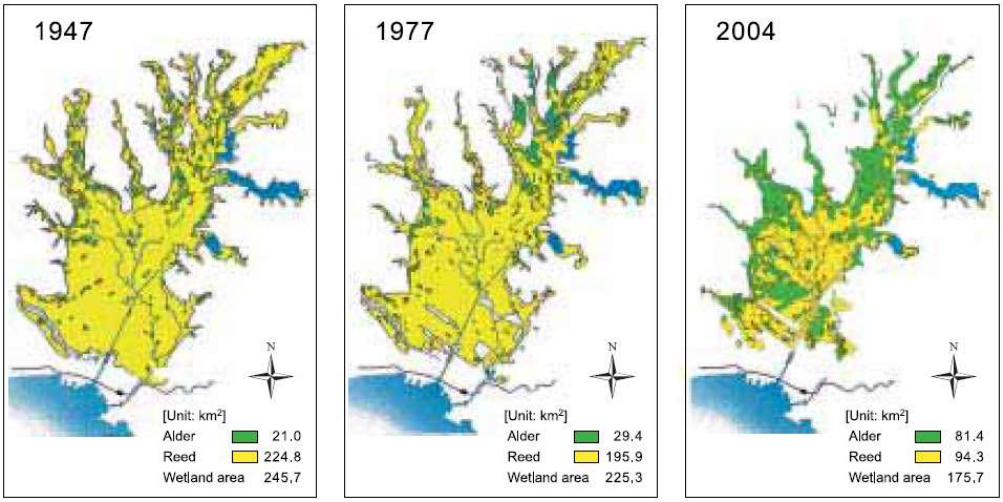


Figure 17: Graphic illustrating the encroachment of Japanese alder forest into Kushiro Marsh National Park (images by the Ministry of Land, Infrastructure and Transport, Hokkaido Regional Development Bureau, scale not provided).

Figure 18: Satellite images of Kushiro Marsh wetlands showing signs of agriculture's encroachment into the upland watershed (Google Earth).

Chapter 5

Global endangered species management regimes: The legacy of the United States Endangered Species Act of 1973

5.1 Abstract

December 2023 will mark the 50th anniversary of the passage of the 1973 Endangered Species Act of the United States. This landmark Act by the US Congress was made possible through strong bipartisan political cooperation on environment protection, capping off a string of progressive legislative victories that would set the tone for US environmental policy at local, state, and federal government levels for decades. Beyond its domestic significance, the 1973 Endangered Species Act had a clear and recognizable impact on global environmentalism by influencing and inspiring endangered species legislation in other nations as well as the 1992 United Nations Convention on Biological Diversity. At the time of its passage, the US Endangered Species Act (ESA) was far and away the most comprehensive piece of legislation ever enacted to halt and reverse rising rates of species extinction and biodiversity loss. Other nations emulated the ESA in past and present endangered species laws and regulations, even as late as 2019, leading to the eventual emergence of a set of global standard practices for species and habitat protections that endure to this day, practices with clear American roots. As it is written, the ESA also reflects the strong influence that the experience of AWB whooping crane management has had on US species protection policy. In turn, a textual analysis of the ESA, other countries' endangered species laws, and of Japan's preeminent endangered species protection law reveals how Japan's approach to endangered species management

stands out and apart from the other nations' legalistic approaches and how the experience of red-crowned crane management in Hokkaido helps explains this key distinction.

This study explores the degree to which the past and present endangered species laws of other English-speaking jurisdictions borrowed from or mimicked the US Endangered Species Act in purpose, style, form, and function. Further analysis is undertaken to reveal the extent to which Japan's own endangered species protection statute is likely influenced by the US ESA. This exercise was undertaken to shed light on how the case study of the Aransas-Wood Buffalo migratory whooping crane flock (AWB whooping crane) played an important role in shaping US endangered species management policy, approaches, and philosophy, and in turn to explore how AWB whooping crane conservation management experience may have influenced global endangered species management. A careful assessment of both the US law and Japan's endangered species protection statute reveals clear and important distinctions that are likely a reflection of Japan's unique experience with the Hokkaido red-crowned crane's recovery.

The ESA's influence on global environmental norms and wildlife protection practices is first explored through the lens of international relations theory, in particular the "constructivist" school of thought that helps explain recognized patterns in global environmental cooperation. This chapter then demonstrates how the 1973 Endangered Species Act essentially became a template for other national and provincial governments to model and even mimic when those governments were designing and enacting their own endangered species management protection programs. Historically, the ESA's passage and its emulation by other polities are indicative of the degree to which the United States has and continues to greatly impact and influence global wildlife law and policy. And though it relies heavily on the US ESA precedent in much of its form and function, Japan's

landmark endangered species law shows clear differences that likely arose from the Japanese experience with red-crowned crane management in eastern Hokkaido. In turn, America's approach to species protections as codified in the 1973 ESA (and subsequently borrowed by much of the world) shows clear signs of having been influenced by America's long-standing experience with AWB whooping crane conservation and recovery, further evidence of the critical importance of these two crane conservation stories, an importance that has been overlooked up to now.

5.2 Introduction

On December 20, 1973, the US House of Representatives approved the US Endangered Species Act with overwhelming bipartisan support, sending the bill to President Richard Nixon for his signature per congressional records. President Nixon signed the US Endangered Species Act into law on December 28, 1973, per congressional records. At the time of its passage, the US Endangered Species Act (ESA) was the most comprehensive piece of legislation addressing protections for wildlife and their habitat ever enacted. Over the next several years, other governments at the state, provincial, and national levels operating on every continent (even Antarctica considering that nationals engaging in activities on Antarctica are subject to the laws of their home jurisdictions, including endangered species statutes) would follow America's lead. These laws were either designed for the same purposes as the ESA or as instruments through which governments planned to implement their responsibilities under the United Nations Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), a multilateral environmental agreement that preceded the ESA and which the ESA itself references.

The Wildlife Act of Ireland was enacted in 1976 (and later amended in 2000). Norfolk Island, then a self-governing territory of Australia, passed its own Endangered Species Act in 1980. The United Kingdom enacted the Wildlife and Countryside Act in 1981. The Canadian province of Manitoba passed its Endangered Species and Ecosystems Act in 1990. Australian central government lawmakers enacted that nation's Endangered Species Protection Act in 1992. Lawmakers in the Philippines adopted the Republic Act No. 9147 in 2001. Canada's central government implemented the Species at Risk Act in 2002. Kenyan lawmakers adopted the Wildlife Conservation and Management Act of 2013. Guyana passed the Wildlife Conservation and Management Bill in 2016. And more recently, Uganda's legislature enacted the Uganda Wildlife Act in 2019. This is, of course, not a comprehensive list of national and subnational endangered species laws that followed the 1973 ESA, and this list of national and subnational endangered species legislation is restricted to English-speaking jurisdictions, the most consequential limitation of this study. Japan's national government enacted the Act on Conservation of Endangered Species of Wild Fauna and Flora (ACES) in 1992, drafted and finalized the same year as member states of the United Nations adopted the Convention on Biological Diversity. Japan's ACES law entered into force in early 1993.

Enforcement of the ESA is handled through the US Department of the Interior, with enforcement actions further delegated to the US Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (Sec.4.a General, 1). The ESA directs the Secretary of the Interior to carry out assessments of native plants and animals to determine their status in the wild, and the Secretary is further directed to determine, based on these assessments, whether a species is threatened with possible extinction or at risk of imminent extinction, and then accordingly list such categorized species as "threatened"

or “endangered” in accordance with ESA procedures (Sec.4.a General, 1). The law then directs the Secretary of the Interior to identify habitat critical to the survival of a species, and then draft a plan for the protection of such critical habitat as deemed necessary to ensure a species is saved from extinction (Sec.4.a General, 1). The process must be transparent and made available for the public to review and comment on; the general public is also invited to propose species for listing and protection.

The US Endangered Species Act is also remarkably international in scope. The ESA specifies that the Department of the Interior is to cooperate with foreign governments in pursuing endangered species conservation (Sec.2.a Findings, 4, A-G). The ESA explicitly mentions Japan, Canada, and Mexico as nations with which the United States must cooperate on biodiversity protection, and the law even directs the Secretary of the Interior to inform foreign governments of listing decisions regarding species also existing in foreign territories, and foreign governments are also invited to comment on listing decisions proposed by the US Department of the Interior (Sec.2.a Findings, 4, A-G). The law also says that the ESA is the vehicle through which the United States Government will enforce provisions of the CITES multilateral environmental treaty (Sec.2.a Findings, 4, A-G).

With slight variations, this general species management approach as outlined above is repeated in form and function in other nations’ endangered species protection laws at the state, provincial, and national levels, including in Japan’s ACES law. There are important distinctions to be highlighted between other governments’ species protection acts and the ESA, especially with regards to Japan’s ACES law. However, the following review of specific examples of legislation that followed the 1973 ESA demonstrates how the United States has had a profound influence on the way the world

pursues measures to slow or halt the alarming decline in global biodiversity being witnessed today.

What follows is a demonstration of how the US Endangered Species Act has shaped much of the foundation of worldwide endangered species management and conservation law and custom (as they pertain to the English-speaking world, at least), a theoretical basis for explaining the ESA's influence in this regard, and an argument demonstrating why the ESA's international influence is likely to endure for decades to come. Furthermore, an explanation is offered for how America's lengthy experience with protecting and recovering the critically threatened AWB whooping crane population left its own mark on the US ESA; alternately, a careful textual analysis of multiple national and provincial endangered species laws reveals how Japan's ACES law stands out from the pack, and why Japan's equally lengthy experience with Hokkaido red-crowned crane conservation best explains these important legal and, arguably, cultural distinctions.

5.3 Methodology

This paper explores the degree to which other nations (mainly English-language jurisdictions) have emulated the letter and spirit of the US Endangered Species Act and how the landmark ESA has essentially served as a template for the world's approach to endangered species management and biodiversity protections since its enactment. First, the review begins with a look at how a portion of the existing academic literature interprets the legacy of the ESA. Second, patterns in global environmental protections are examined and explained through the lens of international relations theory, in particular the mode of theoretical assessment known popularly as "constructivism". The constructivist school is emphasized to explain state behavior in the face of moral pressures

to enact environmental protections but in an absence of any real or meaningful threat of force, violence, or penalty if a government fails to respond to these pressures. Third, endangered species laws as enacted by governments in Australia, Canada, Ireland, the Philippines, Guyana, Kenya, and Uganda are assessed to determine just how similar in structure and approach they are to America's ESA. Complete texts of endangered species legislation were downloaded from official government websites. Where only PDF file versions of legislation were made available, these files were converted into Word format using Adobe's online PDF-to-Word conversion tool to enable a more thorough textual analysis and comparison. Endangered species trade laws as enacted by the United Kingdom, New Zealand, Nigeria, and Singapore, as well as CITES and the United Nations Convention on Biological Diversity (CBD) were reviewed separately and in addition to other examples of national legislation to provide a more comprehensive picture of the world's approaches to biological diversity protections and their probable roots in American federal legislation.

This initial cross-analysis is unfortunately limited to English-speaking jurisdictions, greatly limiting the utility of this study, but Japan's ACES law was also reviewed in its original Japanese and in English translation (as translated by the author or the online service Japanese Law Translation) to assess the degree to which Japan's own landmark species protection law may have been influenced by earlier protection models pioneered by the US Endangered Species Act. The ESA's impact on Japanese endangered species legislation is discerned and is explained in this review, as well. The ways in which the ACES law departs from the endangered species legislation of the US and other English-speaking jurisdictions are equally important and are highlighted to show how Japan's unique experience with and approach to Hokkaido red-crowned crane

conservation likely left a cultural mark on the way Japan ultimately drafted its landmark endangered species law.

5.4 Legacy of the Endangered Species Act

Science has demonstrated how biodiversity itself, or the mere existence of biodiversity, can be of direct benefit to humans. For example, research has revealed how bird species richness strongly correlates to people's sense of greater well-being (Methorst et al. 2021). One recent study showed that in parts of Europe where bird populations were found to be the most biodiverse, humans living in these same areas reported higher-than-average rates of contentedness and life satisfaction compared to areas of comparatively poor bird species richness (Methorst et al. 2021). This correlation between bird biodiversity and life satisfaction in Europe was found by the researchers to be so strong that the additional quantifiable measure of happiness reported by people living in the mere presence of greater bird biodiversity increased in a way as if those same individuals had reported sizeable increases in their incomes (Methorst et al. 2021). In short, it can be said with great confidence that biodiversity clearly matters for human life satisfaction.

Thus, governments have endeavored in recent decades to prevent species' extinctions because of the widely held and confirmed belief that species richness and greater biodiversity are of benefit to humans. The US Congress states this explicitly in the introduction to the ESA and its contents, titled "Findings, Purposes, and Policy." In Section 2(a)(3), Congress states that species existing in the United States are to be protected from extinction because they "are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." This section avoids mention of the commercial value of species, but this is stated explicitly later in wording

that notes how threatened and endangered species are to be both protected from and for commercial activity—economic activity that doesn't directly involve a species should be pursued in a way as to not threaten the existence of a species, the ESA says, and the direct commercial exploitation of a species must be conducted in a manner to ensure sustainable use and the ongoing, long-term existence of said species (US Endangered Species Act, section 2(a)(3)). A reference to "recreation" also suggests Congress understood the commercial potential of biodiversity in that people will travel and spend money to see and experience species (US Endangered Species Act, section 2(a)(3)). The ESA arguably introduced to the world the concept of legislating the value of wild species to humans in terms of perceived cultural and esthetic benefits, for scientific and educational purposes, and commercial gain (US Endangered Species Act, section 2(a)(3)). In other words, the ESA legislated the concept of biodiversity as another natural resource for humans to manage, much the same as with mineral wealth or timber. As will be demonstrated below, other national and international biodiversity laws continued this practice of commodification for management and trade—humans determined to protect wild species not for their own sake, but as resources to be managed and exploited responsibly by humans for the benefit of humans.

How governments pursue endangered species management varies greatly due to variances in national histories, government structures, governing philosophies, and internal politics. Even countries with very similar histories, cultures, shared species, and shared geographies can approach the same goals of species conservation in very different ways. For instance, a 2013 review of the differences between the US ESA and Canada's Species at Risk Act (SARA) found the two laws result in the Canadian and American authorities often taking far different approaches in pursuing the same goals (Waples et al.

2013). The researchers noted how the SARA law dictates that all species status assessments must be undertaken by a single scientific body charged by the national government to perform this work, whereas in the United States the ESA authorizes species assessments by different parties, with Congress declining to use the ESA to forge a single national scientific body to exist only to assess species' status in the wild (Waples et al. 2013). At the same time, the ESA mandates strict deadlines for listing decisions and prohibits listing decisions that are influenced by social and/or economic considerations, meaning the ESA doesn't allow authorities to forego a scientifically sound listing decision simply because listing a species may prove economically detrimental in some way (Waples et al. 2013). SARA and other national endangered species laws make more explicit concerns about the costs of implementing listing decisions (Waples et al. 2013).

Actions in pursuit of endangered species protections in the United States also tend to be far more litigious than in other jurisdictions, and the ESA itself falls victim to this additional use of time and resources. One example can be seen in a Congressional Research Service (CRS) report highlighting the litigious nature of the ESA and endangered species management in the US with a case study of the listing history of the gray wolf (Ward 2020). Initially listed as endangered in 1967, the FWS has attempted numerous times to either change the listing status or delist certain populations of gray wolves over the past 20 years (Ward 2020). As CRS details, lawsuits filed by interested parties have thwarted every attempt by FWS to do so as groups sued to block FWS delisting attempts (Ward 2020). Though lawsuits over endangered species listing decisions do occur in other jurisdictions, cases of endangered species listing decisions or other management decisions becoming frozen for two decades or more by contentious

litigation is more commonly an American phenomenon, and one key way in which endangered species management in the US may differ from other national approaches.

However, the similarities between other national endangered species management laws and regimes and the ESA far outweigh any apparent and obvious differences. Waples et al. argue in their paper that endangered species management and protection could be enhanced in both Canada and the United States if the ESA and SARA were re-drafted or re-interpreted in ways to see the acts better mimic one another (Waples et al. 2013). In reality, Canada's SARA national endangered species legislation already heavily mimics the ESA in real and very consequential ways.

5.5 Constructivism and environmental cooperation

International relations theory is multifaceted and multilayered, meaning there are many flavors or schools of thought to how principles or foundational rules underpinning states' interactions with on-another are defined and taught. For purposes of simplification, this study narrowed the focus of this inquiry to three broad schools of thought in international relations theory and discourse: realism, institutionalism, and constructivism. Here, the author relies mainly on the succinct definitions of all three theoretical tools as outlined in the text *The Environment and International Relations* (second edition) by Kate O'Neill (University of Cambridge Press 2017). Though all three theoretical lenses hold great analytical power, this study will zero in on constructivism as the tool most useful for thoroughly examining and understanding the ESA's mark on global environmental management.

Traditionally, international relations scholarship begins with a simple premise: there is no one world government, meaning no single entity or authority ruling over the

entire planet. There is no global "Leviathan" as the English philosopher Thomas Hobbes put it—no single, overarching, dominate authority that can enforce peace, cooperation, or compliance among sovereign nations. The United Nations does not operate as a world government as the UN exists solely because separate sovereign and independent nations agree to organize and operate the UN system. The study of international relations is largely a study of how nations compete or cooperate in an environment where there is no overarching authority or power head. One popular way of describing international relations theory is that it's an attempt to explain how states exist and relate to one another in a (more or less) state of anarchy.

Realists, or proponents of realism theory, assert that a condition of anarchy forces states into a condition of mostly competition (O'Neill 2017). In other words, realist theory says states are constantly competing with each other and that this state of relatively constant competition is the main driving reality underpinning global affairs. Realist theory holds that states "are motivated primarily by rivalry and the pursuit of relative power, most particularly power in military or economic terms" (O'Neill 2017). Power is paramount in international affairs, the theory holds, and states navigate turbulent waters as best they can by pursuing alliances and occasional wars in a never-ending attempt at maximizing their gains and minimizing their losses (O'Neill 2017).

Institutionalists, or adherents to institutionalism theory, hold to a brighter assessment of the world. Institutionalism argues that states understand perfectly well that they must not only compete, but also cooperate (O'Neill 2017). In other words, "they posit that states are, in fact, far more interdependent than most realists, or neorealists, recognize" (O'Neill 2017). They understand that there is no Leviathan and that and no single nation is powerful enough to become the dominant legal authority, so in a bid to

avoid excessive and potentially disastrous competition and wars states endeavor to form international institutions through which they can pursue peace and cooperation instead (O'Neill 2017). As proof of this reality, intuitionalists can point to the existence of United Nations system of global governance.

Constructivism or constructivist theory offers a somewhat deeper and arguably more compelling view of states' relations. Constructivism theory places special emphasis on the power of ideas, values, and norms, or "introduces ideational and normative elements into the equation" (O'Neill 2017). One way to describe it is that constructivism makes note of the fact that people think differently today than they did 1,000 years ago, 100 years ago, 50 years ago, or even just 10 years ago. What was once considered normal and natural in the past is no longer deemed acceptable to people living in the present, and people ultimately run international affairs. A classic example offered by O'Neill in her work is slavery, an institution previously deemed normal for thousands of years but that's thankfully no longer viewed this way (O'Neill 2017). The main thesis of constructivism is that the thinking of entire populations changes over time and that, in these recent times, nations are increasingly endeavoring to demonstrate that they are good, responsible actors on the global stage, agents willing to assume an active and productive role in global affairs (O'Neill 2017). Constructivist theory also places greater emphasis on the role or non-governmental organizations or non-state actors (O'Neill 2017).

Through the lens of these three principal theories of international relations—realism, institutionalism, and constructivism—we can better understand and explain why the world developed the global environmental protection or natural resources management architecture that exists today.

Through the United Nations and other fora, the international community has adopted a set of key international environmental treaties, or multilateral environmental agreements (MEAs). A careful reading of MEAs and observation of how states implement them and organize environmental negotiations around them show that modern MEAs perform one or more of three basic functions: they either assign rights to areas of potential resource discovery, they facilitate information-sharing regimes to enhance cross-border environmental protections or rules enforcement, or they encourage (but never force) sovereign states to protect or sustainably manage resources found on their own sovereign territories through various mechanisms, usually award-based (the entire prior assessment and the one that follows in the next five paragraphs is informed by the author's long experience with observing international MEA management and international environmental negotiations and diplomacy at UN Headquarters in New York, where the author was a resident correspondent for more than seven years).

The United Nations Convention on the Law of the Sea (UNCLOS) is primarily an example of how states have opted to assign rights to resource extraction areas to one another. The largest area of assigned rights codified in UNCLOS is the exclusive economic zone or EEZ, a zone extending 200 nautical miles from a nation's shores. In the EEZ, that sovereign nation retains exclusive rights to maintain or manage the resources found within it however it sees fit, per UNCLOS. Nations can appeal for further exclusive rights to exploit the ocean bottom through the Commission on the Limits of the Continental Shelf, an advisory body established by UNCLOS. Moving further out of the EEZ, an extended continental shelf puts one in the high seas, a zone owned or exclusively managed by no single state. But UNCLOS assigns rights to resources found in this region, as well, by its establishment of the International Seabed Authority (ISA), a body assigned

the responsibility of identifying areas of the high seas ocean floor that show the greatest potential for mineral wealth extraction and licensing states to manage or exploit these sections at some point in the future—assigning resource access rights, in other words.

Other MEAs set up complex information-sharing regimes in a bid to help governments head off environmental threats, including threats to endangered species. Arguably the most powerful treaty that protects the environment through information sharing is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Through CITES, governments apply to list species they feel are threatened with extinction. This list is shared with other governments, and all parties have agreed to use this information to strictly monitor and control cross-border trade in live plants and animals and their parts, especially if a species is deemed threatened or endangered in another nation. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal is another classic example of the information-sharing function of some MEAs.

Other MEAs function by encouraging nations to protect or preserve their natural resources. One example is the World Heritage system run out of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). Through the World Heritage Treaty, nations initially sought to develop a mechanism for protecting antiquities and historic sites but later broadened the concept of "world heritage" at UNESCO to include nature, as well. The treaty invites nations to nominate regions of natural beauty and significance to earn the title of World Heritage Site.

Realism and institutionalism help explain the enactment of UNCLOS. Initially, states would unilaterally declare 200-nautical mile exclusive economic zones around their shorelines. Realists would note how powerful states could make and enforce these

unilateral sea grabs, but other theorists would show that states' institutionalist tendencies ultimately led them to cooperation and draft the UNCLOS treaty and form institutions like the International Seabed Authority (O'Neill 2017). Institutionalism arguably came to the fore again when nations negotiated CITES and the Basel Convention, the information-sharing regimes that rely on cooperation among states to make those MEAs operational.

Bestowing UNESCO World Heritage Site status to protected areas is a practice that one can rely on both institutionalism and constructivism to explain. Sovereign governments take the initiative to set aside areas for conservation and then appeal for UNESCO institutional recognition. That they bother to do this at all, constructivists would argue, is due to the fact that nation states are run by people existing in our modern reality, people who want to be seen as good stewards of nature and responsible actors in global conservation efforts.

Though it is not an MEA and was never intended to become a model for other foreign legislation, the ESA has, over time, evolved into a means of encouraging environmental protections far beyond the borders of the United States itself. To explain how, it's helpful to first explore how and why states join and participate in MEA regimes and why MEAs are limited to serving one or all of three primary functions: assigning access rights to resource areas, implementing information-sharing regimes, or encouraging sovereign environmental protection actions.

International environmental relations stand out from other strands of foreign affairs, such as economic relations or military alliances, in that state interactions in global environmental affairs occur in an environment largely absent of great power politics or great power rivalry (Bernstein 2019). Whereas rival powers or poles of authority assume responsibilities in global security concerns, when it comes to the global environment

"evidence suggests a decline and diffusion of responsibility" (Bernstein 2019). The threat of force is also never on the table when MEAs are under consideration or negotiation (Bernstein 2019). Thus, to ensure that a government will agree to voluntarily participate in an MEA, modern diplomatic practice as it's conducted under the auspices of the United Nations or in other multilateral fora has discovered that three general conditions must be met to improve the odds that a state will join an MEA. What follows in the next three paragraphs is an assessment born of the author's own observations of global environmental diplomacy and conclusions on how and why international environmental management takes the form and function it has as reflected in MEAs.

First, MEA participation must be deemed relatively inexpensive or even free-of-charge by the states considering participating. This is likely due to the fact that governments are pressured to spend money on their own citizens first; thus, they seek to avoid additional budgetary expenses—oftentimes, an MEA is drafted in a way that makes use of existing resources or capabilities or recruits from richer nations the funds necessary for helping poorer participant nations build up new capacities.

Second, the odds of state MEA participation increase when these agreements don't require too much from signatories. Any additional burdens placed on nations for their participation are kept to a bare minimum, thereby ensuring that the new treaty body doesn't tread on the preexisting domestic priorities of states.

Third, any failure to comply with any or even all of the provisions of MEAs do not result in any fines levied or punishments rendered to the noncompliant party. In other words, there are generally no real-world consequences for noncompliance.

Again, the above explanations of MEA function and structure, and of state behavior in MEA participation and environmental negotiations, stem from the author's

personal experience observing and analyzing environmental diplomacy within the United Nations system while serving as a UN resident correspondent at UN Headquarters in New York.

In the absence of great power leadership, responsibility, or rivalry, but in the presence of the tendency of states to attempt to resolve differences or collective problems through forming institutions, realist, institutionalist, and constructivist perspectives of international relations can all be utilized to understand why this pattern of state MEA participation has emerged (O'Neill 2017). Constructivism arguably best explains the US Endangered Species Act's influence on global environmental management. Through the ESA, the United States took the initiative (preceded by earlier similar US initiatives beginning with the 1900 Lacey Act) to craft a thorough and far-reaching law regarding extinction prevention and endangered species management. In doing so, the US government in a sense demonstrated to the rest of the world responsible state behavior in the face of a worsening global extinction crisis. As this chapter will demonstrate, seeking to become good actors in their own rights, other states quickly followed suit both unilaterally and multilaterally, giving rise to the global endangered species protection architecture that we see in place today. From the year of its enactment, the ESA has had a tremendous impact on how other nations both perceived of and crafted potential solutions to address the global extinction problem.

Several nations and the United Nations followed the US government's example and came up with their own local solutions to this global dilemma, inspired by the ESA and how that law is structured. Through the lens of constructivism, we can discern how the ESA sparked a trend of benign legislative mimicry in a host of foreign jurisdictions beginning 50 years ago. Hence, there is a strong argument to be made that thousands of

animals and plants that were once on the brink of extinction in Africa, Asia, Australia, Europe, and South America are still with us today thanks to the ESA, even though Congress only ever intended that law to pertain to the United States.

5.6 United States, 1973 Endangered Species Act

The US ESA is both domestic and international in scope. The preambular "Findings, Purposes, and Policy" section references the United States' obligation to international cooperation under migratory bird treaties signed with Canada, Mexico, and Japan, as well as other multilateral wildlife protection conventions, in particular conventions related to fisheries conservation (Sec.2.a Findings, 4, A-G). The ESA also references the United Nations CITES convention and US obligations under that treaty (Sec.2.a Findings, 4, A-G). That these mentions appear early in the text of the law make it clear that international environmentalism and rising concern over threats to global biodiversity had influenced the drafting of the ESA before its adoption in late 1973. Moving beyond 1973, however, the ESA has influenced how other governments frame and pursue endangered species and habitat protection.

The US Congress charged the US Department of the Interior with enforcement of the ESA. The law stipulates that the Secretary of the Interior must make determinations as to "whether any species is an endangered species or a threatened species," with "endangered" defined as facing the imminent prospect of extinction and "threatened" defined as a species declining to such an extent as it may become at risk of extinction in the near future (Sec.4.a General, 1). If such a determination is made, the Secretary is ordered to publicly list the species as threatened or endangered, and to notify the public of any changes to a listing status that may occur, including the removal of a species from

the list of threatened or endangered species (Sec.4.a General, 2, A). Thus, a fundamental pillar of government endangered species protection was enshrined into the ESA: that a designated government agency must make an official determination of a species' threatened or endangered status; that a listing must be formally and publicly made in a clearly stipulated, procedural way; and that any changes to the listing status (additions, alternations, or removals) must also be made public.

Next, the ESA directs the Secretary of the Interior to identify habitat deemed critical to the survival of a species in the wild (Sec.4.a General, 3, A, i). The ESA excludes from Interior's jurisdiction properties held by the Department of Defense (Sec.4.a General, 3, B, i). The formal determination by government of critical habitat is another pillar of species conservation policy enshrined by the ESA and sets the stage for governments to develop management plans for these areas of land or marine habitat. The policies pursued are wide-ranging, from basic legal restrictions on activities conducted in these areas to outright government appropriation or purchase of tracts to remove them from commercial considerations entirely.

The ESA empowers the public to participate in endangered species management. Upon receipt of a petition for a listing decision (add, revise, or remove) the ESA then sets a deadline of 90 days for the Secretary to determine whether or not the third-party petition is warranted and would prompt an Interior Department review of a species' status in the wild (Sec.4.b Basis for Determinations, 3, A). The law then gives Interior another 12 months to notify the public as to how it intends to proceed with the petition for a listing decision (Sec.4.b Basis for Determinations, 3, B). Another common feature of the ESA is strict timelines for listing decisions to be made and announced, the requirement that listing decisions be made public (in the Federal Register and in local newspapers where

a species is known to be prevalent), and that the public is invited to review and even participate in the listing process. The ESA attempts to enforce transparency, accountability, and public participation in listing considerations and determinations. And as noted earlier, listing actions or petitions also fall under judicial review and court challenges are common.

All the above core principles of procedural, participatory, and timely endangered species listing decisions and policies, subject to judicial oversight, are enshrined in other nations' endangered species management laws and regulations.

5.7 Canada, 2002 Species at Risk Act

Though Waples et al. argue that Canadian and American endangered species laws are too different and should be harmonized, a careful reading of Canada's national 2002 Species at Risk Act (SARA) reveals how lawmakers in Ottawa were likely inspired by both the letter and spirit of the US ESA in drafting their own foundational endangered species management act.

Whereas the ESA designates the Department of the Interior as the responsible enforcement authority, SARA stipulates the formation of a "Canadian Endangered Species Conservation Council" consisting of ministers of three federal agencies (Environment, Fisheries and Oceans, and Parks Canada) and ministers from concerned provinces or territories (Composition 7(1)). Enforcement obligations can be delegated to a specific ministry after consultation with other parties to the Council, with a delegation determination made public within 45 days from commencement of a species status review (Responsibility of Minister, 8). The Council must also act in consultation with

representatives of First Nations groups where endangered species management decisions may impact them (National Aboriginal Council on Species at Risk, 8).

SARA establishes a clearly defined listing process to be undertaken by the Committee on the Status of Endangered Wildlife in Canada, or COSEWIC (Establishment, 14). In this section, SARA goes beyond ESA in listing specificity, authorizing the Committee to make a determination on whether a species is "extinct, extirpated, endangered, threatened, or of special concern", all subcategories of the more general "species at risk" classification (Establishment, 14). The Committee is also ordered to note publicly whether there is no cause for concern over a species' status, or in cases where scientific data are lacking to make any specific determination (Functions, 15). COSEWIC is directed to establish subcommittees to undertake reviews of the status of individual species (Subcommittees, 18(1)) and as with the ESA, SARA specifies a timeline for action: the law gives COSEWIC one year upon receipt of a subcommittee report to make an assessment and listing decision (Time for assessment, 23(1)). SARA also authorizes any interested group or member of the public to petition COSEWIC for a listing decision (Applications, 22(1)). The SARA law also gives COSEWIC a 90-day deadline to make public its intention on how to list a species (Report on response, 3).

5.8 Manitoba, Canada, 1990 Endangered Species and Ecosystems Act

The ESA's influence on endangered species management regimes is felt at the Canadian provincial level, as well.

The provincial government of Manitoba adopted its 1990 Endangered Species and Ecosystems Act (ESEA) as an updated version of earlier provincial endangered species management legislation. In it, the provincial Lieutenant Governor is authorized to appoint

a minister in charge of policy direction and enforcement, and the ESEA also establishes an advisory committee with members appointed by the Lieutenant Governor (Part II Administration, 6(2) and 6(3)). Upon receipt of a report by the advisory committee and minister, the Lieutenant Governor is authorized to determine whether or not a species can be listed as endangered, threatened, extirpated, or of "special concern" (Part III Species at Risk). Upon a listing determination, a recovery plan must be drafted which may include special designation of habitat or areas deemed critical to the survival of a species, including legal restrictions on activities that might be detrimental to a species' survival (Part III Species at Risk). The ESEA also empowers Manitoba's Lieutenant Governor to designate "endangered ecosystems," a provision mimicking the ESA's authorization of critical habitat designation (Part III.1). Public notification and participation are also required: the law requires a 90-day public notification prior to a listing decision or new regulation being enacted, to give time for public comment (Part III.1, 12.5(1)).

5.9 Australia, 1992 Endangered Species Protection Act

The ESA's influence on other governments' endangered species management regimes is apparent beyond North America.

Australia's 1992 Endangered Species Protection Act establishes the Endangered Species Advisory Committee under the direction of the National Parks and Wildlife Service (Part 1, 3(2)(e)). The Committee is established to undertake assessments of species and to make a determination on whether to list the species as endangered, vulnerable, or presumed extinct (Part 2-Listing, 14). The law provides definitions for each listing category and how such a determination is to be made. Listing decisions are to be made public in both a national government periodical and in newspapers published in

states where that particular species is known to be found (Part 2, Division 2, 18). Members of the public are also invited to nominate species for certain listing statuses (Part 2, Division 2, 25). A species recovery plan must also be drafted and made available for public review and comment (Part 3, Division 1). The Act also details a timeline for action and even includes a detailed timetable determining the steps and length of time authorized for implementing and reviewing recovery plans (Part 3, Division 2). The law also directs the ultimate regulatory authority, the minister of the National Parks and Wildlife Service, to accept advice on listing decisions from a Scientific Subcommittee, and that the public must be notified of decisions on listings or de-listings within 30 days of such a determination (Part 2, Division 2, 24).

5.10 Ireland, 1976 Wildlife Act

Ireland's Wildlife Act of 1976 also follows the pattern pioneered by the ESA. Ireland's law established the Minister of Lands as the primary authority responsible for species management and protection, again for the benefit of the citizenry (Part 2, Chapter 1, 11-1). The law directs the minister to consult with other government agencies, a committee of experts, and the public in determining policy (Part 2, Chapter 1, 12-1 and 13-1). The Act directs Ireland's Minister of Lands to identify habitat of importance to protected species and to set up mechanisms to protect the habitat so that it may continue to sustain that species, including through establishing wildlife refuges and other protected lands (Part 2, Chapter 2). The public must also be notified of any actions or changes in policy, as outlined in several sections of the Act, and for a specified period.

5.11 The Philippines, 2001 Republic Act No. 9147 (Wildlife Resources Conservation and Protection Act)

The Philippines Republic Act No. 9147 (Republic Act), enacted in 2001, establishes the Department of Environment and Natural Resources as the primary authority charged with enforcing the Act as it pertains to terrestrial plants, animals, and ecosystems; the Department of Agriculture is vested with enforcement authority in aquatic ecosystems (Sec. 4). This division of labor closely resembles the US Department of the Interior's practice of splitting enforcement of the ESA between FWS for continental ecosystems and the National Marine Fisheries Service for oceanic ecosystems. The Republic Act directs the secretary of the responsible department to make a determination as to whether a species should be listed as critically endangered, endangered, vulnerable, or "other accepted categories" (Sec. 22). The Republic Act directs the secretary of the responsible agency to make public a list of species and their statuses and to accept petitions from the public concerning proposed listing and delisting decisions (Sec. 22, d). The Philippines' law stipulates that the respective secretary has one year from the enactment of the law to develop a comprehensive list of species and their statuses, and two years to determine critical habitat beyond already protected areas (Sec. 25). The law then directs authorities to formulate conservation plans in collaboration with local governments.

5.12 Kenya, 2013 Wildlife Conservation and Management Act

Kenya's Wildlife Conservation and Management Act of 2013 shares the ESA's ethos that wildlife should be protected from extinction primarily for the benefit of humans and not for the sake of the endangered species in question. The law states that wildlife

conservation efforts will be practiced "to meet the benefits of present and future generations" (4, f) and that such benefits shall be "enjoyed and equitably shared by the people of Kenya" (4, g). Just as the ESA directs agencies to publish their management decisions, Kenya's law also stipulates that management authorities will publish actions in that government's *Gazette*, including "a national wildlife conservation and management strategy" to be published once every five years (5, 1). The law establishes the Kenya Wildlife Service as the ultimate authority responsible for endangered species management (6, 1), and determines that this service will be governed by Board of Trustees (8,1) to approve strategic planning and budgeting matters (9, b). As with the ESA, Kenya's wildlife law designates a top authority responsible for species conservation, and determines that this authority shall make its conservation and management decisions public. Wildlife managers must also arrange a process of public consultations before final management decisions can be taken and implemented (44, 5).

Kenya's law also directs the Kenya Wildlife Service to identify threatened and endangered habitat and ecosystems and make the list of threatened and endangered areas or ecosystems public (46, 1). The Kenya Wildlife Service is further directed to spell out conservation measures that will be taken to ensure the protection of endangered habitat and to conduct regular periodic reviews of lists and management plans (46, 3). And as is more typical in endangered species protection laws, under Kenya's 2013 law the Kenya Wildlife Service must identify and list species as either critically endangered, vulnerable, or nearly threatened under public guidance and scrutiny (47, 2). Species protection plans must also be drafted and subjected to public comment and consideration, and the service is instructed to be as detailed as possible in its plans, including details such as "estimates of the time required and the cost to carry out those measures needed" (49, b, iii). Species

recovery plans must also incorporate "objective, measurable criteria which, when met, would result in the species being removed from the list" (49, b, ii). The law also details how wildlife use licensing and permitting will operate and under what circumstances, and what actions entail violations of endangered species law. And as in the ESA, Kenya's law is also designed to facilitate Kenya's international legal obligations under CITES.

Kenya's Wildlife Conservation and Management Act differs most from the US ESA in its early and explicit references to bioprospecting, effectively banning the practice of mining Kenya's biodiversity for genetic information without a permit (22, 1, a). The dispute over bioprospecting represents the most series rift between states parties to the UN Convention on Biodiversity, a disagreement pitting developed nations with advanced genetic research and commercial interests like the United States against developing countries rich in biodiversity such as Kenya. The subsection on biodiversity contains the same provisions regulating bioprospecting that the developing nations bloc at the UN would like to see incorporated into the CBD, provisions that the US and other nations are rejecting for fear of their impact on commercial interests and medical research. Otherwise, to read the Kenya Wildlife Conservation and Management Act is to read a law clearly inspired by the ESA, or at the very least reflective of patterns inherent to nations' endangered species management laws that were initially inspired by the ESA. There are important and substantive differences between the laws, but the spirit and regulatory foundations of the two laws are the same: to benefit humans living today and in the future, both laws determine that species will be protected from extinction by designated federal government authorities subject to public scrutiny and review, in consultation with the public and with other state agencies at the federal and provincial (or state) levels, and in

a manner clearly stipulated in a way to facilitate maximum transparency and public buy-in.

5.13 Guyana, 2016 Wildlife Conservation and Management Bill

Guyana's Wildlife Conservation and Management Bill of 2016 includes provisions designed to regulate economic activities involving wild species that existed in that country before this law was implemented, including the captive breeding of wild animals, the artificial propagation of wild plants, and the operation of ranches for holding and breeding nominally wild animals. The law is also mainly designed to detail how Guyana's government plans to comply with and implement its international obligations under CITES, a common feature found in the wildlife legislations of smaller jurisdictions and nations with relatively small populations (Guyana's population is about 800,000 according to the United Nations Population Fund).

But the law also includes provisions common to other national endangered species conservation laws adopted after the ESA. It appoints the Guyana Wildlife Conservation and Management Commission as the authority responsible for endangered species protections (Part III, 1). The commission is instructed to devise and implement strategies for species conservation adopting the classifications of "threatened" or "endangered" species as the ESA does (Part III, 5, f). Special areas critical to endangered species survival are to be identified and protected (Part III, 5, h) and special licenses and permits must be issued for any party conducting activities that might prove detrimental to protected areas or protected species, essentially rules governing incidental takes (Part III, 5, i). Decisions or changes to regulations or listing decisions must also be made public in the government *Gazette* and in a newspaper (Part II, 3). A separate body, the Wildlife

Scientific Committee, is assigned the responsibility of managing compliance and cooperation with CITES, according to Guyana's endangered species law (III, 8).

5.14 Uganda, 2019 Wildlife Act

Uganda's 2019 Wildlife Act (Act 17) stipulates that all wild fauna and flora in the country are property of the national government, to be managed by the government for the benefit of the people of Uganda unless a specific wild plant or animal has been lawfully taken possession of by an individual or group (Sec. 3). The minister (simply defined in the Wildlife Act as "the minister responsible for wildlife") is then directed to make a listing determination on various species as determined by an advisory board (Part V, Sec. 34, 3). The minister can list a species as either extinct, extinct in the wild, critically endangered, endangered, vulnerable, threatened, nearly threatened, or data deficient; a listing determination must be made public in the Gazette, a government periodical (Part V, Sec. 34, 3). These listing status options closely resemble the classifications used by the International Union of Conservation of Nature (IUCN) in their periodic species assessments. Uganda's law does not specify a length of time by which the minister must arrive at the listing determination or issue public notification of a listing determination. Uganda's Wildlife Act also is much more focused on user rights and the processes by which an individual or group may receive a license to exploit species, including for bioprospecting purposes (the practice of harvesting species for their potential genetic value). The ESA includes provisions for licenses to be issued to permit "incidental takes" of species but makes no mention of bioprospecting. Still, Uganda's law contains the same core provisions found in other countries' endangered species legislation: a designated national authority charged with undertaking species assessments (with expert input),

making listing decisions, and then notifying the public of said decisions while allowing the public space to both give input on decisions and to offer their own listing additions or change proposals.

5.15 Japanese endangered species law and the ESA

This author would argue that the top-down endangered species management structure as laid out in the US ESA has likely been influenced by the US government's experience with managing and saving the whooping crane, in particular the endangered AWB whooping crane population. Although it has much in common with the American legislation, Japan's landmark endangered species conservation law differs in important ways that suggest the drafters of Japan's primary endangered species law were heavily influenced by the historical bottom-up approach taken toward red-crowned crane conservation in Hokkaido beginning in the 1950s, and thus they were inspired to codify this approach in Japan's endangered species legislation.

First, it's beneficial to review what the US and Japanese laws share in common. As in the US ESA, Japan's Act on Conservation of Endangered Species of Wild Fauna and Flora (ACES) begins with a declaration of a purpose or reason for drafting legislation to prevent extinctions. That stated purpose is identical to that first articulated in the ESA: because maintaining greater biodiversity is of benefit to humans. Chapter 1, Article 1 of ACES declares that Japan has drafted this legislation "in view of the fact that wild fauna and flora are not only important components of ecosystems but also serve an essential role in enriching the lives of human beings," and because biodiversity helps contribute to "wholesome and cultured lives for present and future generations of citizens" (Chapter 1, Article 1). Though culturally distinct and often far apart in terms of attitudes toward living

natural resources (an excellent example is the rift between the United States and Japan on the question of commercial whaling), Japan still shares the American view that humans seek to prevent extinctions so that humans, and not animals, may experience greater benefits.

As in the ESA, Japan's ACES designates an ultimate authority responsible for endangered species designation and protection, in this case, the Ministry of the Environment (MOE). The law gives the minister of MOE the power and responsibility to declare species as “rare” plants or animals warranting protection, noting that MOE retains this authority from prior Japanese law and practice (Article 2, 1). The ACES law also empowers the Ministry of the Environment to make a unilateral temporary declaration of a species’ “rare” status (Article 5, 1). The law deems the minister of MOE responsible for ACES and also requires MOE to make public its decision in the national government’s Gazette, and specifies that this temporary designation is only good for three years (Article 5, 3 and 4). The law also specifies the kinds of restricted activities related to a rare species that the minister is authorized to regulate, as well as penalties to individuals for non-compliance.

The ACES law also empowers the MOE to designate and protect habitat deemed critical for the survival of rare plants and animals (Article 36, 2). Before making that call, MOE is directed to consult with other relevant government authorities and with the Central Environmental Council, a body established in prior chapters of the law (Article 36, 4). MOE is also required by law to notify the public of any forthcoming designation of species or habitat status prior to making such a determination, and that the public has a right to provide its input into the decision-making process (Article 36, 5). ACES makes Japan’s MOE the ultimate authority over rare species conservation decisions but

mandates that the minister of MOE and that ministry take every opportunity to invite public participation and cooperation at nearly every step of the regulatory process, much in the same way that ESA requires public notification and comment periods, invites public petitions for listing decisions, and directs authorities to incorporate and cooperate with other levels of government (including foreign governments) and members of the public in the endangered species conservation processes.

As mentioned earlier, Japan's endangered species law departs from the US ESA precedent in the way it seems to reflect a more bottom-up or grassroots history of species protections, an approach likely most influenced by the historical experience with red-crowned crane conservation. For example, the language of ACES makes explicit the role of the public in species conservation; it authorizes the minister of MOE to appoint individuals as "rare wildlife species conservation promoters" for their expertise and enthusiasm for rare species conservation (Article 51, 1). It directs the MOE to cooperate with the nation's zoos and botanical gardens on species conservation initiatives and even captive breeding programs (Chapter V: Certified Zoos and Botanical Gardens Conserving Rare Species). ACES also directs MOE to educate the public on the importance of rare plant and animal conservation (Article 53, 2). ACES also differs most from ESA in that it goes into great detail regarding how MOE may authorize and regulate various business dealings concerning designated rare species. ACES is also not as detailed as ESA in that it appears to forgo reliance on different levels or categories of extinction threat (going with a general "endangered" or "rare" definition and avoiding the language of "threatened" or "near threatened" species). The ACES law borrows the same general procedural framework or skeleton as established in America's ESA law, but differs in its language that's aimed at empowering individuals and local communities to be more actively

involved in species conservation, a difference that his author believes is rooted in the fact that Japan's most famous endangered species recovery case study—the red-crowned crane of eastern Hokkaido—began as a citizen-led initiative, with the national government only taking over later.

As with the ESA, in Japan's foundational endangered species law a central government authority is made responsible for assessing and determining a species' status, in collaboration with experts and members of the public. That central authority must also designate habitat areas deemed important or critical for the survival of that species, and then impose restrictions on activities allowed in these areas to conserve the species. Decisions on designations must be made public and in a timely manner; for example, ACES specifies 14 days as the length of time MOE must give as prior public notice of species or habitat designations or changes to designations (Article 36, 5). ACES establishes a supreme power over endangered species management but also mandates transparency in decision-making and ample opportunities for public participation in the conservation process, all concepts borrowed from the ESA and found in other national endangered species legislation.

5.16 Discussion and Conclusion

Most national comprehensive endangered species laws reference the United Nations Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The ESA is no exception; in fact, the United States signed onto CITES the same year as the ESA was drafted and finalized, in 1973, and the ESA devotes an entire section to establishing the Secretary of the Interior as the managing authority of US compliance with CITES and to outline how the US will pursue said compliance

(Convention Implementation Sec. 8A). Other governments followed this script, and in some cases, governments weighted their endangered species legislation more heavily toward CITES compliance and less towards domestic protections of endangered species. In some cases, government endangered species laws are focused primarily on managing endangered species trade restrictions rather than domestic conservation initiatives. This is likely a reflection of the relatively small size of the particular territorial jurisdictions and populations falling under these pieces of legislation. Singapore's Endangered Species (Export and Import) Act of 2006 explicitly states that it exists for purposes of CITES compliance. Norfolk Island, Australia's Endangered Species Act of 1980 is also drafted primarily as a CITES compliance vehicle, and the Norfolk Island act even includes the entirety of the CITES treaty in its Schedule addendum. Other endangered species laws that can be best described as hybrid approaches to codifying CITES compliance measures and domestic ESA-type overarching conservation measures (such as Guyana's law).

But in the national and provincial endangered species legislation reviewed here, a clear pattern is apparent, and one with obvious American roots. The United States Endangered Species Act of 1973 states that it is the duty of the government to prevent species' extinctions because greater biodiversity is of benefit to humans. The entire world echoed this stance in the preamble of the 1992 United Nations Convention on Biological Diversity when the UN member states adopted language certifying member states' awareness of "the intrinsic value of biodiversity and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational, and aesthetic values" worthy of protection (preamble, UN Convention on Biological Diversity 1992).

The ESA law identifies a governing authority responsible for national endangered species protections. It specifies that this authority can assess and identify endangered

species according to certain standards that it determines, but that these standards must be informed by science and scientific advisors. The ESA demands full transparency, ordering those determinations to be made public and that the public be afforded sufficient time to consider proposals and respond. The public is also empowered to petition for endangered species determinations or changes to species' status. The pattern is one of establishing a central responsible authority that nevertheless recognizes it must cooperate with the public to achieve the goal of preventing extinctions, and because of this fact, the legislation similarly empowers the public to appeal to this strong central authority for policy changes. And the entire process must be made open, transparent, and participatory. The national endangered species laws of other English-speaking jurisdictions and Japan embraced this same foundational pattern, a clear demonstration of the degree to which America's 50-year-old Endangered Species Act has set the tone for government-driven biodiversity protections throughout the world since its passage.

The above describes "how" the ESA influenced endangered species protection legislation in other jurisdictions around the world; in other words, how governments leaned on the ESA when devising their own systems of endangered species management and conservation. To explain "why" those jurisdictions followed the US example as represented by the ESA requires an analysis of state behavior as it occurs in quasi-anarchic conditions lacking any central governing power to regulate the behaviors of disparate states. Of the tools in the international relations theory toolbox, the constructivist school of thought is the most useful here as constructivism emphasizes the importance of ideas, values, and norms in influencing and shaping state behavior (O'Neill 2017). Constructivism also makes clear that states do not function as automatons but are rather driven by the choices people make, and people desire more than just material

wealth, resources, and security, all considered the three main concerns of states (O'Neill 2017). Environmentalism is driven by human values, which change over time, and these values are also subjective and are influenced by the values and behaviors of other actors.

International relations scholarship already recognizes the important role values play in driving government policy and international affairs, and "to adopt a values-based paradigm for international relations is thus to automatically deny the axiom that domestic politics and international relations are fundamentally different" (Willetts 1996). In other words, the lines that divide the "domestic" from the "international" are blurred, and largely erasing the imaginary line between domestic politics and international politics "seems appropriate for analyzing what is commonly called global environmental politics" (Willetts 1996).

Values-driven international environmental policymaking need not only occur within multilateral negotiation settings. A domestic piece of legislation known as the ESA became the foundation for a worldwide endangered species management regime even in the absence of a comparable MEA (as an aspirational multilateral statement of intent, and not a prescriptive legal framework, the UN Convention on Biological Diversity is fundamentally different). This author argues that in drafting and enacting the ESA, the United States presented to the world its values with regard to the importance of biodiversity and of species conservation. Other governments later adopted as their own not only these same values, but also many of the same legal definitions, tools, rules, and regulatory structures. At the 50th anniversary of the US Endangered Species Act of 1973, we can today look back and marvel at how the ESA not only gave the world an embodiment of a new set of values concerning how other lifeforms should be treated (new values radically different from the historical values that drove so many species to

extinction in the first place) but also at how it provided the world a convenient template for codifying these new values into national and subnational law.

Most relevant and critical to this entire study, the form and function of the US ESA and Japan's ACES law show clear signs of both having been heavily influenced by the US and Japanese governments' earliest experiences with endangered species management as best illustrated by their separate histories of crane conservation—the AWB whooping crane in southeast Texas and the red-crowned crane in southeast Hokkaido. The experiences wildlife managers have earned in both nations from saving these two very similar crane species from extinction reverberate today in the way both nations have drafted their principle endangered species laws and in how these laws are enacted and enforced.

The study outlined in this chapter was undertaken on the advice of a faculty member at Hokkaido University's Graduate School of Environmental Science. The faculty member recommended that the author explore the cultural differences underpinning the way Japan and the United States engage in endangered species management. One way this effort could be approached is through qualitative research based on interviews, surveys, or questionnaires directed at conservation authorities in the US and Japan and at members of the general public. However, any researcher adopting such an approach runs the risk of having their findings corrupted by that researcher's own subjective viewpoints rooted in his or her own culture. For a more objective and neutral assessment, this author chose the methodology as described above: a detailed textual analysis of the major endangered species laws of the United States, Japan, and other countries. In the US, the federal government exerted its prime authority to save the whooping crane from extinction, setting the tone for top-down, federally directed

endangered species management and legislation in subsequent laws, including the drafting of the 1973 ESA. In Japan, it was the citizenry that took the initiative to save the red-crowned crane through intervention supplemental feeding; though recovery efforts were later coopted by the Japanese government, government authorities nevertheless maintained their relations with local community members and those communities' involvement in red-crowned crane protection, a bottom-up relationship that is today enshrined in Japan's ACES law.

Conversations that the author has had with conservation authorities in the US and Japan do reveal potentially interesting and distinctive viewpoints that likely reflect differences in values and cultures between the two countries. Though not a principal part of this larger analysis, it may be valuable to briefly illustrate these culturally different viewpoints and how they might further reflect cultural differences apparent in the ways the ESA and ACES were influenced by these respective crane conservation histories, and subsequently drafted.

In discussions with US Fish and Wildlife Service authorities in Washington, D.C. and at the Aransas National Wildlife Refuge, the US authorities described their roles in protecting the AWB whooping crane in very managerial tones. When speaking with the author about their perceptions of interactions between AWB whooping cranes and the general public, these managers spoke of members of the public as another potential risk factor that needed to be managed and mitigated against at the wildlife refuge and at whooping crane layover sites, much in the same way as they spoke of managing invasive plant species or predator risks. In Japan, authorities spoke to the author in more holistic terms, meaning they described their management practices but also frequently mentioned their concern for the attitudes and experiences of the surrounding communities, and how

these community considerations are also important factors they must be cognizant of in their daily work. With regard to how these managers viewed the general public, they spoke to the author more in terms of seeing the general public as a resource that should be more effectively utilized to ensure the long-term survival of Hokkaido's red-crowned crane population.

It's left to the reader to determine the relative weight or importance of these anecdotal takes offered in the previous paragraph. They are only offered here to reiterate and further stress the importance of this chapter to the author's total study. The differences in the ways that wildlife managers in Japan and the US conducted crane conservation have not only led to vastly different population outcomes for these two separate populations of crane species, but these different policy approaches clearly reverberate today in the different spirits and letters of Japanese and American endangered species legislation. The case studies of the Hokkaido red-crowned crane and AWB whooping crane are not only stories of the likely impact of sustained artificial feeding. These two cases studies also tell the stories of how both nations came to conceive of the state's role in saving critically endangered wildlife from extinction.

Chapter 6

Conclusions: Assessing emerging threats to crane conservation in Japan and North America and the way forward

6.1 Summary and conclusions

The previous chapters detailed evidence supporting the author's thesis that the long-standing winter artificial feeding campaign in Japan is the most likely cause for the vastly different population recovery trajectories witnessed for the east Hokkaido red-crowned crane and North American AWB whooping crane. Prior research agrees that winter artificial feeding is the principal driving force behind the strong recovery in the Hokkaido red-crowned crane population (Masatomi 1991, Masatomi et al. 2007, Inoue et al. 2013). There is little indication that the AWB whooping crane population has suffered higher mortality rates over its recovery history compared to the red-crowned crane (with the exception of two relatively recent episodes, periods of winter droughts in Texas, that do not explain the longer-term pattern revealed in the population data), and no other explanation is found to explain the must faster rates of reproduction apparent in Hokkaido's red-crowned crane population. In addition, there is accumulating evidence in the academic literature that supplemental feeding can induce faster rates of reproduction and faster overall population growth for a wide array of species, especially avian species, than compared to wild population management strategies operating in the absence of supplemental feeding as a management tool (for purposes of this study, an ecological definition of "population growth" is given as a net positive increase in the numbers of individuals of a species as recorded in that species' primary habitat in the wild, thus excluding increases in the number of individuals of a species held in captivity). This study

is not limited to only explaining why these two crane species protection regimes demonstrate such vastly different population recovery outcomes. This study carefully reviewed the past, present, and futures of these two endangered species recovery stories in a comprehensive and holistic way in an attempt to shed better light on the vastly different rates of population growth recorded, to better understand ongoing and emerging threats to both species' population recovery trajectories, and to consider the legal and cultural legacies that these two case studies have left on approaches toward endangered species management in the US, Japan, and the world.

Figure 19: Photograph of red-crowned cranes gathered at the Itoh Tancho Crane Sanctuary in Tsurui, Hokkaido, Japan (Nathanial Gronewold).

Chapter 2 provides a side-to-side comparison of these two conservation stories, covering in detail the two crane species' habitats (a critical piece of this puzzle, given that all endangered species conservation initiatives usually begin with habitat protections and management), the dominant management approaches pursued by the official conservation authorities in both countries, historical trends in the species' conservation histories, significant mortality incidents that may have impacted population recovery trajectories, and the present status of the Hokkaido red-crowned crane and AWB whooping crane populations. Chapter 2 introduces this study's primary thesis: upon considering other probable explanations, the extended artificial feeding campaign in Japan best explains why the red-crowned crane population recovered at a much faster rate over the course of 70 years. Chapter 3 further strengthens this hypothesis by illustrating how the academic literature is increasingly uncovering evidence that supplemental or artificial feeding can elicit a positive reproduction effect on managed endangered species; in other words, other researchers are finding that artificial feeding appears to lead to faster population growth in endangered animal populations. The evidence for a net positive effect of supplemental feeding on rates of reproduction and population growth is particularly strong with regards to avian species, as past research has shown.

In Chapter 4, this study more carefully assesses conditions at critical red-crowned crane habitat and how those conditions might be improved upon in order to ensure the ongoing success of Japan's crane conservation initiative. This chapter is limited to a focus on the red-crowned crane's habitat in Japan because there are no existing or emerging threats to critical AWB whooping crane habitat in North America—on the contrary, and as described in Chapter 2, the extent of protected AWB whooping crane habitat is expanding dramatically.

This analysis of efforts to conserve and restore the red-crowned crane's core habitat in eastern Hokkaido was undertaken in recognition of the fact that direct population management via artificial feeding is not the only conservation strategy wildlife authorities in Hokkaido have at their disposal. As this chapter explains, the greatest long-term threat to the red-crowned crane's strong and impressive population recovery compared to that of the AWB whooping crane is habitat loss in eastern Hokkaido—thus, the additional attention paid to the present and future management of Kushiro Marsh National Park and adjacent lands that could one day be converted to additional red-crowned crane ideal habitat. Again, it's important to emphasize that the AWB whooping crane of North America faces no such habitat constraints: the volume of acreage set aside for the AWB whooping crane's benefit in Texas is already vast and is expanding dramatically with the addition of Powderhorn Ranch, and the AWB whooping crane enjoys access to abundant breeding habitat at Wood Buffalo National Park in central Canada, in addition to protected lands found along the crane's migratory corridor. Conditions at red-crowned crane habitat in eastern Hokkaido have already been thoroughly investigating by scientists, including by researchers based at Hokkaido University, so the author chose to focus only on two areas that these researchers have up to now overlooked: the potential for hardwood incursions in Kushiro Marsh to further "dry up" crane habitat through interception and evapotranspiration, and the creation of vegetated buffer zones to protect the habitat from further siltation caused by erosion from surrounding dairy operations. Upon careful inspection, the author concludes that the threat of interception and evapotranspiration is likely mitigated by the region's naturally humid and wet climate. However, given the ongoing risk of further habitat contraction,

the author further recommends that vegetated buffer zone creation be added to the list of officially chosen habitat protection and restoration methods in and around Kushiro Marsh.

Additionally, after analyzing the past and present statuses of red-crowned crane and AWB whooping crane conservation and habitat management, this study (on the advice of a faculty member at Hokkaido University's Graduate School of Environmental Science) attempts to delve into the cultural differences and social legacies of US vs. Japan crane conservation practices in an effort to better understand the different conservation management approaches. This effort is outlined in Chapter 5. In order to accomplish this task as objectively as possible, the author undertook a thorough textual analysis of the key endangered species laws of Japan, the US, and other nations (limited to English speaking jurisdictions, unfortunately). This exercise allows us to more deeply consider intrinsic legalistic and cultural differences between AWB whooping crane and red-crowned crane management strategies. An in-depth analysis of the US Endangered Species Act in comparison to other monumental endangered species legislation, including Japan's Act on Conservation of Endangered Species (ACES), illustrates the lasting legacy the US ESA has left on global endangered species management. This exercise further revealed how the experience of AWB whooping crane management and recovery in the US likely influenced American conservation philosophy and thus the US Endangered Species Act itself. In turn, a careful textual analysis and consideration of subtle yet important differences in these laws reveals how Japan's unique history of managing and reviving the red-crowned crane of eastern Hokkaido likely greatly influenced the letter and spirit of the ACES law, even as that law and other nations' endangered species statutes leaned heavily on the path forged by the US Endangered Species Act.

The ultimate purpose of Chapter 5 is to more intimately intertwine and bind these two conservation case studies' histories together. This chapter reveals the permanent mark the 50-year-old US ESA left on global endangered species management, how Japan stands apart in this regard, and how we can see traces of both the AWB whooping crane and Hokkaido red-crowned crane recovery projects and experiences in the endangered species laws of the US, Japan, and other countries, and why some obvious differences in species management approaches between Japan and the US likely reflect differences in histories and cultures, as well as the influence of the two different endangered crane management experiences. In short, the author argues that Japan's "bottom-up" history of red-crowned crane protection (with recovery efforts initially led by local citizens, and not government authorities) influenced the spirit and letter of the ACES law, and this key difference makes Japan's main endangered species law stands out and apart from other countries' endangered species laws. By contrast, the more "top-down" management approached used to save the AWB whooping crane from extinction (with the US federal government taking the lead) is reflected in the letter and spirit of the US ESA, as Chapter 5 explains.

Figure 20: Artificial feeding of red-crowned cranes conducted at the Itoh Tancho Crane Sanctuary, Tsurui, Hokkaido, Japan (Nathanial Gronewold).

Moving forward, defenders of the Hokkaido red-crowned crane and AWB whooping crane must be cognizant of other emerging risks to the long-term survival and success of these two remarkable species.

Researchers in the United States are aware that wildlife in North America is impacted by organic and inorganic pollutants and heavy metals, a consequence of air pollution finding its way into the waters, plants, and animals. In some places, these pollutants are a result of mining operations. In Japan, the red-crowned crane has not escaped this fate either, and pollution concentrations in red-crowned cranes have risen along with Japan's industrial rise. For example, a 2015 study discovered a slow but steady accumulation of mercury in red-crowned crane kidneys, reporting that "red-crowned cranes in Hokkaido were highly contaminated with mercury in the 1990s and that the contamination rapidly decreased to a moderate level in the 2000s" (Teraoka et al. 2015). That study did not definitively pinpoint the source of the mercury contamination but speculates that it might have something to do with historic mercury mining operations that previously existed in parts of the region near the red-crowned crane's core habitat (Teraoka et al. 2015). The risk posed by mercury contamination to red-crowned crane health and survival should be closely monitored. Meanwhile, mercury is not the only threat. In 2018, researchers discovered that red-crowned cranes are increasingly contaminated with persistent organic pollutants (POP), especially polychlorinated biphenyls (PCBs), and that "detected POP concentrations were at levels that negatively affected health in other avian species" (Kakimoto et al. 2018). On a positive note, these same researchers say POP concentrations were found to be lower than for some species, probably because red-crowned cranes are omnivorous whereas bird species suffering

higher POP concentrations in their tissues tend to be strictly carnivorous (Kakimoto et al. 2018).

Mercury also poses a serious long-term threat to the health of the AWB whooping crane population (Hebert 2019). Much of the AWB whooping crane's stomping grounds are found adjacent to regions hosting major crude oil and natural gas extraction operations. As mentioned previously, oil wells are located inside the Aransas National Wildlife Refuge, but these are old marginal well probably pumping only a few barrels a day. Aside from eastern Texas, AWB whooping cranes spend time in Oklahoma and parts of Kansas where some drilling activity happens. And, of course, the AWB whooping crane spends a significant part of the summer in northern Alberta and Wood Buffalo National Park. This park is downstream from the Athabasca tar sands, the center of Alberta and Canada's oil sands industry (Hebert 2019). Oil sands extraction releases tons of carbon dioxide into the atmosphere, aggravating global warming. In addition, this extraction activity releases considerable amounts of mercury. The Athabasca River flows through an active patch of oil sands surface mining activity, collecting mercury along the way, which it then carries to Wood Buffalo National Park as it flows northward (Hebert 2019).

The presence of environmental pollutants in AWB whooping crane tissues is an issue that warrants monitoring in the future, especially if the problem gets worse. A Canadian study published a few years ago confirmed a probable link between Athabasca tar sands mining and processing operations and mercury levels in AWB whooping cranes, though the author cautioned that no definitive link or firm proof had been detected (Hebert 2019). By measuring the mercury content detectable in AWB whooping crane eggs, the study determined that during periods of heavier rainfall and higher water flows mercury concentrations rose in AWB whooping cranes and for a host of other aquatic birds that

rely on the same prey as the AWB whooping cranes do (Hebert 2019). “For the majority of species/site analyses, higher egg [total mercury] concentrations were observed in eggs laid following years of high river flow,” the study showed, “hence, flow was likely of critical importance in moving contaminated sediments to downstream areas with resultant impacts on the bioavailability of Hg to wildlife such as birds” (Hebert 2019). Again, this particular study stressed caution and uncertainty, noting that “this study provides no direct evidence linking Hg levels in eggs to oil sands sources...however, previous studies have demonstrated that oil sands developments are a source of Hg to the local environment” (Hebert 2019). Further investigation should be undertaken both in Canada and the United States to determine whether or not mercury contamination from oil mining and other industrial operations poses a threat to the long-term survival and population recovery of the AWB whooping crane.

Hunting may become an issue of concern in AWB whooping crane rehabilitation, but much less so for the red-crowned crane in Japan, despite one recent case where a farmer was found to have illegally killed a red-crowned crane using an air rifle (Tokachi Mainichi News 2021). In the United States, studies have found that hunting has seriously impacted efforts to revive whooping crane populations in the east (Condon et al. 2019). For instance, a small population in Florida used to migrate to Wisconsin aided by a specialist guiding them in an ultralight aircraft. Experts report that hunting has likely impacted that flock badly (Condon et al. 2019). Hunting has also inhibited the recovery of whooping crane population in Louisiana, but there is little indication that hunting is a contributing factor to the relatively lower reproductive success rate in the AWB whooping crane flock compared to Japan’s red-crowned cranes (Condon et al. 2019). Of the

monitored whooper flocks in North America, experts agree that the AWB whooping cranes have been least impacted by illegal hunting (Condon et al. 2019).

However, sandhill cranes, a separate and distinct species that shares some habitat with whooping cranes, now number in the hundreds of thousands of individual birds, and pressure to open this species up to legal hunting is now mounting. Some subspecies of sandhill cranes are still protected under the Endangered Species Act, but sandhill crane hunting is now authorized to some degree in at least 15 states in the United States (Barzen and Ballinger 2017). The number of states where you can hunt sandhill cranes is likely to increase (Barzen and Ballinger 2017). Some level of sandhill crane hunting can almost certainly be sustained and may even be called for in some circumstances, however, in the past hunters have killed whooping cranes while insisting that they thought they were shooting sandhill cranes instead (Barzen and Ballinger 2017). Should sandhill crane hunting expand, this may emerge as another threat to long-term AWB whooping crane recovery.

Climate change may be the greatest long-term threat to the whooping crane, while posing comparative less of a risk to the red-crowned crane. Specifically, some authors conclude that climate change poses a potentially serious risk for AWB whooping cranes because of the seasonal migration they endure to facilitate their survival (Waller et al. 2018). Relying on two indexes designed to gauge when spring starts, the “first leaf index” and “first bloom index” or FLI and FBI, one investigation sought to estimate how earlier onsets of spring attributed to climate change could be impacting important national wildlife refuges and the flyways for the whooping crane and blue-winged warbler, another migratory avian species (Waller et al. 2018). The researchers said they detected big changes occurring over time, especially in higher latitudes, reporting “our results show

that relative to the historical range of variability, the onset of spring is now earlier in 76 percent of all wildlife refuges and extremely early (i.e., exceeding 95 percent of historical conditions) in 49 percent of refuges" (Waller et al. 2018). Seasonal abnormalities caused by climate change pose several troubling questions for AWB whooping crane survival. Will their seasonal forage be plentiful enough? Will there be enough blue crabs left when they arrive at the Aransas National Wildlife Refuge every winter? What would happen if the whooping cranes turned up at Wood Buffalo National Park too late for the start of spring? Could this affect their breeding and overall reproductive success? As one team of researchers warn, "it is unclear whether shifts in migratory timing are able to keep pace with alterations in plant phenology and food resource availability across broadly distributed habitats" (Waller et al. 2018).

Studies have determined that anthropogenic global warming could pose risks to migratory bird species in general globally, though no clear impacts found conclusively to be negatively affecting a migratory bird species' population have been determined. Researchers find that rising global average temperatures risk damaging or destroying critical migratory bird habitat through droughts, flooding, and warmer temperatures leading other species to invade critical habitat and thereby compete with migrating bird populations for available resources (Chaudhary et al. 2015). Modeling suggests that a 10 percent decrease in average rainfall volumes would dramatically reduce the available habitat for the golden bowerbird, a tropical species found in Australia, possibly risking that species' extinction (Hilbert et al. 2004). A study on the likely impacts of climate change on three species of crossbill found that changes in the start of seasons and variations in precipitation could lead to consequential declines in food availability for migratory crossbill species, likely reducing the range of crossbill species (Mezquida et al.

2017). However, the literature on climate change impacts on bird migration emphasizes caution in reaching broad-ranging conclusions. Research suggests climate change will induce changes to bird migration at shorter distances, but likely impacts on mid-range and long-range migrating bird species have still yet to be determined conclusively (Miller-Rushing et al. 2008).

Supplemental or artificial feeding could help mitigate against the risk climate change poses to migratory bird species. However, yearly or seasonal food availability is just one consideration that wildlife refuge and parks managers need to juggle as ever-increasing atmospheric concentrations of greenhouse gases deliver steadily rising temperatures. Invasive species problems could get worse. Diseases may propagate more easily. Parasite infestations could become more acute. Other wildlife may move in and out at different times and in different locations, upsetting some natural balance AWB whooping cranes have grown accustomed to. An even greater impact could result from an increased human presence: warmer weather could lead to ever greater numbers of visitors enjoying the Aransas National Wildlife Refuge and Wood Buffalo National Park during the AWB whooping cranes' stay. Milder winters may entice more visitors to travel to eastern Hokkaido to see the red-crowned crane, exacerbating traffic in the region and increasing chances of inadvertent mortality incidents for the red-crowned cranes.

By contrast, this author theorizes that climate change could lead to overall beneficial impacts on Hokkaido red-crowned crane survival. Shorter winters may lessen the need for supplemental winter feeding as the natural habitat increases its capacity to provide sufficient natural forage for Hokkaido red-crowned cranes. Changes induced by climate change coupled with expected declines in the human population in the region could also over time expand the area of available habitat for a larger population of red-

crowned cranes. However, there may be risks posed to the red-crowned crane's survival as climate change induces changes in weather patterns and precipitation. The projected impacts of climate change on the Hokkaido red-crowned crane need to be more thoroughly investigated before it can be determined with some confidence that red-crowned cranes will likely be spared any negative side effects from climate change.

This tale to two cranes concludes that a comparison of these two landmark endangered species recovery stories adds to the mounting volume of evidence that supplementary feeding of wildlife may lead to faster rates of reproduction and overall faster population growth. It also concludes that such a strategy should be pursued with great caution, especially in endangered species conservation, as a species recovery strategy based heavily on supplemental feeding may lead to unforeseen consequences or outcomes that wildlife managers may deem less than desirable. This study chose to not limit itself only to explaining the vastly different outcomes in population growth apparent in a review of the case studies of the AWB whooping crane and Hokkaido red-crowned crane. Rather, throughout this study the opportunity was taken to explore present challenges facing the success of red-crowned crane recovery, differences in endangered species management between the US and Japan as codified by national endangered species laws, and how the two crane conservation case studies gave rise to these important differences.

This investigation finds that managers of Kushiro Marsh National Park should consider another creative approach toward protecting and expanding the available area of ideal wetland habitat critical for red-crowned crane survival. There is as yet no indication that the presence of intrusive hardwood species into the marsh may lead to a further drying effect in a sort of feedback loop, one driven in particular by increased rates of interception

and evapotranspiration. Still, the park's managers would be wise to pursue all options available to them to recover lost wetland habitat and to protect what's left, including using a purported enemy in the form of Japanese alder as an ally in upland erosion control by planting alder to form vegetated erosion barriers at upland agricultural sites.

This study further concludes that the endangered species laws of the US and Japan have been greatly influenced by these two separate crane conservation case studies. While the US Endangered Species Act came first and has been far more influential on a global scale, Japan's Act on Conservation of Endangered Species shows unique cultural differences that reflect the impact red-crowned crane conservation has had on Japan's approach to endangered species management. The bottom-up species management approach apparent in the ACES law (compared ESA's top-down ethos) also illuminates important aspects of the Japanese people's relationship to nature and to their wildlife.

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